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CONTRIBUTION AND ROLE OF ARTIFICIAL INTELLIGENCE SYSTEM IN THE DEVELOPMENT OF THE EDUCATION SYSTEM

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Annotation: ***In order to organize the education system in our republic at the level of modern requirements, create a national system of electronic educational resources in all areas of knowledge, access to the necessary educational resources around the world and improve the infrastructure in this regard, establish the use of world and national electronic educational resources in the educational process, the material and technical base of educational institutions, the problems of development, digitalization of all spheres and the effective use of digital technologies are among the pressing issues in the education system. briefly describes issues such as artificial intelligence and its role in the development of the education system.***

Keywords:Local area network, agent, proxy servers, technologies, computer networks, firewall.

Decree of the President of the Republic of Uzbekistan dated January 28, 2022 No. UP-60 "On the Development Strategy of the New Uzbekistan for 2022-2026", Decree of the President of the Republic of Uzbekistan dated October 8, 2019 "On Approval of the Concept of Development of the Higher Education System of the Republic of Uzbekistan until 2030" Decree No. UP-5847 and Resolution of the President of the Republic of Uzbekistan dated April 20, 2017 No. RP-2909 "On Measures for Further Development of the Higher Education System" and No. RP-4996 of the President of the Republic of Uzbekistan dated February 17, 2021. The resolution "On measures to create conditions for the rapid implementation of artificial intelligence technologies" considers issues that need to be addressed. implemented today in the field of education, reforming the higher education system, the need for widespread use of digital technologies in education and other regulatory documents related to this activity, specifies a number of tasks. In the modern conditions of rapid development of science and information and communication technologies, digital technologies and artificial intelligence are used in developed countries of the world in the spheres of public administration and society, economy, industry, social protection, education, medicine, employment, agriculture. , defense, security, tourism and other areas, the widespread use of intellectual capabilities remains one of the main issues.

Today, China and the United States of America are leaders in the field of scientific research and education in the field of artificial intelligence. In addition to the location of world-famous centers of higher education and scientific research in these countries, the countries also fully regulate the situation. mechanisms that support innovative activities and provide great financial support. As a result, this attracts many knowledgeable specialists from countries around the world. The introduction of digital technologies and the development of the digital economy in our republic is a priority task. place among the countries-leaders of innovative development by 2030.

AI (artificial intelligence) is engaged in the creation of computer systems with the capabilities of the human mind: understanding language, learning, reasoning, problem solving, translation and similar capabilities. AI consists of algorithms and software systems designed to perform various actions and performs a number of tasks that the human mind can perform based on information entered into the information base. Artificial intelligence is also a "smart" technology capable of making logical and consistent judgments and recommendations, including programs that work with complex analysis and large amounts of data. Experts believe that artificial intelligence is the basis of the fourth industrial revolution. The following four main types of AI can be distinguished:

We can say that artificial intelligence is a software package that can transform human knowledge and skills, plan, solve problems, give advice, and also train and improve its work when performing tasks. Human thinking is based on brain neurons, and artificial intelligence is based on neural networks.

The use of AI not only automates any process, but also allows you to adapt it to a specific task of a person, organization or production, becoming more efficient over time - the better the neural network knows the details and needs, the better it works.

The digital economy requires an integrated approach that sets new goals, changes the structure and content of the educational process, and not the "digitalization" of individual processes of the educational system. The emergence of modern information and communication technologies and their "integration with educational technologies" have led to fundamental changes in the field of education:

- Firstly, teaching tools based on the use of information technology in education began to be used: Blackboard, online courses, simulators, simulators, online worlds, etc.;
- Secondly, information technologies have individualized education, in which the process and content of training are adapted to the needs of students and their individual characteristics (reading speed, reading preferences, etc.);

- Thirdly, game forms of training have begun to be actively introduced, allowing for effective and comprehensive mastery of the subjects studied in education.
- Fourthly, education is becoming increasingly subject-oriented and practice-oriented, especially for students of higher education institutions and adults; projects such as Startup, Business Project, Business Plan are hosted in the educational center.

1.Jet machines.
- An example is the computer Deep Blue, which was equipped with a chess program and beat world champion Garry Kasparov in the 1990s. Deep Blue is considered a computer that can recognize and predict the pieces on a chessboard.

2.Limited memory.
- This AI system can use previous experiences to form future decisions. Some decision-making functions in autonomous vehicles have been developed in this way. Observations made are used to obtain information about actions to be taken in the future. These observations are not permanent.

3.Theory of mind
- It is a psychological topic and term that refers to the understanding that others have their own beliefs, desires, and intentions that influence decision making.

4.Self-awareness.
- The advent of artificial intelligence involves the creation of systems for recording and storing information virtually forever at the quantum level. A self-aware machine understands its current state and can use this information to determine how others are feeling.

Thanks to the rapid development of the Internet and digital technologies, online education can be very effective due to the ability to analyze student data and change the educational process based on the results of this analysis.

The forced transition to distance learning during the COVID-19 or pandemic period has been confirmed: electronic textbooks still cannot make education digital, and the formal transfer of the standard lesson form to the Zoom distance learning platform does not allow. lead to good results. It is known that online education requires appropriate methods, and information helps to raise the quality of this process to a new level. Of course, distance education can be made more effective by expanding the content and creating new scenarios. There is also an additional option: you can collect and evaluate data on students and their activities, that is, analyze their digital footprints. More precisely, based on the results of such an analysis, it is necessary to change the educational process, and the shortest path from a digital footprint to changing the educational process lies through artificial intelligence technologies.

The simplest and most understandable use of AI is knowledge control, that is, checking homework in an automated form, identifying and correcting errors, helping the teacher in grading. It can be used both in distance learning and in regular education. In addition, intelligent technologies help to eliminate copying, which is the main problem when conducting online exams. The AI-powered proctoring system analyzes video camera images and user activity to determine whether a person is taking the test or not and help eliminate cheating.

Having collected a large amount of information about the behavior of students in the learning process, they can be classified not only by the grades they received, but also by their ability to absorb the material: some start quickly and get tired quickly, while others enter the process slowly, but then speed up. Such information allows you to adapt the education system to the characteristics of each student. Adaptability is the most promising area of application of artificial intelligence in education, which is often carried out in conjunction with the personalization of education.

The data collected today on almost all subjects taught within the framework of distance learning are enormous in size and volume. Consequently, specialists involved in the development and application of distance education systems are not able to cover the entire volume of this information, which significantly reduces the effectiveness of distance education programs.

Currently, there is a need to use programs based on the use of artificial intelligence in the system of distance computer education. Artificial intelligence systems can be used in distance education programs, as well as in the direct development of the structure of the information content of the educational program, in the search, collection and analysis of the necessary information (that is, in the creation of methodological and pedagogical databases).

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THE ROLE OF ARTIFICIAL INTELLIGENCE SYSTEMS IN THE DEVELOPMENT OF DEVELOPED COUNTRIES

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***Abstract*:Artificial intelligence has the potential to change many aspects of human life, including development. This thesis explores the role of artificial intelligence in development and highlights the opportunities and challenges it presents. At the same time, he also acknowledges the problems associated with its use, including ethical concerns, prejudice, and the digital divide. The research shows that future research and policy development is needed to ensure the ethical and effective use of AI in development projects. Overall, AI can play an important role in achieving the Sustainable Development Goals and improving the lives of people in developing countries.**

Keywords: Developed countries, Artificial intelligence, Technological innovation, Economic development, Social impact, Intelligent systems.

Artificial intelligence is a rapidly developing field of technology that is concerned with creating intelligent machines that mimic human behavior and perform tasks with human-like precision. The field of artificial intelligence focuses on the creation of software and systems that allow us to learn from data, reason, understand natural language, perceive images and sounds, and make decisions based on information collected through various means. That is why it is so important in our lives.

Fraud detection:	• Artificial intelligence algorithms can analyze large amounts of data to identify patterns and anomalies that may indicate fraudulent activity.
Trade:	• AI-powered trading systems can analyze market data and make predictions about future trends, helping traders make more informed decisions.
Risk Management:	• Artificial intelligence can analyze historical data to identify potential risks and suggest ways to mitigate them.
Customer Service:	• AI-powered chatbots can provide 24/7 customer support, answer common questions, and resolve issues quickly.
Personalized Recommendations:	• Artificial intelligence algorithms can analyze customer data to provide personalized investment recommendations based on their risk tolerance, investment goals and other factors.
Credit score:	• Artificial intelligence can analyze a wide range of data points to assess creditworthiness and make more accurate lending decisions.
Portfolio management:	• AI-powered portfolio management tools help investors optimize their portfolios based on their investment objectives, risk tolerance and other factors.

Artificial intelligence is a branch of computer science that focuses on creating intelligent machines that can perform tasks that typically require human intelligence. These machines are designed to learn from their experiences and adapt to new situations, enabling them to perform complex tasks with minimal human intervention.The concept of artificial intelligence has been around for decades, but recent advances in technology have made it more accessible than ever. Today, artificial intelligence is used in a wide range of applications, from self-driving cars and virtual assistants to medical diagnostics and financial analytics. One of the main advantages of artificial intelligence is its ability to quickly and accurately process and analyze large amounts of data.

The progress of artificial intelligence (AI) in developing countries is significant and significant. Artificial intelligence has its role and advantages in various fields. The following examples illustrate the role of artificial intelligence in developing countries:

In addition, AI can also improve healthcare operations by optimizing resource allocation, reducing wait times, and improving patient flow. For example, AI algorithms can predict patient demand and optimize staffing levels to ensure patients are seen quickly. However, the use of AI in healthcare raises ethical issues such as privacy and data security, as well as the potential for algorithmic decision-making bias.

The reason why artificial intelligence is currently developing in developed countries is that these countries are doing many things to develop their own country, one of them is artificial intelligence. Examples of these countries include the USA, Japan, Germany, France, and Singapore. Japan is using artificial intelligence in many fields; health care. , used in various fields and industries such as finance, transportation, manufacturing and robotics. Some specific areas where

AI is being used in Japan include: Healthcare: AI is used to analyze medical images, diagnose diseases, and develop personalized treatment plans for patients.

Finance: Artificial intelligence is used to detect fraud, predict market trends and automate financial processes.

Transportation: Artificial intelligence is used to optimize traffic flow, improve safety, and develop autonomous vehicles.

Manufacturing: Artificial intelligence is used to optimize manufacturing processes, improve quality control, and reduce waste.

Robotics: Japan is a leader in the development of robotics, and artificial intelligence is being used to improve the capabilities of robots in various fields.

In general, Japan is investing heavily in the research and development of artificial intelligence with the goal of becoming a world leader in this field. The development and application of artificial intelligence in developing countries will help to reduce costs, improve efficiency and expand health opportunities. It is expected to be widely used in the future with its role and advantages.

In conclusion, artificial intelligence can disrupt several industries and bring great benefits to society. However, it is necessary to develop AI in an ethical and inclusive manner, taking into account potential negative impacts such as redundancy and privacy issues. All members of AI society should also have strict vital indicators. Therefore, it is necessary to prioritize the development of IS with emphasis on ethics and inclusiveness for the broad benefit of humanity.

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APPLICATION OF ARTIFICIAL INTELLIGENCE SYSTEMS TO SUBJECTS IN SCHOOL IT AND INFORMATION TECHNOLOGY TEXTBOOK

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***Abstract*: At the same time, it is difficult to imagine the development of society without computer technologies, in which it organizes a global information system, is applied to all areas of human activity, and provides a wide spread of information flow in society. The computerization of the educational process is an integral and very important part of this process. This article deals with such issues as the educational purpose of the section on the basics of programming in the school computer science textbook.**

Keywords: Artificial intelligence, programming, modeling, algorithm, information technology, digital technology.

Today, in our country, great attention is paid to issues such as the use of information technologies in every field, digitization and automation of many fields. In the decision of the President of the Republic of Uzbekistan dated October 6, 2020 No. PQ-4851 "On measures to further improve the education system in the field of information technologies, develop scientific research and integrate them with the IT industry", the following "Improving the system of personnel training in the field of information technologies is one of the important conditions for the successful implementation of the "Digital Uzbekistan - 2030" strategy, the development of digital technologies and the wide introduction of them into the daily life of the population. measures taken to increase efficiency create a solid foundation for providing state bodies and network organizations with qualified IT specialists. The educational and developmental goal of teaching programming languages in the computer science textbook at school is to provide each student with the initial fundamental knowledge, including ideas about the processes of information transformation, transfer and use, and on this basis It shows students the importance of information processes in the formation of a modern scientific picture of the world, as well as the role of information technologies and computing in the development of modern technologies.

Studying the basics of programming course in the computer science textbook at school is designed to equip students with the basic skills necessary for continuous and conscious mastering of this knowledge, as well as the basics of other subjects studied at school. mastering, as well as the acquisition of relevant skills and competencies, is intended to have a significant impact on the formation of personality traits, such as the general mental development of students, the development of their thinking and creative abilities. The practical purpose of the programming basics course in the textbook is to contribute to the mental and logical (logical) preparation of students, that is, to develop them with knowledge, skills and abilities that will ensure preparation for work after graduation.

This means that the computer science and information technology course at school should not only introduce the basic concepts of computer science, which will certainly develop the mind and enrich the child's inner world, but also be practical - teach the student to work with a computer and use new information technology tools. use. Career orientation informatics course provides students with information about computer and informatics-related careers, as well as various applications of subjects taught in school using computers. should give.

In addition to the production side of the issue, the practical goals of the course on the basics of programming in informatics also include the "everyday" aspect - preparing young people for the rational use of computer technologies and other information and communication technologies in everyday life.

The educational goal of the school's course on the basics of programming in computer science is primarily provided by the strong influence of the worldview of students, which has an awareness of the possibilities and role of computing technologies and information technology tools in the development of society and civilization. The contribution of the course on the basics of programming in computer science to the scientific worldview of schoolchildren is determined by the formation of the idea of information, which is one of the three main concepts of science: the world of matter, energy and information, which is the basis of the modern scientific structure. When learning the programming fundamentals course at a qualitatively new level, intellectual work culture is formed and important universal features such as planning one's work, rationally performing it, and critical connection with the real process of its implementation are formed.

Based on the above considerations, the main educational goals of the "Fundamentals of Programming" section in the school computer science textbook are:

- Using modern e-learning tools to demonstrate complex physical, chemical and biological processes to students in a convenient time frame. Through this, students will have the opportunity to understand and study these processes more deeply.
- Creating an opportunity to study phenomena and processes that occur at very high or very low speed based on computer graphics and modeling. It

increases students' mastery of scientific processes in the macro and micro world.

- By learning the fundamentals of programming, requiring mental and volitional actions, attention, consistency and developed imagination from students. This serves to develop important personal qualities in students.
- Creating algorithms and programs, forming skills for computer implementation. It helps students develop logical thinking, problem solving, and programming skills.

In short, the "Basics of Programming" section is aimed at developing students' knowledge and practical skills in the field of modern technologies and programming, as well as their personal qualities.

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INTEGRATING AI FOR ENHANCED MANAGEMENT INFORMATION SYSTEMS

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A B S T R A C T **The convergence of the Big Data revolution and Artificial Intelligence (AI) presents unprecedented opportunities for organizations to revolutionize their Management Information Systems (MIS). This article explores the integration of AI within MIS as a strategic imperative for organizations aiming to harness the power of data for enhanced decision-making and operational efficiency. By leveraging AI technologies such as machine learning and predictive analytics, organizations can unlock valuable insights from vast volumes of data, enabling them to stay competitive in dynamic markets. However, ethical considerations surrounding data privacy and bias must be carefully navigated to ensure responsible AI adoption. This article delineates the significance of the Big Data revolution and the transformative potential of AI within MIS, emphasizing the need for organizations to embrace this paradigm shift to thrive in the digital age.**

K E Y W O R D S Artificial Intelligence (AI), Management Information Systems (MIS), Big data, Real-time, AI-powered, Risk management, Data security, Strategic planning, Predictive analytics.

INTRODUCTION

In an era characterized by the proliferation of data and rapid technological advancements, the traditional paradigms of Management Information Systems (MIS) are undergoing a profound transformation. The advent of the Big Data revolution has ushered in an era where organizations are inundated with unprecedented volumes of data from diverse sources. Concurrently, Artificial Intelligence (AI) has emerged as a game-changer, offering organizations the ability to extract actionable insights from this wealth of data with unprecedented speed and accuracy.

The integration of AI within MIS represents a paradigm shift in how organizations gather, process, and utilize information to drive decision-making and operational efficiency. By harnessing AI technologies such as machine learning, natural language processing, and predictive analytics, organizations can unlock the full potential of Big Data, gaining deeper insights into customer behaviors, market trends, and operational processes. However, the journey towards AI-enhanced MIS is not without its challenges. Ethical considerations surrounding data privacy, bias, and transparency loom large, necessitating robust governance frameworks and responsible data stewardship practices. Moreover, organizations must contend with technical complexities and skill gaps as they seek to integrate AI into their existing MIS infrastructure. Despite these challenges, the benefits of integrating AI within MIS are manifold. From enhancing decision-making capabilities to improving operational efficiency, AI-powered MIS enables organizations to stay agile and responsive in an increasingly dynamic business environment. Moreover, by embracing AI, organizations can unlock new opportunities for innovation and growth, positioning themselves as leaders in their respective industries.

UNDERSTANDING THE BIG DATA REVOLUTION.

In the contemporary landscape of business and technology, the term "Big Data" has become ubiquitous, representing the colossal volumes of structured and unstructured data generated by various digital interactions. The Big Data revolution marks a paradigm shift in how organizations collect, process, and leverage data to drive insights and decision-making. At its core, the Big Data revolution is characterized by three defining attributes: volume, velocity, and variety. Volume refers to the sheer scale of data generated from sources such as social media, IoT devices, sensors, and transactional systems. The exponential growth in data volume presents both opportunities and challenges for organizations, as they grapple with the task of managing and extracting value from massive datasets.

Velocity pertains to the speed at which data is generated, collected, and processed. In today's hyperconnected world, data is generated in real-time, necessitating agile and responsive systems capable of analyzing streaming data streams instantaneously. This rapid pace of data generation requires organizations to adopt advanced analytics tools and technologies to derive timely insights and drive informed decision-making. Variety refers to the diverse range of data types and formats, including structured data from databases, semi-structured data from web logs, and unstructured data from text documents, images, and videos. The heterogeneous nature of data presents challenges in terms of integration, storage, and analysis. However, it also offers rich opportunities for organizations to gain holistic insights by correlating data from disparate sources.

The Big Data revolution has profound implications for organizations across various industries. By harnessing the power of Big Data, organizations can gain deeper insights into customer behaviors, market trends, and operational inefficiencies. For example, retailers can analyze customer purchase histories and social media interactions to personalize marketing campaigns and optimize product offerings. Similarly, healthcare providers can leverage Big Data analytics to improve patient outcomes by identifying patterns in medical data and predicting disease outbreaks.Moreover, the Big Data revolution has catalyzed the emergence of new business models and revenue streams. Companies like Google, Facebook, and Amazon have built their empires on the foundation of Big Data, leveraging insights gleaned from user interactions to deliver targeted advertisements, personalized recommendations, and tailored services.

CHALLENGES IN TRADITIONAL MANAGEMENT INFORMATION SYSTEMS (MIS).

Traditional Management Information Systems (MIS) have long been the backbone of organizational decision-making, providing structured processes for collecting, processing, and disseminating information. However, in the face of rapid technological advancements and evolving business landscapes, traditional MIS face a myriad of challenges that hinder their effectiveness in meeting the demands of modern organizations. Some of these are:

1. Data Silos. One of the most pervasive challenges in traditional MIS is the existence of data silos. Data silos occur when information is stored in isolated systems or departments, making it difficult for organizations to access and integrate data across different functional areas. This fragmentation of data inhibits holistic decision-making and leads to inefficiencies in data management.

2. Limited Scalability. Traditional MIS are often built on legacy systems that lack the scalability required to accommodate the exponential growth of data in today's digital age. As organizations generate vast volumes of data from diverse sources, traditional MIS struggle to cope with the increased demands for storage, processing, and analysis. This limitation impedes organizational agility and hampers the ability to derive actionable insights from Big Data.

3. Slow Decision-Making. In traditional MIS, decision-making processes are often slow and cumbersome due to manual data entry, processing, and analysis. Decision-makers rely on static reports and predefined metrics, which may not provide real-time insights or account for dynamic market conditions. As a result, organizations may miss out on opportunities or fail to respond promptly to emerging threats, compromising their competitive advantage.

4. Lack of Predictive Analytics. Traditional MIS are primarily focused on reporting historical data rather than predicting future outcomes. While historical data is valuable for assessing past performance and identifying trends, it fails to provide actionable insights for proactive decision-making. Without predictive analytics capabilities, organizations are unable to anticipate market trends, forecast demand, or mitigate risks effectively.

5. Inadequate Data Security. Data security is a critical concern for organizations operating in today's interconnected digital ecosystem. Traditional MIS often lack robust security measures to protect sensitive information from cyber threats, data breaches, and unauthorized access. As a result, organizations face the risk of data theft, compliance violations, and reputational damage, undermining stakeholder trust and confidence.

6. Resistance to Change. Implementing new technologies and processes to modernize traditional MIS can be met with resistance from stakeholders within the organization. Employees may be hesitant to adopt unfamiliar tools or methodologies, fearing job displacement or disruption to existing workflows. This resistance to change impedes innovation and stifles organizational growth, making it challenging to address the evolving needs of the business.

7. Integration Challenges. Integrating disparate systems and data sources within traditional MIS can be complex and time-consuming. Legacy systems may lack interoperability, requiring custom integration solutions that are costly and prone to errors. Moreover, integrating external data sources such as social media feeds, IoT devices, and third-party APIs adds another layer of complexity to the process. As a result, organizations may struggle to achieve seamless data integration and consistency across their MIS.

INTEGRATION OF ARTIFICIAL INTELLIGENCE (AI) IN MANAGEMENT INFORMATION SYSTEMS (MIS).

Integration of Artificial Intelligence (AI) in Management Information Systems (MIS) marks a significant leap forward in organizational capabilities, empowering businesses to harness the power of data for strategic decision-making and operational efficiency. AI technologies such as machine learning, natural language processing, and predictive analytics are revolutionizing the way organizations collect, process, and utilize data within their MIS infrastructure.

One of the key advantages of integrating AI in MIS is the automation of routine tasks. AI-powered algorithms can streamline data entry, processing, and analysis, reducing manual effort and human error. For example, machine learning algorithms can automatically categorize and tag incoming data, enabling organizations to extract valuable insights more efficiently. This automation frees up human resources to focus on higher-value tasks, such as strategic planning and innovation. Furthermore, AI enhances data processing and analysis capabilities within MIS. Machine learning algorithms can analyze vast volumes of data at unprecedented speed and scale, uncovering patterns, correlations, and trends that may have previously gone unnoticed. Natural language processing techniques enable MIS to extract insights from unstructured data sources, such as text documents and social media feeds, enriching the depth and breadth of available information.

Predictive analytics is another powerful application of AI in MIS, enabling organizations to forecast future outcomes and trends based on historical data patterns. By analyzing past performance and identifying predictive indicators, AI-powered MIS can anticipate customer behaviors, market trends, and operational challenges, enabling proactive decision-making. For example, predictive analytics can help retailers forecast demand for specific products and optimize inventory levels accordingly, reducing stockouts and excess inventory. Moreover, integrating AI in MIS enables organizations to deliver personalized customer experiences tailored to individual preferences and behaviors. Machine learning algorithms analyze customer data to segment customers based on their unique characteristics and preferences, enabling organizations to deliver targeted marketing campaigns, personalized product recommendations, and tailored services. This personalized approach enhances customer satisfaction and loyalty, driving business growth and profitability. Real-time insights are another key benefit of integrating AI in MIS. AI-powered algorithms analyze streaming data in real-time, enabling organizations to detect emerging trends, identify opportunities, and address issues before they escalate. This real-time visibility empowers organizations to make agile and informed decisions, responding quickly to changing market conditions and capitalizing on opportunities as they arise.

ENHANCED DECISION-MAKING WITH AI-INTEGRATED MANAGEMENT INFORMATION SYSTEMS (MIS).

In today's rapidly evolving business landscape, organizations are inundated with vast amounts of data. To effectively navigate this data-rich environment and make informed decisions, businesses are increasingly turning to Artificial Intelligence (AI)-integrated Management Information Systems (MIS). Here's how the integration of AI enhances decision-making processes:

1.Real-Time Insights. AI-powered MIS can process and analyze data in real-time, providing decision-makers with up-to-date information to make timely decisions. By continuously monitoring data streams and identifying relevant trends and patterns as they emerge, AI-enabled MIS empower organizations to respond swiftly to market changes, customer preferences, and operational challenges.

2.Predictive Analytics. AI algorithms within MIS can forecast future outcomes based on historical data and trends. By leveraging predictive analytics, organizations can anticipate market shifts, customer behavior changes, and potential risks, allowing them to proactively adjust strategies and allocate resources accordingly. Predictive analytics enable organizations to stay ahead of the curve and capitalize on emerging opportunities before they become apparent to competitors.

3.Personalized Recommendations. AI-integrated MIS can analyze customer data to generate personalized recommendations and insights. By leveraging machine learning algorithms, MIS can segment customers based on their preferences, purchase history, and behavior patterns. This enables organizations to deliver tailored products, services, and marketing messages to individual customers, enhancing customer satisfaction and loyalty while driving revenue growth.

4.Risk Management. AI-powered MIS can identify and mitigate potential risks by analyzing vast amounts of data for patterns and anomalies. By leveraging predictive analytics and machine learning algorithms, organizations can detect early warning signs of potential risks, such as cybersecurity threats, supply chain disruptions, or financial irregularities. This proactive approach to risk management enables organizations to implement preventive measures and minimize the impact of potential threats on business operations.

3.Strategic Planning. AI-integrated MIS provide decision-makers with actionable insights to inform strategic planning and goal setting. By analyzing historical data, market trends, and competitive intelligence, AI algorithms can identify opportunities for growth, optimization, and innovation. This enables organizations to develop data-driven strategies that align with business objectives and drive sustainable competitive advantage in the marketplace.

IMPROVED OPERATIONAL EFFICIENCY.

Improved operational efficiency is a critical goal for organizations striving to optimize performance and drive growth. Integrating Artificial Intelligence (AI) into Management Information Systems (MIS) is a powerful strategy to achieve this objective. AI-enhanced MIS automate repetitive tasks, streamline processes, and provide real-time insights, leading to enhanced productivity and cost-effectiveness. By leveraging machine learning algorithms, AI-powered MIS can analyze vast amounts of data to identify patterns, trends, and opportunities for optimization. Predictive analytics capabilities enable organizations to anticipate future demands, allocate resources effectively, and minimize risks. Additionally, AI-integrated MIS facilitate better collaboration and decision-making by providing centralized access to data and insights across departments. Overall, the integration of AI within MIS enables organizations to operate more efficiently, respond to market changes more effectively, and ultimately, gain a competitive edge in today's dynamic business landscape.

ETHICAL CONSIDERATIONS.

Incorporating Artificial Intelligence (AI) into Management Information Systems (MIS) raises crucial ethical considerations that demand careful attention. Firstly, data privacy and security must be safeguarded, ensuring that sensitive information remains protected from unauthorized access and potential misuse. Organizations must implement robust measures such as encryption and access controls to uphold individuals' privacy rights.

Secondly, mitigating bias and ensuring fairness in AI algorithms is essential to prevent discriminatory outcomes in decision-making processes. This involves diversifying training datasets, regularly auditing algorithms for bias, and promoting transparency in algorithmic decision-making. Moreover, transparency and explainability are vital for building trust and accountability in AI-integrated MIS. Stakeholders must understand how AI algorithms operate and the factors influencing their decisions to ensure ethical use and mitigate concerns about opacity.

Overall, prioritizing ethical considerations in the integration of AI within MIS is imperative to uphold principles of privacy, fairness, transparency, and responsible technology use. By adhering to ethical guidelines and practices, organizations can foster trust, mitigate risks, and promote societal well-being in the adoption of AI-integrated MIS.

CONCLUSION.

In conclusion, the integration of Artificial Intelligence (AI) within Management Information Systems (MIS) represents a transformative leap forward in how organizations collect, process, and utilize data to drive decision-making and operational efficiency. Throughout this discourse, we have delved into the myriad benefits and complexities associated with AI-integrated MIS, as well as the ethical considerations that must be carefully navigated to ensure responsible adoption.

From enhancing decision-making processes with real-time insights and predictive analytics to improving operational efficiency through automation and optimization, AI-powered MIS empower organizations to stay agile, competitive, and responsive in today's fast-paced business environment. By leveraging machine learning algorithms and advanced analytics techniques, organizations can unlock the full potential of their data assets, gaining deeper insights into customer behaviors, market trends, and operational performance. However, as organizations embrace AI technologies within MIS, it is imperative to address ethical considerations surrounding data privacy, bias, transparency, and responsible use. Safeguarding data privacy and security, mitigating bias in AI algorithms, promoting transparency and explainability, and considering the broader societal impacts of AI adoption are essential for fostering trust, accountability, and ethical use of technology. Ultimately, the integration of AI within MIS holds immense promise for driving innovation, efficiency, and growth. By prioritizing ethical principles and responsible AI adoption practices, organizations can harness the transformative power of AI to unlock new opportunities, mitigate risks, and create value for stakeholders. As AI continues to evolve and shape the future of business, ethical considerations will remain central to ensuring that AI-integrated MIS contribute positively to organizational success and societal well-being in the digital age.

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CREATION OF A MULTI-FUNCTIONAL DEVICE FOR REAL-TIME MONITORING IN EVALUATION OF THE BASIC CHARACTERISTICS OF WATER

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A B S T R A C T **This article is about finding an effective solution to the problems of determining the temperature, acidity PH and salinity TDS of groundwater. The spectral-impedance method proposed in the article allows for the creation of devices for measuring all the main quality indicators of water . Increasing the accuracy of remote monitoring devices using artificial intelligence.The purpose of this paper is to improve the accuracy of well water quality assessment using the IoT measurement method. For this purpose, a device in the form of a "poke" floating on the water surface with many electrodes (sensors) is lowered into the well, and the main indicators of the water are monitored using wireless radio waves. It was found that the measurement results from the multi-electrode sensor correspond to the quadratic approximation. The proposed method, in comparison with the currently used methods, increases the reliability of the estimation of the composition of groundwater based on the simultaneous measurement of the spectral impedance of the ions contained in the hydrogen indicator.**

K E Y W O R D S ISM radio transmitter, radio receiver, microcontroller, SoC, IoT, PH, TDS, temperature, humidity, frequency.

INTRODUCTION

Mathematical modeling system of geofiltration processes of regional hydrogeological regions, rapid analysis of groundwater level changes, creation of effective water resource management systems in necessary cases is of great importance in the world [1]. In this regard, during the years of water scarcity, the role of groundwater in the total water resources and their interdependence, the study of hydrogeological characteristics of groundwater, the justification of hydrotechnical structures and the procedure for meliorating water supply, and the prevention of groundwater pollution one of the important tasks is to improve the intellectual systems that support decision-making on the rational use of water resources and monitoring the state of hydrogeological objects, mathematical modeling, and eliminating the salinity of agricultural areas. In the method proposed in this article, the device part consists of 2 parts, the main part is installed at the wellhead of the well being monitored, and the second part floats on the surface of the water like a pod and is constantly in contact with the water with its sensors. [2].

METHODS

The method of spectral impedancemetry (or impedance spectroscopy) is based on the measurement of its electrical properties for the analysis of water content. This method allows to determine the concentration of various ions and molecules present in water. The working principle of the method is as follows: Impedance measurement is performed as per the procedure. Water is placed between two electrodes, through which a sinusoidal alternating current of different frequencies is passed. The impedance (resistance) of water is determined and measured at each frequency .

RESULTS

The block diagram of the device for measuring the distance and temperature of underground water consists of 3 parts consisting of the main module at the wellhead, the part located inside the well in the floating state, and a computer for the central control and monitoring system. The proposed method has a high detection accuracy compared to the known ones, because it is located directly on the surface of the liquid and the gas in the interval is measured taking into account the temperature, which increases the reliability [3].

The proposed method is intended to be used for determining the water level of hydrostatic wells.

For more accurate mathematical modeling, complex circuits involving parallel and series connections of various components, including resistors and capacitors, must be used. For example, parallel additions are used in the formula to account for the effect of ions[4].

$$Z(f) = R(f) + \frac{1}{j2\pi f C(f)} + \sum_i \left(Ri + + {}^{1}/{}_{2\pi f Ci}\right) \quad (1)$$

here

Ri and Ci are parameters corresponding to different ions and molecules.

In order to adjust the mathematical model to correctly predict the water content, it is necessary to perform the following operations:

- conduct impedance measurements at different frequencies for different water samples;

- build an impedance spectrum and determine the frequency dependence of the real and abstract parts of the impedance;
- to select model parameters R(f),C(f), Ri and Ci values using non-linear optimization methods (for example based on the least squares method) to provide minimization of the difference between the experimental data and the model. Positioning Figures and Tables: Place figures and tables at the top and bottom of columns. Avoid placing them in the middle of columns[5]. Large figures and tables may span across both columns. Figure captions should be below the figures; table heads should appear above the tables. Insert figures and tables after they are cited in the text. Use the abbreviation "Fig. 1", even at the beginning of a sentence.

TABLE 1

MEASURED TIME	WATER LEVEL, CM	TEMPERATURE	SALINITY TDS	ALKALINE PH
June 27, 2024 14:23	300,0	10,0	2,0	7,0
June 27, 2024 10:15	255,0	10,0	2,0	8,0
June 27, 2024 9:54	250,0	11,0	24,0	7,0
June 27, 2024 9:23	245,0	10,0	28,0	8,0
June 27, 2024 9:20	240,0	12,0	2,0	7,0
June 27, 2024 9:19	230,0	10,0	24,0	8,0
June 27, 2024 9:17	220,0	9,0	24,0	7,0
June 27, 2024 9:15	220,0	10,0	2,0	8,0

Our web application is built on the Django framework, a high-level web framework for the Python programming language. With the help of our web program, it is possible to observe and monitor the indicators of the well during the measured time, which gives the opportunity to collect data based on accurate measurements collected over the years and to compare them over the years. This increases the possibilities of groundwater monitoring.

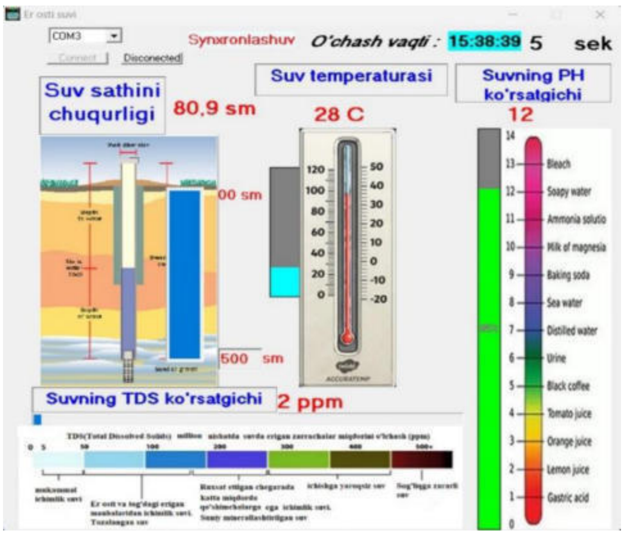

Fig. 1. Device software for desktop.

Figure 1: From figure 1 we will be able to monitor the data received from the measurement devices in clear and relevant views for each measurement.

As can be seen from the measurement indicators of our program, the depth of the water level is 80.9 cm, the water temperature is 20 °C, the PH indicator of the water is 12 PH, and the TDS indicator of the water is 2ppm. These indicators are updated every 20 seconds.

DISCUSSION

The discussion section would interpret the results in light of the research question and relevant literature. It would discuss the implications of the findings, considering both the strengths and limitations of the study. Any unexpected or contradictory results would be addressed, and potential explanations or alternative interpretations would be explored. The section would also highlight the theoretical and practical implications of the study's findings, such as the potential for exercise interventions to be implemented in geriatric care settings. Finally, the discussion would conclude with suggestions for future research directions, such as investigating the long-term effects of exercise on cognitive function or examining the impact of different exercise modalities on specific cognitive domains.

CONCLUSION

In this work, we have given recommendations on how to find an effective solution to the problems of determining the level, temperature, acidity, PH and salinity TDS of groundwater using ultrasound and radio waves, as well as the creation of mathematical models, devices and software. With the help of this method, we had the opportunity to accurately measure the level and quality of underground water up to 150 mg and monitor it for years, and we increased the possibilities of comparing our collected data over the years. We have developed a software for monitoring our device developed for personal computers (desktop), at the same time, we have also developed a web application and a telegram bot that work at the same time. We have the ability to increase the accuracy of remote monitoring devices with the help of artificial intelligence. Our proposed device allows to reduce human intervention in underground wells containing substances harmful to human life.

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UTILIZING THE NATIONAL VIRTUAL ACADEMY SYSTEM'S (VACADEMIA.UZ) OPPORTUNITIES TO START A VIRTUAL EDUCATION PROCESS

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A B S T R A C T **This article discusses how to set up a virtual 3D university's educational program by developing courses that make use of the National Virtual Academy system's (vacademia.uz) features. The virtual lesson is examined in the article as an illustration of how to develop a "Scientific Education" training course. The course covers scientific education, including the guidelines for writing scientific theses, how to write and publish articles for international conferences, the EHM program, and how to upload documents from the database to the official website in order to receive a program certificate.**

K E Y W O R D S Courses, virtual worlds, 3D environments, vAcademia.uz, distant learning, teaching, and scientific education.

INTRODUCTION

Come on in. Because virtual worlds facilitate the formation of communities or groups that unite subject matter experts, educators, and learners from various nations or places, they provide good prospects for effective distance and online learning. New approaches to collaborative e-learning are thus made easier to create.[1,2].

METHODS

Most significantly, distant education enables students to learn at their own pace via virtual simulators and virtual simulations, making it more affordable and convenient for users than traditional education in academic institutions. permits the use of virtual classrooms for knowledge assessment, virtual trips to universities, and participation in the educational process. After enrolling on the website, you must download the Vacademia.uz program in order to create a course in the national virtual system of Vacademia.uz. Because the primary courses are structured using objects in 3D view, the computer program must be installed.[1.2].

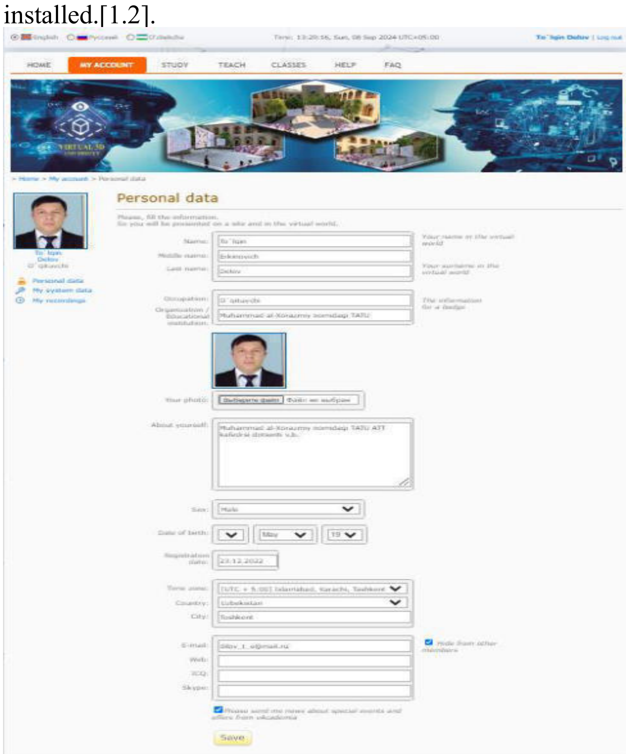


Figure 1: Sign up with Vacademia.uz.

When entering personal data, the user (tutor) must be sure to include all required information. It is crucial to note the time zone provided here when working virtually. You must become acquainted with the guidelines for operating in the virtual environment after entering all the required data. Through this procedure, all students will be able to learn in addition to tutors.

In order to overcome the challenges they encounter when setting up courses, users without the necessary skills to operate in the national virtual system of Vacademia.uz can learn by following the Uzbek instructions found in the "Questions and answers" area. [3]

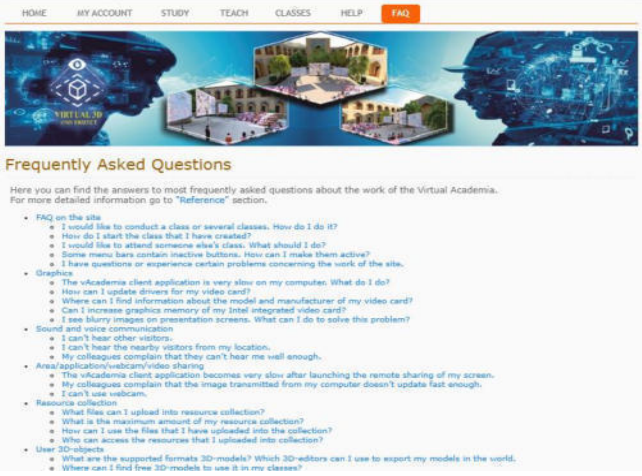


Figure 2: Assistance portion

From the "teaching" portion of the program's menu bar, a new course or subject is established.

The procedure of submitting course information is the next step in this process.

The method of organizing the educational process in a virtual 3D university, that is, the process of generating educational courses, is considered using the capabilities of the National Virtual Academy system (vacademia.uz). We'll use the online lesson as an illustration of how to design a "Scientific education" training program. In Uzbek, this course was developed. The course covers scientific education, including the guidelines for writing scientific theses, how to write and publish articles for international conferences, the EHM program, and how to upload documents from the database to the official website in order to receive a program certificate. The course's title, description, language, keywords, enrollment, length of training, location, and other details are provided at the outset. In other words, the course is first described in detail. The scientific education course is described in depth in the graphic that follows.[3]

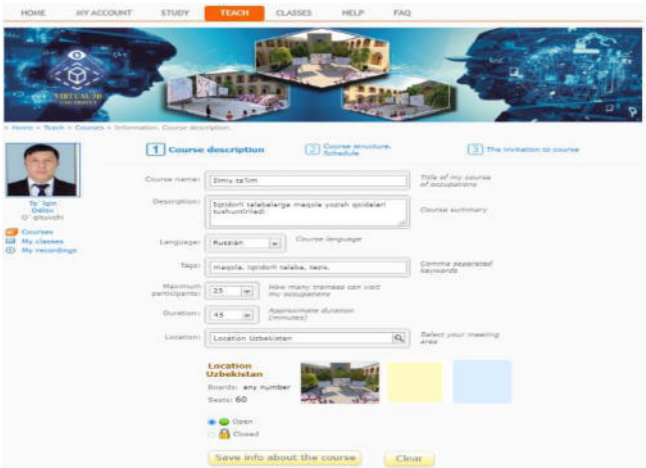


Figure 3: Course description for scientific education

The course syllabus and material will be decided upon in the following phase. This section allows you to designate the total number of training sessions, the number of weeks it will last, and the training dates.

The image below illustrates how to create a science education course activity in the Virtual Academy application.

Here, you can choose the training's name (subject), time, date, brief comment, and language.

Figure 4: Lesson schedule fragment

The next step is to draw the audience to the training or course after deciding on its description. We will go on to the next phase for this.

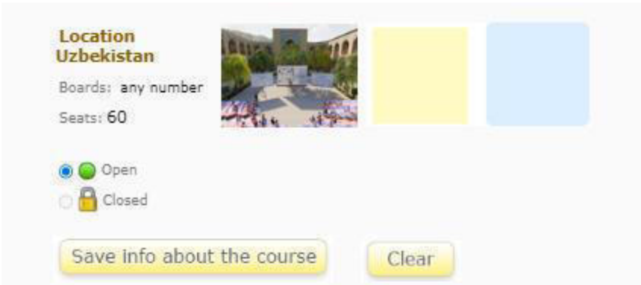
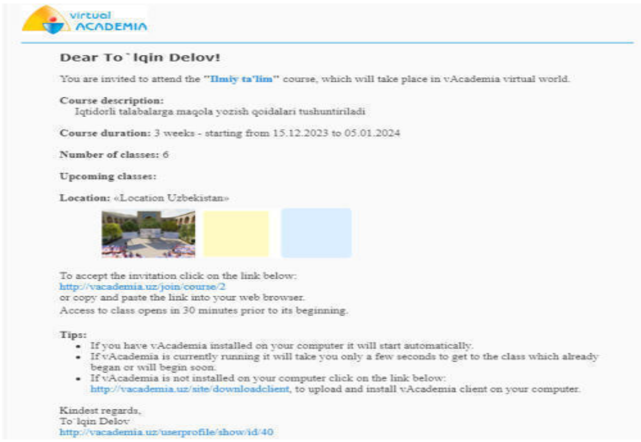


Figure 5: Open the window to provide lessons and save

Thus, once the times are established, the "save and bid" button is clicked. The location, lesson subjects, and class name are shown below.



virtual ACADEMIA

Dear To`lqin Delov!

You are invited to attend the "Ilmiy ta'lim" course, which will take place in vAcademia virtual world.

Course description:
Iqtidorli talabalarga maqola yozish qoidalari tushuntiriladi

Course duration: 3 weeks - starting from 15.12.2023 to 05.01.2024

Number of classes: 6

Upcoming classes:

Location: «Location Uzbekistan»

To accept the invitation click on the link below:
http://vacademia.uz/join/course/2
or copy and paste the link into your web browser.
Access to class opens in 30 minutes prior to its beginning.

Tips:
- If you have vAcademia installed on your computer it will start automatically.
- If vAcademia is currently running it will take you only a few seconds to get to the class which already began or will begin soon.
- If vAcademia is not installed on your computer click on the link below: http://vacademia.uz/site/downloadclient, to upload and install vAcademia client on your computer.

Kindest regards,
To`lqin Delov
http://vacademia.uz/userprofile/show/id/40

6-Figure: The format of the course invitation (training).

The invitation includes the course name, a synopsis of the instruction, time, date, and location. If necessary, you can also make changes to the invitation form.

This window is used in the Virtual Academy program to extend an invitation to listeners to enroll in a training or course.

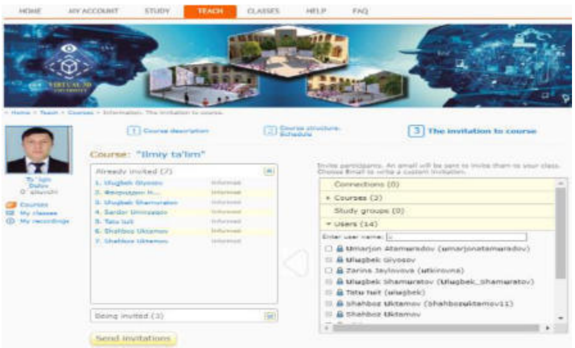


Figure 7. Window of invitation to the course (training)

(Details regarding the individuals invited to the course on scientific education)

The entire window for extending an invitation to the scientific education course is displayed. Here, the instructor has the option to send the students who are listening an email. The name of the lesson and user information, including those who have been invited or are currently invited, are displayed in this window. [4]

Sending an invitation will be feasible by entering group or user email addresses in the course section.

The lesson will be moved to the Vacademia.uz 3D application after the start time is decided. To accomplish this, go to the website listed above and enter the 3D program with your login password.

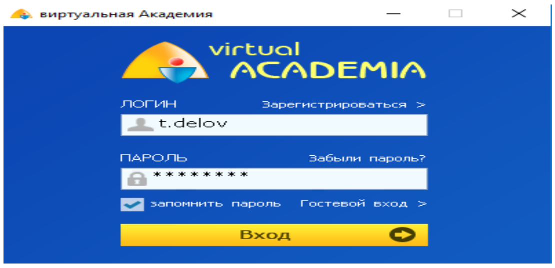


Figure 8. Access to the Vacademia.uz 3D program

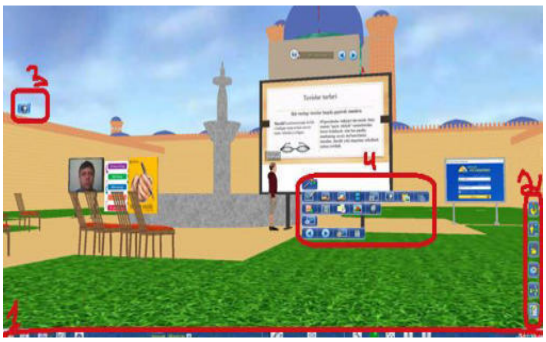


Figure 9. Working with an interactive whiteboard in the 3D virtual environment of Vacademia.uz

1. The application settings, avatar movement, and communication controls are all accessible through the buttons on the main menu.

2. Toolbar: This section has buttons that let you set up objects, conduct lessons, and alter the avatar's appearance.

3. The notification panel is made up of buttons that offer several alternatives to be used when interacting with the selected object's context menu.

4. The context menu is made up of buttons that, when clicked with the right mouse button, can be used to perform several actions on the object that is selected.[5]

Based on the capabilities of this application, we will observe the primary features of the virtual academy system. The program's primary features include application configuration, avatar management, movement control, and communication control.

The figure below displays the primary characteristics of the Virtual Academy program.

Figure 10. The main features of the virtual academy

- Informational tools. enabling a straight transition between the media and the client program.
- Talk. You may use chat to communicate information with Virtual Academy.
- List of users. The list of users in this virtual world is displayed by the virtual academy;
- Signs and maps. The primary means of facilitating effortless and rapid navigation within the virtual academy is the user's ability to automatically teleport by simply clicking the mouse button at the desired location on the map; any information left at an arbitrary spot on the map will be visible and audible to all users;
- Where "My house" is. The user can select and customize the setting to suit his needs when conducting private courses;
- Location list. the capability to choose locations from the list of accessible ones and view the courses offered there;
- Handle the microphone. Using a microphone, Virtual Academy enables voice conversation with users;
- Camera management. Users of Virtual Academy have the ability to adjust the camera perspective;
- Modification. enables you to modify interface components, sound reproduction (broadcasting), and graphics quality according to the specifications and capabilities of the user's machine;
- Movement. the availability of settings to control the avatar in the user's preferred mode;
- Motions. the capability of using gestures to convey emotions to others;
- Modes of avatar movement. the option to select between two modes for operating the virtual academy avatar;
- Registration. the capacity to videotape online courses that people can watch.

It was determined that the formation and development of competencies among the participants of the educational process is primarily based on the students' varied educational backgrounds. Our lesson covers the process and regulations of writing theses, wherein, based on the particular laws of writing articles and theses, it occurs as a result of independent work with educational training. Additionally, the use of communication networks like the Internet enriches the experience of creative activity continuously and to a greater extent, aids in the formation of a self-management mechanism. and methodical manuals (electronic textbooks, interactive educational programs, electronic knowledge bases). [6, 7]

Classes conducted in Vacademiya, a virtual environment.Images are distinct in that they are captured and stored within the digital realm.

The video lectures from the "Scientific Education" course that were uploaded to Vacademiya's virtual "My Lessons"

section.UZ is going to be preserved. Click the (record) button to start recording. The lesson management box will open after you hit the record button.

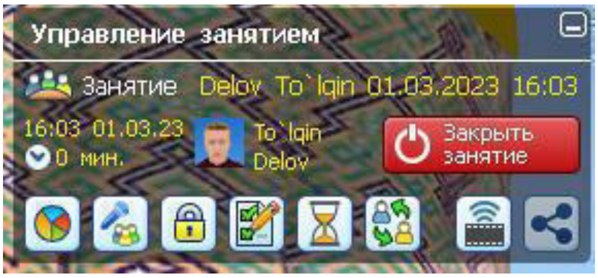


Figure 11. Lesson management window

Similar to traditional lessons, this one also has the resources needed to plan and deliver the lesson in a step-by-step fashion. There are also chances to develop test questions that are pertinent to the subject matter and determine how the lesson is structured based on a survey.[10]

The constructor is used to create tests. In this instance, single-answer and multiple-answer alternatives can be employed, much like in the Ispring application and other test-creating systems.

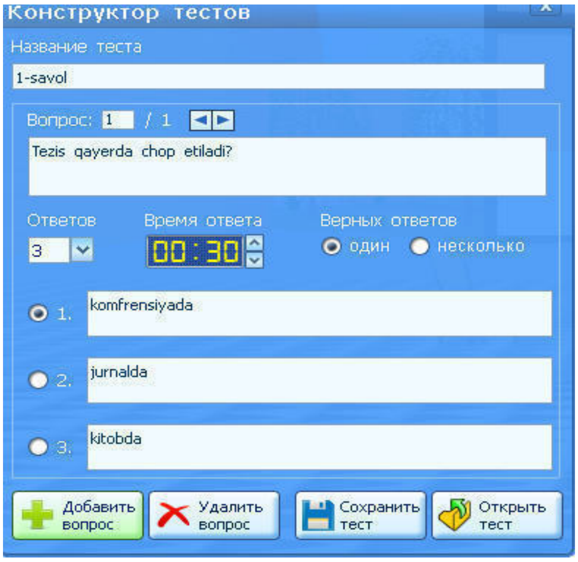


Figure 12. Test creation constructor

Vacademia.uz's test creation feature streamlines the evaluation process, enabling teachers to more easily gauge students' comprehension and offer focused comments for development. [8,9] Teachers can provide an engaging learning environment for their pupils by implementing these procedures. can make good use of this feature to advance.

In brief. We may enhance the gifted identification paradigm by combining several gifted assessment techniques, dynamic digital portfolios, real-time data analytics, collaborative feedback, and virtual communities into a digital learning environment. Innovative methods are essential for identifying and interacting with gifted kids in the digital sphere as we keep up with the changes in the educational landscape.

DISCUSSION

Education is benefiting greatly from digital technologies, and one significant step in this regard is the National Virtual Academy system (vacademia.uz). This platform's ease of use and capacity to reach a larger audience for education make it significant. Additionally, it is crucial to keep up the educational process in the face of adverse circumstances like a pandemic.

The National Virtual Academy system's vacademia.uz platform presents excellent prospects in the field of virtual education; nevertheless, to fully capitalize on these prospects, it is imperative to enhance the technological infrastructure and raise the level of digital literacy among educators and students. Simultaneously, more and more profound opportunities for all members of the educational system can be created by fusing virtual and traditional education.

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NON-CREATIVE CREATIVITY: A PERSONAL CRITICAL PERSPECTIVE ON HOW ARTIFICIAL INTELLIGENCE PARALYZES INNOVATION?

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A B S T R A C T **This paper focuses on the concept of creativity and the long-term effect of artificial intelligence on creativity. It aims to illustrate the dilemma that arises from the current development of artificial intelligence. So far, human creativity has fueled artificial intelligence. Artificial intelligence has extracted and applied patterns that are the result of thousands of years of creative human effort. However, the current market trend of suppressing creative humans and replacing them with artificial intelligence will ultimately render this tool useless. This paper shows that artificial intelligence creativity is not real, and we are facing artificial creativity. The expansion of artificial creative powers will threaten the future of mankind.**

K E Y W O R D S Creativity, Artificial Inteligence, Artificial Creativity, Innovtion, Cold Start Problem

INTRODUCTION

Artificial intelligence (AI) has been investigated for decades [1-5]. However, what happened after November 2022, i.e., launching the fourth version of ChatGPT, is in no way comparable to the progress of artificial intelligence in the last fifty years. It seems that the new powerful version of AI will absolutely be in conflict with creativity. There are plenty of people who produce copies of everything in a short period of time. They are not creative, they don't work hard, and they don't have a long-term plan for their career. They basically want to change their business in favor of human and legal standards.

What about creative people? The benefits of artificial intelligence are undeniable. Nevertheless, the question is: What is the relationship between artificial intelligence and creativity? What will artificial intelligence do with the creativity of intelligent humans in the long run? Sam Altman, director of Open AI, states that "many jobs are affected and lost" [6]. We have to ask: What if these jobs are directly related to creativity, like works of art? How will creativity be affected? To what extent has creativity the chance to survive? How will creativity be transformed along with the transformation of AI? This paper tries to shed light on this challenging issue.

METHODS

This study is based on a review of research related to creativity and artificial intelligence. Each of these two concepts has been investigated separately in Computer Science on the one hand and Psychology and Education on the other hand. However, only a few studies considered the role of AI in the evolution of creativity and the effect of creativity on the development of AI [7-10]. Also, it must be kept in mind that it is rare to find research that has studied the negative impact of these two on each other. The purpose of this paper is to highlight the negative and even dangerous aspects of artificial intelligence interference in creativity. In order to do this, relevant studies have been reviewed and the researchers' viewpoints have been analyzed. Therefore, this study can be considered a small and perhaps successful example of a qualitative analysis. In this study, we have not placed ourselves in the framework of qualitative research and the standards of analysis and extraction of concepts. Since this study reflects a personal critical perspective, the researcher's inference of the current state-of-the-art of the AI market and the challenges facing creativity as a result of the ever-increasing development of artificial intelligence will shape our discussion.

CHALLENGE: HOW CAN CREATIVITY BECOME A PROBLEM?

Intelligent systems based on large language models are on the rise. What makes one superior to the other is the data used to train the machine. First, when ChatGPT came, it was said that they fed a diverse set of internet text, and it uses that data to generate human-like text based on the input given to it. It is understandable that trillions of data points will build a huge library with a large language model: what a strange power it will have in retrieving information, and what better answers it will prepare for millions of questions. Almost all users are surprised by the power of artificial intelligence. Of course, we do not enter into the discussion of whether artificial intelligence development companies are legally allowed to use this data or not.

It was said that a diverse set of internet texts have been used, which is undoubtedly the largest collection of information in all scientific, cultural, litrary, social, and other fields. However, the answers that AI gives are based on this data and nothing more. Artificial intelligence itself does not produce creativity, nor does it produce creatively. Because machines are not based on creativity. The seemingly creative information that AI can act on has already been produced and used by a creative human. AI will respond to you based on other people's creations, animate, design, and even write scripts. Therefore, it is said that programmers, graphic artists, screenwriters, and a number of other workers are not needed anymore, and these jobs should be eliminated. Even business managers, who have always had problems paying for advertising, now believe that they can reduce their advertising costs to almost zero with artificial intelligence.

We need to consider these questions. In 2024, creative work is still being done in the market: the output of people's creativity is somehow placed in the network, and as a result, artificial intelligence can take and use them with permission and often without permission. In the coming years, when these jobs are eliminated and new creations are not added to the collection of knowledge and artistic skills, how will artificial intelligence be able to innovate? Should it still use the same reserve it has, plus its productions, which are not creative at all? Doesn't this process make a weak artificial intelligence?

These questions are very important and vital. If we automate all of the world's creative endeavors (e.g., filmmaking, photography, music production, painting, drawing, and writing), won't human life become even more meaningless? If there were no human creativity and creative people, the same initiatives that come from artificial intelligence would not exist today, and if we are going to leave creation and innovation to artificial intelligence, what role will be given to creative people in society? Should they be assigned simple tasks?

Think of all the books, magazines, movies, theaters, sculptures, monuments, and paintings. Human creativity is the backbone of artificial intelligence. Large language models have been trained using human creativity, and now AI even creates without human permission or copyright payment. Artificial intelligence benefits from creativity that is created with great effort and is based on the sharing of thoughts, knowledge, and even human errors. Artificial intelligence benefits from the result of human learning, hard work, and sacrifice. In the absence of human creativity, where will the raw material needed for artificial intelligence be provided?

Add to these questions the speculative approach of prominent artificial intelligence companies against creativity. They act as if they are going to a creative war. Their motivation is to turn creativity into goods and make profit. However, will there be new and more profitable goods without creative people? These companies take away what makes creativity unique: talent and insight.

DISCUSSION: ARTIFICIAL CREATIVITY AND THE DEAD END OF COLD START

Artificial intelligence creates artificial creativity [11]. Theories of creativity in psychology [12] and its systematic effect in education have been discussed [13]. Artificial intelligence can be creative. However, the creativity of artificial intelligence is different from the creativity of humans. AI outputs are attributed to creativity even if they are not creative. Therefore, it is better to use the word artificial creativity for all innovative actions of artificial intelligence. Artificial creativity may be novel and effective, but it lacks the basic characteristics of human creativity.

Artificial intelligence runs on something called a neural network [14]. The neural network is modeled after the human brain. AI learns to recognize and predict patterns. Imagine what will happen in the absence of creativity or, more precisely, new patterns. Artificial intelligence will quickly encounter the cold start problem [15]. Cold start is the dead end of pattern making, where no chance to detect new phenomena is available. It stops AI's new understanding of input data and creates information blockage. If this problem is not solved, artificial intelligence will create a great danger. In a world where artificial intelligence cannot behave as creatively as humans, previous patterns will be used to solve new problems, and this will greatly increase the risk of every decision and action. People's health and safety are areas that are threatened by the dominance of artificial creativity.

CONCLUSION

This study showed how artificial intelligence can be separated from its roots. Artificial intelligence imitates human behavior to invent any new product. The performance of artificial intelligence is creative in appearance. However, the creativity of artificial intelligence is also artificial. This technology invents based on patterns deduced from previous human creativity. Nevertheless, its dominance on the market will lead to unemployment and a quantitative and qualitative reduction of creative people. As a result, the bubbling fountain that fed AI eventually runs dry. This is the Achilles heel of artificial intelligence.

It seems that the digital transformation should guarantee an agreement to maintain this source of power or imply a mechanism that involves the cooperation of a group of experts in psychology, education, economics, and management with the aim of developing a solution to support geniuses and help the innovators. Otherwise, the authority of the market will fall into the hands of technocrats. The consequence of the dominance of the technological perspective on social, educational, and economic affairs is to ignore the soft aspects of technological developments.

Further research can focus on the development of an economic model to support innovators from the financial aspect, changing the center of gravity of artificial intelligence technology from perception and pattern repetition to approximating the machine model to the current human intelligence, and postponing any fundamental modeling to the approval of experts, as well as focusing on creating and strengthening political alliances in order to balance the growth of artificial intelligence and control the digital divide.

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THE ROLE OF DIGITAL TRANSFORMATION AND ARTIFICIAL INTELLIGENCE IN MOTOR INSURANCE RISK ASSESSMENT

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Abstract: Digital transformation and artificial intelligence (AI) are revolutionizing the insurance industry, particularly in the realm of motor insurance risk assessment. By leveraging advanced technologies, insurers can enhance the accuracy of their risk assessments, streamline operations, and deliver personalized customer experiences. This article explores how digital transformation and AI are reshaping motor insurance risk assessment.

Keywords: digital transformation, artificial intelligence (AI), Machine Learning (ML), Predictive Analytics, Natural Language Processing (NLP), Usage-Based Insurance (UBI).

INTRODUCTION

Digital Transformation in Motor Insurance

Digital transformation refers to the integration of digital technologies into all aspects of business operations, fundamentally changing how organizations operate and deliver value to customers. In motor insurance, this transformation manifests through several key innovations:

1. Telematics and IoT: The use of telematics and Internet of Things (IoT) devices allows insurers to collect real-time data on driving behavior. By analyzing data on speed, braking patterns, and mileage, insurers can more accurately assess the risk profile of individual drivers and offer usage-based insurance (UBI) policies.

Telematics and IoT devices, typically installed in vehicles or accessed through smartphone apps, capture a wealth of data on driving behavior. This data includes:

- **Speed**: Monitoring how fast a driver is traveling at any given time.
- **Braking Patterns**: Recording instances of hard braking, which can indicate aggressive driving habits.
- **Mileage**: Tracking the distance traveled, which correlates with exposure to potential accidents.
- **Acceleration and Deceleration**: Measuring sudden starts and stops.
- **Location and Route Information**: Understanding driving environments, such as urban versus rural areas, and common routes taken.

Usage-Based Insurance (UBI) Policies

Usage-based insurance (UBI) is a revolutionary model made possible by telematics and IoT technology. UBI policies tailor premiums based on the actual usage and driving behavior of the insured. Key features include:

- Pay-As-You-Drive (PAYD): Premiums are based on the number of miles driven. This model benefits low-mileage drivers who are less likely to be involved in accidents.
- Pay-How-You-Drive (PHYD): Premiums are adjusted based on driving behavior, such as speed, braking patterns, and adherence to traffic rules. Safe drivers are rewarded with lower premiums.
- Behavior-Based Discounts: Drivers exhibiting safe driving behaviors can earn discounts or rewards, incentivizing better driving habits and reducing overall risk.

Big Data and Analytics: Insurers now have access to vast amounts of data from various sources, including social media, weather reports, and traffic patterns. Advanced analytics tools help insurers process this data to identify trends and make informed decisions about risk assessment and pricing.

Big data in motor insurance comes from a variety of sources, including:

- **Telematics Data**: Information from in-vehicle telematics devices provides insights into driving behavior, such as speed, acceleration, braking patterns, and mileage.
- **Social Media**: Publicly available data from social media platforms can offer additional context about a policyholder's lifestyle and behavior, helping to refine risk profiles.
- **Weather Reports**: Real-time and historical weather data helps insurers understand the impact of weather conditions on driving safety and accident risk.
- **Traffic Patterns**: Data on traffic flow, congestion, and accident hotspots enables insurers to assess risks associated with different routes and times of day.

- **Claims History**: Historical claims data provides a basis for identifying patterns and predicting future claims.
- **External Databases**: Information from government databases, industry reports, and other external sources can be integrated to enrich the data pool.

Methods

Advanced Analytics Tools

To harness the power of big data, insurers utilize advanced analytics tools that can process and analyze large datasets quickly and accurately. Key technologies include:

- Machine Learning (ML): ML algorithms can identify patterns and correlations in data that are not apparent through traditional statistical methods. These models improve over time as they are exposed to more data, enhancing their predictive accuracy.
- Predictive Analytics: By analyzing historical data, predictive analytics tools can forecast future events, such as the likelihood of an accident or a claim. This allows insurers to set premiums more accurately and identify high-risk drivers.
- Data Visualization: Visualization tools help insurers understand complex data through intuitive charts and graphs, making it easier to identify trends and outliers.
- Natural Language Processing (NLP): NLP technology can analyze unstructured data, such as customer reviews and social media posts, to extract valuable insights about customer sentiment and behavior.

Benefits of Big Data and Analytics

The integration of big data and advanced analytics in motor insurance offers numerous benefits:

- Improved Risk Assessment: By analyzing a wide range of data points, insurers can develop more accurate and nuanced risk profiles. This leads to fairer pricing and reduces the likelihood of underwriting losses.
- Dynamic Pricing: Big data allows for real-time adjustments to premiums based on current risk factors, such as changes in driving behavior or environmental conditions. This dynamic pricing model ensures that premiums are always aligned with the actual risk.
- Enhanced Fraud Detection: Advanced analytics can detect unusual patterns and anomalies that may indicate fraudulent claims. This helps insurers mitigate fraud-related losses and maintain the integrity of their risk assessment processes.
- Personalized Customer Experiences: By understanding individual drivers' behavior and preferences, insurers can offer personalized recommendations, discounts, and services. This improves customer satisfaction and loyalty.
- Operational Efficiency: Automation of data analysis and risk assessment processes reduces the need for manual intervention, lowering operational costs and speeding up decision-making.

Challenges and Considerations

Despite the advantages, the use of big data and analytics in motor insurance also presents challenges:

- Data Privacy: Collecting and analyzing large amounts of personal data raises privacy concerns. Insurers must ensure compliance with data protection regulations and implement robust security measures to protect customer information.
- Data Quality: The accuracy of risk assessments depends on the quality of the data. Insurers need to invest in data cleaning and validation processes to ensure the reliability of their analytics.
- Integration: Integrating data from diverse sources can be complex and requires sophisticated data management systems. Insurers must also ensure that their existing infrastructure can support advanced analytics tools.
- Ethical Considerations: The use of big data and analytics in decision-making raises ethical questions about transparency, bias, and fairness. Insurers must address these issues to maintain trust with customers and regulators.

Results

Mobile Applications: Mobile apps provide a seamless interface for policyholders to interact with their insurers. These apps enable customers to report claims, receive real-time assistance, and access personalized insurance recommendations based on their driving habits.

Mobile apps offer a variety of features that make insurance processes more efficient and user-friendly:

- Claims Reporting: Policyholders can report claims instantly through mobile apps by uploading photos of the damage, providing details of the incident, and tracking the progress of their claims in real time. This speeds up the claims process and enhances transparency.
- Real-Time Assistance: Mobile apps provide policyholders with immediate access to support services, such as roadside assistance, emergency contacts, and step-by-step guidance in case of an accident. This timely assistance improves the overall customer experience during stressful situations.
- Personalized Insurance Recommendations: By analyzing data on driving habits collected through telematics, mobile apps can offer personalized insurance recommendations. For instance, safe drivers might receive notifications about potential discounts or customized coverage options.
- Policy Management: Policyholders can easily manage their insurance policies through mobile apps, including renewing policies, updating personal information, and reviewing coverage details. This convenience encourages customer engagement and loyalty.
- Usage-Based Insurance (UBI): Mobile apps enable insurers to implement UBI programs by tracking driving behavior and mileage. Policyholders can monitor their driving patterns and understand how their behavior affects their premiums, promoting safer driving habits.

- Digital Payments: Secure payment gateways within mobile apps allow policyholders to pay premiums, settle claims, and make other financial transactions quickly and conveniently.

Benefits of Mobile Applications

The integration of mobile applications in motor insurance offers several benefits:

- Enhanced Customer Experience: Mobile apps provide a user-friendly platform for policyholders to interact with their insurers. The convenience of managing policies, reporting claims, and receiving real-time assistance improves customer satisfaction.
- Improved Risk Assessment: By collecting and analyzing real-time data on driving behavior, mobile apps enable insurers to develop more accurate risk profiles. This leads to fairer pricing and better risk management.
- Operational Efficiency: Automating routine tasks such as claims processing, policy renewals, and customer support reduces the workload for insurers, lowering operational costs and improving efficiency.
- Increased Engagement: Mobile apps keep policyholders engaged by offering personalized recommendations, timely notifications, and interactive features. This ongoing engagement helps build stronger relationships between insurers and their customers.
- Data-Driven Insights: Mobile apps provide insurers with valuable data on customer behavior and preferences. These insights can be used to develop new products, improve existing services, and tailor marketing strategies.

Challenges and Considerations

Despite the advantages, the implementation of mobile applications in motor insurance presents challenges:

- Data Security: Ensuring the security of sensitive customer information is paramount. Insurers must implement robust cybersecurity measures to protect data from breaches and unauthorized access.
- Privacy Concerns: Collecting data on driving behavior and personal information raises privacy issues. Insurers must ensure transparent data practices and obtain informed consent from policyholders.
- Technical Integration: Developing and maintaining mobile applications requires significant technical expertise and investment. Insurers must ensure seamless integration with existing systems and infrastructure.
- User Adoption: Encouraging policyholders to adopt and regularly use mobile apps can be challenging. Insurers need to demonstrate the value and benefits of the apps to drive adoption.

Artificial Intelligence in Risk Assessment

AI technologies, including machine learning (ML) and deep learning, play a crucial role in enhancing motor insurance risk assessment. Here are some ways AI is being utilized:

- Predictive Modeling: AI algorithms analyze historical data to predict future risks. Machine learning models can identify patterns that human analysts might overlook, resulting in more accurate risk assessments and pricing strategies.
- Automated Claims Processing: AI-powered systems can automatically process claims by analyzing photos of vehicle damage, assessing the extent of the damage, and estimating repair costs. This reduces the time and cost associated with manual claims processing.
- Fraud Detection: AI tools can detect fraudulent claims by analyzing inconsistencies in data and identifying unusual patterns. This helps insurers reduce losses from fraudulent activities and maintain the integrity of their risk assessment processes.
- Customer Segmentation: By leveraging AI, insurers can segment customers based on risk profiles, driving behavior, and other relevant factors. This enables personalized insurance offerings and targeted marketing campaigns, improving customer satisfaction and retention.

Benefits of Digital Transformation and AI in Motor Insurance

The integration of digital transformation and AI in motor insurance offers numerous benefits:

- Enhanced Accuracy: AI-driven risk assessment models are more accurate than traditional methods, leading to fairer pricing and better risk management.
- Improved Efficiency: Automation of routine tasks, such as claims processing and data analysis, reduces operational costs and frees up resources for more complex activities.
- Personalized Services: Insurers can offer tailored policies and recommendations based on individual driving behavior, improving customer satisfaction and loyalty.
- Faster Claims Settlement: AI-powered claims processing accelerates the settlement process, providing quicker resolutions for policyholders.
- Reduced Fraud: Advanced fraud detection algorithms minimize the impact of fraudulent claims, protecting insurers' financial health.

Challenges and Considerations

While the benefits are significant, the adoption of digital transformation and AI in motor insurance also presents challenges:

- **Data Privacy and Security**: Collecting and analyzing vast amounts of personal data raises concerns about privacy and security. Insurers must ensure compliance with data protection regulations and implement robust security measures.
- **Technology Integration**: Integrating new technologies with existing systems can be complex and costly. Insurers need to invest in infrastructure and training to ensure a smooth transition.
- **Ethical Concerns**: The use of AI in decision-making processes raises ethical questions about transparency,

bias, and accountability. Insurers must address these issues to maintain trust with customers and regulators.

- **Regulatory Compliance**: The insurance industry is heavily regulated, and the use of AI and digital technologies must comply with various legal and regulatory requirements. Insurers need to stay updated with evolving regulations to avoid legal complications.

Conclusion

Digital transformation and artificial intelligence (AI) are reshaping motor insurance risk assessment, offering enhanced accuracy, efficiency, and customer experiences. By leveraging technologies like telematics, IoT, and AI-driven analytics, insurers can develop personalized risk profiles, streamline operations, and provide innovative usage-based insurance (UBI) policies.

Big data and advanced analytics are transforming motor insurance risk assessment by providing deeper insights and more accurate predictions. By leveraging these technologies, insurers can enhance risk management, offer personalized services, and improve operational efficiency. However, they must also navigate challenges related to data privacy, quality, and ethical considerations. As these technologies continue to evolve, they promise to further revolutionize the insurance industry, leading to smarter, more efficient, and fairer risk assessment processes.

These advancements enable insurers to stay competitive in a rapidly evolving market and better serve their customers. However, to fully harness the potential of digital transformation and AI, insurers must navigate challenges such as data privacy, security, regulatory compliance, and ethical considerations.

As technology continues to advance, the future of motor insurance looks promising, with smarter, more personalized, and efficient risk assessment processes. This evolution not only benefits insurers by improving risk management and reducing costs but also offers policyholders fairer premiums and tailored insurance solutions. Embracing these technologies will be key to thriving in the modern insurance landscape.

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METHODS OF LINEAR PREDICTION AND SPECTRAL CENTROID IN THE SELECTION OF FEATURES CHARACTERIZING SOUND IN THE SPEAKER RECOGNITION PROBLEM

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A B S T R A C T **Biometric technologies are a promising direction in the field of information security. Voice biometrics is widespread today, and work on improving the quality of voice systems does not lose its relevance. The choice of a method for extracting speech features is one of the key stages in the design of voice automatic systems. The topic of the work concerns the methods of their extraction. Attention is also paid to algorithms for linear prediction of the spectral and centroid. Parameterization of speech characteristics is included in the recognition of speech, emotions, language, and gender. Although the paper lists the main approaches to extracting acoustic signs of speech in order to recognize the speaker, the material can also be useful in the above-mentioned tasks of processing speech signals.**

K E Y W O R D S Speaker recognition, speech analysis, linear prediction, perceptual linear prediction, spectral centroid.

INTRODUCTION

Biometric technologies are being actively introduced into society. This is evidenced by the existing and projected growth of the biometrics market at both the global and domestic levels [1].

Voice recognition is a popular biometrics used in the field of information security due to the wide availability of equipment, the possibility of remote identification, a simple learning process and use for the consumer. Improving the quality of personality recognition in various conditions and countering fake attacks remain urgent problems of speech signal processing. An important component of automatic voice biometrics systems is the extraction of informative parameters of the speech signal. The purpose of this work is to provide an overview of existing methods for extracting individual speech characteristics in the tasks of determining a speaker by voice for developers and researchers interested in digital processing of speech information.

METHODS

Linear prediction

Linear prediction has been one of the main approaches to digital speech processing tasks for a long time. It can be used to evaluate the pitch period, formants, and other basic speech parameters. The principle of the linear prediction method is that a section of the speech signal can be approximated by a linear combination of the previous sections of the signal. It is assumed that speech is created by excitation of a linear time-varying filter (speech tract) by random noise for non-vocalized speech segments or by a sequence of pulses for vocal speech. The simplified process of speech formation (Figure 1) is described by a linear system with variable parameters and a transfer function:

$$H(z)=\frac{G}{1-\sum_{k=1}^{p}a_k z^{-k}},$$

where G – is the gain factor, a_k is the prediction coefficients, and p is the order of linear prediction [5].

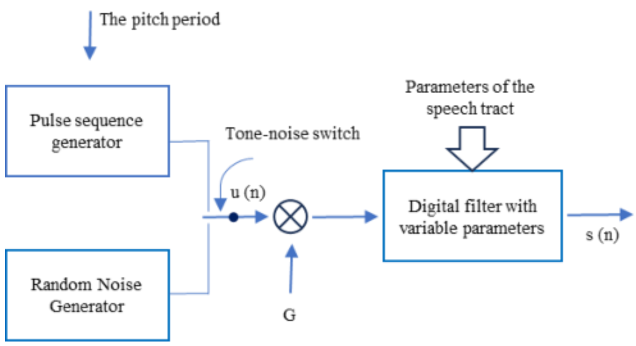

Fig. 1. Block diagram of the basic model of speech formation

From the concept of linear prediction, the dependence of the n-th sample of the speech signal on the excitation signal for the circuit in Figure 1 is expressed as

$$s(n)=\sum_{k=1}^{p}a_k s(n-k)+Gu(n).$$

A linear predictor with coefficients is represented as a system with an output signal:

$$s(n) = \sum_{k=1}^{p} a_k s(n-k).$$

The essence of the calculations is to find linear prediction coefficients (linear prediction coefficients (codes) – LPC) by speech signal with minimization of prediction error. The prediction error e(n) is defined as

$$e(n) = s(n) = \sum_{k=1}^{p} a_k s(n-k).$$

There are three basic algorithms for calculating linear prediction coefficients: covariance, autocorrelation and ladder (Figure 2). Their detailed description can be found in [5], and a summary with a comparative analysis in the article [6].

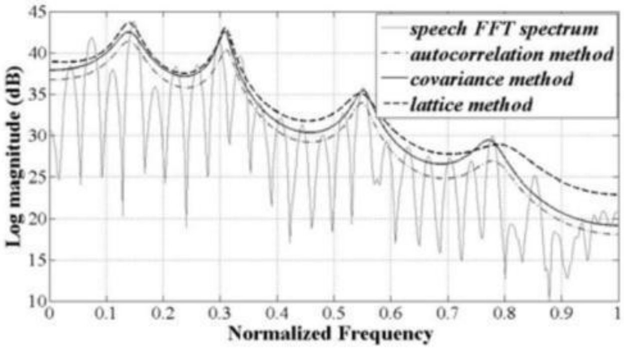

Fig. 2. Comparison of the effectiveness of LPC algorithms

Spectral centroid

The spectral centroid frequency (SCF) is a weighted average frequency for a given sub–band, where the weighting coefficients represent the normalized energy of each frequency component in this subband [7]. Using the frequencies of the spectral centroid, it is possible to estimate the approximate location of the formants, which manifest themselves as peaks in the neighboring subband. SCF is affected by changes in pitch and harmonic structure. The frequency of the spectral centroid of the F_k for the k-th subband is defined as follows:

$$F_k = \frac{\sum_{f=l_k}^{u_k} f \left| S[f] \omega_k [f] \right\|}{\sum_{f=l_k}^{u_k} \left| S[f] \omega_k [f] \right\|}$$

where u and l are the upper and lower boundary frequencies of the subband; S[f]– is the spectrum of the frame divided into k subbands, ω_k– is the frequency response of the filter. The amplitude of the spectral centroid (SCM) is the weighted average value of the amplitude for a given subband, where the weighting coefficients are the frequencies of each component of the amplitude in this subband, calculated using the formula

$$M_k = \frac{\sum_{f=l_k}^{u_k} f \left| S[f] \omega_k [f] \right\|}{\sum_{f=l_k}^{u_k} f}.$$

The SCM captures, in a first-order approximation, the energy distribution in the subrange. Due to the weight function, each of the two signals will be represented by different values of SCF and SCM. The difference in the steepness of the weight function relative to the width of the subrange can also be noted this leads to different variances of the elements. The average energy can be calculated using the equation above . Since the amplitude of the spectral centroid is the amplitude at the frequency position of the spectral centroid, it will also carry information related to the formants, which is useful for speaker recognition.

CONCLUSION

Conclusion. To summarize, we can say that linear prediction and spectral centroid methods have long remained one of the main approaches to digital speech processing problems. Using these methods, speech recognition error can be somewhat reduced.

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CONSTRUCTION OF RECOGNITION ALGORITHMS USING $\mathscr{k}$-DIMENSIONAL THRESHOLD RULES

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A B S T R A C T **In this article, we consider the problem of recognition in conditions of a high-dimensional feature space. To solve the problem, we propose a new approach based on the formation of $\mathscr{k}$-dimensional subspace of features and the construction of decision rules at this stage. A structural description of the proposed recognition algorithms is given, presented as a sequence of computational procedures, the main ones of which are the procedures for forming a set of "independent" subsets of strongly related features, extracting representative features from these subsets, searching for preferred separating functions, and synthesizing a generalized recognition operator. The practical significance of the results lies in the fact that the developed models of algorithms can be used in various applied problems related to the classification of objects specified in a high-dimensional feature space. To assess the performance of the proposed model of recognition algorithms, it was experimentally tested using the example of solving a model problem.**

K E Y W O R D S pattern recognition, recognition algorithms, subset of strongly related features, representative feature, separating function, basic function, preferred function

INTRODUCTION

One of the central tasks of pattern recognition is to construct a recognition algorithm that classifies objects defined in a feature space of high dimensionality. It is well known that the construction of a recognition algorithm in such a space faces great computational difficulties. In this regard, the issues of construction of recognition algorithms in conditions of high dimensionality of the feature space are very relevant [1, 2].

The purpose of this paper is to build a family of algorithms for recognizing objects defined in a feature space of high dimensionality. In this case, many features are interrelated and the initial description of objects is redundant, which generates significant computational difficulties.

METHODS

A new approach is proposed to solve the problem of pattern recognition in a feature space of high dimensionality. On the basis of this approach, a family of recognition algorithms based on the construction of $\mathscr{k}$-dimensional threshold rules have been developed. The main idea of the proposed family of algorithms is to form a set of representative features and the construction of threshold rules in the $\mathscr{k}$-dimensional subspace of representative features. Assignment of recognition algorithms based on the construction of $\mathscr{k}$-dimensional threshold rules include the following steps.

1. *Identify independent subsets of highly related features (ISHRFs).* As a result of this step, the following is determined $n^{'}$ $(n^{'} < n)$ ISHRFs [3, 4].

2. *Identification of a set of representative attributes.* As a result of this step, one representative is selected from each ISHRF, which is a typical element of its group of attributes, i.e. a representative attribute (RA) [4, 5]. As a result, $n^{'}$ RA, which is described by n-dimensional boolean vector $\mathbb{r}$ ($\mathbb{r} = (r_1, .., r_i, .., r_n), n' = \|\mathbb{r}\|_B$, where $r_i = 1$ if the feature x_i is a RA; $r_i = 0$ – otherwise).

3. *Defining separating functions for the class K_j.* Consider the set of boolean vectors $\mathbb{W}$, each of which consists of $n^{'}(n^{'} = |X^{'}|)$ components: $\widetilde{\omega} = \left(\omega_1, \dots, \omega_i, \dots, \omega_{n^{'}}\right)$, $\omega_i \in \{0, 1\}$. Let us select all unit coordinates of the vector $\widetilde{\omega}$whose number is equal to $\mathscr{k}$. Let these elements correspond to $i_1, \dots, i_u, \dots, i_{\mathscr{k}}$-th coordinates of the vector $\widetilde{\omega}$. Let us remove from consideration all elements of the set of representative features $X^{'}$except for the features $x_{i_1}, \dots, x_{i_u}, \dots, x_{i_{\mathscr{k}}}$ $\left(x_{i_1}, \dots, x_{i_u}, \dots, x_{i_{\mathscr{k}}} \in X^{'}\right)$ which correspond to the unit coordinates of the vector $\widetilde{\omega}$. The obtained part of the set of $\mathscr{k}$-dimensional features denote $(x_1^{'}, \dots, x_u^{'}, \dots, x_{\mathscr{k}}^{'})$ and call the $\widetilde{\omega}$-feature space. It is assumed that the definition of separating functions is performed in one of the $\mathscr{k}$-dimensional subspaces of representative features. $\mathscr{k}$-dimensional subspaces of representative features $\mathcal{D}_u$ $(\mathcal{D}_u \subset \mathfrak{D}$, $\mathfrak{D} = (\mathcal{D}_1, \dots, \mathcal{D}_u, \dots, \mathcal{D}_\mathfrak{n})$, $\mathcal{D}_u = \left(x_{u_1}^{'}, \dots, x_{u_{\mathscr{k}}}^{'}\right)$, $x_{u_1}^{'}, \dots, x_{u_{\mathscr{k}}}^{'} \in X^{'}\big)$. Then each object can be represented as a point in $\mathscr{k}$-dimensional Euclidean space.

Formation $\mathscr{k}$-dimensional subspace of representative features $\mathcal{D}_u$ is based on the corresponding boolean vector $\widetilde{\omega}_u$:

$$\widetilde{\omega}_u\, X^{'} \rightarrow x_{u_1}^{'}, \dots, x_{u_{\mathscr{k}}}^{'};$$

$$\widetilde{\omega}_u = \left(\omega_1, \dots, \omega_i, \dots, \omega_{n^{'}}\right), \omega_i \in \{0, 1\}.$$

The set of objects (or points) represented in the $\mathscr{k}$-dimensional subspace of representative features $\mathcal{D}_u$ can be divided into classes. Such a division is performed by separating functions of a simple enough kind, for example, linear functions [6, 7]:

$$y_u = w_{u0} + \sum_{i=1}^{\mathscr{k}} w_{ui} x'_{u_i}, \qquad (1)$$

where w_{ui} is the vector of weight coefficients.

4. Defining the normalizing transformations. At this stage we define scaling transformations of the results obtained after applying the separating function (1) to the objects $\tilde{S}^m$. As a result of this step the scaling transformations are formed.

5. Formation of groups of strongly connected separating functions. As a result of this step the set $\mathbb{V}_A$ consisting of $\mathfrak{n}$ $\left(\mathfrak{n} = C_{\mathfrak{n}'}^{\mathscr{k}}\right)$ elements. The actions used in determining the elements of the set are based on the idea of pairwise comparison of the evaluation results obtained using separating functions for their proximity and formation of "independent" groups of strongly related separating functions according to their proximity estimates. As a result of realization of this stage, we distinguish $\mathfrak{n}$ non-overlapping groups of strongly coupled connected functions (GSCCFs).

6. Identification of basic separating functions. As a result of this step, a set of basic separating functions that are typical representatives of each GSCCF is determined. The main idea of selecting a basic separating function from the GSCCFs is their "independence" within the selected set of basic separating functions. The following conditions are used in its formation: 1) the basic separating functions should be strongly connected in their GSCCF; 2) the selected basic separating functions should be mutually independent.

As a result of this step, we obtain $\mathfrak{n}'$ of basic separating functions.

7. Selection of preferred separating functions. As a result of this step, a set of preferred separating functions (PSFs) is selected. The main idea of PRF selection is to compare them on the basis of evaluation of dominance of the considered solving rules for the objects of the training sample. After performing this stage, the preferred separating functions are selected. n'' preferred separating functions.

8. Synthesis of the generalised recognising operator. As a result of this step, a generalised recognition operator based on the PRF is determined. In this case, the generalised algorithm can be represented as an algorithmic polynomial from the selected admissible PRFs, for example:

$$B\left(K_j, \mathfrak{D}\right) = \sum_{\tau=1}^{\mathfrak{n}'} \mathscr{v}_\tau \mathfrak{H}\left(E_q^\tau, \mathfrak{D}^\tau\right), \qquad (2)$$

where $\mathscr{v}_\tau$ is the parameter of the generalised recognition operator; $\mathfrak{n}'$ is the number of admissible PRFs.

9. Decision rule. The decision is made on the basis of comparison of estimates calculated by formula (2):

$$\beta_{ij} = C\left(\mathfrak{E}_j(S_i)\right) = \begin{cases} 0, if\ B\left(K_j, S_i\right) < c_1, \\ 1, if\ B\left(K_j, S_i\right) > c_2, \\ \Delta, if\ c_1 \le B\left(K_j, S_i\right) \le c_2, \end{cases}$$

where c_1, c_2 are algorithm parameters.

Thus, we have defined a family of recognition algorithms based on the construction of $\mathscr{k}$-dimensional threshold rules. An arbitrary algorithm A from this model is completely determined by specifying a set of parameters $\mathbb{p}$ [8]. The set of all recognition algorithms from the proposed family is denoted by $A(\mathbb{p}, S)$. Determination of the best algorithm within the considered family is carried out in the parameter space $\mathbb{p}$. In order to evaluate the performance of the developed recognition algorithms, experimental studies have been carried out.

RESULTS

The main result of this paper is a family of recognition algorithms based on the construction of $\mathscr{k}$-dimensional threshold rules. The construction of this family is performed within the framework of families of algorithms based on the separation principle [2].

To verify the performance of the proposed family, an experimental study was carried out when solving a model problem. This problem was solved with the use of recognition algorithms based on potential functions (A_1), recognition algorithms based on the calculation of estimates (A_2) and the proposed family of recognition algorithms (A_3). The recognition accuracy during training for A_1 is 95.1%, for A_2 – 95.9%%, and finally, for A_3 – 97,3%. The results of solving the problem under consideration using A_1, A_2 и A_3 in the control process are given in Table 1.

Table 1.Results of solving the problem using various recognition algorithms

Recogniti on algorithm s	Time (in sec.)		Recogniti on accuracy (in %)
	traini ng	recogniti on	
A_1	3,97	0,015	79,9
A_2	5,95	0,013	83,1
A_3	10,21	0,004	93,8

Comparison of these results shows (see Table 1) that the proposed family of recognition algorithms has improved the accuracy of object recognition in a high-dimensional feature space. However, there is a slight increase in the training time of the proposed family of recognition algorithms.

DISCUSSION

The developed family of recognition algorithms differs from traditional families in that it is based on: the formation of a set of representative features; the construction of separating functions in the subspace of $\mathscr{k}$-dimensional representative features; the determination of preferred separating functions.

The developed family of recognition algorithms differs from traditional families in that it is based on: formation of a set of representative features; construction of separating functions in the subspace of the of k-dimensional representative features; determination of preferred separating functions.

The results of the above experimental study show that the proposed family of recognition algorithms allows us to solve the problem of pattern recognition more accurately in conditions of high dimensionality of the feature space. At the same time, the time spent on recognizing objects is much less than the same parameter A_1 и A_2 (see Table 1). This is due to the fact that the proposed recognition algorithms use only the preferred separating functions for object recognition, which caused an increase in the speed of object recognition. Therefore, this family of recognition algorithms can be used in the development of systems operating in real time. At the same time, it should be noted that the time spent on training the family of recognition algorithms has increased, because the construction of the optimal recognition algorithm requires optimizing a large number of parameters than when using the traditional family of recognition algorithms, in particular A_1 и A_2.

A comparative analysis of the quality assessment of these families of recognition algorithms shows that the proposed family solves the recognition problem under conditions of large dimensionality of the feature space more accurately. The recognition accuracy for the problem under consideration for this algorithm is much (more than 10%) greater than for A_1 и A_2.

CONCLUSION

A new approach for the construction of a family of recognition algorithms is proposed and on the basis of this approach a family of recognition algorithms based on the construction of k-dimensional threshold rules. This family of algorithms is oriented to solve the problem of object recognition in conditions of high dimensionality of the feature space.

The application of the developed family of algorithms for recognition of images defined in a high-dimensional space allows to improve the accuracy of recognition and expand the scope of application in solving applied problems. This family of recognition algorithms significantly reduces the number of computational operations in the recognition of an unknown object and can be used in the compilation of various programmes aimed at solving problems of diagnosis, classification and control of objects in hard-to-formalize areas of science and technology.

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OPTIMAL SEGMENTATION METHODS USED IN MEDICAL IMAGE RECOGNITION

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A B S T R A C T **The era of big data and the rapid growth of computing power have opened new horizons in the field of medical imaging. Segmentation of medical images, being a key stage of analysis, requires increasingly efficient and accurate algorithms. In this paper, we will review existing segmentation methods, starting from classical approaches (threshold methods, region-based segmentation) and ending with modern deep neural networks using dental images as examples. Particular attention will be paid to convolutional neural networks and modern architectures that have shown impressive results in segmentation of various medical images. In conclusion, we will discuss current trends and prospects for the development of this field.**

K E Y W O R D S Segmentation, images, medicine, deep learning, threshold

INTRODUCTION

In order to improve the diagnostic efficiency and reduce the pressure on doctors, computer-aided diagnosis and treatment has become a hot spot of intelligent medical research at the moment. The combination of computer and medical fields has created a new era of digital medical diagnosis. Medical image processing mainly includes image detection, image segmentation, image registration, image fusion and other aspects. Among them, medical image segmentation plays an important role in medical image processing, through which the diseased tissue can be extracted and its size can be measured to observe the disease, which is directly related to the accuracy of the computer-aided medical diagnosis system. Segmentation subdivides an image into its constituent regions or objects. The level of detail to which this division is carried out depends on the task at hand. In other words, segmentation should be stopped when the objects or regions of interest have been detected. Segmentation of non-trivial images is one of the most challenging image processing tasks. The ultimate success of computer image analysis procedures is largely determined by the accuracy of segmentation, for this reason, considerable attention should be paid to improving its reliability. [1] However, medical image segmentation is a complex and difficult task, and no ideal solution has been obtained so far. Compared with ordinary images, medical images are characterized by blurriness, complexity, and individual differences. In addition, segmentation algorithms are usually focused on specific segmentation tasks, and there is no general algorithm that can perfectly perform effective segmentation for all medical images. At present, medical image segmentation algorithms based on traditional methods and medical image segmentation based on deep learning are more commonly used.

METHODS

Depending on the degree of human involvement in the segmentation process, methods can be divided into three categories:

- Manual segmentation: A traditional method in which a medical professional manually selects regions of interest in the image. Although highly accurate, this method is labor-intensive and subject to inter-subject variability.
- Semi-automated segmentation: A hybrid approach that combines automatic algorithms and manual correction. Automatic algorithms provide an initial segmentation, which is then refined by a human expert. This approach reduces the workload of the expert and increases the efficiency of the process.
- Automatic segmentation: A fully automated method based on machine learning algorithms, in particular deep learning. Modern neural networks are capable of segmenting medical images with high accuracy, which significantly speeds up the data analysis process. However, the quality of the results is highly dependent on the quality of the data used to train the model.[2]

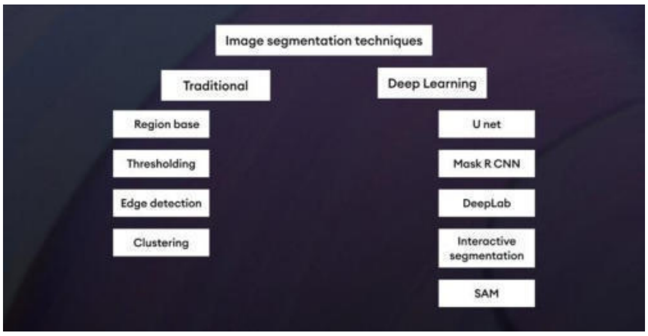
Segmentation methods and algorithms can be considered as a formalization of the concept of object distinguishability from the background.

The reliability of segmentation algorithms depends on how accurately and completely additional information is taken into account, which mainly consists of the following data:

- number of objects S;
- some characteristics of the brightness distribution in the object or background areas, such as extreme brightness values, number of brightness differences;
- estimates of the brightness difference when moving from the background area to the object area;
- object shape;
- information about what part of the visual field is occupied by the union of object areas

There are a great many segmentation methods, and different methods are oriented toward different properties of image partitioning. Therefore, when choosing a segmentation method for a particular task, one should be guided by what partitioning properties are really important and what properties the original image has. It is also necessary to decide what level of detail, to which the division into classes is brought, is acceptable. Everything depends on each specific task being solved.

The article discusses the following most common image segmentation methods.



1. Thresholding segmentation is a simple method that relies on selecting a threshold for pixel intensity or color to divide an image into two or more regions. Global Thresholding, Adaptive Thresholding, Otsu's Thresholding.

The segmentation method based on threshold has the advantages of small computation, simple implementation and high efficiency, which is one of the most common means of medical image segmentation direction. However, it also has some limitations. For example, this method is only applicable to some images with simple targets and large differences in background gray values, and is sensitive to noise, so its robustness is not high.

2. Region-based methods are methods that segment an image by combining adjacent pixels with similar properties (into one region). Region Growing, Split-and-Merge, Watershed.

The region growth is the process of combining pixels or subregions into larger areas according to pre-defined growth criteria. This method needs to solve three problems: 1) Select seed pixels that can accurately represent the desired region; 2) Determine the criteria for adding adjacent pixels to seeds during growth; 3) Set the conditions for stopping the growth process. The region growth method is simple to calculate and has a good segmentation effect on connected regions with the same characteristics. However, for images with noise, over segmentation is highly likely to occur. In medical image applications, region growing and region splitting and merging algorithms are usually combined. Such algorithms have a better effect on the segmentation of complex scenes defined by some complex objects or the segmentation of some natural scenes with insufficient prior knowledge.

3. Edge-based segmentation methods are methods that use the boundaries of objects in an image to isolate different regions. Sobel Operator, Canny Operator.

4. Clustering-based methods are methods that use clustering algorithms to group pixels into clusters of similar properties. K-Means Clustering, Mean Shift, DBSCAN.

5. Active contour segmentation is a method that uses curves called contours to extract objects in an image. An active contour is a curve that "actively" moves across the image toward the object's boundary and follows the contours of the object until it completely encloses it. Snakes, Active Contour Model (ACM), Gradient Vector Flow (GVF). The active contour model [14] can transform the process of image segmentation into the process of solving the energy functional minimum, extract the edge of the target, and define an energy functional to make its independent variable include the edge curve, so the process of segmentation becomes the process of solving the energy functional minimum. General energy functional segmentation methods include two categories: Parametric active profile model and geometric active profile model. Energy functional segmentation method is more accurate in target location and segmentation precision, but the calculation is more complicated, and there may be isolated points and lines after processing.

Nowadays, methods based on deep learning are also widely used - these are methods that use convolutional neural networks for image segmentation. Neural networks are trained on large data sets with labeled images. For example, networks such as U-Net, Mask R-CNN and Panoptic FPN are most often used for segmentation. Methods based on the use of a graph to represent an image are also used. These methods find the minimum cut in the graph, which allows dividing the image into several areas: Normalized Cut, Max-Flow/Min-Cut, Random Walks.[3]

U-net

Another notable model is U-Net which resembles a 'U' shape when the architecture is visualized. It is composed of two parts: the upsampling and downsampling, also referred to as the contracting path and expanding part respectively. The significance of U-Net is the accuracy and speed it achieves for image segmentation by repurposing the same feature maps that are initially used to expand a vector into a fully segmented output image. The most prominent use of the U-Net architecture is for image segmentation for medical imaging.

Mask R-CNN

Mask R-CNN is an efficient and simple method for instance segmentation mask generation. The model output also contains bounding boxes for each instance, making the model more flexible to use in different applications. Mask R-CNN is a two-stage convolutional neural network; the first stage is the Region Proposal Network (RPN), which, as the name suggests, proposes regions of interest. The second stage is region-based parallel processing of finding instance bounding box, classification, and binary mask.

Interactive segmentation. Interactive segmentation is another deep learning segmentation technique. With such types of image segmentation models, the user should provide pixels for segmentation. Then the model outputs the instance segmentation based on the image and provides input points. It is also possible to provide points for multiple segments and get instance segmentation based on each region.

- f-BRS**:** The feature Backpropagating Refinement Scheme (f-BRS) is an example of an interactive image segmentation model, using clicks from the user as input for the training model. The clicks can be inclusive and exclusive for instance. The backpropagation is optimized in a way to not go all the way back to the input features, but only updates parts of the network using auxiliary.
- DEXTR: The Deep Extreme Cut model (DEXTR) takes four extreme points (left-most, right-most, top, and bottom pixels) and generates Gaussian for each point. The total distribution of the Gaussian is added to the input as an additional input channel.

Meta's SAM

The Segment Anything Model (SAM) was developed by Meta and gives an opportunity for non-machine learning experts to use it for image segmentation. The model was trained over 1 billion masks for its ability to make accurate predictions on new datasets without additional training. The SAM is also useful for complex semantic segmentation tasks such as medical and satellite images.[4]

RESULTS

Medical image segmentation plays a crucial role in various healthcare applications, including:

- Diagnosing and monitoring diseases
- Planning surgical interventions
- Assessing treatment response
- Quantitative analysis of anatomical structures
- Creating anatomical atlases

Accurate and reliable medical image segmentation is essential for precise and meaningful analysis of medical images. It allows healthcare professionals to focus on specific areas of interest, enhancing their ability to detect, diagnose, and treat various conditions effectively.

In the previous chapter we looked at traditional and deep learning-based segmentation methods

Classic image segmentation uses either pixel similarity (how similar a pixel is to its neighbors) to form clusters or discontinuity (how different a pixel is from its neighbors) to detect edges. Classical segmentation fails when a single object may have disparate parts, since the segmentation process lacks semantic understanding.
Finally, classical segmentation often processes only one segmentation condition (e.g., one threshold). Deep segmentation learning can be trained to segment many different objects simultaneously.

Deep learning has shown impressive results in medical image analysis, from identifying specific areas to classifying and diagnosing diseases. While promising, these methods face challenges that need to be overcome for widespread clinical use. A major hurdle is the need for vast amounts of labeled data. Deep learning models learn from examples, requiring images with accurate markings like outlines or disease classifications. Creating labeled medical datasets is a difficult and costly process. The quality and consistency of these labels can also vary, potentially affecting model accuracy. Medical datasets for rare diseases or specific patient groups may be limited,hindering model development. To address these issues, we need collaboration between healthcare providers, researchers,and data experts to create large, well-labeled datasets and establish consistent data standards. Techniques like data augmentation, transfer learning, and semi-supervised learning can also help make the most of limited labeled data and improve model performance. Deep learning models in medical image analysis need to be reliable and transparent, especially in critical applications where trust is important. These models are often seen as "black boxes," meaning we can't easily understand how they make decisions. In healthcare, knowing how a model reaches a diagnosis is crucial for doctors to trust and use it. The complex nature of deep learning makes it hard to explain how these models work. Additionally, deep learning models can be fooled by small changes to images, leading to wrong results. This is a serious problem in medical imaging, as mistakes can have bad consequences for patients.

To address these challenges, we need techniques that make deep learning models in medical image analysis more understandable, reliable, and resistant to attacks. Explainable AI (XAI) methods like attention mechanisms, saliency maps, and gradient-based visualization can help explain why a model makes a certain decision. Additionally, robust training, regularization, and adversarial defense techniques can make these models more resistant to attacks and better at working with different types of patients and imaging methods.

Another challenge is making deep learning models work well with different types of patients and imaging methods.Medical images can vary a lot depending on patient characteristics, imaging machines, and how images are taken. Models trained on data from one group of patients or one hospital may struggle to work well with data from different groups or hospitals. This problem is worse because there aren't always standard ways to take medical images.

DISCUSSION

To overcome this challenge, researchers are studying techniques like domain adaptation, transfer learning, and collaboration between different medical centers to improve the ability of deep learning models to work well with different types of data and imaging setups. By using techniques like domain-specific normalization, feature alignment, and adversarial training, deep learning models can learn patterns that are less affected by differences in data and imaging methods.

CONCLUSION

Medical images are essential for accurate disease diagnosis. Effective image segmentation plays a crucial role in assisting doctors in this process. This paper explores traditional and deep learning-based segmentation techniques. While deep learning models offer high accuracy by learning from large datasets without manual feature extraction, they often require extensive labeled data, which can be resource-intensive. Future research aims to develop more efficient segmentation methods that require less labeled data.

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DATA VISUALIZATION STEPS TO SORT DATA BY REMOVING MISSING VALUES AND CONVERTING DATA TO NUMERIC TYPE

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A B S T R A C T **In this article, Data visualization is a crucial aspect of data analysis that enables clear interpretation of complex datasets. Before visualizing data, it is essential to preprocess it to ensure accuracy and clarity. This paper outlines key steps in data preprocessing, specifically focusing on sorting data by removing missing values and converting data into a numeric format. The process begins with identifying and handling missing data points, which can skew visualizations and lead to misleading conclusions. Various techniques, such as deletion or imputation, are discussed for addressing these gaps.**

K E Y W O R D S Visualization, sorting data, normalization, institution, email…

INTRODUCTION

As large amounts of data continue to be collected, the need for effective data visualization becomes increasingly important. Data visualization allows researchers and analysts to draw conclusions from complex data sets. As the amount of data generated and collected globally continues to grow exponentially, data visualization helps organizations and decision makers understand, analyze and present patterns, trends and relationships that are difficult to discern. is becoming increasingly important to help. Although data visualization enables human cognition to work with data more effectively, it presents several challenges that researchers and practitioners must address. One of the key issues is the development of advanced visualization techniques that can handle the often complex and multidimensional demands of big data. In addition, poorly designed visualizations can distort or misrepresent data, leading to incorrect conclusions.

METHODS

According to scientists Muskan, Gurpreet Singh, and others[1], they proposed to implement visualization in several stages. According to him, it is a preliminary and very important process to determine what kind of question the visualization will answer or what kind of problem it will solve [2]. At the next stage, if there is a part of obtaining or creating data, then a large database of numerical, statistical or geospatial information is used. After receiving the data, it is important to sort them, that is, to extract the necessary part. Sorted and consistent data visualization becomes much easier [1]. At the next stage, it is necessary to choose the type of chart corresponding to the sorted data. The right choice of a graph or diagram gives an opportunity to effectively deliver the idea to the audience. The first step in choosing a graphic is to determine what message to convey. After choosing the type of diagram, you can move on to choosing a software tool. It is advisable to choose the software based on the purpose and data of the visualization. After all the above processes are done, individual diagram or graph can be created using this software tool.

The general technique of drawing is as follows:

- Import data into the software
- Select the type of chart to be created
- Evaluation of graphic performance
- Application of design for improvement

This process can be divided into the following 7 stages [3]:

- Get data - Get data from a file on disk or from a network resource.
- Analyzing-Providing some structure for the meaning of the data and categorizing it.
- Filtering-Remove all but necessary data.
- Mining—Applying statistics or data mining techniques as a way to identify features, or putting data into a mathematical context.
- Presentation—Choose a basic visual model, such as a line graph, list, or tree.
- Sort-Enhance the main image for clarity and more engagement.
- Using interaction methods—Adding methods to manipulate data or control the appearance of properties.

1. Removing Missing Values

Missing values in a dataset can lead to inaccurate visualizations and interpretations. Therefore, it's essential to handle these missing values before proceeding with any data visualization. Here are the common steps:

Identify Missing Values: The first step is to identify which values in the dataset are missing. This can be done by checking for NaN, None, or blank entries in your dataset. Tools like Pandas in Python (isnull() or notnull()) help in identifying these values.

Deletion: If the dataset is large and the number of missing values is small, you might choose to delete the rows or columns with missing data (dropna() in Pandas). However, this can lead to data loss, which may not always be desirable.

Imputation: Alternatively, you can fill in the missing values with a specific value, such as the mean, median, or mode of the column in Pandas. This approach retains more data but introduces assumptions**.**

Flagging: You can also add a flag to indicate where data was missing and filled in, which can be useful in maintaining transparency in your analysis**.**

Visualize Before and After: It's often helpful to visualize your data both before and after handling missing values. Tools like heatmaps (to see where data is missing) or bar charts (to compare distribution before and after imputation) can be useful.

2. Converting Data to Numeric Type

Many visualization techniques require numerical data types to function correctly. Therefore, non-numeric data must often be converted to a numeric format.

Identify Non-Numeric Data: The first step is identifying which columns contain non-numeric data. This can include text, categorical data, dates, or other formats.

Conversion Strategies:

Categorical to Numeric: Categorical data (e.g., "Yes", "No") can be converted to numeric values using techniques like label encoding or one-hot encoding. One-hot encoding creates binary columns for each category, which is useful for non-ordinal categories.

Text to Numeric: Text data can be transformed using methods like tokenization and vectorization (e.g., TF-IDF for text frequency). In some cases, it may involve counting specific keywords or phrases.

Dates and Times: Date and time fields should be converted to a format that allows for meaningful comparisons, such as timestamp values or extracting components like year, month, or day.

Handle Conversion Errors: Not all data converts neatly. You'll need to handle errors by catching exceptions, using try-except blocks in Python, or explicitly defining how to handle problematic data points.

Visualize and Validate: After conversion, visualize the data to validate that the transformations have been successful. For example, histograms or scatter plots can help verify the distribution of newly converted numeric data.

RESULTS

If these stages are analyzed, several differences can be observed, in particular, the scientist Ben Fry emphasized the acquisition of data without stopping to define the visualization question. In turn, data analysis and mining were not mentioned in the above [1] analysis. These processes are partially described in the data sorting section. In general, it can be concluded from the above analyzes that the stages of visualization have a general structure, but it is natural that these stages change due to the rapid development of computer technologies, artificial intelligence and information in general. Based on these analyses, the following conclusions can be drawn: the stage of data sorting for visualization and the representation of a new visual image based on certain algorithms through this sorting is the most important process. Data cleaning, also known as data cleaning or data preprocessing, is an important step in the data visualization process. This involves preparing raw data for analysis and visualization by identifying and correcting inaccuracies, inconsistencies and errors. The goal is to ensure that the data is suitable for creating high-quality, reliable, accurate and meaningful visualizations[4].

Based on the above analysis and developing technologies, the main tasks related to data cleaning can be suggested as follows:

• Filling in missing values, i.e. imputation (mean, mode, median), or removing rows or columns with a high percentage of missing values using domain-specific knowledge.

• Error correction, that is, identifying and correcting errors and inaccuracies in data. Correct typos, eliminate inconsistencies, and check information against reliable sources.

• Remove duplicates. Identifying and removing duplicate entries that may confuse the analysis. Using algorithms to find and eliminate duplicate records.

• Data normalization. Standardize data formats and scales to ensure consistency. Convert data to a common format (eg, dates, currencies), scale numerical data, and ensure consistent units of measurement.

• Data filtering. Irrelevant or invariant data points that do not contribute to the analysis should be removed. Apply filters to remove unwanted data, identify and process changes based on statistical methods or domain knowledge[5].

• Data validation. Ensuring that data complies with certain rules or restrictions. Check for logical consistency (eg age cannot be negative), ensure that data falls within expected ranges, and check for relationships between data fields.

• Change data types. Convert data into suitable types for analysis and visualization. That is, converting data types (eg strings to dates, integers to floats), parsing strings to structured data, and encoding categorical variables.

• Standardization of naming conventions. Ensure consistency in naming conventions across datasets. Renaming columns and variables to follow a consistent naming scheme, making sure the labels are descriptive and understandable.

Fig. 2. Visualization example after data preprocessing

DISCUSSION

Sorting data by removing missing values and converting data to numeric types are critical preprocessing steps in data visualization. By ensuring that your data is clean and appropriately formatted, you pave the way for creating accurate, insightful visualizations that can effectively communicate your findings. Proper visualization after each step not only helps in validating the preprocessing but also in understanding the impact of these transformations on the data.

CONCLUSION

In conclusion, sorting data by removing missing values and converting it to numeric types are foundational steps in the data visualization process. These steps ensure that the data is clean, consistent, and ready for accurate representation. By carefully handling missing values through deletion, imputation, or flagging, and by converting non-numeric data into meaningful numeric formats, you set the stage for creating clear and insightful visualizations. These preprocessing tasks not only enhance the quality of the visual output but also improve the reliability of the insights drawn from the data. Properly prepared data leads to more effective and meaningful visualizations, ultimately supporting better decision-making and analysis.

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REVOLUTIONIZING MEDICAL IMAGING: THE ROLE OF AI AND DEEP LEARNING IN DIAGNOSIS AND TREATMENT

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A B S T R A C T **The integration of Artificial Intelligence (AI) into medical imaging has revolutionized diagnostic practices, offering the potential for enhanced accuracy, speed, and reduction of errors in clinical decision-making. This article explores the key applications of AI in medical imaging, such as image segmentation, classification, object detection, and image generation, highlighting advanced techniques like U-Net, ResNet, YOLO, and Generative Adversarial Networks (GANs). Despite its transformative potential, AI in medical imaging faces significant challenges, including data privacy concerns, the need for large annotated datasets, model interpretability, and the risk of overfitting. Furthermore, current AI models are limited by potential biases in training data and difficulties in generalizing across diverse populations and imaging modalities. Addressing these challenges is essential to ensure that AI can be effectively and ethically integrated into healthcare, ultimately improving patient outcomes and advancing the field of medical diagnostics.**

K E Y W O R D S Artificial Intelligence (AI), Medical Imaging, Deep Learning, Image Segmentation, Image Classification, Object Detection, Transfer Learning

INTRODUCTION

Artificial Intelligence (AI) broadly refers to any method or algorithm that mimics human intelligence. Historically, AI has been approached from two main directions: computationalism and connectionism. Computationalism attempts to directly imitate formal reasoning and logic, relying on hard-coded axioms and rules to derive new conclusions. This approach resembles how computers are designed to store and process symbols. On the other hand, connectionism uses a bottom-up approach, starting with models of numerous interconnected biological neurons, from which intelligence emerges through learning from experience. Expert systems, which became very popular in the 1980s, are a classical example of computationalism [1]. Notable applications of expert systems in medicine include **MYCIN** (for diagnosing bacterial infections in the blood) [2], **PUFF** (for interpreting lung function data) [3], and **INTERNIST-1** (for internal medicine diagnosis) [4]. However, the complexity of acquiring the necessary knowledge in the form of production rules led to a decline in interest in computational algorithms starting from the 1990s.

Connectionism and AI based on learning, by contrast, offer a different appeal. They transfer the responsibility for accuracy and completeness from human experts, who may be prone to errors, bias, or subjectivity, to data. This shift in focus aligns with the growing role of **machine learning** in AI, particularly in fields like medical image analysis.

AI in Medical Image Analysis

The integration of AI into medical practice has simplified various clinical procedures and provided invaluable assistance in decision-making processes. One significant application is **Computer-Aided Diagnosis (CAD)**, which plays a crucial role in medical imaging research. CAD systems rely on machine learning to create models that assist doctors in quickly assessing a patient's condition by analyzing prior patient data. This technology is particularly useful in radiology for interpreting X-rays, endoscopies, CT scans, MRIs, PET scans, and ultrasound diagnostics [5]. The primary goal of medical image processing is to clarify data and facilitate understanding, which includes tasks such as enhancing image quality, smoothing images, segmenting specific areas, classifying results, detecting issues, and identifying abnormalities[6].

Historically, simple methods like thresholding, region growing, and edge tracing were used for processing medical images. However, as the volume and complexity of medical image data increased, the use of machine learning techniques became more widespread. **Deep learning algorithms** have since outperformed traditional methods in accuracy and speed when detecting abnormalities in medical images. This advancement has significantly improved diagnostic accuracy, treatment efficacy, and the overall standard of patient care [7].

Machine learning can be categorized into two complementary approaches inspired by human learning: **supervised learning** and **unsupervised learning**. Supervised learning involves tasks like regression and classification, where the goal is to map input data to known output labels. For example, classification tasks might involve simple binary classes (e.g., the presence or absence of pathology) or more complex multi-class problems (e.g., determining which of several possible pathologies is present). Image segmentation, where specific regions or each pixel of an image is analyzed, also falls under this category. Examples of regression tasks include improving image quality (e.g., enhancing a low-quality image based on a high-quality reference) or image-to-image mapping (e.g., aligning a CT image with a corresponding MRI image). Clinical applications of supervised learning and common machine learning methods used in this context are detailed in the following sections.

METHODS

The article employs a comprehensive review methodology to explore the current state of AI in medical imaging, focusing on its applications, challenges, and limitations. We conducted a thorough search of peer-reviewed journals, conference proceedings, and reputable medical and AI databases such as PubMed, IEEE Xplore, and

Google Scholar. The search included keywords like "AI in medical imaging," "deep learning in healthcare," "image segmentation," "image classification," "GANs in medical imaging," and "AI challenges in healthcare." Articles were selected based on relevance, recentness (primarily focusing on publications from the last decade), and their contribution to understanding AI applications and challenges in medical imaging. Studies not directly related to medical imaging, those focusing on non-AI-based imaging methods, or publications lacking empirical evidence were excluded. We categorized AI techniques into key application areas in medical imaging, such as image segmentation, classification, object detection, and image generation. We provided detailed descriptions and examples of commonly used AI models like U-Net, ResNet, YOLO, and GANs. The performance of these AI models was analyzed based on standard metrics in medical imaging, including accuracy, sensitivity, specificity, and computational efficiency. We identified and discussed the primary challenges in the adoption of AI in medical imaging. These include data privacy issues, the need for large annotated datasets, interpretability of AI models, and the risk of overfitting. AI models, such as the potential for bias in training data and the difficulty in generalizing models across different populations and imaging modalities (Table 1).

Application of AI in Medical Imaging: Methods and Examples

AI and deep learning methods used in medical image analysis consist of several stages, each addressing different challenges to speed up diagnostics, improve accuracy, and reduce medical errors. Here's how various methods and algorithms are applied:

1. Image Segmentation

Image segmentation is the process of dividing an image into distinct regions, each representing a specific object or tissue. This technique is essential in medical imaging for tasks like identifying tumor locations.

- **U-Net**: A convolutional neural network (CNN) highly effective in medical image segmentation [8]. For instance, U-Net has been successfully used to segment brain tumors in MRI scans, achieving high accuracy by clearly differentiating between tumor tissue and healthy brain tissue. In a study on the BraTS dataset, U-Net demonstrated superior performance in segmenting gliomas [9].
- **Fully Convolutional Networks (FCNs)**: These networks are used to classify each pixel in an image, which is crucial for high-precision tasks like segmenting liver tumors in CT scans. FCNs have been used in segmenting organs in abdominal CT scans, where they help in outlining organs like the liver, kidneys, and spleen, enabling precise volumetric assessments [10].

2. Image Classification

Image classification involves categorizing an image into predefined classes. This method is widely used in scenarios like classifying X-ray or MRI images as showing signs of disease or being normal.

- **ResNet**: Residual Networks (ResNet) are deep learning models widely used for complex image classification tasks. For example, ResNet-50 has been used to classify chest X-rays for detecting pneumonia, including COVID-19, with high accuracy [11]. In particular, ResNet models have been instrumental in early detection of COVID-19 in chest radiographs, helping reduce diagnostic time in emergency settings.
- **VGGNet**: Another CNN architecture known for its simplicity and effectiveness. VGGNet has been employed in classifying skin lesions in dermatology images, distinguishing between benign and malignant lesions with high precision. This has been particularly useful in large-scale skin cancer screening programs [12].

3. Object Detection

Object detection involves finding and labeling specific objects within an image. In medical imaging, this is often used to detect tumors or anomalies.

- **YOLO (You Only Look Once)**: A real-time object detection algorithm known for its speed and accuracy. YOLO has been applied to detect polyps in colonoscopy images, significantly aiding in the early detection of colorectal cancer. Its ability to process images quickly and detect polyps in real-time makes it a valuable tool in endoscopy procedures[13].
- **Faster R-CNN**: This algorithm is widely used in medical imaging for detecting abnormalities like lung nodules in CT scans. Faster R-CNN's ability to provide highly accurate object detection has been proven in studies where it identified lung nodules that were missed by radiologists, thus improving early lung cancer detection rates [14].

4. Generative Adversarial Networks (GANs)

GANs consist of two neural networks (a generator and a discriminator) that compete to create realistic images. In medical imaging, GANs are often used for data augmentation and improving the quality of low-resolution images [15].

- **Data Augmentation**: GANs have been used to generate synthetic MRI images of brain tumors, which are then used to train deep learning models. This helps in overcoming the issue of limited data availability, especially in rare diseases. GANs have also been employed to enhance the resolution of PET scans, leading to clearer images that aid in better diagnosis[16].
- **Image Quality Improvement**: GANs have been used to improve the quality of low-dose CT scans, which are often noisy. By generating high-quality images from these low-dose scans, GANs reduce the need for higher radiation exposure, making the diagnostic process safer for patients.

AI Technique	Application	Advantages	Limitations
U-Net	Image Segmentation	High accuracy in segmenting medical images	Requires large amounts of labeled data
ResNet	Image Classification	Handles deep architectures without vanishing gradients	Complex and computationally intensive
YOLO (You Only	Object Detection	Real-time object detection	May struggle with detecting small objects in images
GANs (Generative	Image Generation and Enhancement	Generates high-quality synthetic images	Prone to instability during training and potential for mode collapse
Transfer Learning	Various (Classification, Segmentation)	Effective with small datasets by leveraging pre-trained models	May not generalize well to significantly different tasks

Table1. Summary of AI Techniques in Medical Imaging

5. Transfer Learning

Transfer learning involves adapting a pre-trained model to a new task. This method is particularly useful for medical images where the dataset may be small but the task requires high accuracy[17].

- **COVID-19 Detection**: Transfer learning has been extensively used to adapt models like ResNet and DenseNet for detecting COVID-19 in chest X-rays. By leveraging models pre-trained on large datasets, these algorithms have achieved high accuracy even with limited COVID-19 data, facilitating rapid and reliable diagnosis in pandemic situations.
- **Tumor Segmentation and Classification**: Transfer learning has been applied to U-Net models pre-trained on general image segmentation tasks to improve their performance in segmenting tumors in MRI scans. This approach has led to significant improvements in detecting and segmenting brain tumors in glioblastoma patients, where precise delineation of the tumor is critical for treatment planning.

Clinical Application Examples

- **Breast Cancer Detection**: CNNs, particularly ResNet, have been used to analyze mammograms, helping radiologists in early detection of breast cancer. These models have shown high sensitivity in detecting even small lesions that are difficult to identify visually.
- **Lung Disease Detection**: YOLO and Faster R-CNN have been used to analyze chest CT scans to detect lung nodules and other anomalies. These models have significantly improved the accuracy and speed of lung cancer screening programs.
- **Polyp Detection in Endoscopy**: Both YOLO and Faster R-CNN have been applied to detect polyps during colonoscopy, which is crucial for preventing colorectal cancer. Their ability to detect even small and flat polyps in real-time has made these models indispensable in clinical practice [1-3].

RESULTS

Table 2 presents a detailed overview of various pretrained deep learning models and their application in medical imaging across different modalities, ranging from MRI and X-ray to histopathological and cytological images. Each model is evaluated based on its performance in tasks like classification, detection, or segmentation, with reported accuracy values highlighting the effectiveness of AI in medical diagnostics. The models listed include popular architectures like VGG16, ResNet50, GoogleNet, and advanced techniques such as ensemble learning and hybrid models like Faster R-CNN. These models are applied across a broad range of medical imaging tasks, such as:

Tumor classification: VGG16 and ResNet50 are prominently used in MRI scans for brain tumor classification, achieving high accuracy rates (95.71% and 97.2%, respectively).

Disease classification: Models like GoogleNet perform exceptionally well in Alzheimer's disease classification (97.15%) using MRI and colorectal polyps classification (98.44%) using gastrointestinal images.

Segmentation: More complex tasks like brain tumor segmentation (Faster R-CNN + VGG16) show slightly lower accuracy (77.60%) due to the inherent difficulty in segmenting tumor boundaries from MRI data.

Across different modalities, the pretrained models excel in classification tasks. For instance, AlexNet achieves a near-perfect score (99.6%) in lung nodule classification from CT and X-ray images, while ResNet50 shows remarkable performance in classifying breast tumors in histopathological images with 99% accuracy. Models applied to skin lesion and thyroid nodule classification also exhibit high accuracy (99.29% and 96.04%, respectively). These results demonstrate the ability of deep learning algorithms to extract critical features from medical images with precision.

2021	VGG16	Brain tumor classification	MRI	95.71 %
20	ResNet50	Brain tumor classification	MRI	97.2%
2020	GoogleNet	Alzheimer's disease classification	MRI	97.15 %
2020	Ensemble of AlexNet, DenseNet121, ResNet18, GoogleNet, InceptionV3	Pneumonia detection	X-ray	96.4%
20	AlexNet	Lung nodule classification	CT and X-ray	99.6%
2020	ResNet50	Breast tumor classification	Mammogram	85.71 %
2020	ResNet50	Breast tumor classification	Histopathological images	99%
2021	VGG16	Breast tumor classification	Mammogram	98.96 %
2020	DenseNet201	Skin lesion classification	Skin images	96.18 %
2020	GoogleNet	Skin image classification	Skin images	99.29 %
2021	VGG19	Thyroid nodule cell classification	Cytology images	93.05 %
2021	GoogleNet	Thyroid nodule classification	Ultrasound	96.04 %
2021	GoogleNet	Colorectal polyps classification	Gastrointestinal polyp images	98.44 %
2020	Faster R-CNN + VGG16	Brain tumor segmentation and classification	MRI	77.60 %
2021	U-Net + InceptionV3	Breast tumor segmentation and classification	Mammogram	98.87 %
2020	Mask R-CNN + ResNet-50	White blood cells detection and classification	Cytological images	95.3%

DISCUSSION

Despite the promising advancements, several challenges must be addressed for AI to reach its full potential in medical imaging. One of the primary concerns is data privacy. The use of large datasets for training AI models necessitates stringent measures to protect patient confidentiality. Another significant challenge is the need for large, annotated datasets to train AI models effectively. While deep learning models like ResNet and YOLO excel with extensive data, acquiring and annotating such datasets is resource-intensive. Additionally, the quality and diversity of the training data directly influence the model's performance, with biases in the data potentially leading to skewed outcomes. For example, if a model is trained predominantly on data from one demographic group, it may perform poorly when applied to other populations, thereby limiting its generalizability.

The interpretability of AI models also presents a considerable hurdle. Many AI systems, particularly those based on deep learning, operate as "black boxes," where the decision-making process is not easily understood by clinicians. This lack of transparency can be a barrier to clinical adoption, as healthcare providers need to trust and understand the rationale behind AI-generated diagnoses or treatment recommendations. Developing AI models that are both accurate and interpretable is therefore a critical area of ongoing research.Overfitting is another limitation, especially in models trained on limited or non-representative datasets. Overfitting occurs when a model performs well on training data but fails to generalize to new, unseen data. This issue is particularly problematic in medical imaging, where the stakes are high, and incorrect predictions can lead to misdiagnosis or inappropriate treatment.

Looking forward, the focus of AI research in medical imaging should be on addressing these challenges to enhance the reliability, interpretability, and generalizability of AI models. Efforts to develop explainable AI (XAI) models that offer transparent decision-making processes are critical for gaining clinician trust and ensuring safe clinical implementation. Additionally, strategies to mitigate bias in AI models, such as diversifying training datasets and using transfer learning to adapt models to new populations, are essential for improving the robustness and fairness of AI-driven healthcare solutions.

CONCLUSION

The integration of artificial intelligence (AI) into medical imaging represents a transformative leap in healthcare, offering unprecedented opportunities for enhancing diagnostic accuracy, treatment planning, and overall patient care. In this paper, we presented a comprehensive review of convolutional neural networks (CNNs) applied to medical image analysis, covering tasks such as classification, detection, and segmentation. Our survey highlights the significant role CNNs play in enhancing computer-aided diagnosis through the analysis of medical images. Additionally, we examined critical factors necessary for the effective application of CNNs in medical image classification, segmentation, and detection. Lastly, we identified several key areas for future research to address the ongoing challenges faced by CNNs in medical imaging applications.

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SEMI-STRUCTURED DECISIONS MAKING ON THE BASIS FUZZY MEASURES

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A B S T R A C T **The task selection, i.e. quality assessment of alternatives analyzed objects (information - communication systems, technical - technological objects, varieties of agricultural crops, etc.) and a selection of the best alternative in many cases solved in conditions of information, procedural and functional, parametric and criteria uncertainties of various types. The article considers the fuzzy-set approach to the construction of models of description and evaluation of alternatives, as well as problem solving semi-structured decision making based on fuzzy measures and fuzzy integral.**

K E Y W O R D S Semi-structured decisions making, selection, fuzzy set, alternative, evaluative functional, efficiency criterion, fuzzy measure, fuzzy integral.

INTRODUCTION

A large class of complex systems and processes is characterized by integration, multi-level, distribution and a variety of performance indicators. Due to the increasing complexity of the problems being solved in weakly structured systems, the control and decision-making tasks themselves are also becoming more complicated. It should be noted that modern control and decision-making systems are human-machine systems, and with the increasing complexity of control objects, the so-called "human factor" arises when assessing the states of a control object. This necessitates taking into account subjective factors when solving complex management problems. Known classical methods do not provide solutions to problems of decision-making and control of semi-structured systems in such conditions with the required efficiency.

The solution of problems of this type is carried out under conditions of informational, procedural-functional, parametric and criterion uncertainties of various types [1]. In particular, such uncertainties include fuzzy (vague) uncertainty, characterized by incompleteness, inaccuracy and linguistic vagueness (fuzziness) present in the initial information, criteria and assessments of customers and developers, as well as in the models and procedures used for describing and evaluating alternatives to the analyzed variants of objects and their states.

The need to take into account several criteria, including the preferences of decision makers (DMs), in the process of selecting optimal options, also characterizes one of the conditions of uncertainty. This determines the expediency of developing and using models and methods for describing and evaluating options (alternatives) of the analyzed objects, as well as making semi-structured decisions (SSSD) to select the best option under conditions of fuzzy uncertainty, which represent a special class of decision-making problems [2, 3]. In such problems, alternatives to decisions made are assessed based on the analysis of soft estimates of the effectiveness of their implementation (outcomes) and the values of the risk of losses corresponding to certain outcomes. The theoretical and methodological apparatus for solving such problems is the means of intelligent information technology "Soft Computing" - "Soft Computing" [4,5,6].

The fuzzy analogues of the classical Bayes, Wald, Hurwitz and dispersion criteria proposed in [2] make it possible to effectively solve a certain class of PSSR problems of static and dynamic types. In [3], PSSR problems are considered in selection problems - evaluation and selection of the best alternative based on the totality of all given characteristics in a fuzzy environment in conditions of multicriteria and fuzzy non-dominance of alternatives and criteria [8].

The main goal of this work is to consider another fuzzy set approach to solving this problem, based on the use of fuzzy measures and a fuzzy integral.

II. CALCULATION OF FUZZY MEASURE

It is known that measure, in the classical mathematical understanding, has a fundamental property of additivity, characterized by the fact that the number that serves as a measure of several combined characteristics must be equal to the sum of the numbers that are measures of the corresponding characteristics. However, it is obvious that the use of linguistic variables directly in fuzzy-set mathematical models of the objects under study violates the assumption of additivity of fuzzy measures, which leads to the need to study and form fuzzy measures free from the requirements of the additivity property. Measures of this type can be used in constructing fuzzy models using fuzzy integrals.

Let us introduce the definitions of the main elements of the problem under consideration, a fuzzy measure.

Submit a reviewThe triple (Γ, $\beta(\Gamma)$, g) is called a space with fuzzy measure.

In [8,9] it is proposed to construct $g(A \cup B)$ a fuzzy union measure as follows:

$$g(A \cup B) = g(A) + g(B) + \lambda g(A) g(B).$$

Here the parameter λ takes values in the interval $-1 < \lambda < \infty$, while $A \cap B = \varnothing$. The given expression is called the λ - rule, and the fuzzy measure g_λ, accordingly, λ is the Sugeno measure.

Let us consider in more detail the special case when a finite set is used as $\Gamma = \{x_1, x_2, ..., x_n\}$. In this case, the fuzzy measure g_λ will be constructed using λ - the fuzzy density measure, denoted as $g(x_i) = g_\lambda(\{x_i\})$, $i = 1,2\ldots,n$. Further, for the fuzzy density we will use the notation $g_i = g(x_i)$.

Given that fuzzy densities $0 \le g_i \le 1$ are given, the measure g_λ will be constructed according to the λ rule: $g_\lambda(\{x_1, x_j\}) = g_i + g_j + \lambda g_i g_i$. Generalizing, we can write that: $g_\lambda(\{x_1...x_k\}) = \sum_j^k g_i + +\lambda \sum_{i_1=1}^{k-1} \sum_{i_2=i_1+1}^{k} g_{i_1} g_{i_2} + ... + \lambda^{k-1} g_1 g_2 .... g_k$. Or, in equivalent form:

$$g_\lambda(\{x_1,...., x_k\}) = \begin{cases} \frac{1}{\lambda}(\prod_{i=1}^{k}(1+\lambda g_i) - 1), \lambda \ne 0), \\ \sum_{i+1}^{k} g_i, \quad \lambda = 0. \end{cases}$$

If $-1 < \lambda < 0$, then $\sum_{i+1}^{n} g_i > 1$, and in the case, $0 < \lambda < \infty$, always takes place $\sum_{i=1}^{n} g_i < 1$.

Moreover, if the value of any one of the fuzzy densities is equal to one, then the values of the remaining fuzzy densities are always equal to zero, i.e. if there exists an x_j such that g_j =1, then for each $x_i \ne x_j$, necessarily, $g_i = 0$.

Taking into account the above, we will describe the algorithm for constructing a fuzzy measure:

Step 1. From the normalization condition $\frac{1}{\lambda}(\prod_{i1}^{n}(1+\lambda g_i) - 1) = 1$ we calculate the parameter λ ;

Step 2. The measure of any set is $A \in \beta(\Gamma)$ determined from the relation $g_\lambda(A) = \frac{1}{\lambda}(\prod_{x_i \in A}(1+\lambda g_i) - 1)$ that satisfies λ - Sugeno rule.

III. COMPUTATIONAL EXPERIMENT

Let us consider the proposed approach using the example of PSSR in the problems of selecting cotton varieties with the best biological and technological indicators under conditions of unclearly specified initial conditions: sowing and growing conditions (agrotechnological regimes, components of the fertilizer application rate, irrigation, boundary conditions for these varieties and soil types).

The problem of the making semi-structured decisions is formulated as follows.

The following are given:

- a set of alternatives $\Gamma = \{x_1, x_2, ..., x_n\}$ - selection varieties of cotton;
- sets of features: biological and technological characteristics, according to which the choice of an acceptable variety is made $H = \{h_1, h_2, ..., h_k\}$.
- the importance of each feature in the alternative $x_i \in \Gamma$,
- initial conditions: soil types, irrigation and fertilization regimes, weather conditions (solar activity: clarity, cloudiness).
- Required:
- select the most acceptable alternative - a variety that ensures, for the given initial conditions of sowing and growing (agro-technological regimes, components of the dose of fertilizers, irrigation, boundary conditions for these varieties and soil types), obtaining the maximum yield with the best agro-technological characteristics.

The experiment was carried out for the task of choosing from four breeding varieties $\Gamma = \{x_1, x_2, ..., x_4\}$ cotton: C-4727 (x_1), Ташкент 1(x_2) , 159-Ф (x_3) 108-Ф (x_4) the best according to given characteristics $H = \{h_1, h_2, ..., h_4\}$: yield ($h_1$), fiber length ($h_2$), fiber strength ($h_3$), seed oil content ($h_4$) [2,3].

The importance values of each feature are set by experts and expressed through fuzzy densities

$$g_1 = 0{,}66, \ \ g_2 = 0{,}89, \ \ g_3 = 0{,}96, \ \ g_4 = 0{,}93,$$

$$h_1 = 0{,}19, \ \ h_2 = 0{,}21, \ h_3 = 0{,}22, \ \ h_4 = 0{,}24.$$

Provided that fuzzy densities are given in the interval , the measure g_λ is constructed according to the λ - rule:

$$g_\lambda(\{x_1,...., x_k\}) = \begin{cases} \frac{1}{\lambda}(\prod_{i=1}^{k}(1+\lambda g_i) - 1), \lambda \ne 0) \\ \sum_{i+1}^{k} g_i, \quad \lambda = 0 \end{cases}$$

$$g_\lambda(x_1, x_2, x_3, x_4) = 1.$$

From the normalization condition $\frac{1}{\lambda}(\prod_{i1}^{n}(1+\lambda g_i) - 1) = 1$ we calculate the parameter λ

$$g_1 g_2 g_3 g_4 \lambda^3 +$$
$$+(g_1 g_2 g_3 + g_1 g_2 g_4 + g_1 g_3 g_4 + g_2 g_3 g_4)\lambda^2 +$$
$$(g_1 g_2 + g_1 g_3 + g_1 g_4 + g_2 g_3 + g_2 g_4 + g_3 g_4)\lambda +$$
$$+g_1 + g_2 + g_3 + g_4 = 1.$$

$$0{,}524\lambda^3 + 2{,}49\lambda^2 + 4{,}409\lambda + 2{,}44 = 0.$$

$$\lambda^3 + 4{,}75\lambda^2 + 8{,}41\lambda + 4{,}66 = 0.$$

$$\lambda = -0{,}96.$$

Based λ on the Sugeno rule $\beta(\Gamma)$ and taking into account the given densities, the measures of all subsets are calculated and this completes the construction of the Sugeno measure:

$$g_\lambda(x_1,x_2,x_3) = g_1g_2g_3\lambda^2 + \\ +(g_1g_2+g_1g_3+g_2g_3)\lambda + g_1+g_2+g_3 = \\ -0{,}96^2\times 0{,}66\times 0{,}89\times 0{,}96 - \\ -(0{,}66\times 0{,}89+0{,}66\times 0{,}96+0{,}89\times 0{,}96)\times 0{,}96 \\ +0{,}66+0{,}89+0{,}96 = 1{,}03$$

$$g_\lambda(x_1,x_2,x_4) = g_1g_2g_4\lambda^2 + \\ +(g_1g_2+g_1g_4+g_2g_4)\lambda + g_1+g_2+g_4 = \\ -0{,}96^2\times 0{,}66\times 0{,}89\times 0{,}93 - \\ -(0{,}66\times 0{,}89+0{,}66\times 0{,}93+0{,}89\times 0{,}93)\times 0{,}96 \\ +0{,}66+0{,}89+0{,}93 = 1{,}04$$

$$g_\lambda(x_1,x_3,x_4) = g_1g_3g_4\lambda^2 + \\ +(g_1g_3+g_1g_4+g_3g_4)\lambda + g_1+g_3+g_4 = \\ -0{,}96^2\times 0{,}66\times 0{,}96\times 0{,}93 - \\ -(0{,}66\times 0{,}96+0{,}66\times 0{,}93+0{,}96\times 0{,}93)\times 0{,}96 \\ +0{,}66+0{,}96+0{,}93 = 1{,}05$$

$$g_\lambda(x_2,x_3,x_4) = g_2g_3g_4\lambda^2 + \\ +(g_2g_3+g_2g_4+g_3g_4)\lambda + g_2+g_3+g_4 = \\ -0{,}96^2\times 0{,}89\times 0{,}96\times 0{,}93 - \\ -(0{,}89\times 0{,}96+0{,}89\times 0{,}93+0{,}96\times 0{,}93)\times 0{,}96 \\ +0{,}89+0{,}96+0{,}93 = 1{,}042$$

$$g_\lambda(x_1,x_2) = g_1g_2\lambda + g_1 + g_2 = \\ = -0{,}96\times 0{,}66\times 0{,}89+0{,}66+0{,}89 = 0{,}99,$$

$$g_\lambda(x_1,x_3) = g_1g_3\lambda + g_1 + g_3 = \\ = -0{,}96\times 0{,}66\times 0{,}96+0{,}66+0{,}96 = 1{,}02,$$

$$g_\lambda(x_1,x_4) = g_1g_4\lambda + g_1 + g_4 = \\ = -0{,}96\times 0{,}66\times 0{,}93+0{,}66+0{,}93 = 1{,}01,$$

$$g_\lambda(x_2,x_3) = g_2g_3\lambda + g_2 + g_3 = \\ = -0{,}96\times 0{,}89\times 0{,}96+0{,}89+0{,}96 = 1{,}03,$$

$$g_\lambda(x_2,x_4) = g_2g_4\lambda + g_2 + g_4 = \\ = -0{,}96\times 0{,}89\times 0{,}93+0{,}89+0{,}93 = 1{,}02,$$

$$g_\lambda(x_3,x_4) = g_3g_4\lambda + g_3 + g_4 = \\ = -0{,}96\times 0{,}96\times 0{,}93+0{,}96+0{,}93 = 1{,}05,$$

Using the calculated values λ -of the Sugeno measures, we obtain an integral assessment of the strategy for selecting the best variety using a fuzzy integral $\int h \circ g$.

Here:

$$h_1 = 0{,}19,\quad h_2 = 0{,}21,\ h_3 = 0{,}22,\quad h_4 = 0{,}24.$$

i=1: $h(x_1) \wedge g(x_1,x_2,x_3,x_4) = 0{,}19 \wedge 1.0 = 0{,}19,$

i=2: $h(x_2) \wedge g(x_2,x_3,x_4) = 0{,}21 \wedge 1{,}042 = 0{,}21,$

i=3: $h(x_3) \wedge g(x_3,x_4) = 0{,}22 \wedge 1{,}05 = 0{,}22,$

i=4: $h(x_4) \wedge g(x_4) = 0{,}24 \wedge 0{,}93 = 0{,}24,$

$$\int h \circ g = \bigcup_{i=1}^{4} (h(x_i) \wedge g(E_i)) = \\ = \max(0{,}19;\ 0{,}21;\ 0{,}22;\ 0{,}24) = 0{,}24 .$$

$$x_4 = 0{,}24$$

The results of ranking all breeding varieties showed that variety 108-F is the best among the proposed breeding varieties of cotton, since the resulting value of the degree of membership of this variety in the fuzzy set is the largest (0.24).

IV. CONCLUSION

The algorithm for solving a selection problem using a fuzzy measure and a fuzzy integral is considered using the example of selecting the best cotton variety that provides optimal values of agrotechnological parameters in various conditions: sowing, growing, vegetation and harvesting. The proposed algorithm is an addition to the fuzzy-set algorithms of the making semi-structured decisions in a fuzzy environment considered in [2, 3].

A promising direction of research on the problem under consideration is the development of methods for solving making semi-structured decisions problems using a combination of "Soft Computing" technology: fuzzy sets, neural networks, genetic algorithms, evolutionary modeling and programming.

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PARALLELISM AND SUPERPOSITION: REASONS FOR THE SUPERIORITY OF QUBIT OVER CLASSICAL BIT

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A B S T R A C T **The future of computing is greatly influenced by the revolutionary characteristics of quantum bits (qubits) and quantum superposition, which offer significant advantages over classical computing. This paper explores the superiority of qubits compared to classical bits, delving into the principles of quantum superposition and its mathematical representation. Additionally, it examines the differences between Shor's algorithm and classical algorithms. Qubits, with their ability to exist in multiple states simultaneously due to quantum superposition, dramatically enhance computational efficiency. This paper provides an in-depth analysis of the mathematical aspects of qubits, highlights the advantages of quantum computing through algorithms like Shor's, and compares quantum and classical algorithms, discussing the capabilities and limitations of quantum computing.**

K E Y W O R D S Qubit, Classical bit, Quantum computing, Superposition, Quantum parallelism, Quantum entanglement, Quantum supremacy, Quantum algorithms, Shor's algorithm

INTRODUCTION

In the field of computational science, quantum computing represents a transformative shift from traditional computing methodologies, with the potential to revolutionize how we approach complex problem-solving. Central to this transformation are quantum bits, or qubits, which offer capabilities that extend well beyond those of classical bits. Unlike classical bits, which can only be either 0 or 1, qubits can exist in a state of superposition, enabling them to perform multiple computations simultaneously.

Quantum superposition is a core principle of quantum physics, allowing a qubit to be in a combination of both 0 and 1 states at once. This attribute greatly amplifies the computational power of quantum computers, making it possible to address problems that are impractical for classical computers due to their exponential increase in complexity.

The mathematical description of qubits, using complex vector spaces and probability amplitudes, offers a framework for understanding their behavior and manipulation. This mathematical basis is essential for creating and applying quantum algorithms that exploit the unique characteristics of qubits.

A prominent example of the potential of quantum computing is Shor's algorithm, which illustrates how quantum computers can solve problems such as integer factorization much faster than classical methods. This paper will delve into the theoretical foundations of qubits and quantum superposition, compare Shor's algorithm with classical algorithms, and explore the implications of these developments for future computational advancements.

Through an examination of the benefits of quantum computing, this paper seeks to provide a thorough understanding of how qubits and quantum algorithms mark a significant advancement in computation, addressing both their potential and current limitations.

METHODS

A qubit, or quantum bit, is the basic computational unit of quantum computers. In traditional computers, information is represented by bits, and they can only be in two states: 0 or 1. In quantum computers, qubits store information in a more complex way, because they can be in both states at the same time.

The following comparative examples can be used to understand the qubit:

a) A coin spinning in the air . As the coin spins in the air, it is both a "coat of arms" and a "number" at the same time. But when it lands, it appears with either the "emblem" or "number" side.

b) Illuminating lamp. In a classic computer, a bit can only be in two states: the light bulb is on (1) or off (0). A qubit is thought of as a light bulb controlled by a dimmer. With the help of a dimmer, the light bulb can be both slightly on and slightly off at the same time. It doesn't have to be fully on or off, it can take any state in between. But if you really look or check, the light bulb is only either fully on or off. This example helps to visualize the superposition of a qubit, which means that it can be in both states at the same time, but falls into one state as soon as it is measured.

Similarly, a qubit can be in both 0 and 1 states at the same time. However, when it is "looked at" (measured), it only comes out as 0 or 1. It is a mixture of these two conditions.

Measuring a qubit is the process performed to determine its state. This process is carried out in quantum computers, and as a result, the state of the qubit is determined: it will be either 0 or 1.

The uniqueness of qubits

The unique property of qubits comes from the phenomena of superposition and quantum entanglement. Superposition allows qubits to simultaneously represent states 0 and 1 together. As a result, quantum computers can perform several calculations in parallel . Quantum entanglement, on the other hand, represents the strong coupling of qubits to each other, which allows them to operate in concert at the same time, even if they are far apart.

Qubits can be created based on a variety of physical systems, such as ions, photons, electrons, and superconductors. Their main purpose is to work according to the laws of quantum mechanics.

Fig. 1. Classical bit and qubit

Since conventional bits can only be in one state, a large number of calculations are required to be performed in sequence. But since qubits can be in many states at the same time, it performs calculations in parallel, which allows solving problems faster.

In computing with quantum computers, great progress can be made in solving some mathematical and scientific problems thanks to qubits. For example, in areas such as factorization of large numbers, data encryption and decryption, and modeling the quantum properties of molecules, quantum computers can be many times more efficient than conventional computers.

Although quantum computers are not yet fully developed, their potential is enormous. Research on qubits continues, and in the future, quantum computers may pave the way for new scientific and technological advances for mankind. Qubits are expected to play a key role in solving future problems with the advanced capabilities of quantum computing.

Qubits are a key part of quantum computers, and their capabilities could take quantum computing to a new level in computing. Due to the unique properties of quantum mechanics, qubits can exist in many states at the same time and perform complex calculations. Therefore, the world of quantum computing is gaining new possibilities with qubits.

Representing a qubit is represented by 0's and 1's, just as bits are represented in classical computers, but with the addition of some parentheses and superposition vectors.

$$|0\rangle = \begin{pmatrix}1\\0\end{pmatrix} \qquad |1\rangle = \begin{pmatrix}0\\1\end{pmatrix}$$

Quantum superposition

Superposition is one of the fundamental concepts of quantum computing and provides the power and efficiency of quantum computers. It allows quantum bits to be in multiple states at the same time, enabling parallel computing to solve complex problems. The study and understanding of superposition will greatly contribute to the development of quantum technologies and increase the possibility that they will open up new computational methods in the future.

The concept of a qubit being in two ground states at the same time is called superposition.

In quantum computing, the concept of superposition provides parallelism. For example, to visualize the superposition of a single qubit, the state of the qubit can be expressed as:

$$a\,|0\rangle + b\,|1\rangle$$

Here a and b are complex numbers that represent the probabilities associated with the specific state of the qubit. During the measurement, the qubit $|0\rangle$ the probability of being in the state $|a|^2$, $|1\rangle$ and the probability of being in the state is represented by $|b|^2$. Also, the sum of these probabilities must be

$$|a|^2 + |b|^2 = 1.$$

Let's look at a simple example to visualize the superposition. Imagine you have one qubit and it is in the state $|0\rangle$. If you apply the Hadamard transform (H) to this qubit, it enters the qubit superposition state:

$$|0\rangle \xrightarrow{H} \frac{1}{\sqrt{2}}(|0\rangle + |1\rangle)$$

This $\frac{1}{\sqrt{2}}$ means that the qubit is equally likely to exist in both cases. The fact that the qubit is in a superposition state indicates that it can be in both the $|0\rangle$ and $|1\rangle$ states at the same time. If you measure this qubit, it will fall into either the $|0\rangle$ or $|1\rangle$ state, and the probability for each is equal.

Superposition is also associated with the following quantum phenomena:

a. Superposition and quantum interference

Superposition is also related to other quantum phenomena, such as quantum interference. Interference is a property of quantum mechanics in which superposition states of qubits can interact with each other. As a result of this effect, some conditions are strengthened, and some are weakened. This process is used in quantum algorithms, especially Grover's algorithm, which speeds up the data retrieval process.

b. Superposition and quantum connection (entanglement)

Superposition is also closely related to quantum entanglement. In a quantum entanglement, two or more qubits can be in a entangled state. The connection between these qubits is very strong and they can change their states at the same time, regardless of their distance from each other. Entanglement enables quantum computers to perform complex parallel computations, and this condition becomes a very powerful tool when used in conjunction with superposition.

c. Practical applications

Superposition has many practical applications in quantum computing. For example, the problem of factorization of quadratic multiplication can be solved very efficiently using Shor's algorithm. While classical computers take a long time to solve such problems, quantum computers solve them very quickly using superposition.

d. Quantum simulations.

Superposition is very important in simulating the laws of quantum mechanics. These simulations are of great help in the development of new materials and drugs in the fields of chemistry, materials science, and pharmaceuticals.

Limitations and problems of superposition

Despite the enormous potential of superposition in quantum computing, it also has its limitations and challenges. Understanding and overcoming these limitations is important to get the most out of quantum computers.

Decohiration (Decohiration) problem

Quantum systems in the state of superposition themselves are very fragile and can be corrupted by interactions with their environment. This process is called decoherence and complicates the operation of quantum computers.

Quantum error correction (QEC) algorithms have been developed to prevent or minimize decoherence . These algorithms are necessary to maintain the state of the qubits and perform calculations correctly.

b. The finite number of qubits

Currently, the number of qubits used in quantum computers is limited. This makes it difficult to perform large-scale calculations. To fully exploit the efficiency of superposition, more qubits are needed, which creates limitations in solving problems on quantum computers.

c. The uncertainty of quantum measurement

In the process of measuring quantum systems, superposition collides and only one state is accepted. This raises issues of accuracy and reliability in the measurement process. Since the process of measuring the results of calculations in quantum computers is carried out on the basis of probability, the results can be unreliable. This makes it necessary to re-measure and check the results several times.

As quantum computers develop, new methods, algorithms, and practical applications of superposition are expected to emerge. Examples include:

a. Quantum games and simulations

The future development of quantum computers could have a major impact on the fields of games, simulations and virtual reality (VR). Through superposition and quantum interference, very realistic and complex simulations can be made in these fields.

b. New cryptographic systems

Superposition may open new possibilities in quantum cryptography. Superposition can be used to provide security through quantum key distribution (QKD). These new cryptographic systems will be robust against attacks by quantum computers.

c. Big data and artificial intelligence

Quantum computers can make great strides in processing big data and training artificial intelligence algorithms. With the help of superposition, it is possible to analyze large amounts of data simultaneously and make decisions faster. This will encourage the further development of artificial intelligence.

MATHEMATICAL REPRESENTATION OF A QUBIT

A qubit can be represented mathematically as the following two-element column vector.

$$|\Psi\rangle = \begin{pmatrix} \alpha \\ \beta \end{pmatrix}$$

Here, element a is the probability of the qubit being close to zero, b and the element represents the probability of proximity to one.

Based on this expression, the | 0 ⟩ and | 1 ⟩ qubits are described as follows.

$$|0\rangle = \begin{pmatrix} 1 \\ 0 \end{pmatrix} \qquad |1\rangle = \begin{pmatrix} 0 \\ 1 \end{pmatrix}$$

The probability that the qubit will receive a value (0 or 1) after measurement can be determined by its **amplitudes.** Amplitude is a complex number in quantum mechanics that represents the probability that a qubit will enter a certain state. The general state of a qubit can be expressed by the following mathematical formula:

$$|\psi\rangle = \alpha|0\rangle + \beta|1\rangle$$

Here:

- | Ψ ⟩ is the general state of the qubit (superposition).
- α is the probability amplitude of the qubit transition to the 0 state.
- b is the probability amplitude of qubit transition to state 1.

After the measurement, the probability that the qubit will be in state 0 or 1 can be calculated as follows:

- The probability of a qubit being 0 is $|a|^2$
- The probability of a qubit being 1 is $|b|^2$

Here $|a|^2$ and $|b|^2$ are squares (modules) that are always equal to 1 (ie, $|a|^2 + |b|^2 = 1$).

For example, if the qubit amplitudes are $a = \frac{1}{\sqrt{2}}$ and $b = \frac{1}{\sqrt{2}}$, then:

- The probability of a qubit being 0 $(\frac{1}{\sqrt{2}})^2 = 0.5$.
- The probability of the qubit being 1 is also $(\frac{1}{\sqrt{2}})^2 = 0.5$

In this case, after the measurement, the qubit takes the state 0 or 1 with equal probability. Quantum gates (operations) that control the qubit shift change the amplitudes before the measurement, and by this the probability of the measurement result can be controlled.

Quantum physics , when a measurement is made, the state of a quantum system goes into a "measured state", that is, into a single fully defined state. For example, if a photon is present and it is polarized vertically and horizontally at the same time (in superposition), then during the measurement it can only be seen in one state—that is, either vertically or horizontally polarized. can be obtained.

Polarization of a photon represents the direction of oscillation of the electric field of the photon (particle of light). Light as an electromagnetic wave consists of mutually perpendicular oscillations of electric and magnetic fields.

Polarization shows the direction in which the electric field oscillates.

For example, if the light waves are oscillating in only one direction, such as only up and down, this is called linear polarization. If the direction of vibration is continuously rotating, it will be circular polarization. So polarization refers to the direction in which the light waves are oscillating. That is, as a comparative example, a simple case can be given to visualize the polarization. If you hold a small ball attached to a string and swing it up and down, the ball moves in only one direction—this vibration can be likened to linear polarization.

If you try to swing the ball in a circle, the ball will change direction with each swing, but it will always move in a circle. This is similar to circular polarization.

Light also performs the same vibrations. A light wave can vibrate linearly, circularly, or elliptically. Polarization refers to the direction in which these vibrations occur.

The main types of polarization are:

1. **Linear polarization**: The electric field oscillates in a single plane, for example, vertically or horizontally.

2. **Circular Polarization:** The electric field oscillates in a circle. In this type, the electric field constantly changes its direction, but the amplitude of the oscillation is always the same.

3. **Elliptical polarization**: The electric field oscillates in an elliptical shape. This is a general case of circular polarization, in which the direction and amplitude of the electric field oscillation are constantly changing.

Polarization is often controlled by special filters and used in optical devices, such as sunglasses, to limit the passage of light in a certain direction.

If, when measuring a photon, it is found to be horizontally polarized, then after the measurement, it will only be horizontally polarized, and it will now be considered horizontally polarized. This means that when a photon is in superposition, it has probabilities: it could have been in two states before the measurement, but the measurement puts it in a specific state.

SHOR'S ALGORITHM

Shor's algorithm, one of the qubit-based quantum algorithms, brought new approaches to cryptography. Because in the field of cryptography, in the process of deciphering the RSA encryption algorithm, the problem of factorization was encountered. Shor's algorithm found an exponentially faster solution to this problem. This algorithm was developed by Peter Shore in 1994. Shor's algorithm is divided into two main parts: the classical part and the quantum part. In the quantum part, there are usually two important formulas:

1. Finding the Period:

$$f(x) = a^x \mod N$$

Here, ***a*** is a random number used in quantum computing, ***x*** is an exponent, and ***N*** is a divisible number. The period ***r*** satisfies this equality:

$$f(x+r) = f(x)$$

Here ***r*** is the period.

2. Interference of Qubits:

In quantum computing, quantum interference is used to determine the period. A quantum state shows the following sequence:

$$|\psi\rangle = \frac{1}{\sqrt{r}} \sum_{k=0}^{r-1} |k\rangle$$

In this case, r is the period and ∣k⟩ is the quantum state. Shor's algorithm uses a quantum Fourier transform to determine the period r.

Through these formulas, Shor's algorithm allows to effectively solve the problem of factorization of large numbers by quantum computing.

Below is an example of a comparison of calculations performed using Shor's algorithm and classical algorithms. In this example, we will consider the process of factorization of large numbers using Shor's algorithm and classical factorization algorithms.

Problem: Factorize 15 (that is, express it as a product of two prime numbers)

Classic Algorithm Example: Factorization by Division

Classical factorization algorithms usually work like this:

Divide 15 into a series of smallest primes (2, 3, 5, etc.).

If the division of 15 is exact, this result will be part of the factorization.

Sequence of actions:

We divide 1.15 by 2: 15 % 2 ≠ 0, so 2 is not a divisor of this number.

2.15 divided by 3: 15 % 3 = 0, so if we divide 15 by 3, 15 / 3 = 5.

3. Now the factorization result: 15 = 3 × 5.

In this small example, the classical method is easy and quick to perform, but this method requires a lot of time and resources when working with large numbers.

Shor's Algorithm Example: Quantum Factorization

Shor's algorithm performs much more efficient computation by computing quantum states and spatial frequencies instead of sequential division using quantum computers when factoring large numbers.

Sequence of actions:

1. If the number is 15, Shor's algorithm factors the number as two primes (3 and 5).

2. uses quantum Fourier transform and periodicity detection for factorization of numbers.

o Shor's algorithm calculates a modular exponent and searches for a large number with a given periodic algorithm.

o This algorithm is very efficient and runs in polynomial time rather than exponential time.

3. the number 15: Shor's algorithm correctly factorizes the number 15 and the answer is 15 = 3 × 5.

RESULTS

A comparative analysis of dividing the number 15 into prime numbers using classical and Shor's algorithm is given.

TABLE 1. CLASSICAL AND SHOR'S ALGORITHM

Description	Comparative Analysis	
	Classical Algorithm	Shore Algorithm (Quantum Algorithm)
Type of issue	Factorization (division)	Factorization (determining periodicity)
Result	15 = 3 × 5	15 = 3 × 5
Complexity	Exponential time	Polynomial time
Efficiency for large numbers	Too slow	Very fast
Application in practice	Common in classic computers	Only used in quantum computers

For example, let's take the following 15 numbers and provide the calculation times for them. The indicated times for this are given only on the basis of theoretical and experimental data. Actual times will depend on computer specifications and software.

TABLE II.CLASSICAL AND SHOR'S ALGORITHM

Number (N)	Comparative Analysis	
	Classical Algorithm (Pollard's rho)	Shore Algorithm (Quantum Algorithm)
15	0.01	0.5
35	0.05	0.5
77	0.1	0.5
91	0.2	0.5
143	0.5	0.5
221	1	0.5
299	2	0.5
391	5	0.5
493	10	0.5
627	20	0.5
779	30	0.5
899	50	0.5
1009	70	0.5
1153	100	0.5
1287	150	0.5

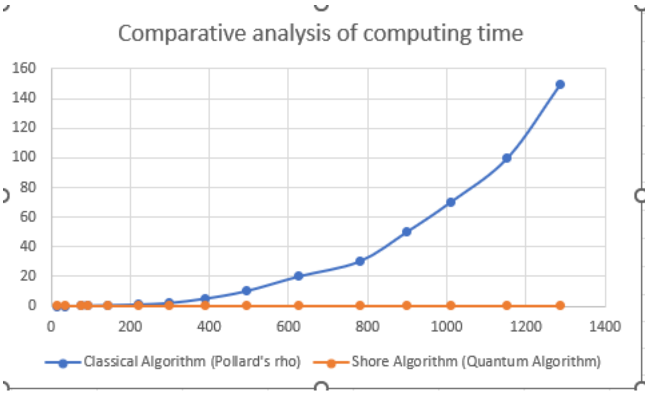

Fig. 2. Factorization times graph

DISCUSSION

In this section, we will explore the differences between classical algorithms and Shor's quantum algorithm, particularly in the context of number factorization. The comparison table highlights how these two types of algorithms vary in several key areas, including the nature of the task, the results they produce, computational complexity, efficiency, and their practical usage.

Task Approach:

Both classical and quantum algorithms aim to solve the factorization problem, but their methods differ significantly. Classical algorithms use a sequential approach, repeatedly dividing the target number by smaller prime numbers until the factors are found. In contrast, Shor's quantum algorithm takes advantage of quantum principles, such as superposition and period finding, to make this process much faster and more efficient. This distinction illustrates the divergence between classical deterministic methods and quantum's probabilistic and parallel processes.

Output:

For a small number like 15, both classical algorithms and Shor's quantum algorithm give the same result: 15=3×5. The key difference, however, emerges when larger numbers are considered. While both methods arrive at the correct factors, Shor's algorithm is designed to handle much larger numbers far more efficiently than classical methods, which become impractical as the number size grows.

Computational Complexity:

Classical algorithms exhibit exponential time complexity, meaning that as the input number grows, the time needed to factorize it increases exponentially. On the other hand, Shor's algorithm operates within polynomial time, which scales much more favorably with larger inputs. This makes Shor's algorithm significantly faster and more practical for large numbers, giving it a substantial edge over classical algorithms. This is especially important in applications such as cryptography, where large prime numbers are fundamental.

Efficiency for Large Numbers:

Classical algorithms work well with small numbers but become inefficient as the numbers increase in size. This limitation is particularly important when considering applications that involve extremely large integers, such as those used in encryption methods. Shor's quantum algorithm is far more efficient for such cases, as it leverages quantum phenomena like parallelism and entanglement to process multiple possibilities simultaneously, greatly speeding up the factorization process.

Practical Use Cases:

Currently, classical algorithms dominate practical applications because classical computers are widely available and capable of solving most everyday computational problems. However, Shor's algorithm holds significant promise, particularly in areas like cryptography. While quantum computers that can execute Shor's algorithm efficiently are still in development, the potential of these systems is enormous. Once the necessary quantum hardware becomes more advanced, Shor's algorithm is expected to revolutionize areas that depend on factoring large numbers, including breaking modern encryption techniques.

CONCLUSION

The analysis shows that while classical algorithms are useful and widely applied today, quantum algorithms like Shor's offer significant advantages, particularly for complex, large-scale problems. Shor's algorithm demonstrates its potential by efficiently factoring large numbers in polynomial time, in stark contrast to the exponential time required by classical algorithms. This makes Shor's algorithm a transformative tool in computational science, especially as quantum computing technology continues to advance. This allows quantum computers to perform complex calculations more efficiently than classical computers. As quantum computing technology matures, the combined power of qubits and advanced algorithms like Shor's is expected to revolutionize fields dependent on the factorization of large numbers and beyond, ushering in a new era of computational science.

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APPLICATION OF THE ALGORITHM FOR ENRICHMENT THE KNOWLEDGE GRAPH WITH NUMERICAL PREDICATES IN DECISION-MAKING SUPPORT SYSTEMS

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A B S T R A C T **In this paper, the theoretical and practical principles of creating a knowledge graph by forming a set of rules for expert systems are studied. At the same time, the method of enriching the graph made from the predicates created according to First Order Logic by numerical predicates was studied. as the object of the research, the classification problem of selecting crops for repeated cropping was taken, among which, using the set of real data collected in agriculture, test-experimental work was carried out on the algorithm mentioned above and the results were obtained. All results were presented in table and graph form.**

K E Y W O R D S **Expert systems, knowledge base, first order logic, partial completeness assumption, numerical predicate, rule generator, intelligent systems, numerical rule.**

INTRODUCTION

In technology-focused world intelligent and expert systems are widely used in all subject areas of industry and production. In particular, expert systems that help people make decisions stand out among intelligent systems in terms of efficiency. The concept of expert systems cannot be imagined without a knowledge base. In order to develop the simplest set of rules for the knowledge base, a combination of logical and heuristic models of knowledge representation was used and the necessary parameters were determined. Studies and experiments show that when a set of rules developed on the basis of predicate logic is integrated with a KB based on a semantic network model or a production model, the efficiency is 12-15% higher than a model built on the basis of a single model. Various standards have been created regarding the correct formulation by the data engineer of the rules considered as an element of the knowledge base. Since basic information about the system being modeled, or in other words "intelligence" is stored in the rule base, its correct formation is an important condition. This allows for different levels of error handling based on the importance of the rule base to the logic model. Below are the main features included in these standards:

Key features of knowledge based on rules, rule bases, or logical models include:

- local nature of rules,
- to be able to reflect the amount of rules through the logic of predicates,
- completeness of the model,
- non-contradiction of the rule base,
- dependence of the rule base,
- that the rule base is not redundant.

The complexity of the model (increasing the amount of variables in the rules or predicates) expands the possibility of describing the real system. However, with the increase in complexity, the amount of information representing the modeled system increases significantly (for example, the parameters of the Dumpster-Shafer function of the sets of all considerations). In addition, the amount of information about the modeled system may not be enough to build a more complex model, in which case the complexity of the model becomes its disadvantage. The main field of application of KB is expert systems, and in such systems, one of the important tasks is to constantly update the rules and create an environment for acquiring knowledge. D.Makarov stated: - "In expert systems, the knowledge acquisition environment must have the following functional characteristics:

1) Ability to create and edit knowledge base.

2) Ability to work directly with industry experts to build knowledge base. Direct acquisition of knowledge from experts reduces the burden on the knowledge engineer and the subjectivity of the transferred knowledge.

3) Ability to combine knowledge bases created by experts in different (several) fields. This feature is designed to overcome the problem of incomplete knowledge of the individual expert by using the previously acquired knowledge base. In addition, it is possible to obtain knowledge from several experts at the same time and then combine them, which leads to a reduction in the time of creation of practical expert systems (ES). In merging, it is important to eliminate data redundancy, ensure consistency and maintain integrity. Redundancy refers to the duplication of knowledge base elements. The existence of redundancy can cause the uniqueness of knowledge base names and the violation of data integrity. Consistency refers to the absence of KB elements of the same type that differ in internal structure. For example, objects of the same class cannot have different number of attributes. Data integrity refers to the condition that object names, link types, sections, and link types are unique,

and the condition to enforce referential integrity: knowledge base items cannot refer to non-existent knowledge base items. Disputes arising during the merger process will be resolved by a knowledge engineer.

4) Ability to undo changes made to the knowledge base. It allows to reduce the fear of the specialist in working with the environment.

5) Ability to convert knowledge bases created using software packages working with KB (for example, SIMER+MIR).

6) Highly effective knowledge base. This is achieved by using a cross-platform knowledge base management module at the source code level implemented in programming languages. In addition, the high productivity of ES is achieved by using a file that stores the procedures of the compiled knowledge base involved in the work of the solver.

7) The ability to create new types of connections that increase the descriptive capabilities of the knowledge acquisition environment and, as a result, the scope of its potential application [1].

METHODS

It is known that another shortcoming of intelligent systems designed for prediction through the knowledge base is the low efficiency of working with digital data. However, the main information supply of the agricultural crop selection system is based on digital indicators, and therefore it is necessary to work on a "rule generator" model aimed at eliminating this shortcoming. The model of logical-heuristic knowledge representation is based on the theory of predicates and the theory of graphs, and the mathematical support of tasks such as forming logical rules and determining their reliability level is based on mathematical logic (numerical predicates) or formal axiomatic theory. One of the difficulties in finding logical rules in a knowledge graph is the exponential size of the search space, which varies depending on the language being considered. Several recent approaches to this problem have relied on sampling or approximate confidence calculations [2], [3] and [4]. Another common technique from standard inductive logic programming (ILP) [3] is to develop enough rules to cover positive samples, rather than all rules. Similarly, it speeds up the calculation, but there is a risk of losing some important rules. Although existing rule generation approaches are effective, they face a number of challenges when dealing with rules that contain constraints defined by numerical values . It turns out that such restrictions are very relevant in the fields of finance, health, agriculture or natural science, because they help to reveal useful information, for example, the five years of a patient with heart disease. increased probability of receiving mood stabilizers over a year, crop seed size, soil salinity value, etc. Rule extraction technique Calculation of constraints while exploring the search space (generalizes or refines the rule) until recalculating the interval at each step, and this approach is time-consuming on large graphs. To this end, we propose a new algorithm that includes two steps: first, we extract First Order Logic (FOL) rules using existing efficient rule generation tools, and then we enrich the rules with numerical predicates and constraints. In this second step, we treat the problem as a classification problem based on the quality of the rules to obtain intervals based on the correct and incorrect predictions of the rule. First of all, it is appropriate to briefly touch on the widely used method that is considered as a solution to this problem.

Associative rule extraction is a widely used data mining method that identifies frequent patterns between objects and data based on a minimum number of observations. It usually generates IF-THEN (production) rules, expressed as X→Y associative rules , where the presence of X implies the presence of Y. However, one of the disadvantages of this method is that it is difficult to work with numerical attributes. Quantitative associative rules are developed as a solution to this problem, and the rule structure contains at least one numeric attribute (for example, (5<average_temperature<38)∧(0.2<salinity<0.53)→(0.62<beans<0.83)). The formation of quantitative associative rules is carried out using various approaches, such as discretization, statistical analysis, optimization (genetic algorithms) [5]. However, such rules retain the limitation of numerical data, which is not enough to express logical rules in graphs [6].

The following relational operations to convert facts in a data set into rules $r \in \{<, \leq, =, \neq, \geq, >\}$ is implemented by ($R_1 : p_1(x, v_0) \wedge p_2(y, v_1) \wedge v_0 > v_1 \rightarrow p_3(x,y)$). In classification problems, numerical predicates in the rules can be reduced to a certain interval through the sigmoid function ($f\{y_1, y_2 : p_1(X, y_1), p_2(X, y_2)\} > 0.5 \wedge p_3(X, Z) \rightarrow p_4(X, Z)$ – here, f *is* a sigmoid function, p_1, p_2, p_3, p_4 are numerical predicates). Concepts and principles related to FOL used in the algorithm for enriching rules with numerical predicates in the knowledge graph:

The knowledge graph of KB contains the set of facts G {(subject, predicate, object) | subject $\in I$, predicate $\in P$, object $\in I \cup L$ } is expressed in ternary form, where the set of objects is denoted as I , the set of predicates is denoted by P , and the set of literals (numbers and strings) is denoted by L. We also define $P_{numerical}$ as the subset of predicates whose range consists of only numerical values.

An atom is a FOL formula of the form $p(X, Y)$, where p is a predicate and X, Y are constants or variables. If the arguments of an atom consist of constants, the atom is called "constant" and is treated as a fact.

The rule $r : B \rightarrow H$ is a FOL formula, where B is a conjunction of atoms $B_1, B_2,...,B_n$ and H is the only atom. A rule completes when each variable is used at least twice in the rule. Two atoms are linked if they have at least one variable in common.

If all atoms of $\sigma(B)$ belong to the graph G, then $\sigma(H)$ is a prediction for the rule r : B →H. If $\sigma(H) \in G$, then the prediction is true. In [7] mentioned, the following quality indicators are defined for the rule r : $B \rightarrow H$. In the absence of identity links, the Unique Name Assumption (UNA) is assumed to be met. If identity links are present, preprocessing steps are required to correctly calculate quality measures and functionality scores, and partial completeness assumption (PCA) is followed to account for counterexamples.

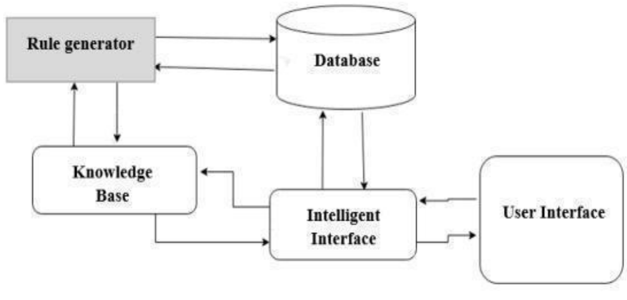

Figure 1. General functional diagram of a knowledge base-based decision support system

The partial completeness hypothesis is an approach based on the formal theory that a data set can be assumed to be complete only for certain types of data or queries and incomplete for other types of data. accepted. This approach is widely used in determining mathematical regularities between data sets and making inferences even when the data set is incomplete. For example, if a knowledge graph contains information about certain objects or relations, PCA assumes that all relevant information about these objects or relations is contained in the graph. The incompleteness of other parts of the graph is not taken into account. In this research work, enriching the knowledge graph with numerical predicates is the main approach of the algorithm, where PCA is used as a numerical rule generator. The number of correct predictions made by the rule is determined by the function *S(r)*.

$$S(r) := |\{(x,y) : B \wedge H(x,y)\}| \qquad (1)$$

H_c- the ratio of the number of correctly predicted head atoms according to the rule to the total number of samples.

$$H_c = \frac{S(r)}{|\{(x,y): H(x,y) \in G\}|} \qquad (2)$$

$F_s(p)$ – the functionality indicator of the predicate is a variable value in the range from 0 to 1, and is a property that determines the ratio of the subjects in G to the total number of subjects with this predicate. *An* inverse $F_i(p)$function is a functional indicator of the inverse predicate *p*.

$$F_s(p) = \frac{|\{x: \exists y: p(x,y) \in G\}|}{|\{(x,y): p(x,y) \in G\}} \qquad (3)$$

According to the PCA , if $p(x, y) \in G$ is true and $F_s(p) > F_i(p)$the conditions are satisfied, then the predicate *p* and no other fact for *x* is true and cannot be counterexampled (i.e., $p(x, y') \notin G$). On the other hand, $F_i(p) > F_s(p)$, then ∀ $p(x', y) \notin G$. The PCA reliability index of the rule r calculates the accuracy of the rule by the rule, i.e. if $F_i(H) > F_s(H)$,

$$C_{QTF} = \frac{S(r)}{|\{(x,y): \exists y\prime: B \wedge H(x,y\prime)\}|} \qquad (4)$$

Based on the definition of counterexamples on the PCA, if $F_i(H) > F_s(H)$, then the denominator, i.e., the size of the body of the PCA in the above equation turns into |{(x,y) : ∃ x′: B ∧ H(x′ , y)}|.

The logical-heuristic model not only provides logical rules and their integration into graphs, but also connects and closed rules formed in the generated knowledge graph, regardless of the method used to extract them, by limiting the entered numerical values in specified intervals with numerical predicates. automatically enriches. This model aims to increase the PCA reliability index of the considered rules, while ensuring the reduction of rule errors. This approach aims to identify numerical rules defined as follows:

Numerical rule. A numerical rule is a first-order logical formula, $B \wedge C \rightarrow H$, where *B* is the conjunction of atoms in the knowledge graph, the range values of the numerical atoms of *B* are determined using *C* , it is checked that the conjunction of atoms belongs to the interval [*i,k*]. Examples of such rules include:

M1: r1: precipitation_amount(x,y) ∧ salinity(y,w) ∧ w ∈ [1000, 500] ∧ nitrogen_amount(x, z) → precipitation_amount (z, y)

M2: r2 : Rainfall (x, y) ∧ NitrogenAmount (x, z) ∧ MaturityDuration(z, a) ∧ Salinity (y, w) ∧ (w ∉ [1000, 5500] ∨ a ∉ [50, ∞]) → Rainfall (z, y)

Creating complete numerical rules that fulfill the quality measurement limits can be very time-consuming [7] . This is because the intervals used to constrain the range of numerical predicates need to be recalculated each time the rule is generalized or the search space is explored. This ensures that the restrictions applied to the rules are consistent with the updated rules. To overcome this problem, the study proposes an approach that builds on the rules developed by an existing rule generation method (i.e. parent rule) and expands this set of rules through an "enrichment" process to generate digital rules. In more detail:

- The process of enriching the basic rule (basic rule) is carried out taking into account a set of different predicates. This means that if a numerical rule containing a given number of predicates *p* contains n atoms, the approach ignores a larger set of atoms that also contains the predicate *p.*
- The search strategy relies on tree-based algorithms to select constraints on numerical predicates.

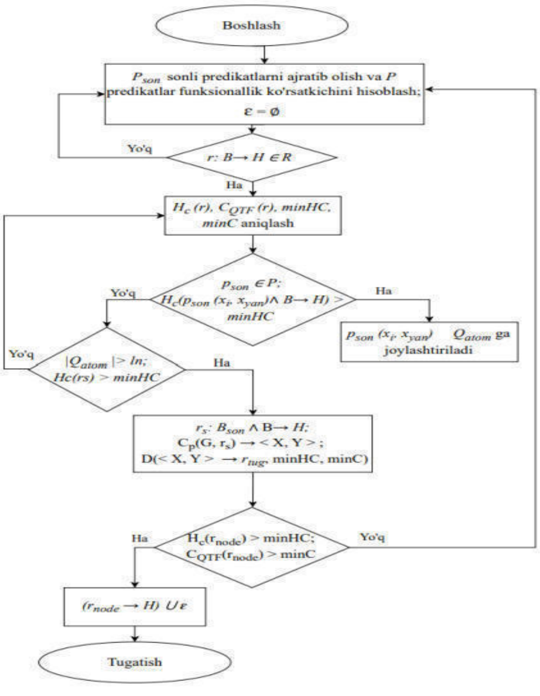

Figure 2. An algorithm for enriching the knowledge graph with numerical predicates

A closed set of rules *R* obtained from the knowledge graph *G (R ∈ G)* is considered as base rules and takes into account the limits of *C* and *HC* (head coverage - the ratio of samples in which the body and head parts of the rule are true at the same time to all samples in the base) In this case, a logic-heuristic approach can enrich the basic rules of *R* to generate numerical rules and includes the following steps:

Step 1. As an initial processing step, a set of P_{number} of predicates is determined from the graph G. Domain and range definition axioms are used if available in the ontology, otherwise, they are searched considering the range of values. Also all R base rules for predicates $F_s(p)$ the functionality index is calculated.

Step 2. The PCA reliability of the numerical rule obtained as a result of the enrichment of the base rule *r is at least C* threshold values and its coverage boundary boundary conditions are introduced. If the rule generator does not provide such rules, the H_c and C_{QTF} values are calculated by the knowledge graph and the following threshold values are set:

$$minHC = (1 - HC)\, H_c\,,$$

$$minC = (1 - C) C_{QTF} \quad (5)$$

Step 3. In this step , all numerical atoms that can enrich the base rule and store them in Q_{atom} queue are taken. $vars = \{x_1, x_2, \ldots, x_n\}$ *contains* all $P_{numerical}(x_i, x_{yan})$ atoms from the set of *variables* $x_i \in vars$ relation is provided (x_{yan} is a new variable), which leads to the condition $P_{number}(x_i, x_{yan}) \wedge B \rightarrow H > minHC$. Otherwise, the atom is discarded, because its conjunction with other atoms leads to a decrease in the threshold values due to monotonicity. For example, if there is a basic rule r_1 *: nitrogen_amount*$(x_1, x_2) \rightarrow$ *pH_amount* (x_1, x_2), then there is a variable x_1 with a numerical predicate *stress_endurance, stress_resistence*$(x_1,x_3)\wedge$*mean_temperature* $(x_1,x_2)\rightarrow$ *yield* (x_1, x_2) is dropped because *minHC* does not satisfy the value.

Step 4. The goal of the algorithm is to determine the appropriate numerical rules that meet the requirements of the quality measure using the least number of predicates. To construct these numerical rules, we iteratively search the space of possible combinations of atoms present in Q_{atom}. We start with a single digit atom ($ln = 1$) and continue until the next Q_{atom} has *ln* or more atoms. For this, the following iteration operations are used: *ln* atoms are obtained from Q_{atom} and their conjunctions are $B_{numerical}: P_{numerical1}(x_i, x_{n+1}) \wedge \ldots \wedge P_{numuerical1}(x_j, x_{n+l})$:

$$r_s : B_{numerical} \wedge B \rightarrow H \qquad (6)$$

In the knowledge graph, the enrichment process is continued only if the rule *rs* satisfies the *minHC* threshold value. In the third iteration, the numerical predicate can satisfy the conditions and an approximate rule can be generated as follows:

r_s:salinity(x,y) ∧ precipitation_amount(x, z) ∧ sunny_days(y, w) ∧ pH_amount(x, v) ∧ stress_tolerance(x, u) → variety(z, y) three different number predicates salinity, sunny_days and stress_tolerance minHC corresponds to the threshold.

Step 5. p_s created in the previous step rules $B_{numerical}: p_{numerical1}(x_i, x_{n+1}) \wedge \ldots \wedge p_{numerical1}(x_j, x_{n+l})$ rule was evaluated for correctness in solving the problem of binary classification. Represent the set of examples of numerical values $B(x_{n+1}, \ldots, x_{n+l})$ that lead to the correct prediction of $H(x_a, x_b)$ for the rule r_s in this classification step for $A\ (\{(x_{n+1}, \ldots, x_{n+l}) \mid B(x_1, \ldots, x_n) \wedge B_{numerical}(x_i, \ldots, x_j, x_{n+1}, \ldots, x_{n+l}) \wedge H(x_a, x_b)\}$ is created. At the same time, to represent the set of examples of numerical values B $(x_{n+1}, \ldots, x_{n+l})$ B $(\{(x_{n+1}, \ldots, x_{n+l}) \mid B(x_1, \ldots, x_n) \wedge B_{numerical}(x_i, \ldots, x_j, x_{n+1}, \ldots, x_{n+l}) \wedge \exists x_{b'} H(x_a, x'_b)\}$) class is included, but $F_s(p) > F_i(p)$ in case r_s rule leads to an incorrect prediction, i.e. $H(x_a, x_b) \notin G \wedge \exists H(x_a, x'_b) \in G$. In addition, the current step creates a data structure $< X, Y >$ representing the set of numerical values of the numerical predicate of B for each true and false prediction $H(x_a, x_b)$. $C_p(G, r_s) \rightarrow < X, Y >$ *and* $D(< X, Y > \rightarrow r_{node}, minHC, minC)$ are considered the end of the fifth step, to write the final form of the rule to the current node data structure serves.

RESULTS

A supervised learning method is used to discretize continuous values of numerical predicates in Bnumerical and to keep track of the number of correct and incorrect predictions in each interval to account for membership constraints. This method involves constructing a variable CART (Classification And Regression Tree) decision tree (DT), where numerical predicates serve as features. The top node of the tree corresponds to r_s : $B_{numerical}$ ∧ C ∧ B → H (C is empty by silence condition). In each division, the area Bnumerical The range values of one of the atoms in C are defined as the partition boundary and C is divided into two other fields (nodes) by updating the range. Each node's rules are created through a parent node's rule and a partition boundary on that node. More precisely, if the split is performed using the atom p(x, y) at the i -node and the threshold a, then for the left subnode C threshold $y \in [-\infty, a]$, and for the right node A new rule is created by updating $y \in [a, \infty]$ with a conjunction of intervals.

Also, make sure that each node contains the shortest rule. This means that if the atom *p(x, y)* is selected for the division from the root node to subnodes , the threshold values are already present in the root node itself. Therefore, it is enough to update the threshold values (the range values of the atom *p(x, y)* are changed sequentially). And stop splitting uses criteria based on *minHC* and *minC* for inclusion criteria and exclusion rules. The basis for this is the $< X, Y >$ data structure and class sizes *A* and *B* defined in the initial stages. If the number of different samples for a rule belonging to class *A is minHC ∗ headsize(r)* and *B* If the number $bodysize_{QTF}(r_s) - \frac{S(r_s)}{minC}$ of samples is less than the difference, the rule generation is stopped locally. In order to prevent the increase in the number of created digital rules and the repetition of rules, a strategy was developed to compare the signs of similarity to extract the most common rules along each path from the root node to the lower nodes (leaf node, subnode). In order to preserve the diversity, at the end of each iteration, the numerical rule atoms built on the basis of *minHC* and *minC conditions are changed to* Q_{atom} we remove from the queue. Below are some test results (experiments were conducted on a single machine with 2.5 GHz and 8-core processor, 8 GB of RAM, and Windows 11 operating system).

TABLE I. A SET OF RULES DEVELOPED THROUGH DS1 AND DS2 DATASETS

A set of rules	Predicates ($\|P\|$)	Numerical predicates ($\|P_{numerical}\|$)	Graphs ($\|G\|$)	Graphs for evaluation ($\|G_t\|$)
RDS1	162	98	21	6

RDS2	186	116	19	6

DISCUSSION

The use of this algorithm is an effective method for selecting repeated crops in agriculture. Previously, during our research, we tried to find a solution to this problem using several machine learning and deep learning algorithms such as SVM, KNN, Neural Network, GBRT. As mentioned above, the knowledge graph enrichment algorithm with numerical predicates, which works with an average of 7-8% more accuracy than other algorithms, can be applied to a number of other classification problems.

TABLE II. RDS1 AND RDS2 RULE SET INDICATORS

A set of rules	Number of rules ($\|R\|$)	Number of enriched rules ($\|E\|$)	C_{PCA} (basic rules)	C_{PCA} (enriched rules)	$\|G_t\|$ results on (%)
RDS1	700	458	0.74	0.83	86
RDS2	649	433	0.79	0.93	93

In order to create a set of rules for a graph node in KB and to enrich the existing rules with numerical predicates, *minHC=0.01, minC*$_{PCA}$*=0.3, max_length =3* and *HC , C threshold values* were set as *20%* and *10%,* respectively.

CONCLUSION

In the course of our research, we got acquainted with the algorithm and model for the decision-making support system for the selection of repeated crops, at the same time, the results were obtained using the collected data sets and some indicators were compared. This problem has been organized a lot by world scientists, and this article is one of them. The next stage of our research is directly dependent on this research and its results. The next stage of research is to predict the yield of selected crops for the next season. For this issue, it is planned to conduct research on several machine learning algorithms such as Multiple Linear Regression, Random Forest, Support Vector Regressor.

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SELECTION OF FEATURES IN THE PROBLEMS OF PERSONAL IDENTIFICATION BY KEYSTROKE DYNAMICS

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A B S T R A C T **In this article examines the problem of identifying features when authenticating the identity of a user of computer systems based on keyboard handwriting. To solve this problem, a feature extraction method is proposed. The main idea of this method is to search for a set of representative features. In this case, the search for representative features is carried out in two stages. At the first stage, time and frequency features are determined. At the second stage, the following are determined: 1) a subset of strongly related features 2) a set of representative features. Experimental studies have been conducted to assess the performance of the proposed method. The results of the experimental study showed that the proposed method of feature extraction showed high accuracy in solving the problem of personal authentication by keyboard handwriting.**

K E Y W O R D S Identity authentication,Feature extraction,Temporal features,Frequency features,Strongly related features,Representative features

INTRODUCTION

In the modern world, the most important place is occupied by issues of protecting confidential information of users of information systems (IS). Information security threats can arise both as a result of the negligence of IS users and the use of low-quality software. Violation of security policy may lead to loss of confidentiality, violation of integrity and availability of protected information, which may entail significant moral and material costs for both an individual and an entire organization. Therefore, tasks related to the issues of creating an access control and management subsystem and their application in delimiting access to the information system remain relevant.

In most modern IS, the user's identity is verified by entering a login and password. However, these methods have significant drawbacks. One of these drawbacks is the complete lack of information security in the event of a password breach. Another drawback is the lack of protection against user substitution after authorization in the system. If an authorized user leaves the IS unattended, any intruder in close proximity to this system can gain access to it.

Currently, there are other methods that, although not as widespread, are potentially much more reliable. In particular, there is a whole class of promising biometric approaches. For example, these include methods [1]: voice recognition; face recognition; iris recognition; fingerprint recognition; keystroke dynamics (KD) recognition. Among them, the technology of personal recognition by KD occupies a special place. This is due to the fact that the use of the KD recognition method has a number of advantages over other authentication methods, for example: KD recognition systems do not require additional equipment, as a result of which the cost of implementing such a system is low; KD monitoring can be performed continuously and unnoticed by the user, without distracting his attention from the work process. Despite this, issues related to user authentication based on keystroke dynamics analysis, in particular, the selection of vectors of characteristic features during KD authentication, have not been sufficiently studied.

The purpose of this report is to highlight the characteristic features of user identity authentication using the KD. In this case, time (TF) and frequency features (FF) are used.

METHODS

The method of identifying characteristic features of the KD consists of two stages [1]. At the first stage, the TF and FF are determined for each n-gram (i.e. a sequence of n symbols) of the KD. In the second, a set of representative features is identified.

1. Determination of the TF and FF for each n-gram of the KH. It is known that the pressing time (DT- Dwell time is the time duration that a key is pressed) is calculated as the time between pressing and releasing a key. In the case of calculating the DT value for n-grams, the time interval between pressing the first key and releasing the last key of the n-gram is used, i.e. interval $\mathrm{N}_1\mathrm{O}_n$.

The time between keystrokes Flight time (FT) is the time duration in between releasing a key and pressing the next key, i.e. time $\mathrm{O}_1\mathrm{N}_2$. For n-grams, the FT value can be calculated as the sum for each interval included in the n-gram. Press duration (PD) is the time interval between pressing two keys: interval $\mathrm{N}_1\mathrm{N}_2$. For n-grams, the PD value is calculated as the sum for each pair of keys included in the n-gram.

Frequency characteristic (FC) is often used as FF. FC are calculated for different groups of characters, such as alphabetic characters, digits, punctuation marks, special characters, and functional characters.

Based on FC, statistical features can be formed, such as the mean value of these characteristics and the standard deviation value.

2. Selection of a set of representative features. This stage consists of the following parts: 1) definition of subsets of strongly related features of the KD. As a result of the first part, a set of "independent" subsets of strongly related features of the KD is determined. 2) definition of representative features in each subset of strongly related features. As a result of the second part, a set of representative features is formed.

The error rate is calculated based on the frequency of pressing the <Delete>, <Backspace>, <Home>, <End>, <Insert> keys, and the arrow keys, which users typically use to edit entered text.

Based on the time characteristics, statistical features can be formed, such as the average value of these characteristics and the value of the standard deviation.

Thus, the main idea of identifying characteristic features when authenticating users by KD and the corresponding method for calculating them are described. To assess the performance of the considered method, experimental studies were conducted when solving the problem of authentication of a person by KD.

RESULTS AND DISCUSSION

The main result of this report is the method of identifying characteristic features of the KH (see Section II). In order to check the performance and evaluate the effectiveness of the considered method of identifying characteristic features, an experimental study is given. During the experimental research, the problems of user identity authentication using the KD were solved. The following initial information was used in the considered identity authentication problem. Number of classes (users) $l = 3$, sample size $|V| = 240$ objects. Each class contained 80 observations. The division into training and control samples was carried out on the basis of the sliding control method [2]. In this case, the training sample included 180 observations, i.e. $|\widetilde{K}_j| = 50$, $j = \overline{1,3}$, and the control sample included 60 observations.

The conducted experimental studies showed high accuracy of the developed feature extraction model in solving the problem of personal authentication using the KD. As a result of the experiment, a set of features was formed that allows the signatures of the sample under consideration to be divided into 3 classes with an acceptable error.

A comparative analysis of the quality assessment of the proposed method shows that it solves the problem of identifying characteristic features of the KD relative to existing methods, in particular [3,4]. This is explained by the fact that the works do not take into account the conditions of the interrelation of features [3,4].

CONCLUSION

In conclusion, we note that this report proposes a method for identifying features when authenticating a person using a KD. This method is based on calculating various time, frequency and statistical characteristics for each person.

The developed method can be used in the development of various software packages aimed at solving the problems of authentication and identification of a person by KD.

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IMPROVING AND ASSESSING THE EFFECTIVENESS OF ARTIFICIAL INTELLIGENCE-BASED DECISION-MAKING IN DIGITAL BANKING SYSTEMS

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Abstract: This article explores the application of artificial intelligence (AI) in digital banking systems, focusing on improving and assessing the effectiveness of AI-based decision-making processes. It discusses the current state of AI in the banking industry, the methods used to enhance AI-driven decision-making, and the results of implementing these methods.

Keywords: artificial intelligence, digital banking, decision-making, effectiveness, Uzbekistan

INTRODUCTION

The banking industry has undergone significant transformations with the advent of digital technologies, and artificial intelligence (AI) has emerged as a key driver of innovation in this sector [1]. AI-based systems have the potential to revolutionize decision-making processes in digital banking, improving efficiency, accuracy, and customer experience [2]. In Uzbekistan, the adoption of AI in the banking sector is gaining momentum, with financial institutions recognizing the benefits of AI-driven solutions [3]. This article aims to explore the methods for improving and assessing the effectiveness of AI-based decision-making in digital banking systems, with a focus on the context of Uzbekistan.

METHODS AND LITERATURE REVIEW

To understand the current state of AI in digital banking and identify methods for improving AI-based decision-making, a comprehensive literature review was conducted. Relevant articles, research papers, and industry reports were sourced from reputable databases, including IEEE Xplore, ScienceDirect, and Google Scholar. The literature review focused on key themes such as AI applications in banking, machine learning algorithms, data analytics, and performance metrics for AI systems.

The literature suggests that AI can be applied in various areas of digital banking, including fraud detection, risk assessment, customer service, and personalized recommendations [4]. Machine learning algorithms, such as neural networks and decision trees, are commonly used to train AI models for these applications [5]. Data analytics plays a crucial role in improving the effectiveness of AI-based decision-making by providing insights into customer behavior and market trends [6].

RESULTS

The literature review revealed several methods for improving the effectiveness of AI-based decision-making in digital banking systems. These methods include:

Data Quality and Preprocessing. Ensuring the quality and integrity of data used to train AI models is essential for accurate decision-making. Data preprocessing techniques, such as data cleaning, normalization, and feature selection, can improve the performance of AI algorithms [7].

Model Selection and Optimization. Choosing the appropriate AI model for a specific banking application is crucial for effective decision-making. Techniques such as cross-validation and hyperparameter tuning can help optimize model performance [8].

Explainable AI. Implementing explainable AI techniques, such as rule-based systems and decision trees, can enhance the transparency and interpretability of AI-based decisions, building trust among stakeholders [9].

Human-AI Collaboration. Integrating human expertise with AI-based systems can improve decision-making effectiveness. Collaborative approaches, such as human-in-the-loop learning, allow for the refinement of AI models based on human feedback [10].

ANALYSIS AND DISCUSSION

The analysis of the literature and the identified methods suggests that improving the effectiveness of AI-based decision-making in digital banking requires a holistic approach. Data quality, model selection, explainability, and human-AI collaboration are key factors that contribute to the success of AI implementations in the banking sector.

In the context of Uzbekistan, the adoption of AI in digital banking is still in its early stages. However, the government and financial institutions are increasingly recognizing the potential of AI to transform the banking landscape [3]. Implementing the identified methods can help Uzbekistan's banking sector harness the benefits of AI while ensuring the effectiveness and reliability of AI-based decision-making.

One of the primary challenges faced by Uzbekistan's banking sector in implementing AI is ***the lack of a comprehensive data infrastructure*** [4]. Effective AI-based decision-making relies on the availability of high-quality, diverse, and representative data. Uzbekistan's banks need to invest in data collection, storage, and management systems to ensure the reliability and integrity of the data used to train AI models [5].

Another challenge is ***the shortage of skilled professionals in the field of AI and data science*** [6]. Uzbekistan's educational institutions need to adapt their curricula to include courses on AI, machine learning, and data analytics to build a talent pool capable of driving AI adoption in the banking sector. Collaboration with international universities and research centers can help bridge the skills gap and facilitate knowledge transfer [7].

The regulatory framework governing the use of AI in Uzbekistan's banking sector is also evolving. The Central Bank of Uzbekistan has recognized the need for guidelines and standards to ensure the responsible and ethical use of AI in financial services [8]. Policymakers should work closely with industry stakeholders to develop a comprehensive regulatory framework that balances innovation with consumer protection and financial stability.

The application of AI in digital banking presents both challenges and opportunities. While AI has the potential to streamline processes, reduce costs, and enhance customer experience, there are concerns regarding data privacy, algorithmic bias, and the ethical implications of AI-based decisions. Addressing these challenges requires a collaborative effort from policymakers, financial institutions, and technology providers.

Uzbekistan's banking sector can benefit from the experiences and best practices of other countries that have successfully implemented AI in digital banking. Collaboration with international organizations and technology partners can help accelerate the adoption of AI and ensure its effective use in decision-making processes.

One of the key opportunities for Uzbekistan's banking sector is ***the potential for AI to increase financial inclusion***. AI-based systems can help banks reach underserved populations, such as rural communities and small businesses, by automating credit assessment and loan approval processes. This can help reduce the cost of financial services and improve access to credit for traditionally marginalized groups.

Another opportunity is ***the use of AI to enhance customer experience and personalization***. AI-powered chatbots and virtual assistants can provide 24/7 customer support, while machine learning algorithms can analyze customer data to offer personalized product recommendations and financial advice. This can help banks build stronger relationships with their customers and increase customer loyalty.

However, the adoption of AI in Uzbekistan's banking sector also raises ethical concerns. AI algorithms can perpetuate biases present in historical data, leading to discriminatory decisions in areas such as credit scoring and loan approval. Banks must ensure that their AI models are transparent, explainable, and subject to regular audits to detect and mitigate bias.

Data privacy is another critical concern. As banks collect and process vast amounts of customer data to train AI models, they must implement robust data protection measures to safeguard sensitive information. Compliance with international data protection regulations, such as the General Data Protection Regulation (GDPR), can help build trust and confidence among customers.

On balance, the effective implementation of AI in Uzbekistan's digital banking sector requires a multi-faceted approach that addresses technical, regulatory, and ethical challenges. By investing in data infrastructure, talent development, and collaborative partnerships, Uzbekistan's banks can unlock the full potential of AI to drive innovation, improve customer experience, and promote financial inclusion. However, this must be balanced with a commitment to responsible and ethical AI practices that prioritize transparency, fairness, and data privacy.

CONCLUSIONS

This article has explored the methods for improving and assessing the effectiveness of AI-based decision-making in digital banking systems, with a focus on the context of Uzbekistan. The literature review and analysis have highlighted the importance of data quality, model selection, explainability, and human-AI collaboration in ensuring the success of AI implementations in the banking sector.

As Uzbekistan continues to embrace digital transformation in the banking industry, it is crucial to prioritize the effective use of AI in decision-making processes. Future research should focus on developing industry-specific guidelines and frameworks for AI implementation, addressing the challenges associated with AI adoption, and fostering collaboration between stakeholders.

By leveraging the power of AI and implementing best practices for effective decision-making, Uzbekistan's digital banking sector can drive innovation, improve customer experience, and contribute to the overall economic growth of the country.

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MAIN CHALLENGES RELATED TO ARTIFICIAL INTELLIGENCE IN THE FIELDS OF INFORMATION TECHNOLOGY

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ANNOTATION **The change of generations of computing technology is equivalent to another scientific and technological revolution. With the advent of new generations of computers, communication facilities, multiprocessor systems and the development of Internet technologies, it will be possible not only to solve fundamentally new problems in all areas of science and technology, but also to significantly expand the possibilities for their implementation. Solving previously traditional problems at a new, qualitative level, the qualitative level of solving problems, first of all, involves providing the necessary and sufficient intellectual support. Intellectualization of information and computing systems means not only the use of new-generation tools, but also the use of a new generation of mathematical, algorithmic and software tools. Information and computing systems with intellectual support are usually used to solve complex problems where logical information processing is superior to computational processing. Examples of such problems are: understanding and synthesizing texts in natural language, understanding and synthesizing speech, analyzing visual information, controlling robots, analyzing situations and making decisions.**

KEYWORDS Artificial intelligence, management information systems, database, development of yield assessment program, Risk management.

INTRODUCTION

Artificial intelligence (AI) technologies are becoming the main tools for generating and evaluating data on the Internet. If implemented responsibly, AI can benefit society in many ways. However, there is also a risk that such technologies will have a negative impact on fundamental freedoms. The use of artificial intelligence for commercial, political or state interests can seriously threaten human rights, especially freedom of expression and media pluralism. The problem of AI governance is an issue in the field of artificial intelligence technology and philosophy. The goal is to create artificial superintelligence that benefits people, while avoiding the accidental creation of intelligence that causes harm. It is especially important to avoid a situation where AI takes over control and makes it impossible to switch off. The results of research on AI governance can also be applied to the governance of existing AI systems.

RISKS OF USING ARTIFICIAL INTELLIGENCE IN EDUCATION

Without scientific tools, it is impossible to participate in the software and information support industry race. At the same time, modern tools should be based not only on scientific achievements, but also on engineering, hardware and software innovations and developments and contribute to solving urgent problems in various spheres of human activity (economic, technological, medical, social, etc.). In the development of information technology, a special place is occupied by processes aimed at modeling the functions inherent in human analytical abilities, his knowledge and creative abilities and tasks, as well as transferring them to computer platforms, they are called by one concept - intelligence or intelligent systems. Engineering research in order to determine current and future needs in the production of various methods, algorithms and service apparatus of information technology and informatization of various areas of management, adaptation of science to specific production technologies, providing them with effective, balanced software. ; Hardware and information support has been developed. The increase in the volume of information, the increase in the number and quality of tasks solved in the management process, the complexity of management and control systems impose increasingly stringent requirements on information systems as decision support systems. To the traditional conditions of ensuring high efficiency, reliability, flexibility, etc., a requirement is added that can be characterized as the ability to solve intellectual problems at the present stage of development. Information security, complexity of functions and expansion of capabilities of computing systems put a number of tasks in the first place, including systematization and classification of data, research, forecasting and methods for solving classification problems, which are called problem identification problems. The complexity and intellectualization of information systems, among other things, leads to the need to provide them with such advanced artificial intelligence capabilities. This, in turn, makes it possible to solve urgent problems included in the scope of development of the theory of problem identification, forecasting, expert systems, expert creativity, etc. In recent years, theoretical research has been active in various mathematical areas of artificial intelligence: logical algebra and predicate theory (proofs), semantic analysis, knowledge and data models, formal language theory, dialog and expert procedures, cognitive graph theory and natural language. text detection and others are included. In the early 60s of the last century, there were heated debates about what a machine "thinks", "creates", "analyzes" and so on. The past decades have given a clear positive answer. Together with sensor systems, modern software systems form high-level robotic systems equipped with artificial intelligence, capable of performing complex functions at great depths, on other planets and in places where human production is difficult (dangerous). Artificial intelligence systems are capable of performing tasks that were previously considered the competence of only natural intelligence: proving mathematical theorems, translating texts from one language to another, diagnosing diseases, identifying mineral deposits, skillfully playing chess and other intellectual games. Intelligent systems, referred to as expert systems, have become widespread and widespread, that is, systems that allow collecting, updating and correcting knowledge in various fields of science based on computers. Since the second half of the last century, expert systems have undergone qualitative changes in their development and improvement with a significant increase in the role of information processes in decision-making. Expert systems help not only to collect and store information in a user-friendly form, but also to obtain new knowledge in the field of medicine, geology, geophysics, mechanical engineering, robotics, economics, ecology and other sciences. 9 In recent decades, a group of gradually isolated information systems based on intelligent data analysis (IDA) technologies has proven its effectiveness. It is safe to say that mastering this technology is an integral part of the successful competitiveness of a technical specialist (and not only) in the labor market. Intelligent data analysis technologies are an advanced direction of analytical systems, the development of statistical analysis methods, forecasting methods. Production is a direct source of increased efficiency, effectiveness and decision-making at various business enterprises, as a result of which it is protected by confidential corporate technologies and systems.

Artificial intelligence technologies have been widely used in education before. Pedagogical tools based on intelligent technologies have increasingly found their application in recent years. Traditionally, the introduction of new high-tech educational solutions is accompanied by highlighting their positive aspects.

Thus, among the advantages of artificial intelligence, it is necessary to emphasize the possibility of designing an individual educational trajectory that meets individual needs. Researchers note that, unlike traditional teaching methods, artificial intelligence is able to develop a scenario that allows increasing motivation for learning.

PROBLEMS OF TRADITIONAL MANAGEMENT INFORMATION SYSTEMS (MIS).

The change of generations of computing technology is equivalent to another scientific and technological revolution. With the advent of new generations of computers, communication equipment, multiprocessor systems and the development of Internet technologies, it will be possible not only to solve fundamentally new problems in all areas of science and technology, but also to significantly expand their capabilities. solving previously traditional problems at a new, qualitative level. A high level of problem solving quality, first of all, involves providing the necessary and sufficient intellectual support. Intellectualization of information and computing systems means not only the use of new-generation tools, but also the use of a new generation of mathematical, algorithmic and software tools. Information and computing systems with intelligent support are usually used to solve complex problems where logical (semantic) information processing surpasses calculations. Examples of such problems are: understanding and synthesizing texts in natural language, understanding and synthesizing speech, analyzing visual information, controlling robots, analyzing situations and making decisions, etc.

INTEGRATION OF ARTIFICIAL INTELLIGENCE INTO INFORMATION MANAGEMENT SYSTEMS.

Information technologies are understood as a set of methods using information laws, models and processes of production of means and methods of information processing . Recently, within the framework of the scientific direction of artificial intelligence, the concept of "modern information technologies" has appeared, which includes: knowledge engineering, fuzzy data processing, soft computing, neural network technologies, evolutionary modeling (genetic algorithms), multi-agent systems. The listed technologies implement not only new models of knowledge representation, but also modern heuristic algorithms for obtaining approximate solutions that cannot be found an exact solution or require a lot of work. Intelligent information technologies are a means of developing intelligent information systems, which has recently become a very common commercial product, in great demand among users in various fields of activity. Examples of such systems are expert systems, intelligent control systems, intelligent databases, cognitive graphic systems, self-learning systems, flexible information systems. Most of the listed systems can be implemented as fuzzy systems that use a linguistic model to represent information, and problem solving, a special case of knowledge-based inference, is based on logical inference.

ORGANIZING DECISION-MAKING WITH THE HELP OF ARTIFICIAL INTELLIGENCE AND INTEGRATED MANAGEMENT AND INFORMATION SYSTEMS.

The Master's programme in Fundamental Computer Science and Intelligent Information Technologies includes the study of the following subjects: Knowledge engineering and knowledge base design (characteristics of knowledge as a special type of information, strategies for working with knowledge, knowledge representation models: logic, framework, network), production, formalization of linguistic logical inference, methods of forming a knowledge base for production systems, parametric and structural optimization of knowledge bases), processing of uncertain data (uncertainty factor and methods of its formalization; the concept of a fuzzy set and related definitions; fuzzy numbers and); Fuzzy modeling in MatLab and focused on linguistic information, intelligent information systems and technologies for their development (modern information technologies providing intelligent functions); main classes of intelligent information systems: expert systems, intelligent interface systems, self-learning and adaptive systems; design features of intelligent information systems; technologies and development tools), decision support systems (the main stages of the decision-making process; multi-criteria decision-making model and the Pareto principle; multi-criteria structural analysis; decision-making under uncertainty and risk; linguistic approach to decision-making). - architecture of decision support systems, features of information presentation and development), modern heuristic algorithms (ideas of modern algorithms; basic concepts of evolutionary modeling; genetic algorithms and genetic programming; ant algorithms; cellular automata and DNA computing; areas of application of technologies). and possible modifications), Intelligent data analysis (the main tasks of data analysis; problems of recognition and pattern recognition; methods of logical recognition; fuzzy classification; fuzzy regression analysis; trend detection; models; evaluate multidimensional objects for data analysis); The areas of professional activity of graduates studying under the Master's program "Intelligent Information Technologies" are IT industry enterprises, as well as enterprises and organizations using IT systems, products and services in their activities.

WORK EFFICIENCY INCREASES.

Improving operational efficiency is an important goal for organizations looking to optimize performance and drive growth. Integrating artificial intelligence (AI) into management information systems (MIS) is a powerful strategy to achieve this goal. An AI-enabled MIS automates repetitive tasks, streamlines processes, and provides real-time insights that improve efficiency and cost effectiveness. Using machine learning algorithms, an AI-powered MIS can analyze large volumes of data to identify patterns, trends, and opportunities for optimization. Predictive analytics capabilities allow organizations to anticipate future needs, allocate resources efficiently, and minimize risks. Additionally, an AI-integrated MIS improves collaboration and facilitates decision making by providing centralized access to data and insights across departments. Overall, integrating AI into a MIS allows organizations to operate more efficiently, respond more effectively to market changes, and ultimately gain a competitive advantage in today's dynamic business environment.

ETHICAL CONSIDERATIONS.

The inclusion of artificial intelligence (AI) in management information systems (MIS) raises important ethical issues that require careful consideration. First, data privacy and security must be maintained to ensure that sensitive data is protected from unauthorized access and potential misuse. Organizations must implement strict measures, such as encryption and access control, to protect people's privacy.

Second, it is important to ensure that AI algorithms are trained to prevent undesirable outcomes in decision-making processes. This training includes diversifying data sets, regularly reviewing faulty algorithms, and encouraging transparency in algorithmic decision-making. Additionally, transparency and understandability are critical to building trust and accountability when integrating with AI. Stakeholders need to understand how AI algorithms work and the factors that influence their decisions to ensure ethical use and mitigate transparency concerns.

Overall, prioritizing ethical considerations when integrating AI is necessary to support the principles of privacy, fairness, transparency, and responsible use of technology. By following ethical standards and practices, organizations can increase trust, reduce risk, and improve social well-being when implementing AI-integrated management information systems.

CONCLUSION.

According to the arguments proposed, today the idea that artificial intelligence is changing the traditional educational paradigm, but at the same time, high-quality educational solutions cannot be obtained by simply using advanced products. As we can see, there are a number of problems that require careful consideration not only at the educational but also at the technological level. The question that needs to be answered is: is artificial intelligence really intelligence? or just a beautiful metaphor. It seems important to reconsider the educational policy that has a place in artificial intelligence, the scope of its application, as well as the range of functions that can be transferred to intelligent machines without losing the traditional descriptive quality of education.

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REVOLUTIONIZING TOURIZM: THE ROLE OF BIG DATA AND AI IN INDUSTRY 4.0

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A B S T R A C T **In this article, we explore the integration of big data and AI technologies into the tourism industry, examining its role in enhancing market analysis, personalization, and revenue generation. We discuss the evolution of digital business ecosystems and the significance of advanced technologies in reshaping tourism. Through a comprehensive review, this paper highlights the impact of sophisticated technologies on consumer experiences and strategic marketing, providing insights into potential changes as increased profitability within the industry.**

K E Y W O R D S **Tourism industry, AI technologies, big data, market analyzation, personalization, consumer data analyzation, space-time data, industry 4.0, digital business, marketing, sales, revenue.**

INTRODUCTION

The ongoing improvement of geographical information field of knowledge widely opening doors for tourism industry to embrace the opportunities of high resolution technologies that is of a great help in space-time data analyzation concerning ever volatile desires of consumers, success of which bridges the way to seizing the chance of making higher profits.

AI-driven technologies are enhancing the ability of tourism businesses to personalize experiences and predict consumer behaviors, making data-driven decision-making more effective and precise.The integration of big data in the tourism industry is increasingly intertwined with artificial intelligence (AI), which plays a pivotal role in processing and analyzing the vast amounts of data generated by consumer interactions and travel trends. Big data's application in the tourism industry is projected to grow by over 20% annually through 2025 as companies increasingly rely on data-driven insights to optimize operations and enhance customer experiences[1].

Big data and AI implication and integration into tourism realm shifts the forms and types of services and commodities to be manufactured and provided. Tourism being a service sector is undergoing a insuperable upheaval due to the rapid pace of information technology and digitization, deals with consumer preferences which is designated being as a culprit for low incomes in the past, and meanwhile serving as a fetile ground for generating ever increasing profits for those who are well-informed about the essence and methods of efficient application of sophisticated technology. There are three stages of technological development in tourism. They are coprised of:
1.Sales and Marketing - The last 10 years of the 20th century, the emergence of the Internet allowed entire organizations business organizations included, to use it as a marketing tool. Digital shopping centers for consumers and their supporting software have simplified the internal management processes of small businesses. Web pages have put an end to the system of keeping paper marketing documents, and business transactions have become a little easier with the possibility of booking a product or service through web pages.
2. Digital business ecosystems - in the first decade of the 20th century, the Internet further strengthened its position as a large database for travelers. The continuous development of technologies has led to the emergence of virtual markets where products and services can be searched, their prices compared, and getting familiar with comments left by consumers and making purchase decisions reflecting on them is readily available and easily possible. The shift in focus from products to the traveler's emotions and experiences has fueled an increased interest by suppliers in connecting more closely with their customers' needs, wants and desires, age, tastes and preferences in general. During this period, various tourist service sites are created, they provide a number of conveniences to their users, and as a result, the number of people visiting traditional and usual tourist advisory centers is following a dwindling trend.
3. Systems Integration – From 2011 to now, cloud computing, mobile technologies, augmented and virtual reality tools, real-time geo-location, and high-level interoperability and inerrability of digital systems have made the connection between the physical and digital worlds possible. Social media platforms and Web 2.0 facilitating user-generated content have led to the creation of new innovative goods.

According to statistics from the World Economic Forums' predictions by 2025, daily 463 bytes of data are expected to be generated [1]. Data is an asset of the 21st century, and its proper use can help move all of humanity forward, says Jordan Morrow in his book on data analytics. So how can these assets be used in the tourism industry? Big data analytics, part of the 3rd stage, is the easiest way to prepare for an unexpected tourist flow in the tourism industry, to eliminate existing shortcomings, to predict the most favored and probable locations of travelers in advance, and to determine the needs and desires of visitors in general.

II.METHODS

This study considers the role of AI in big data analytics, where machine learning algorithms are utilized to identify patterns in consumer behavior, optimize pricing strategies, and forecast market trends with greater accuracy. AI techniques, such as natural language processing (NLP) are employed in sentiment analysis to monitor and manage brand reputation through social media platforms.

This review included an examination of industry reports, case studies, and academic literature. We focused on key areas such as revenue management, brand reputation control, strategic marketing, consumer experiences, and market analysis. The data was collected from various sources, including company reports, statistical analyses, and real-time data tracking tools. We employed both qualitative and quantitative approaches to assess the impact of big data on the tourism sector. The results were then interpreted within the context of existingtheoretical frameworks and industry trends.

III.RESULTS

Tourism is such a field that it is completely anthropogenic in nature. The purpose of tourism business is human-centered. It is known that nowadays business needs forecasting together with analytics. By monitoring and analyzing the impressions of travelers on their previous journeys on the Internet, predicting their next destinations, the likelihood of returning, and the needs that may arise is a feasible way to make business proposals and make the industry thrive at a faster pace. In addition, having a thorough understanding of the flow of tourists, their likely directions, the environment and conditions they are preparing for, will lead to the improvement of the quality indicator in tourism services, the successful satisfaction of needs and, of course as a result, higher income can be generated. Travel companies have reported cost savings of up to 15-20% by using big data analytics, particularly in areas such as dynamic pricing, resource management, and targeted marketing.

Big Data and AI technologies can be used for 5 purposes in the field of tourism. They are:

Revenue Management – it is common knowledge that goal of every manufacturer is to deliver the right product to the market, with high demand. In the field of tourism, in order to improve the financial situation, hotels, motels, rental places and other tourism companies should offer the goods and services that are in demand at the same time to the customers who have the needs at the prices they want. In performing this complex task, Big Data does not encounter any obstacles and shows the way to achieve the goal with maximum accuracy. Internal and external data are effectively used in the analysis process.

For example, internal information such as comments left by previous guests of the hotel and the number of stars given to it, its monthly income, the number of rooms booked in real time, local holidays in the area where the hotel is located, the location of the hotel to the center, are used to predict the potential choice of the traveler proximity and other similar external information is then evaluated and the probability of selection by the traveler is determined.

Brand Reputation Control - the Internet is a space for sharing advice and exchanging ideas, providing every traveler with information. Currently, there are official web pages of each tourist service organizations, mobile applications created for travelers to share their experiences, impressions and thoughts, to write down, to show the way for other travelers. The impressions left make it possible for a specific organization to get acquainted with the opinions of its customers about it and to take strategic action to eliminate problems and shortcomings accordingly. This information describes the organization's strengths and weaknesses. Travelers openly share their opinions about the country, organization, and product for other potential travelers and advise them to visit this or that tourist destination or buy a product, or vice versa.

Strategic marketing - Potential customers differ from each other in terms of personal desires, age, origin, customs, cultures along with tastes. These factors determine the sustainable development or decline of marketing in tourism. Big Data knows the similarities between tourists and the most optimal marketing opportunities. In addition, Big Data is useful in determining the real-time locations of tourists and predicting the type of demand they may have depending on the region. With its help, companies can send targeted and appropriate marketing messages based on space and time information and achieve their sales.

Consumer Experiences – The travel and tourism industry interacts with customers in a wide variety of ways. Each contact is new, necessary and useful information. All of them add up to improve the customer experience. Correctly used information determines which services travelers use the most, which organization, service or product is discussed the most, as well as their level of satisfaction and quality.

Market analysis - Big Data can also provide information about the advantages of competitors, the number and services they offer, the convenience they create for customers, and the innovations they introduce. A business organization familiar with the capabilities of competitors in the same field fills its gaps, strives to innovate, offer a completely new type of service, competes with price and quality and maintains its position.

Purpose		Company	Example	Impact on revenue(in billions for 2023y)
Big data and AI technologies applocation purposes in tourism sector	Revenue management	Delta Airlines	Dynamic Pricing	Increased revenue to $47
	Brand reputation control	Airbnb	Social Media Monitoring and Sentiment Analysis	Increased revenue by $12
	Strategic marketing	Hilton Hotels	Targeted Campaigns	Conversion rates $10
	Consumer experiences	Marriott International	Personalized Guest Experience	Boosted loyalty, $20
	Market analysis	TUI Group	Demand Forecasting	€18.5

Fig. 1. Impact of Big Data and AI technologies Applications on Revenue in the Tourism Sector (2023)

As an additional information it can be stated that the use of AI in conjunction with big data analytics has allowed companies like Delta Airlines to implement dynamic pricing models that adjust in real-time, significantly boosting revenue and through AI-powered predictive analytics, Marriott International has been able to tailor personalized guest experiences, enhancing customer loyalty and driving up revenue by $20 billion in 2023.

IV. DISCUSSION

Scrupulous data analysis that come with supporting industrial case examples suggest that the impact of big data and AI technologies on continuous thrive of tourism industry is vital. Here, it must be outlined that by 2030, travel activity is expected to increase by 85% from 2016 levels, largely driven by data-driven insights that allow companies to better understand and anticipate consumer needs[2]. This view is consolidated by the research of Du (2024), who explores the strategic importance of big data in driving local tourism development. The study argues that big data not only enhances the ability of tourism businesses to forecast demand and personalize marketing efforts but also supports local governments in making informed decisions about tourism infrastructure and policy[3]. Another aspect is researched in the paper A study conducted by the World Travel & Tourism Council (WTTC) and McKinsey & Company found that AI has the potential to significantly enhance the tourism sector by improving operational efficiency, personalizing customer experiences, and optimizing pricing strategies. The research identified that AI-driven personalization could increase revenue by up to 10% while reducing marketing and customer acquisition costs by as much as 20%[4]. A study by the European Travel Commission (ETC) revealed that AI technologies, particularly machine learning and natural language processing, have revolutionized customer service in the tourism industry. The research showed that AI-powered chat bots and virtual assistants improved customer satisfaction by 30% by providing instant, 24/7 support. These AI tools also reduced operational costs for travel agencies and hotels by automating up to 70% of customer inquiries, allowing human agents to focus on more complex tasks. Furthermore, AI-driven predictive analytics enabled companies to anticipate traveler needs and personalize services, leading to a 15% increase in customer retention rates.[5].

V. CONCLUSION

As AI continues to evolve, its integration with big data analytics will be crucial for the tourism industry, enabling businesses to innovate and remain competitive in a rapidly changing digital landscape AI and Big Data technologies are useful for national tourism organizations, service providers and of course travelers alike. Effective use of them for the above-mentioned purposes can be implemented by organizing tourist information centers, which are being established to help to form and distribute its tourist information and develop not only domestic, but international tourism in our country. The combination of AI and big data not only improves operational efficiency but also opens up new possibilities for creating more personalized and engaging travel experiences.

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OPTIMAL SOLUTIONS FOR DETERMINING THE DISTANCE TO AN OBJECT IN AN AUTONOMOUS MOBILE DEVICE FOR PEOPLE WITH DISABILITIES

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A B S T R A C T **This article describes an analysis of methods for measuring the distance to obstacles and objects for a device that helps people with disabilities move independently inside the house and find the necessary objects, as well as the results of the process of selecting the most optimal method for this device. The article also presents the results of an analysis of the capabilities of the methods used for this purpose.**

K E Y W O R D S LiDAR device, stereo cameras, laser lights, disparity difference.

INTRODUCTION

It is known that today many modern technologies are widely used in the lifestyle of people with disabilities to increase their level of independence. With the help of such technologies, people with disabilities can move independently and even perform certain tasks. In particular, since the level of independence of people with visual impairments in everyday life is limited, the development of various devices and gadgets using modern technologies, especially the capabilities of neural networks, is considered a more pressing issue for such people with disabilities. Many scientific studies have been conducted for this purpose, and today it is considered relevant to conduct new scientific studies in order to further increase the level of independence of such people in everyday life, to develop devices that allow them to perform important tasks in everyday life.

LITERATURE REVIEW

As mentioned above, many scientific studies have been conducted to develop devices that create additional opportunities for people with disabilities. In particular, the work (1) considered the possibilities of making the conditions of the "Smart Home" more convenient for people with disabilities through the use of currently available modern communication technologies in the "Smart Home" systems. This work considers the issue of further improving the control of the "Smart Home" system through the Android system based on Blynk technology and the Raspberry Pi Model B platform. References (3) consider the possibilities of using machine learning to make the "Smart Home" systems accessible to people with disabilities. Also, the work (4) considered the possibilities of using the neural network architecture "RNN-recurrent neural networks" to provide additional opportunities for residents with disabilities in the "Smart Home" system. The following work (5) proposes a design for a device for free movement in areas for the blind. In the proposed device, the presence of obstacles when blind people move is detected using sensors (for example, an ultrasonic sensor). If the distance to the obstacle approaches 2 meters, the camera takes an image of the object considered to be this obstacle, classifies it using the Yolo v5 algorithm and passes it through identification, and also informs the user about the bypass of the object using a sound signal. The following work (6) discusses methods and modules for high-precision object detection based on deep neural networks for independent movement of blind people. Also, the work (7) proposes a design for a wearable device for the blind based on a neural network with a CNN architecture, with the help of which a blind person can independently move along the street. The following work (8) describes the results of research on the use of LiDar technology in detecting objects and measuring the distance to them for unmanned vehicles.

METHODS

As a result of the analysis of the above-mentioned scientific studies, it can be concluded that today there is a lot of scientific research considering the issues of identifying surrounding objects and measuring the distance to them for systems that provide autonomous movement. In particular, many scientific studies have been conducted and are ongoing aimed at developing solutions that allow unmanned moving vehicles and blind people to move independently. However, it is necessary to conduct scientific research and offer effective solutions to develop optimal solutions in the lifestyle of people with visual impairments to increase their level of independence. In particular, it should be taken into account that blind people spend most of their daily lives at home. Now it is necessary to develop solutions that ensure not only their independence in moving around the house, but also the ability to independently perform other small but very important work movements. Most of the peer-reviewed research papers proposed solutions to the problems of identifying various obstacles to independent movement and indicating the direction to bypass them. For example, for a blind person, finding the things he needs in the house is quite a difficult task. Therefore, developing a device that can be used as an assistant in performing this task will allow such people to further increase their independence in everyday life. When developing such a device, determining the distance to an object is considered a very important issue. This article draws conclusions based on analytical and experimental research methods. This work highlights existing methods for measuring the distance to an object in a device that allows you to determine the desired objects in the residential area of blind people and the distance to this object, the theoretical foundations of the principles of their operation. Also in such a device, the method of using stereo cameras is chosen as the most optimal method for determining the distance to an object. The Jetson Nano B01 microcomputer, the IMX21-83 stereo camera are used to obtain the results of experimental studies on determining the distance to an object when using a stereo camera.

RESULTS

Today, there are many methods that can be used to measure the distance to the observed object. These methods include measurement methods using ultrasonic sensors, LiDAR technology, and stereo cameras. Methods for measuring the distance to the observed object on mobile devices include LiDAR technology and methods using stereo cameras. We will consider the possibilities of using these two methods to determine the distance to the observed object on a device that helps blind people in everyday life. Using the ultrasonic measurement method is an undesirable solution for this device due to the high probability of error in the process of measuring the distance. The reason is that with the ultrasonic measurement method, the electromagnetic wave in the ultrasonic range is reflected not from the observed object, but from another object in the field of view, which may result in a measurement error.

LiDAR (Light Detection and Rendering) technology is a technology based on the use of pulsed laser radiation to measure the distance to an object. The principle of LiDAR is based on the calculation of the time it takes for the pulsed radiation of the laser beam to reflect back from the object and reach the optical receiver installed near the transmitter (Fig.1). The main components of the LiDAR device are [8]:

- The laser transmitter generates short-pulse radiation in a given direction.
- Scanning mechanism. It ensures the distribution of laser radiation over the required field of view. This can be a mechanical rotating mechanism.
- The sensor receiving laser radiation receives the pulsed radiation returned by the object and converts it into a suitable electrical signal.
- Signal processing device. It calculates the distance to the object based on the return time of the pulse signal from the object.

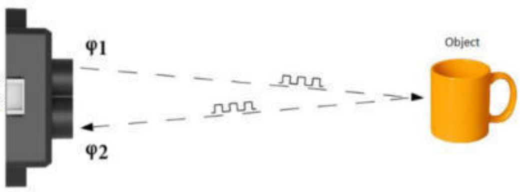

Fig.1. Operating principle of LiDAR technology

$$D = \frac{c}{2}\frac{1}{2\pi f}\Delta\varphi \qquad (1)$$

Here:

D – Distance to object

c – speed of light

f – scanning frequency

Δφ – phase shift

Although the accuracy of measurements using LiDar technology in determining the distance to an object is high, the integration of this method with other systems is considered very difficult. The optimal method for the designed device may be the use of a stereo camera, with which it is possible to measure the distance to the observed object. For this purpose, a research stand based on the Nvidia Jetson Nano B01 microcomputer equipped with an IMX219-83 stereo camera was used in the work (Fig. 2).

Fig. 2. Research stand based on the Nvidia Jetson Nano B01 microcomputer, equipped with an IMX219-83 stereo camera

When determining the distance to an object using a stereo camera, the following are used:

- A research stand equipped with an IMX219-83 stereo camera;
- A chessboard template;
- A rangefinder.

Measuring the distance to an observed object from a stereo image obtained from a stereo camera involves several stages. In this method, measuring the distance to an object is based on detecting disparity between images obtained from two cameras. The process is carried out in the following sequence:

- The imx219-83 stereo camera is checked for proper installation using the appropriate command. Make sure that both cameras are recognized by the system.
- To enable Jetson nano to process images, the OpenCV library with CUDA support is checked for proper installation using the appropriate command.
- In the Python compiler, an image is captured from both cameras of the module using the OpenCV library using a script with the appropriate code.
- The stereo camera calibration process is performed. To improve the accuracy of distance measurement using the stereo camera, both cameras must undergo the calibration process. A checkerboard pattern is used to calibrate the cameras. The OpenCV library has a special function for calibrating cameras. To do this, several images are captured from both cameras. Using

these images, the camera calibration parameters are determined.

- After both cameras have undergone the calibration process, a disparity map is calculated for each pair of matching images from the left and right cameras. This process determines how objects (cells) in one image are located in different coordinates in images taken from both cameras. Each pixel in the disparity map stores information about how many pixels the corresponding pixels in the object images taken from the left and right cameras have shifted along the OX axis. To calculate the disparity map, the OpenCV library uses the StereoSGBM method. In this case, the SGBM algorithm is used.
- The next step is the process of calculating the distance to the observed object. The distance calculation is based on the information specified in the disparity map.

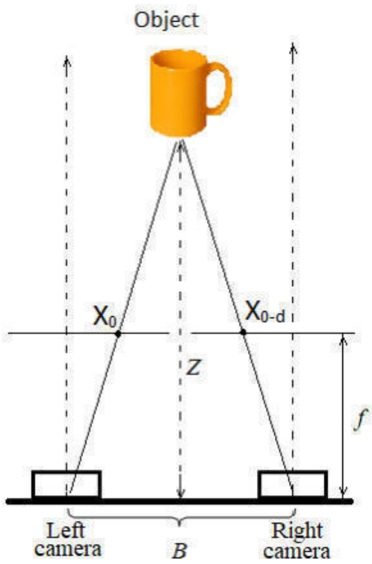

Fig. 3. Calculation of the distance to the object based on the disparity map data

$$Z = \frac{f \times B}{d} \qquad (2)$$

Here:

Z - distance to the object.

f -focal length of the camera (from calibration).

B - baseline (distance between two cameras).

d - disparity (difference in the position of the object in the images from both cameras).

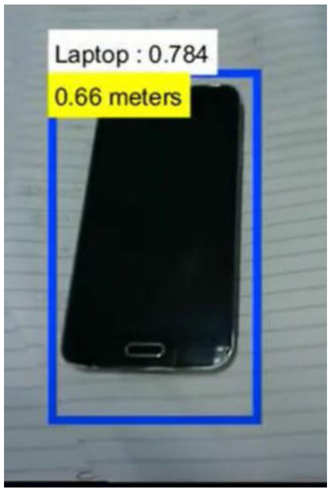

Fig.4. The distance to the object is displayed as follows

The method of determining the distance to the observed object based on a stereo image obtained by a stereo camera may be natural for the designed device, since it does not have a constantly moving mechanism and does not require a large amount of electricity for laser radiation, as is the case with the LiDAR sensor. However, it should be noted that the measurement of accuracy when measuring the distance to the observed object based on a stereo image obtained by a stereo camera is directly proportional to the proportional base between the cameras (Fig. 5). That is, the larger the size of the stereo camera base, the higher the accuracy of measuring the distance to the nearest object. But an increase in the stereo camera base leads to an increase in the dimensions of the final device.

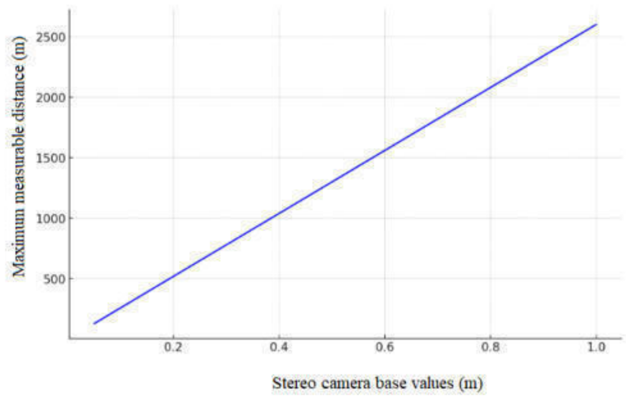

Fig. 5. Graph of the dependence of the maximum value of the distance measurement to an object based on a stereo image obtained from a stereo camera on the stereo camera base

DISCUSSION

Based on the above analysis and research results, it can be noted that when designing a device that helps blind people find the necessary objects in everyday life, several methods for measuring the distance to the observed object can be used.

This paper considered the use of LiDar technology and methods for measuring the distance to an object based on a stereo image obtained using a stereo camera. Both methods have their advantages and disadvantages.

LiDar technology has high measurement accuracy. With this method, measurements can be made with an accuracy of up to several mm. The measurement accuracy with the stereo camera measurement method depends on the distance between the cameras, on how far the object is from the line connecting the centers of the stereo camera cameras. Also, the level of illumination of the room significantly affects the accuracy of measurements using a stereo camera.

In terms of the complexity and cost of the method used, the method of measuring the distance to an object using stereo cameras is considered an effective method. This is due to the fact that LiDar technology uses complex elements, and their integration into a specific system is considered a very complex process. The use of stereo cameras is a relatively inexpensive solution, and their integration into the system is a simple process. But complex algorithms are used to calculate the distance to the observed object based on the difference in disparity of stereo images.

CONCLUSION

Having considered several methods by which you can determine the distance to the observed object, you can draw the following conclusions:

- In such projects, the requirements for measurement accuracy are not very high. This is due to the fact that indicating the distance to the desired object to a blind person with an error of several centimeters does not cause a serious problem in finding the object.
- The price of the designed device should not be too high. Because users of such devices can belong to different social classes.
- The autonomy of the device should be high. Since such gadgets are powered by an autonomous power source, their need for electricity should not be high.

Based on the above requirements, it can be noted that the method of using stereo cameras to measure the distance to the observed object is an effective solution for such devices being designed. Because stereo cameras do not have a constantly rotating mechanical scanning system, as in the LiDAR device, and this leads to lower power consumption. As mentioned above, using stereo cameras is a cheap solution. Therefore, the optimal solution may be a method of measuring the distance to the object using stereo cameras.

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ACTUAL TASKS OF INTELLECTUALIZING THE SEARCH FOR SCIENTIFIC INFORMATION

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A B S T R A C T **The article substantiates the relevance of research on the use of AI for scientific and educational information search systems. The results of research on the creation of the integrated intelligent system for information retrieval in an electronic library are given. The purpose of the research is to develop applied methods for the intellectualization of data retrieval in library systems, through the integration of various subsystems for data processing, evaluation, and output.**

K E Y W O R D S Artificial intelligent, database, digital library, scientific information

INTRODUCTION

The relevance of research in the field of scientific and educational information search and the need to use artificial intelligence (AI) methods and tools is determined by the following reasons [1]:

- Up-to-date scientific and educational information is the main source of new knowledge and scientific and technological progress. Accordingly, the speed of information retrieval significantly affects the development of society as a whole;
- The volume of scientific and educational information is growing and is almost doubling every year;
- The importance of access to valuable information resources for the development of not only science and education, but also the economy and society as a whole is increasing every year, because it is scientific and technical solutions that influence progress in all areas of activity;
- Traditional methods of information retrieval have exhausted themselves. Using only classical methods that require a lot of time to process information and big volume of memory doesn't give the expected results;
- There is an urgent need for prompt decision-making in the event of various situations, both in information processing and in solving management problems due to their complexity and the large volume of information being processed;
- Significant progress in the development of AI methods and systems gives hope that their use will significantly reduce the time needed to data search for scientific research and educational activities.

The report (Library Technology Reports) of the American Library Association (ALA) provides an analysis of the state and trends in the development of AI in information and library activities [2]. Specialists, mainly librarians who actively use advanced technologies in libraries, believe that in the near future this activity may change significantly due to the implementation of AI systems and machine learning. The authors argue that AI systems will become commonplace in the formation and use of information resources and they will have a huge impact on information and library activities.

There are a number of difficult-to-formalize processes and functions in information systems [2] that require the direct participation of human intelligence:

- Evaluation of existing information resources, evaluation of information extracted;
- Understanding the nature of information needs and defining this need for the system;
- Identification of information resources that are relevant to information needs;
- Organization of existing information resources, also organization of selected information from extracted elements;
- Management of existing information resources, also management of extracted information;
- Prompt search and selection of information resources, use of extracted information;
- Analysis of information and knowledge;
- Transformation of information into knowledge, with the formation of semantic relationships between data units ("knowledge bricks";
- Dissemination and transfer of information and knowledge;
- Interaction and exchange of information and knowledge.

The above tasks require close study and formalization. We hope that the use of AI methods will allow in the near future to automate these processes, which were performed only by humans. Although nowadays it is a time of rapid development of global and corporate information networks and systems, but still the most reliable information is in libraries, library networks and databases. Therefore, it is important to develop methods and means of intellectualization for information and library systems.

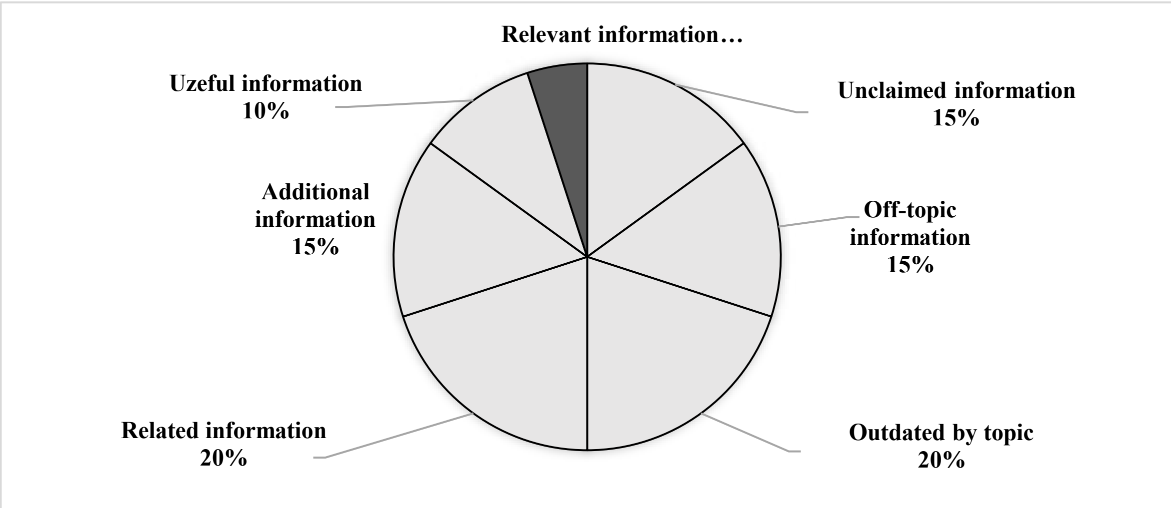
METHODS

The experience of Library and Information Systems(LIS) development has shown that if we limit ourselves to solving standard tasks and creating traditional subsystems related only to library processes, it is not possible to get the desired results. It is necessary to actively use various methods and systems of image recognition, voice, search intellectualization methods, even geoinformation systems.

The purpose of the research is to develop applied methods for the intellectualization of information retrieval in LIS, through the integration of various subsystems for data processing, evaluation, recognition and output.

For scientific research and the educational process, it is very important to use effective means and methods of searching, storing and using scientific and educational resources. The survey conducted among researchers-readers of the National Library of Uzbekistan showed that there are big problems in finding and storing scientific and educational information on the personal computers. To the question: "What proportion of the data stored by your PC is in the following categories: Unclaimed information. Off-topic information, Outdated by topic, Related information, Additional information, Useful information, Relevant information the following answers were received (Fig.1).

That is, we use only 5% accumulated over a certain period of time as the most important and frequently used information for our scientific research and educational process. An important task is to increase the efficiency of searching for the necessary scientific and educational information, including various aspects such as the speed of information search, analysis of the correct formulation of queries, assessment of the importance of the resource, as well as the amount of useful information.



Pic.1 Proportion of the data stored by user's PC

Research is conducted at the Tashkent University of Information Technology (TUIT) by different departments (Information and Library systems, Artificial Intelligence, Computer Systems, etc.). Moreover, initially the applied purpose of each subsystem was different. The integration of subsystems allows for a certain synergistic effect [4].

The integrated system includes subsystems (functions):

- F1. Speech recognition function (in different languages, including Uzbek) and the conversion of a speech command into a text format. The result is obtained in the form of a request file for subsequent processing. This feature reduces the time for entering queries to search for bibliographic records and output the source of information itself.;
- F2. The function of searching for information on request in electronic libraries. This function is a traditional one used in LIS. It conducts a search in the electronic catalog at the user's request (keywords, author, name of the source and other indicators). It is performed both by F1 output data and when entering data in text form;
- F3. Image recognition function for the purpose of identifying the user of information resources. To implement the function, a user database is created, which includes the user's ID, area of interest, previous requests and data on received resources and other data. This function allows to recommend a particular literature to the user, based on the identification of the user's face based on the request history;
- F4. The function of analyzing the information needs of users depending on the level of competence and type of activity. This function is a continuation of the previous function. Depending on the user's category (scientist, student, engineer, teacher, etc.), the subsystem recommends an appropriate source of information;
- F5. The function of evaluating the source of information. It is necessary to identify the most significant sources for the user. Since several sources with different "weights" can be selected for the same request , the function analyzes the source according to several criteria (frequency of use, popularity of the author, year of publication, etc.);
- F6. Geoinformation systems for solving problems of the location of an object (library) as a source of information. Creating a database of coordinates of information sources in corporate networks allows you to determine the location of the library, where you can find a particular source of information.

RESULTS

At each stage of processing and forming a request and obtaining the necessary information, the system gives a certain result: 1) reducing the time to search for information; 2) increasing the level of reliability of the result (matching the response to the request); 3) completeness of the result (more choice from the proposed list of information sources). 4) determining the location of the object (source of information), etc. 5) improving the quality of the required information in the database due to its objective and subjective assessment, taking into account user categories. The work of the subsystem "Evaluation of the source of information" is important. The effectiveness of this function is manifested when it is necessary to process a fairly large amount of information and we get a lot of results per request (references). Integration with other subsystems makes it possible to identify the most valuable sources of information from the available database, which improves the quality of data search [4-5].

DISCUSSION

Creating an integrated system requires solving several tasks: Development of the functional structure of the System; Creation of a unified information model of the System, including data classification, metadata structure for various subsystems; Formation of a unified database and knowledge base; Sequential integration of individual modules; Formation of the software core of the System with integrated modules and databases; Development of versions of the System 1) for educational purposes; 2) for solving applied problems; Creation of a bench model of the System to demonstrate its capabilities and educational goals.

Certain problems arise when applying AI systems in libraries: 1) appropriate training is required, because AI methods are significantly different from traditional ones. 2) It is necessary to change the training programs in educational institutions of the appropriate profile, with the inclusion of disciplines on AI, knowledge bases, BigData, semantic and data mining, etc. 3) great difficulties arise when integrating the AI system with existing traditional LIS systems.

CONCLUSION

The main areas of research remain: request processing not only in the form of keywords, but also in the form of texts (sentences), the development of methods for semantic analysis of search requests, the development of a geoinformation system to clarify the location of the source of information, etc. The implementation of the System will allow solving not only the tasks of optimizing information services in libraries and library corporate networks, but also training highly qualified personnel in the development of AI systems and their application in solving important applied tasks of searching and processing scientific and educational information.

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INTELLIGENT ALGORITHMS TO IDENTIFY CONGESTION IN TRAFFIC UTILIZING VIDEO DATA

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Abstract — Today's urban infrastructure is developing, making traffic congestion reduction one of the most pressing challenges. One of the most efficient strategies to avoid traffic bottlenecks is to know whether they exist or are expected to arise in the near future. One of the primary goals of the research is to collect data to detect the presence of traffic jams or the likelihood of their occurrence in the future, and then use this data to construct prediction algorithms utilizing machine learning and deep learning [1]. In this study, a dataset was initially built utilizing video image data and the YOLO (You Only Look Once) model to predict road traffic. Because the primary purpose of the research is to anticipate the state of traffic on roadways over time, only time-related parameters were included in the data set. In the following stage, traffic conditions were forecasted using artificial intelligence techniques such as XGBoost, Random Forest Classifier, and Logistic Regression, and the results were validated using Accuracy, Recall, Precision, and F1 Score.

Keywords— Traffic forecast, XGBoost, Random Forest Classifier, Logistic Regression, YOLO, Accuracy, Recall, Precision, F1 Score..

The demands on urban infrastructure and transportation networks have grown greater in the age of contemporary technology, as has the trend of global urbanization. Traffic bottlenecks on city streets not only irritate cars and passengers, but they also result in economic losses, environmental issues, and waste of time [2]. Predicting traffic congestion in advance is critical for efficiently addressing these issues. This procedure allows for forecasting of future traffic conditions, optimization of the city's transportation system, effective traffic management, and the provision of reliable passenger information. Furthermore, traffic congestion prediction is critical in urban infrastructure development and disaster preparedness.

Calculating the amount of vehicles using images gathered from video data.

It is critical to know their number while analyzing traffic flow management and road transportation systems. It contributes to better traffic flow management, less congestion, and increased road safety. One of the most successful approaches for counting vehicles today is to use photos from video data [3]. Computer vision and machine learning technologies are commonly employed to count the number of vehicles. One of the most effective of these technologies is the YOLO object recognition paradigm. A dataset was developed from camera data for traffic prediction. Because the study's primary purpose is to anticipate the time-dependent behavior of road traffic, fields such as the number of automobiles, motorbikes, buses, trucks, and total number of vehicles were excluded [4]. Traffic conditions on the roadways were anticipated using artificial intelligence techniques such as XGBoost, Random Forest Classifier, and Logistic Regression, which used month, day of the week, hour, minute, and AM/PM characteristics. The obtained results were verified by evaluation procedures.

XGBoost model

The primary purpose of gradient boosting is to construct a strong model from numerous basic and weak models (often decision trees). The updated XGBoost model employs a second-order Taylor series to simplify and reduce overfitting [5]. The XGBoost model is a sophisticated gradient boosting approach that creates new trees at each iteration using a quadratic extension of the loss function while reducing the objective function.

Road traffic forecasting with XGBOOST

To estimate traffic congestion based on XGBOOST, first build a dataset for prediction.

Data preparation. It is defined as the process of transforming data into the proper format for input into the model. This method is essential for model training and evaluation.

Data cleaning and processing. Generate clean and accurate data collections. This includes working with missing values (filling and deleting), incorrect values (detection, correction and deletion), identifying and deleting duplicate rows, and data processing (properties such as selection, categorical data conversion to numerical data, and data normalization or standardization).

Following are the steps involved in estimating road traffic congestion, which include the following processes:

- Data collection
- Data cleaning
- Data preparation
- Model training
- Model evaluation
- Reporting final results.

The algorithm modifies and estimates the beta (β) parameter in order to identify the ideal parameters and increase model accuracy.

Assessment of a Congestion Prediction Model on Roads

Evaluating the effectiveness of a forecasting model allows you to understand what outcomes it generates and how dependable those predictions are. Several measures are used to assess forecasting models. Here are some of these measures and how to compute them. The tables below show the results from the XGBoost, Random Forest Classifier, and Logistic Regression algorithms used to predict traffic conditions on the route [6].

Accuracy

Accuracy is the ratio of the number of cases predicted properly by the model to the total number of predictions.

$$\text{Accuracy}=\frac{\text{TP}+\text{TN}}{\text{TP}+\text{TN}+\text{FP}+\text{FN}} \quad (1)$$

Accuracy is the percentage of correct forecasts to total predictions. If the model predicts all classes well with an equal distribution, then the accuracy measure is effective.

Recall

The proportion of true positives accurately predicted by the recall model to all true positives.

$$\text{Recall}=\frac{\text{TP}}{\text{TP}+\text{FN}} \quad (2)$$

Recall measures how successfully the model detects all true positives..

Precision

Accuracy is the ratio between the number of true positive cases properly predicted by the model and all positive forecasts [8].

$$\text{P}recision=\frac{\text{TP}}{\text{TP}+\text{FP}} \quad (3)$$

Precision indicates how accurately the model predicts positive cases.

F1 Score

The F1 score represents the harmonic mean of accuracy and total coverage.

$$\text{F1}\,Score=2\times\frac{\text{Precision}\times\text{Recall}}{\text{Precision}+\text{Recal}} \quad (4)$$

The F1 score is especially relevant in circumstances where the data is not equal since it balances accuracy and completeness [7].

RESULTS

The traffic prediction study made use of the Traffic Prediction Dataset, an open data collection available at https://www.kaggle.com. This data set contains 2977 data points, and experiments were conducted using an 80/20 split between training and test sets. Before sending the data to the prediction model, the study's fields of interest were identified. The primary purpose of this study was to investigate the time dependency of traffic congestion on the road [8]. In the following stages of the study, XGBoost, Random Forest Classifier, and Logistic Regression models were trained and tested using the selected fields. These artificial intelligence models were tested using the accuracy, recall, precision, and F1 score assessment techniques. Figure 1 shows the study's outcomes.

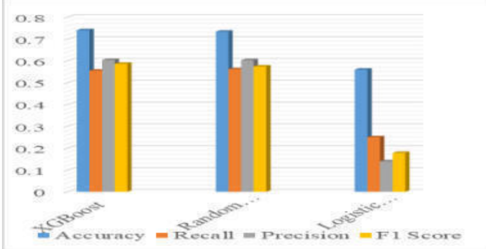

Figure 1. *The results of artificial intelligence models employed in road traffic estimation.*

When the XGBoost algorithm's outcomes were examined using Accuracy, Recall, Precision, and F1 Score, the right strategy produced indicators of 74.1%, 55.5%, 60.4%, and 58.7%, respectively. The Random Forest Classifier algorithm, which produced the second best result, had an average result of less than 1% of the indicators of the XGBoost technique. In any study, a 1% improvement is a good indicator. As a result, the XGBoost algorithm can be considered the best method in this investigation.

CONCLUSION

Today, the time has come to reduce traffic congestion on city streets and therefore accomplish some economic and social efficiency. There are various new approaches to dealing with traffic bottlenecks, one of which is to predict traffic delays using camera data. In this study, a dataset was first generated from video image data using the YOLO object detection algorithm, then divided into training and test sets in an 80/20 ratio. Because the primary goal of the research is to predict traffic conditions in a time-dependent way, only time unit metrics are included in this data collection. The traffic situation on the road was then anticipated using artificial intelligence prediction algorithms such as XGBoost, Random Forest Classifier, and Logistic Regression, and the results were validated using assessment methods such as Accuracy, Recall, Precision, and F1. As a consequence, when compared to other algorithms for predicting road traffic, the XGBoost algorithm produced the highest effective indication (0.741).

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THE MAIN COMPONENTS OF "SMART FARM" FARMS WITH ADVANCED TECHNOLOGY

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This article examines the impact of smart farming technologies on livestock management, focusing on the implementation of an automated management information system. By leveraging IoT devices, sensors, and RFID systems, the system streamlines farm operations, reduces costs, and enhances product quality. Using the IDEF0 methodology, we model farm processes and design a robust communication infrastructure and databases to support real-time decision-making. The findings highlight significant improvements in efficiency, animal welfare, and overall productivity, demonstrating the critical role of smart technologies in the future of sustainable livestock farming.

IDEF0 Methodology, RFID Technology, Smart Livestock Farming, IoT, Automated Management Systems

INTRODUCTION

The rapid advancement of technology is transforming traditional farming practices, paving the way for a new era in agriculture—smart livestock farming. In this context, the integration of advanced technologies such as Internet of Things (IoT) devices, sensors, and automated information systems is revolutionizing the management of livestock farms. The primary objective of these innovations is to reduce operational costs while significantly enhancing the quality and efficiency of product outputs, particularly in dairy and meat production. At the core of smart livestock farming is the development of an automated management information system. This system is designed to streamline the complex processes involved in farm operations, from herd management to health monitoring, by leveraging cutting-edge technologies. Through precise data collection and analysis, farmers can make informed decisions that optimize productivity and animal welfare.

This article delves into the essential components of smart livestock farming, focusing on the implementation of sensor technologies, the establishment of robust communication infrastructures, and the design of comprehensive databases. By examining the practical applications and benefits of these technologies, we aim to highlight how smart farming can lead to more sustainable and profitable livestock operations.

The main goal of building an automated management information system of livestock farming activities is to reduce farm costs and help increase the production of quality products. Modeling its business process is an important link in the design of an information system. Now that modeling through the IDEF0 methodology is popular and understandable to stakeholders, we will focus on the methodology itself. IDEF0 business process has 3 inputs and 1 output (Fig.1.) [1]. In particular, various documents, norms, and clearly immutable legalities and information sets describing the actions in the process of higher inputs in the subject area of the farm; objects that do not change their state during the process, such as people, sensors and external systems; the right-hand side entrances include basic material resources such as animal information, records, journals, feed and breeding. Also, in the process, results such as decisions, prediction indicators and reports are generated from the input parameters [2, 3, 4].

The given diagram describes the general process in the system, which includes identification and localization of objects; herd management; cattle care; diagnosis of diseases; product production management; optimal ration management; consists of several functional management units such as breeding management

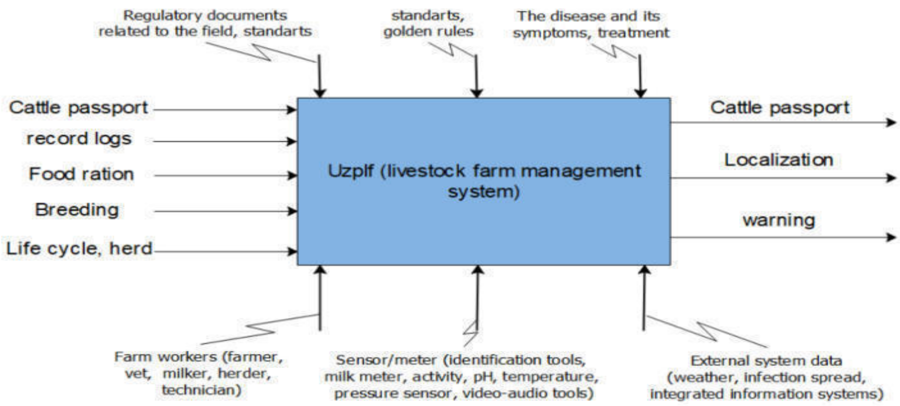

Fig. 1. *Head diagram of farm information flow management*

As a result of research conducted on the issue of construction of "Smart Cattle" farmers' activities, it can be said that initially, the intended platform consists of these main components [6]: identification of advanced sensor technologies related to farm activities; creation of communication infrastructure of advanced technologies and management of information flow in it; database design; creation of functional user roles and interfaces;

As a result of these tasks, it is possible to obtain the maximum product (such as milk, meat) at a low cost in farm activities, help in making decisions, and automate management. Now we will look at the solution of the presented issues in an extended manner.

Advanced technologies. Advanced technologies such as targets equipped with various sensors, IoT devices, actuaries, audio and video devices are used in the organization of the "Smart Cattle" complex. Key elements of PLF are mainly electronic wearable/implantable devices, such as IoT collars and anklets that record each animal's activity; chewing activity and ruminal parameters recording targets; thermal cameras for video surveillance and temperature detection; gastric pH gas detection boluses; includes RFID tools for identification and other sensor targets for detecting disease symptoms [6]. These sensors are widely used alone or in combination with entrance doors, feeding, drinking and milking devices.

The communication infrastructure of the "Smart Cattle" complex and the flow of information in it. In order to form an information flow in a livestock farm, it is necessary to first identify the objects that make up it and the subjects that influence these objects. It is known that the successful creation of a purposeful work process information system depends first of all on the correct description of the information flow. So, it is necessary to build the flow of information in such a way that it forms a coherent sequence of information consisting of objects and natural or artificial events in them. The object, subject and phenomena affecting them in the farm are detailed in [5]. The communication infrastructure describes the interaction of network nodes such as farm data sources and their intermediate transmitters, data processors and consumers (Fig. 2). Network nodes include advanced technologies such as mobile targets, riders, local and global tracking servers, and user mobile devices. Cattle with RFID tags, which change their places on the farm according to the agenda, are also considered as targets. In the farm, the milking hall, the hospital and the clinic are included in the communication area. Now, the tasks of network nodes in these areas will be briefly discussed. Stationary RFID readers with multi-antennas are installed on the sides of the warehouse, and they are connected to the network with cables. These time series RFID readers are used for tracking and locating cattle. The local computing server performs the tasks of activating and stopping the reader, managing the algorithmic software packages that process the data received from it, and managing the exchange of information to the central server. The clinic is a facility for the treatment of sick cattle, insemination, medical examination, calving and maternal and child health services, which uses a mobile RFID reader and mobile thermal cameras connected to a wireless network.

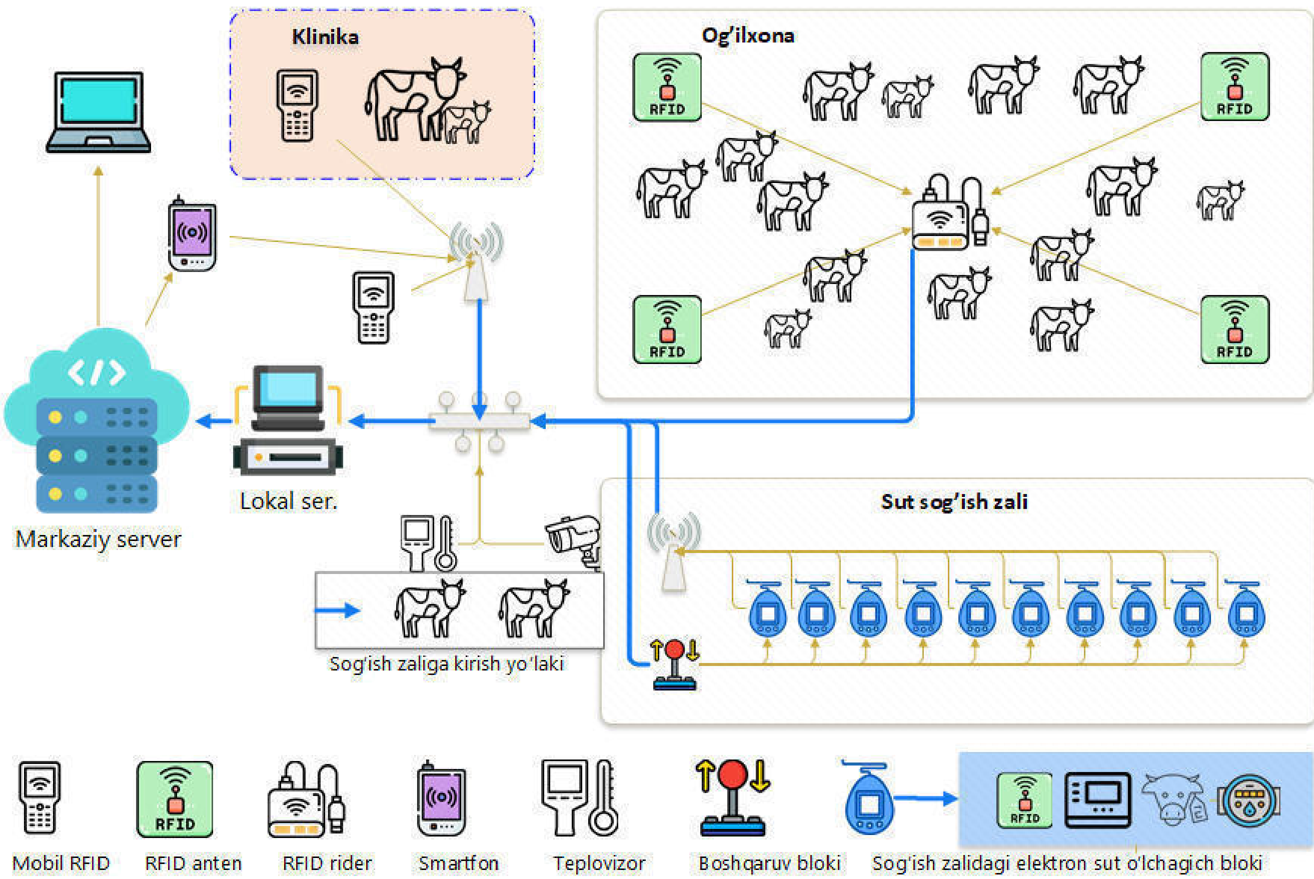

Fig. 2. Communication infrastructure of the "Smart Farm" complex

In terms of the number and complexity of the targets in the regions, the milking hall is considered. The most important thing for a farm is milk yield and milk health. Therefore, a thermal imager to determine the temperature of the udder and a camera to assess the external appearance of the cows are installed in the hall. The milking booths are equipped with individual milk measuring devices and their "control unit" device, as well as stationary multi-antenna RFID reader in each corner of the hall. Stationary RFID readers are placed in buildings according to the radius of the reading distance. For example, RFID antennas with a radius of 10-20 meters (at least 4), 30-50 meters (at least 2), and entrance doors with a radius of 1-5 meters are placed in nursing homes. It is known that RFID devices work in low (LF), high (HF) and ultra high frequency (UHF) modes, and there are separate standards for them (such as ISO 14443, ISO 15693, ISO 18000-3, EPC Class1 Gen2). So, in order for the tag and the rider to support each other, their standards and frequencies should be compatible. Then, tag information (such as time series, object motion, or mechanical reading) is predefined from the rider's setup. Communication with the rider to the computer is carried out via interfaces such as WiFi, RS232, USB, Ethernet. Special system drivers are needed to write the information in the reader to the computer, and these drivers present the information in the form of a signal in the form of open information that the machine can understand. For example, the driver information format is files such as XML, CSV, TXT, XLS, and special software is used to process them on the server.

Now, the process of managing the information flow between the target, rider, terminal and computing nodes according to the given infrastructure is considered (Fig. 3). The RFID reader is activated through a special software package on the computer and emits an RF signal in its radius. This RF signal activates passive RFID tags and returns the game's unique ID number to the rider. The tag ID number detected by the reader, the antenna number read, and the RF signal strength value are returned to the computer. In the infrastructure, the information flow in relation to the RFID tool is mainly divided into 3 groups: for individual animals, herd inverterization and milking hall.

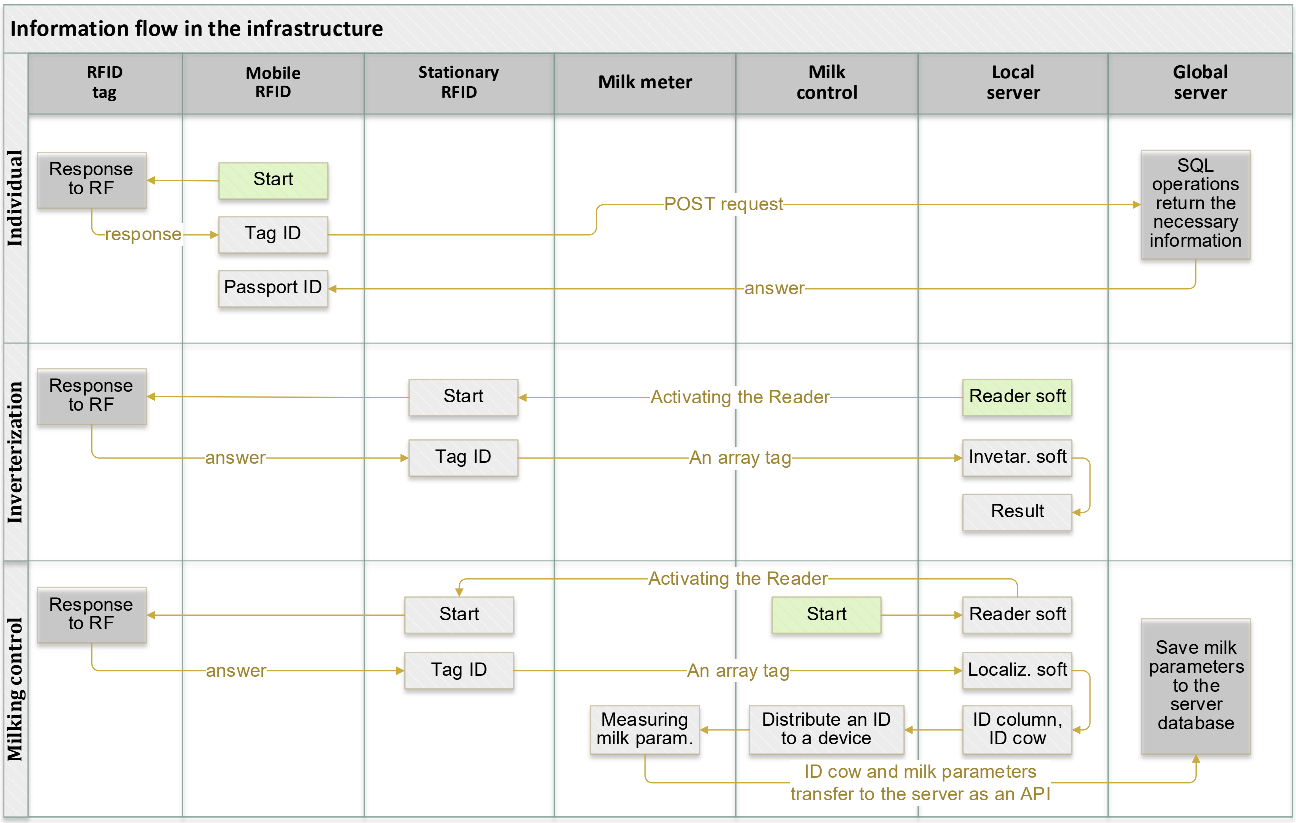

Fig. 3. *Information flow in the "Smart Farm" complex*

In any area of the farm, especially in the clinic, the task of individual identification of cattle and working with their medical records is carried out by a mobile RFID reader. It transmits the ID number of the tag detected by the mobile rider to the server, as a result of which the server receives the reference of this animal. Some mobile riders are equipped with a special veterinary application that synchronizes with the local and global server database, where it is possible to combine cattle and work with passport data. In order to invert the cattle in the barn or pasture, the RFID installed on it is activated from the local computer. The tag parameters returned from the reader to the computer are transmitted to the inverter or localization software. After the cows are placed in the milking booths, as soon as the milking start button is pressed, the "milk meter management" tool is also activated. The control unit activates the RFID readers over the wireless network, identifies the cow ID number in the stalls, and transmits this information to the individual milk measuring device in the stalls, completing the communication. The milk meter tool detects the current milk parameters and sends this data to the server via a wireless network. If the milker notices any symptoms or suspicions of a disease such as mastitis in the cow, this message is also entered through this milk measuring device. Data reading from sensor/tags is done at any or specific time interval and in extreme case. Networked climate sensors will be installed in all buildings. Passive RFID ear tags are placed on all types of cattle (born, imported), and pedometers are temporarily attached to cattle that are close to calving.

Database. The database, which is the basis of the voluntary information system, is developed according to the information flow. Cattle passport is at the center of information flow on farm activities, and almost all information is connected to it. The following are the main data objects in the work: cattle passport (ID, breed, name, bioparameters), veterinarian and zootechnical staff, veterinarian-related vaccination, disease symptoms, cattle disease, treatment, diagnostic samples, insemination and its results , zootechnical ration and feed standards, microclimate, milk productivity indicators and standards, herd and period exchange, identification tools, etc. The summary of databases on the issue under consideration is shown in Fig. 4.

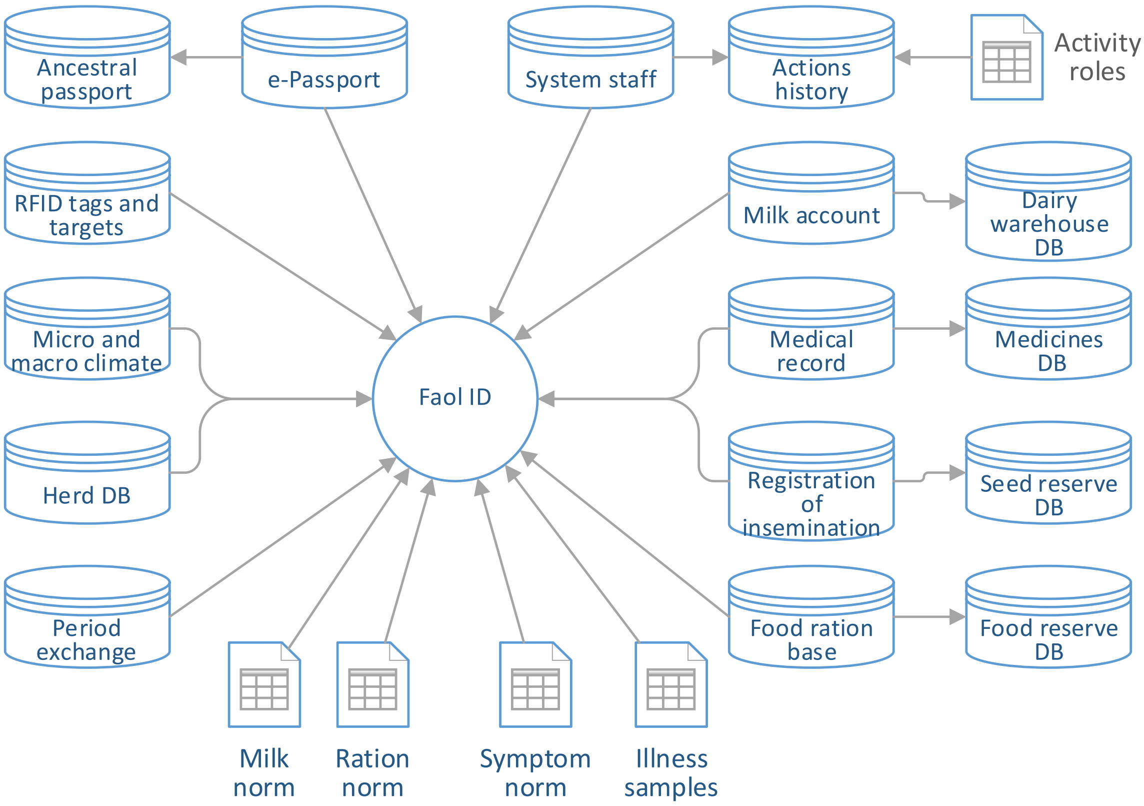

Fig. 4. *An infological model of a sample database*

The system database being designed is mainly divided into three layers: central database (MMB), local database (LMB) and mobile device database [6]. The central database (CMB) stores the sorted data of the inter-object information flow related to the entire system. It is located on the server where the main system is located on the Internet node. It allows online remote access and authorized roles and devices. The local database (LMB) is located on the farm and stores a copy of the MMB. The main task of the local server is to manage the sensors and targets in the infrastructure in real mode and to process a large number of data received from them and send them to the central server. For example, when localizing animals, it processes large array entries generated by the rider. Mobile devices include mobile RFID, smartphones, laptops, and they work offline. When the devices are connected to the network, they automatically exchange synchronized data with the central database.

Functional roles of users and working interfaces for them in the system. Usually, depending on the number of head of cattle and technological support, labor force is attracted and tasks are distributed to them. That is, if on a smaller farm the duties of a veterinarian, zootechnician and IT specialist are assigned to other employees (for example, a farmer or manager), on large farms several specialists are involved in one functional task. Participants related to the internal activities of the farm include farmers, managers, veterinarians, zootechnicians, milkers, cattle breeders, system specialists, external participants are feed, medicine and seed suppliers, milk and meat processors, transporters, including veterinary and prophylactic centers, surrounding farmers, customers, partners, industry-related organizations, and others. Before assigning tasks to employees, it is necessary to identify all functional control units on the farm. The main functional control blocks of the "Smart Farm" complex include:

- registration/removal of farm animals;
- management of the herd (period exchange, grouping of cattle);
- breeding management (insemination, insemination, fetus, calving);
- management of feeding (rationing, feeding schedule);
- warehouse management (food, medicine, seed, equipment RFID tag);
- health management (vaccination and disease treatment measures);
- product production management (milk, meat, wool, waste);

- habitat management;
- medical and preventive measures;
- work with partners;
- Also, the control blocks of IT specialists in the system are as follows:
- management of system users;
- working with publications, financial and statistical reports;
- management of electronic identifiers in the system;
- working with advanced technologies and networks and providing service;
- provision of technical and software services to the system, integration, database and information flow management;
- data analysis in the system, decision-making, reports, data analysis, decision-making, reports.

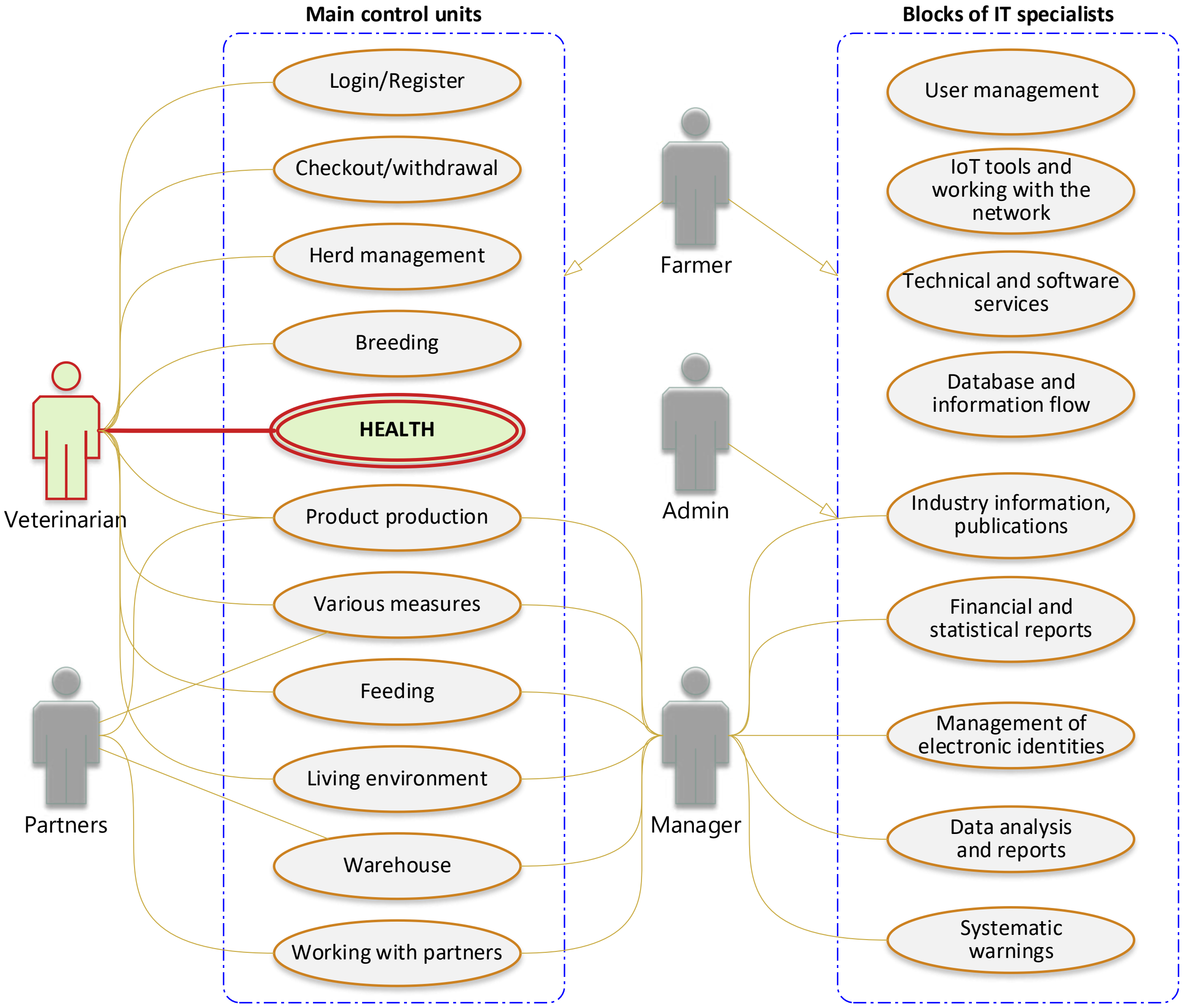

Fig. 5. *User influence on the control units of the "Smart Farm" complex*

In the system, software interfaces for tasks are developed separately and they are attached to users based on roles. The administrator performs program settings, basic data handling, user roles, registration, technical and software services. Users can enter the platform from their mobile and personal computers through login-passwords to the relevant interfaces and perform their assigned tasks based on the defined roles. Systematic controls are carried out in terms of security and monitoring of their activity in the system and work with databases. The UML diagram representing the influence/relevance of users to the tasks in the control blocks is shown in Fig. 5. Here, the influence on the tasks means the authority to access the module, view information, enter new information, edit and delete it is determined by the administrator and the farmer.

CONCLUSION

The adoption of smart livestock farming technologies marks a significant step forward in modern agriculture. By integrating advanced sensors, IoT devices, and automated information systems, farmers can achieve unprecedented levels of efficiency and productivity. The use of these technologies not only reduces operational costs but also enhances the quality and safety of agricultural products, particularly in the dairy and meat industries. The implementation of an automated management information system, designed with the IDEF0 methodology, has proven to be a vital component in streamlining farm operations. The ability to collect, analyze, and act on real-time data enables farmers to make informed decisions, optimize resource use, and improve animal welfare. The robust communication infrastructure and well-designed databases further support the seamless operation of these systems, ensuring that all aspects of farm management are integrated and efficient.

The results of adopting smart farming technologies are clear: improved operational efficiency, better product quality, and more sustainable farming practices. As these technologies continue to evolve, the potential for even greater advancements in livestock farming is vast. Smart farming is not just a trend but a necessary evolution to meet the growing demands of the global population while ensuring the sustainability and profitability of agricultural practices.

In conclusion, the integration of smart technologies in livestock farming is a game-changer, offering farmers the tools they need to meet the challenges of modern agriculture head-on. By continuing to embrace innovation, the agriculture industry can look forward to a future of increased productivity, sustainability, and success.

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THE ROLE AND APPLICATION OF ARTIFICIAL INTELLIGENCE IN IDENTIFYING THREATS TO INFORMATION SYSTEMS

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A B S T R A C T **In this article, In recent years, artificial intelligence has become a necessary technology to enhance the efforts of information security professionals. From a security point of view, it is important that artificial intelligence can identify and prioritize risks, immediately detect any malware on the network, respond to incidents and detect attacks in advance, and develop algorithms to detect and block botnets in computer networks.**

K E Y W O R D S Information system, artificial intelligence, information security, cyber security, attack, threat, risk, method, model, botnet, IDS, IPS, Botminer, BotSniffer, BotHunter, N-gram, Tight, Sustainability, Incremental, FluXor, Tamed, Markov and Synchronization.

INTRODUCTION

Today, information technology plays an important role in all aspects of our life. At this point, it can be said that users widely use computers, smartphones and other digital devices in their daily life, work and study. At the same time, these technologies carry a great responsibility in protecting users' personal information and financial resources. Cybersecurity is very important in this regard.

In this technologically advanced age, Cybersecurity analysis and improvement is no longer the responsibility of humans alone. In response to this unprecedented challenge, artificial intelligence (AI)-based cybersecurity tools have emerged to help information security teams reduce the risk of hacking and increase security. [1-3].

METHODS

Artificial intelligence and machine learning (Machine Learning) have become the most important technologies in the field of information security, because they have the ability to quickly analyze millions of events and identify various threats. Able to detect malicious behavior that can lead to phishing attacks or malicious code uploads, from malware exploiting zero-day vulnerabilities. These technologies build on past experiences and are now evolving over time to detect new types of attacks.

Artificial intelligence and data analysis

Unfortunately, artificial intelligence is a very popular but often misused buzzword these days. Currently, many companies are looking for ways to move to the side of artificial intelligence. But many AI proposals today don't actually meet the requirements of AI testing. Although they use technology that analyzes data and allows certain results to be determined, it is not AI. Pure AI consists of augmenting cognitive abilities to automate tasks.

Artificial intelligence systems are iterative and dynamic. As they analyze more data, they become smarter, "learns" from experience, and become increasingly capable and autonomous.

Data analytics, on the other hand, is a static process that uses specialized systems and software to examine large sets of data to make inferences about the information in them.

Machine learning, expert systems, neural networks, and deep learning are examples of artificial intelligence technologies:

Machine learning – works well only when it is focused on solving a specific task and not on a large-scale mission;

Expert systems – are programs designed to solve problems in specialized fields. These systems mimic the thinking of real experts, solving problems and making decisions through fuzzy rule-based reasoning using carefully selected knowledge sets;

Neural networks use a biological programming paradigm that allows a computer to learn from observational data.

Deep learning is a part of machine learning methods based on providing training data, as opposed to algorithms specific to a specific task. Today, image recognition through deep learning is often used in fields such as autonomous vehicles, scan analysis, and medical diagnostics.

Application of artificial intelligence in cyber security

Artificial intelligence can help solve some of the toughest cybersecurity challenges. With today's ever-evolving cyberattacks and device proliferation, machine learning and artificial intelligence can be used to "track the bad guys" by automating threat detection and responding to threats more effectively than traditional software-based approaches.

However, cyber security comes with a number of unique challenges:

- Huge attack area;
- 10 or 100 thousand devices in each organization;
- Hundreds of attack vectors;
- Lack of qualified security professionals.

An automatic artificial intelligence-based cyber security situation management system is able to solve many of these problems.

Here are the different levels of artificial intelligence:

- - Inventory of information technology assets;
- Exposing threats;
- Effective control
- Predicting the risk of hacking
- Responding to incidents.

RESULTS

Let's consider botnets from attacks aimed at information systems

Top Ways to Prevent Botnet Attacks: Given that a botnet attack is difficult to detect in time and the consequences of a breach can be significant, here are the top preventative measures you can take to protect your organization from botnet attacks.

The fight against botnets is a complex and multifaceted task that requires the joint efforts of security experts, law enforcement agencies, Internet service providers and users.

The following methods can be used to combat botnets:

Botnet detection. To detect a botnet, network activity and computer behavior must be analyzed for signs of infection. For example, you can use antivirus software, network scanners, intrusion detection systems (IDS), and intrusion prevention systems (IPS).

In order to prevent bots from infecting computers, it is necessary to observe the rules of cyber hygiene, for example: use reliable antivirus programs and update them regularly, install patches and updates for the operating system and applications, do not open suspicious attachments and links, do not use pirated programs and downloadable tools , do not grant administrative rights to unverified programs, etc.

Analysis of "Botnet" detection algorithms in computer networks

In order to analyze algorithms for detecting botnets in computer networks, we give a brief description of these algorithms.

BotSniffer can capture spatio-temporal correlations in network traffic and use statistical algorithms to detect botnets with theoretical limits on false positive and false negative rates. BotHunter is not an intrusion detection system, firewall, spam blocker or antivirus tool. These tools usually won't work to rid your network of malware infections. In contrast, BotHunter takes a different approach. It's a network protection tool designed to help everyone from network administrators to Internet-connected PC users detect when coordination-based malware (such as botnets, spam bots, spyware, trojan exploiters, worms, adware) is running on their systems. is a completely new algorithm. BotHunter monitors the two-way traffic between your internal network and hosts on the Internet. We analyzed the algorithms in the table below.

It compares three features: check, define and compare. Verify means to verify the data set. Pre-processing refers to pre-processing a data set. Benchmarking means comparing the results with the results of other offers. Each feature can be fully developed (~), moderately developed (+), or not developed at all (-). So you can quickly compare before reading the description. The analysis text of each proposal describes these features in detail.

TABLE 1.Analysis of botnet detection algorithms

Name	Check	Identify	Comparison
Botminer	+	+	-
BotSniffer	+	+	-
BotHunter	+	-	-
N-gram	-	+	-
Tight	+	~	-
Sustainability	+	~	-
Incremental	-	+	-
Model	+	~	-
FluXor	~	+	-
Tamed	+	+	-
Markov	+	~	-
Synchronization	~	~	-

BotSniffer The first two detection approaches group together hosts that connect to the same remote server and port and sniff network packets with a common baseline, and separate these groups into time windows. With this information, the first approach looks for fingerprints (such as sending SPAM, binary downloads, and port scanning) of the hosts that caused the attack. If more than half of the group has carried out attacks, then the group is defined as a possible botnet. The sequential likelihood ratio test algorithm is used to determine if it is a botnet.

The BotMiner detection system has three different stages of analysis. The first stage unites hosts with similar forms of activity. The second phase groups hosts with similar attack patterns, and the third phase groups hosts based on similarities between the other two phases. The first step uses flow information such as Internet Protocol (IP) addresses, ports, etc. from the network profile. calculates statistics such as fl loan per hour, packets per stream, average bytes per packet, and average bytes per second. A two-step X-means clustering method is used to create clusters of hosts that behave similarly in a network. The second phase uses Snort IDS to extract attacks from each host and group hosts by attack type. Malicious activities detected include SPAM, exploit attempts, port scanning, and binary downloads. The third step calculates a score for each attacking host based on the previous similarities and uses it to calculate a similarity function between the hosts. Finally, a dendrogram is generated using this function to determine the best cluster separation. The most important static properties used were mail exchange DNS queries for SPAM detection and TCP port 25 for SMTP. The proposal uses both virtualized and real botnet images. Unfortunately, there is no information on how the botnet dataset was verified. Normal captures were checked using BotHunter and BotSniffer. Some well-known websites are whitelisted during the pre-processing stage. However, the effects of the filter are not disclosed. This also makes maintaining a list of known hosts, which is error-prone and time-consuming. The results look encouraging. However, the data set could not be reproduced because it is not publicly available. No comparison with other papers was made. Unlike other proposals, this work uses one new idea to distinguish between botnets and manual attacks: botnets act maliciously and always communicate in a similar way, but manual attacks only work with malicious intent.

The BotHunter system recognizes the infection and coordination dialog of botnets by matching a state-based infection sequence model. It captures packets as they exit the network using a modified version of Snort IDS with two proprietary detection plugins. The proposal looks for evidence of botnet life cycle stages to analyze bot dialogue correlations. IDS alerts are tracked through a temporary window and contribute to each host's infection score. When certain thresholds are exceeded, the host is marked as a bot. This proposal associates incoming scans and intrusion alerts with outgoing communication patterns.

The N-gram work proposes an unsupervised, classification-based, and IRC-based bot traffic detection method. It consists of two steps: application traffic classification and bot detection. The first stage consists of several stages. The first phase classifies traffic to specific applications using signature-based payloads and specific ports (the signatures were previously generated). The second stage classifies the unknown traffic from the previous stage using a decision tree based on temporal-frequency characteristics. This tree differentiates certain communities of applications (proposals have temporal-frequency properties of certain flows). In the third step, an anomaly-based approach is used for traffic clustering.

The Tight proposal aggregates traffic to identify hosts that may be part of a botnet.

The training dataset consists of 600 GB of normal wireless traffic from the Crawdad archive and 74 streams of the botnet constructed from an internal testbed. The proposed method consists of five steps. First, the streams are shuffled in the shared data set (unfortunately, there is no information on how the shuffle is done). Second, whitelisting and blacklisting are used to filter streams. Third, streams are classified according to their conversation-like characteristics. Fourth, correlations are used to find similar C&C streams. Fifth, a topological analysis of the flows is carried out to identify common connection points and manually identify the traffic between the controller and the controller. meeting point. The paper makes several assumptions: first, the IRC-based botnet command messages sent by the botmaster are short and text-based; second, two different streams of the same application behave similarly; and thirdly, botnet C&C channels do not provide bulk data transfer. The analysis shows that some filters are better suited to the data, such as removing high bitrate streams. However, these filters have not been tested and appear to be specifically designed to filter out already known botnet traffic. There is a problem with the dataset. When botnet packets were captured, secure shell traffic from the testbed installation was also captured. This will break the capture. Almost every dataset has similarities, but it's important to list and review them. Also, the regular shots have not been confirmed and the data set has not been published. There is another bias in the results. Some results were obtained by applying the classifiers to a single data set; Other results were obtained by applying the classifiers to other datasets. There should be at least three types of data sets generally accepted: training, testing, and validation. Evaluation methodology should also be used. The design of the proposal is believed to be determined in real time, but unfortunately no experiments have been conducted to support this idea. The main point of the article is that it focuses on new behavioral features: the bot communicates with the C&C server, the server is controlled by the botmaster, and the bots synchronize their actions.

In stability, P2P botnets are detected using flow collection and stability metrics. The dataset was created by capturing background traffic on a university campus and then injecting real botnet traffic into it. Botnet traffic is captured in a honeynet and is therefore proven to be malicious by the definition of a honeypot.

Incremental botnet activity is controlled based on traffic similarity between characteristic flows of multiple hosts. The proposal is divided into five stages. The first step captures normal and botnet traffic from the internal network. P2P botnet traffic is received by a third party. The snapshots at this stage were simulated because the internal network did not have access to the Internet. The second step reduces the size of the simple data by applying some filters. Non-TCP files are filtered, several whitelists and blacklists of public websites are applied, and packets larger than 300 bytes are dropped. The third step creates characteristic flows. The traffic is divided into 5-minute time windows and two characteristics are calculated: the average number of bytes per packet and the number of packets. In the fourth step, the measure of the distance between the streams is calculated using the incremental discrete Fourier transform technique. A new feature of this technique is that it is not necessary to recalculate all the coefficients every time a new value arrives. In the fifth step, Snort IDS is used to manually inspect the activity of suspicious hosts (hosts with high similarity streams). This step also decides if the host is part of a botnet or not. Unfortunately, there is no information about this step. The proposal assumes that simulated botnet traffic looks like real botnet traffic, and that the traffic from their network is normal. The proposal is not designed to differentiate between botnet and other attacks. Analysis shows that the results are inconclusive. None were calculated and excellent detection accuracy was reported. The paper also stated that "the false positive rate is still relatively low because we will analyze their performance to confirm the final result. Unfortunately, the confirmation is not in the proposal. The results cannot be compared with other papers. The proposal is pre-processed uses several filters in the giving phase. However, the bias added by these filters is used in the proposal. However, there is no information about the distance measurement and start time of the protocol First, the method is difficult to replicate.The process of the mixture is not explained.It is capable of tracking botnets in real time Second, feature streaming, while not new, is an important improvement in the field.

The models proposal detects single virus machines using previously created detection models. These models consist of two parts. The first part extracts the strings received by the bot on the network to find the commands. The second part tries to find responses (attacks) to the sent command. The models are saved for later use in real networks. The new idea is to look for command signatures (string tokens) in network traffic and then look for responses to those switches.

FluXor's offering identifies and monitors high-flow domains. Given a fully qualified domain name, its purpose is to verify that it is masking an express service network and to identify all agents that are part of the network in such a case. Although not a botnet detection method, this is one of the few suggestions that can identify fast-flowing botnet domains. Suspicious domains are identified when traces of fast flow properties are found in a domain's DNS and WHOIS data. Fast-flow traffic is determined by nine attributes that describe domain characteristics, such as the degree of availability and the heterogeneity of hosts in DNS A records. The experimental setup includes a collector module that collects domains from various sources, a monitor module that tracks domains, and a detector module that provides a classification algorithm from the Waikato Environment for Knowledge Analysis suite. This proposal does not have a detailed performance analysis, so it is not possible to assess how well it has performed. The analysis shows that malware domains are obtained from SPAM emails, while normal domains are obtained from web history. However, there is no description of domain validation. Unfortunately, due to privacy and security concerns with domain names, the dataset has not been made public. On the other hand, the algorithm may be replicable because the Waikato Environment for Knowledge Analysis framework is publicly available.

Tamed's proposal hypothesizes that "even stealthy, previously unseen malware can exhibit detectable communication". The proposal is to "identify infected internal hosts through communication discovery, aggregates that consist of flows with common network characteristics. This is the first proposal that does not attempt to detect botnets themselves, providing a consistent and useful set of features that future work can rely on to detect them. The work is divided into two stages: determination of their cumulative feature function and evaluation of experiments. In the first step, three different aggregation functions are defined: the target aggregation function, the payload aggregation function, and the common platform function. The Destination Aggregate feature finds suspicious destination subnets that have a large number of interactions with the internal network (and IP addresses involved). This is done by comparing the previous network entry with the current network entry. The function consists of two steps. First, past normal traffic is used to remove periodic connections. Second, a principal component analysis algorithm is used to find the most important components, and then a clustering method is used to find hosts connecting to the same address combinations. The payload uses the summation function edit distance with substring moves to output the normalized ratio. This ratio indicates how much distance between two payloads is below a certain threshold (and therefore needs to be trained). The proposal also includes an algorithm for approximating the fraction of pairs of related records that satisfy this distance (using the nearest-neighbor option). The common platform function uses two heuristics to passively fingerprint host operating systems: time fields and communication properties (for example, Windows computers connected to Microsoft Time Server). This last function returns the largest number of internal hosts that can be identified with the same operating system. The suggestion is that the C&C server may be on a different network, and it is assumed that the bots are not using the Tor.* network. The analysis shows that the normality of the traffic recorded at the university is not confirmed, but given as normal. In one experiment, traffic from one botnet was combined with traffic from a university. The IP addresses of the bots were replaced with the IP addresses of the hosts at the university.

Markov: Detected in port scanning activity of botnets. The scanning steps are represented by text symbols and a hidden Markov model (HMM) is used for training and detection. The work is divided into four stages. In the first step, the system is used to retrieve information from the network and create network logs. Unfortunately, this system is not illustrated. The data was collected in 11 C-category university networks for 1 month. By the way, an unknown number of hosts were found to be infected. In the second step, the number of TCP packets with SYN and ACK bits present in certain time windows is calculated. Unfortunately, no information about time windows has been provided. The amount of packets is plotted and a different text symbol is assigned to each individual form of traffic. This step ends with a string of letters (one gram) representing each port scan (observation). In the third step, the training step, the Baum-Welch algorithm is used to find the Markov model that maximizes the likelihood of each sequence of observations over 6 hours. In the fourth step, strings are extracted from the rest of the traffic (presumably of an unknown type). However, not much is known about it. Next, the Viterbi algorithm is used to find the most probable sequence of states in the HMM from each group of observed states, that is, to find the model that best explains the observations. The result of Viterbi algorithms is used as a type of score.

Synchronization: Used to detect bots in network synchronization and clustering methods. There are five stages. At the first stage, data is collected. Three different test beds were used to obtain five sets of data. Three of the datasets correspond to botnet images and two to non-botnet images. Non-botnet images include manual port scans and normal traffic. Validation of captures is performed for both botnet and non-botnet datasets. Non-bot traffic is verified by the operating system, antivirus software, and a fresh installation of Snort IDS. In the second step, TCP streams are extracted using the tcptrace tool. In the third step, the flows are divided into 1-second time windows and three properties are used to aggregate them: the amount of unique source IP addresses in the time window, the amount of unique destination IP addresses in the time window, and the amount. single destination ports in a time window. Each instance represents a time window with aggregated properties. At the fourth stage, the expectation-maximization algorithm is used for clustering examples. A dataset with both types of traffic was obtained by combining botnet and non-botnet data. Four experiments were conducted: first, to distinguish between botnets and port scanning activities; second, separating botnet and non-botnet traffic from a single host; third, distinguish between botnet and non-botnet traffic in an unbalanced dataset; and fourth, separating the network of bot and non-botnet hosts.

Development of an algorithm for identifying and blocking "botnets" in computer networks.

We need to develop an algorithm for detecting and blocking "botnets" in computer networks. This requires detection of unwanted activities in networks, data analysis and security measures. Below is a general description and steps of the algorithm for detecting and blocking botnets.

Botnet *Detection* and *Blocking* Algorithm

1. Data collection. Collection of network traffic data:

- IP addresses;
- Ports;
- Protocols;
- Timestamps of network packets;
- URL- addresses.

2. Preprocessing. Network data cleaning and preprocessing:

- Noise removal;
- Normalization;
- Division by time.

3. Feature extraction. Extracting important features for identification:

- Number of packages;
- Package size;
- Relationship between IP addresses and ports;
- Average traffic speed;
- Number of unique IP addresses.

4. Model training. training the model in the botnet blocking algorithm.

5. Detect botnets:

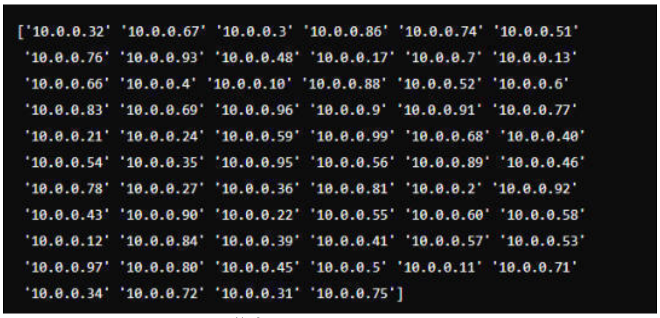
- Detection of botnets using a machine learning model;
- Classification algorithms (Random Forest, SVM, Neural Networks, etc.).
- *6. Block botnets. Block detected botnets*:
- Updating firewall rules;
- Blacklisting of IP addresses;
- Restricting network access.

We have created an algorithm, now we will consider the software part. I wrote the software part in the Python programming language.

Real network data is required for the program to work fully. But for example, it is possible to test the code using artificial data. Below we will create artificial data.

We generate artificial network data, which includes both botnet and normal traffic.

```
import pandas as pd
import numpy as np
from sklearn.ensemble import RandomForestClassifier
from sklearn.model_selection import train_test_split
from sklearn.metrics import classification_report, accuracy_score
# 1. Creation of artificial data
def create_synthetic_data():
    np.random.seed(42)
    # 1000 normal traffic and 100 botnet traffic
    normal_traffic = pd.DataFrame({
        ‘packet_size’: np.random.randint(20, 1000, 1000),
        ‘packet_count’: np.random.randint(1, 100, 1000),
        ‘unique_ips’: np.random.randint(1, 50, 1000),
        ‘avg_packet_rate’: np.random.uniform(0.1, 2.0, 1000),
        ‘duration’: np.random.uniform(0.1, 10.0, 1000),
        ‘protocol’: np.random.choice([‘TCP’, ‘UDP’, ‘ICMP’], 1000),
        ‘is_botnet’: 0,
        ‘ip_address’: np.random.choice([f’192.168.1.{i}’ for i in range(1, 255)], 1000)
    })
        botnet_traffic = pd.DataFrame({
        ‘packet_size’: np.random.randint(500, 1500, 100),
        ‘packet_count’: np.random.randint(50, 200, 100),
        ‘unique_ips’: np.random.randint(20, 100, 100),
        ‘avg_packet_rate’: np.random.uniform(1.0, 5.0, 100),
        ‘duration’: np.random.uniform(5.0, 20.0, 100),
        ‘protocol’: np.random.choice([‘TCP’, ‘UDP’, ‘ICMP’], 100),
        ‘is_botnet’: 1,
        ‘ip_address’: np.random.choice([f’10.0.0.{i}’ for i in range(1, 100)], 100)   })
        data = pd.concat([normal_traffic, botnet_traffic], ignore_index=True)
    return data
```




```
# 2. Preprocessing
def preprocess_data(data):
    data = data.dropna()
    data[‘timestamp’] = pd.to_datetime(‘now’)
    data[‘protocol’] = data[‘protocol’].map({‘TCP’: 0, ‘UDP’: 1, ‘ICMP’: 2})     return data
# 3. Feature extraction
def extract_features(data):
    features = data[[‘packet_size’, ‘packet_count’, ‘unique_ips’, ‘avg_packet_rate’, ‘duration’, ‘protocol’]]
    labels = data[‘is_botnet’]
    return features, labels
# 4. Model training
def train_model(features, labels):
    X_train, X_test, y_train, y_test = train_test_split(features, labels, test_size=0.2, random_state=42)
```

```
        model = RandomForestClassifier(n_estimators=100, random_state=42)
        model.fit(X_train, y_train)
        y_pred = model.predict(X_test)
        print(classification_report(y_test, y_pred))
        print("Accuracy:", accuracy_score(y_test, y_pred))
        return model
    # 5. Detect botnets
    def detect_botnets(data, model):
        features = data[['packet_size', 'packet_count', 'unique_ips', 'avg_packet_rate', 'duration', 'protocol']]
        predictions = model.predict(features)
        botnet_ips = data[predictions == 1]['ip_address'].unique()
        return botnet_ips
    # 6. Botnetlarni bloklash
    def block_botnet_ips(botnet_ips):
        print("Botnet IPs to be blocked:", botnet_ips)
        return botnet_ips
```

	precision	recall	f1-score	support
0	1.00	1.00	1.00	204
1	1.00	1.00	1.00	16
accuracy			1.00	220
macro avg	1.00	1.00	1.00	220
weighted avg	1.00	1.00	1.00	220

Fig. 1. Classification Report

The model was trained and tested. Below are the accuracy reports and detected botnet IP addresses:

Fig. 2. Botnet IP Addresses Expected to be Blocked*Aniqlik*

DISCUSSION

The above results show that the model can detect botnet IP addresses with very high accuracy. Using this information, it is possible to block identified botnet IP addresses.

To work in a real network environment, you need to collect real network data and perform this process in real time.

CONCLUSION

In recent years, artificial intelligence has become a necessary technology to enhance the efforts of information security professionals. In terms of security, artificial intelligence has been developed to identify and prioritize risks, immediately detect any malware on the network, respond to incidents and detect attacks in advance, and develop an algorithm to detect and block botnets in computer networks.

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METHODOLOGY FOR CONSTRUCTING AN *IDEF0* MODEL OF THE JOB PROCESS FOR UNIVERSITY GRADUATES

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A B S T R A C T **The need to form employment algorithms for university graduates is one of the modern trends in the labor market. Their professional competence is selected as a criterion for assessing the effectiveness of the distribution of graduates. Employment of graduates based on competency assessment means assessing the knowledge, skills and abilities they have acquired in various areas of employment and mastering new methods of adaptation in the labor market. Preparing graduates for the realities of the modern labor market is the task and concern of the university, since the indicator "level of employment of university graduates" is one of the main criteria for the effectiveness of training and an indicator of its competitiveness.**

K E Y W O R D S employability, youth labor market, employment technologies, adaptation in the labor market, trans professionalism, competitiveness.

INTRODUCTION

To further analyze and construct functional, dynamic, mathematical, and other models, it is necessary to study the processes of employing university graduates in advance:

- describe the functional modeling area (select independently);
- determine the inputs and outputs of the process (suppliers and consumers), managing influences (internal and external) and necessary types of resources;
- to construct the scheme of the business process algorithm;
- compose a table with information about sub-processes and their content.

The graduates' employment process is a system of consistent, purposeful, and regulated activities, in which the inputs of the process are transformed into outputs, the results of the process, which are valuable to consumers through managerial influence and resources.

Overall, the graduate employment process model should provide answers to the following questions, allowing for a comprehensive analysis, viewing the business process from all perspectives, and detailing it:

- what procedures (functions, work) must be performed to obtain the final result;
- the sequence in which these procedures are carried out;
- what control and management mechanisms exist within the framework of the employment process under consideration;
- who performs the process procedures;
- what input documents/information is used by each employment process procedure;
- what outgoing documents/information is generated by the process procedure;
- what resources are needed to perform each procedure of the process;
- what documents/conditions regulate the procedure;
- what parameters characterize the execution of procedures and the process as a whole?

METHODS

Business process modeling, as a rule, is carried out using case tools. Such tools include BPwin, Silverrun, Oracle Designer, Ramus, Rational Rose, and others. IDEF0 - functional modeling methodology. It is used to create a functional model that reflects the structure and functions of the system, as well as information flows and material objects connecting these functions.

The process of system modeling in IDEF0 begins with the creation of a contextual diagram - a diagram of the most abstract level of system description as a whole, containing the definition of the modeling subject, the goal, and the model's point of view. Each subsequent diagram is a more detailed description (decomposition) of one of the works on the above diagram. The IDEF0 model presupposes the presence of a clearly formulated goal, a single modeling subject, and a single point of view. The point of view is understood as the perspective with which the system was observed when constructing the model. Although different people's opinions are taken into account when building a model, they should all hold a common view of the model. The point of view should correspond to the goals and limits of modeling. As a rule, the point of view of the person who is responsible for the modeled work as a whole is chosen. Usually, the existing AS-IS work organization model is first constructed (as it is). Analysis of the functional model allows us to understand where the weakest points are, what will be the advantages of new employment processes, and how deep changes will be made to the existing structure of the business organization. Detailing employment processes allows for the identification of organizational shortcomings even where the functionality seems obvious at first glance.

The shortcomings found in the AS-IS model can be corrected by creating a TO-BE model (as it will be) - a model of new organization of employment processes. The set of structural components of the language, their characteristics and rules that determine the connections between the components represent the syntax of the language. The components of the IDEF0 syntax are blocks, arrows, diagrams, and rules. Blocks represent functions defined as activity, process, operation, action, or transformation. The block describes the function. Each block contains its name and number. The name should be an active verb or a verb phrase describing a function. The block number is located in the lower right corner. Block numbers are used to identify them in the diagram and in the corresponding text. Arrows represent data or material objects related to functions. Arrows representing a multitude of objects, depending on which edge of the block (working rectangle) they enter or from which edge they exit, are divided into five types [1-4]:

- entrance (enters the left edge of the work) - describe the data or objects that change during the work;
- controls (enter the upper edge of the work) - describe the rules and restrictions according to which the work is performed;
- output (goes from the right side of the work) - describe the data or objects that appear as a result of the work;
- mechanisms (enter the lower edge of the work) - describe the resources necessary for the work, but not changing in the process of work (for example, equipment, human resources, etc.);
- challenges (from the bottom edge of the work) - describe the connections between different diagrams or models, pointing to some diagram where this work is considered in more detail (fig. 1).

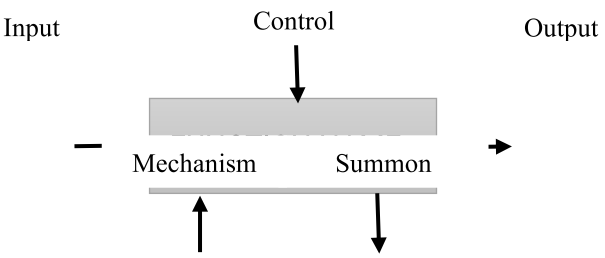

Fig. 1.The interaction diagram of the system.

The arrows on the context diagram serve to describe the system's interaction with the surrounding world. They can start at the diagram edge and end at the work edge, or vice versa. Such arrows on the context diagram are called boundary arrows.

RESULTS

Numeration of works and diagrams. All model works are numbered. The number consists of a prefix and a number. Any length prefix can be used, but usually A prefix is used. The contextual (root) work of the tree has the number A0. The decomposition works A0 have numbers A1, A2, A3 and so on. Lower level decomposition works have the parent work number and the next order number, for example, decomposition works A3 will have numbers A31, A32, AZZ, A34 and etc. Works form a hierarchy where each work can have one parent work and several daughter works, forming a tree. Such a tree is called a node tree, and the numbering described above is called node numbering.

IDEF0 diagrams have double numbering. First, the diagrams have nodal numbers. The context diagram is always numbered A-0, the decomposition of the context diagram is numbered A0, the rest of the decomposition diagrams are numbers for the corresponding node (for example, A1, A2, A21, A213 and etc.).

Tunnel - round brackets at the beginning and/or end of the arrow. Tunnel arrows mean that the data expressed by these arrows is not considered on the parent diagram and/or on the daughter diagram. The arrow placed in the tunnel where it joins the block means that the data expressed by this arrow is not mandatory at the next decomposition level. The arrow placed in the tunnel at the free end means that the data expressed by it is absent on the parent diagram. This situation is explained in more detail in Figure 2. [5-8].

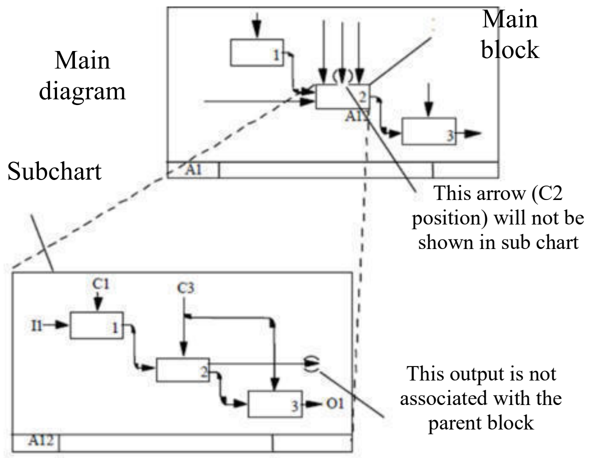

Fig. 2. Example of using tunnel arrows on diagrams.

The purpose of the method is to construct a model of the system under consideration in the form of a data flow diagram (Data Flow Diagram - DFD), which provides a correct description of the output (system response in the form of data) with a given effect on the system input (signal transmission through external interfaces).

Data flow diagrams are the primary means of modeling functional requirements for the projected system. Two different notations are traditionally used to represent DFD: Yodana (Yourdon) and Heine-Sarson (Gane-Sarson) [9-11].

DISCUSSION

Data flows are mechanisms used to model the transmission of information (or physical components) from one part of the system to another. The purpose of the process (work) is to produce output flows from inputs in accordance with the action given by the process name. The process name must contain a verb in an indefinite form with a subsequent addition (for example, "to calculate the maximum height"). Data storage (accumulator) allows you to determine the data that will be stored in the memory between processes in certain areas. In fact, the storage space represents "cuts" of data flows over time.

External essence is a material object outside the context of the system, which is a source or receiver of system data. Her name must contain a noun.

The decomposition of the DFD diagram is carried out on the basis of processes: each process can be revealed using the DFD of the lower level. A special type of DFD - a contextual diagram, which models the system in the most general way, plays an important specific role in the model. Each project should have exactly one context diagram, and there is no need to number its single process.

The IDEF3 standard is a methodology for describing processes that considers the sequence of execution and the causal relationships between situations and events for the structural representation of knowledge about the system.

IDEF3 describes the logic of work execution, the sequence of its execution and completion, i.e. IDEF3 provides a tool for modeling the scenario of actions of employees of the organization, departments, workshops, etc., for example, the order processing procedure or events that need to be reacted to in the final time, the execution of actions for the release of specialists, etc.

The description of the process represents all possible situations (processes, functions, actions, acts, events, scenarios, procedures, operations or solutions) that can occur in the modeled system in logical and temporal relationships. Each process is represented by a field that represents the process name. The process identifier number is assigned sequentially. A link is located in the lower right corner of the UOB element and is used to indicate links either to elements from the IDEF0 functional model or to indicate departments or specific performers who will perform the specified work. [11-12].

CONCLUSION

The connection element is necessary for organizing the relationships between the elements of the diagram and describing the dynamics of the processes occurring. Connections are primarily used to denote the relationship between UOB functional elements, to reflect the temporal sequence of scenario execution in process description diagrams. These elements are mainly used to denote significant connections between UOB. Relationships between functional blocks can be: temporal, logical, causal, natural, and ordinary. In the vast majority of cases, connections are used that reflect a simple temporal relationship between blocks. There are two main types of connections used in IDEF3 schemes: priority (senior) connections and relative (intermittent) connections. The IDEF3 methodology uses five logical types to model the possible consequences of actions in the scenario.

TABLE III. LOGICAL TYPES

Designation	**Name**	**Meaning in case of merging of switches *(Fan-in Junction)***	**Meaning in case of branching arrows *(Fan-out Junction)***
&	*Asynchronus AND*	All previous processes must be completed	All of the following processes must be started
O	*Asynchronus OR*	One or more preceding processes must be completed	One or more of the following processes must be started
X	*XOR (Exclusive OR)*	Only one previous process completed	Only one process is triggered
&	*Synchronus AND*	All previous processes have been completed simultaneously	All subsequent processes run simultaneously
O	*Synchronus OR*	One or more preceding processes are completed simultaneously	One or more of the following processes are triggered simultaneously

The IDEF3 methodology allows for the presentation of the process as a hierarchically organized set of diagrams. The diagrams consist of several elements describing the IDEF3 process, and each UOB functional element can potentially be detailed on another diagram.

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IMPORTANCE OF DIGITAL TECHNOLOGIES IN MEASURING KIDNEY FUNCTION

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Annotation Non-adherence to medications is a critical challenge in the management of people with chronic kidney disease (CKD). This review explores the complexities of adherence in this population, the unique barriers and enablers of good adherence behaviours, and the role of emerging digital health technologies in bridging the gap between evidence-based treatment plans and the real-world standard of care. We present the current evidence supporting the use of digital health interventions among CKD populations, identifying the key research questions that remain unanswered, and providing practical strategies for clinicians to support medication adherence in a digital age.

Key words: chronic kidney disease (CKD), digital health, eHealth, medication adherence

INTRODUCTION.

Chronic kidney disease (CKD) poses a major risk to the wellbeing of those affected, with a risk of impaired quality of life and reduced life expectancy, and imposes a formidable economic burden on health care systems caring for such individuals. A variety of medications are used in the management of CKD to reduce the progression to kidney failure, to ameliorate the high risk of cardiovascular complications, to address symptoms that can deleteriously affect quality of life, and to manage common co-morbid conditions such as diabetes and elevated blood pressure.People with CKD are often prescribed complex medication regimens and are tasked with understanding and taking these medications appropriately, often for the remainder of their life.Unsurprisingly, adherence to medications, defined as the extent to which patients take medications as prescribed by their health care providers,is suboptimal and a significant clinical challenge. Lower levels of medication adherence are associated with increased rates of hospital admissions, poorer health outcomes, increased morbidity and mortality and increased health system costs.It is therefore a major public health priority to explore innovative and evidence-based strategies to improve medication adherence, and digital health developments provide a promising new avenue for change.

MEDICATION ADHERENCE

Despite the rapid advancement in medication development, medication non-adherence remains at an estimated 40%–60% in developed countries among people with chronic disease. Traditionally, medication adherence has been viewed as static and dichotomous (i.e., a person is adherent or non-adherent).However, medication adherence is dynamic and varies in response to factors such as disease activity, treatment methods and psychosocial factors.Adherence has been conceptualized into three core components: initiation, implementation and persistence.A fourth concept, primary non-adherence, where a patient is prescribed a medication but never fills a prescription, is differentiated from these other components of adherence. While non-adherence may reflect an individual's autonomy in self-management, or their decision not to consent to an ongoing treatment based upon their own interpretation of the risk/benefit profile, it remains an important surrogate marker for a variety of patient-important health outcomes.

MEDICATION ADHERENCE IN CKD

Chronic kidney disease poses challenges for optimizing medication adherence as people with advanced CKD require an average of 10 regular daily medications. Adherence can be significantly complicated by the complexity of the medication schedule, medication-related symptoms, and psychosocial burdens which may be disease-related or concomitant. Table highlights the various reported adherence rates in CKD populations. Medication adherence rates vary significantly between studies, in part due to differing definitions and measures, with objective measures such as pill counts and prescription refills tending to indicate worse adherence rates than patient self-report by validated questionnaires, or less specific measures such as serum phosphate levels. Nonetheless, it is clear that medication non-adherence is a key issue in CKD management.

There are well-established risk factors for suboptimal medication-taking behaviours, including demographic (e.g., younger age, male), cultural (e.g., non-Caucasian ethnicity) and psychosocial (e.g., forgetfulness, depression, anxiety, lower socioeconomic status, lower level of education, lack of social support and poor treatment engagement) factors in people with CKD. Forgetting medications remains the most significant patient-reported reason for sub-optimal adherence, raising the possibility of medication reminders as an intervention strategy. The relative importance of individual predictors of non-adherence appears to vary across different clinical settings or stages of CKD. For example, while men show higher rates of non-adherence in predialysis CKD and transplant, this is not the case in dialysis, where men and women show similar rates of non-adherence to phosphate binders. Similarly, while low education levels in people with a functioning kidney transplant predicts poor adherence, this is not seen in the dialysis-dependent populations. The reasons for such differences are not clear, and further evaluation is required.

The impact of out-of-pocket cost on treatment adherence is significant and widespread, affecting those in both high- and low-middle income countries, but with a disproportionate impact upon low socioeconomic households and the uninsured. Out-of-pocket costs are associated with poorer medication adherence, skipping of dialysis sessions, and forgoing of treatment altogether, leading to worse patient outcomes.

Health literacy (HL), reflecting the cognitive and social skills that determine a person's motivation and ability to access, understand and use information to promote and maintain good health, can also significantly influence adherence. In CKD, poor HL is estimated to affect approximately 25% of the population, and is associated with medication non-adherence, more rapid deterioration in kidney function, and higher mortality rates.

Qualitative interview studies with people with CKD have described numerous enablers and barriers of appropriate medication-taking. Factors that may support appropriate medication-taking include people's perception that medications can improve their future health and symptom burden. Medications that could slow disease progression are often prioritized. Patients reported personalized strategies, stable and established routines, and clinician rapport helped to maintain better adherence. However, lack of education regarding medication benefits may lead to patients changing or ceasing their medications, particularly those with adverse side effects – 'some medicines make me dizzy…it is a problem as I get no support at home'.

METHODS TO IMPROVE MEDICATION ADHERENCE IN CKD

Improving medication-taking requires a multidimensional approach, exploring patient factors (knowledge, beliefs about consequences, behavioural regulation, memory and decision-making processes), environmental factors (access, cost) and health system factors (patient-clinician communication). Examples of interventions that have improved medication adherence in CKD have included cost subsidies for phosphate binders and multidisciplinary team patient education. However, such interventions may be time-consuming and costly. The introduction of technology and digital health and its incorporation into medication management may provide new and revolutionary methods in addressing key components of the adherence constructs.

USING DIGITAL TECHNOLOGIES TO IMPROVE MEDICATION ADHERENCE IN CKD

Over recent decades, the rapid evolution of digital technology has resulted in unprecedented opportunities to connect with patients and promote improvements in health behaviours such as medication adherence. These approaches differ widely in mode and style, but can be grouped under the concept of digital health or eHealth, defined broadly as 'health services and information delivered or enhanced through the Internet and related technologies'. This umbrella term includes interventions as diverse as text message programs and mobile phone applications (together known as mHealth), the 'internet of things', and social media engagement. They can revolve around education, behavioural counselling, self-monitoring, reminder systems, clinical decision aids, or combinations of purposes.

The potential of digital health interventions lies in the ability to provide access to education and support regardless of geographical location, reduce the patient-borne costs related to travel and clinic appointments and reduce clinician burden and time. Digital interventions may target modifiable patient-factors and behaviours, however not all factors associated with poor medication adherence can be targeted by digital interventions. While there are evolving opportunities, many questions remain to be answered, including which patients are most likely to benefit, which technologies are most likely to yield results, and how they should be applied in a way that is patient-centred, sustainable, and cost-effective.

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CREATING ADDITIVE FIBONACCI GENERATORS WITH PRIME NUMBERS: A NEW METHOD

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A B S T R A C T **Pseudorandom number and bit sequence generators are highly-respected and extensively used within the domains of cybersecurity, measurement, and other technology domains. One of the major alterations that such emphasis is on the additive Fibonacci generators (AFG). By its nature such a generator is not cryptographic. In this article, we present a modification to AGF which is to implement the primes instead of simple modules in the recurrent equations characteristic of the operation of the generators. This modification attained it possible to guarantee the steadiness of the sequence in relation to the periodical recurrence of the random plot pulse outputted by the module controller. In addition, it has been advanced a novel scheme of a generator consisting of 2 generators the first being a modified AFG and the second a linear feedback shift register. The experimental data confirmed that specific values of modules enable a constant period of repetition for the output pseudorandom pulse sequence over a multifarious range of values of initial settings-keys (seed) and satisfying all the NIST tests for statistical properties of the generated sequence. The Altered Fin Filaments with AFGs are mainly aimed at the hardware realization, hence these AFGs deliver the superior results.**

K E Y W O R D S pulse-width modulation (PWM); pseudorandom sequences generators; PSG; prime numbers; additive Fibonacci generator; AFG; statistical characteristics; cybersecurity;

INTRODUCTION

These days, as science and technology develop faster than ever, pseudorandom bit sequence generators are finding more and more uses in a variety of sectors. Creating high-quality pseudorandom sequences has significant scientific and practical implications, and many researchers are working to build algorithms that produce sequences with properties as close to actual randomness as feasible. Many branches of research and technology make use of pseudorandom sequence generators. Among these generators, additive Fibonacci generators (AFG) are very popular [1–2]. An original method that, in contrast to other approaches, enables the creation of generators with arbitrary modules in the recurrence equation—more especially, prime number modules—is introduced by creating new circuit engineering solutions for the hardware implementation of Fibonacci generators. This development has the potential to significantly enhance the statistical qualities of the generator. This work focused into the hardware implementation of an additive Fibonacci generator using a prime number module-based method and examined the attributes of the generator.

METHODS

Cybersecurity devices frequently use additive Fibonacci generators (AFG) to generate pseudorandom bit or number sequences. These generators are a vital starting point for creating completely safe and resilient cryptographic algorithms, even if they are not cryptographically efficient on their own. As an example, AFGs form the foundation of algorithms such as Fish, Pike, and Mush [1, 3]. Besides encryption and cybersecurity systems, Additive Fibonacci generators have significance in many other disciplines.

The following formula yields the conventional AFG algorithm:

$$x_i = (x_i - l + x_{i-k})\, mod(m), l > k > 0 \quad (1)$$

General view:

$$x_i(x_{\ i-a} + x_{\ i-b} + \ldots + x_{i-p})\, mod(m), a > b > \ldots > p > 0 \quad (2)$$

By choosing variables according to Equation 2 − m = 2^n, an effective hardware implementation of Equations (1) and (2) is accomplished, simplifying the generators' hardware design. The sequence produced by the generators will have a recurrence period of at least $2^n - 1$ if the parameters l, k, and a, b,..., p are correctly chosen in Equations (1) and (2) [3].

$$xi = (x_{i-a} + x_{i-b} + \ldots + x_{i-p}\ \ a)\, mod(2^n), \quad (3)$$

where, $a = a_0 \oplus a_1 \oplus \ldots \oplus a_z$; a_i $((i = 0, 1, \ldots, z), (z \leq n - 1))$ - values of the number x_i binary bits.

The statistical characteristics of the pseudorandom sequence created and the output parameters, in particular the repeated period of the output sequence, exhibit a high association, as our research on AFG and MAGF [4,5,6,7,8] shows. This implies the possibility of "weak keys" that are comparatively simple to find. This work focuses on the hardware execution of the discoveries intended to solve this restriction in AFG and MAGF.

The Structure Schema and the Work Principle of the New AFG

As stated earlier, AGF and MAGF construction employ algorithms where the modulus of the recurrence relation in equations (1–3) is a power of 2. This makes the hardware implementation much easier. Papers [7,9] proposed a new method for the development of two-level frequency synthesizers that can shift the average output frequency by any value. It is important to note that these methods can be easily used in the hardware implementation of the generators that we suggest below. Such an additive Fibonacci generator is depicted one in figure 1[10].

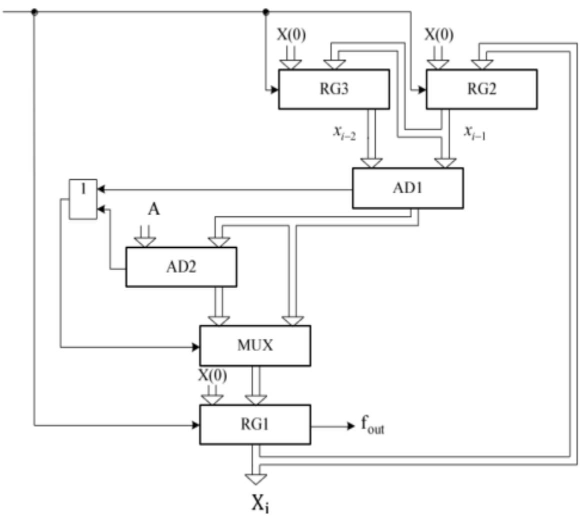

Figure 1. *Structure schema of AFG.*

AFG consists of registers RG1-RG3, adders AD1-AD2, multiplexer MUX and logical element OR. The generator functions according to the equation:

$$x_i = (x_{i-2} + x_{i-1}) \bmod (m), \quad (4)$$

where, m—prime number; x_i, x_{i-1}, x_{i-2}—numbers in registers RG1, RG2 i RG3.

The number of binary bits n of the structural elements of the scheme (RG1-RG3, AD1, AD2) is selected based on the need to ensure the condition $2^n > m$.

Research of the New AFG Characteristics Figure 2 shows the dependences of the repetition periods of the studied pseudorandom numbers sequence generators on the value of the key X(0).

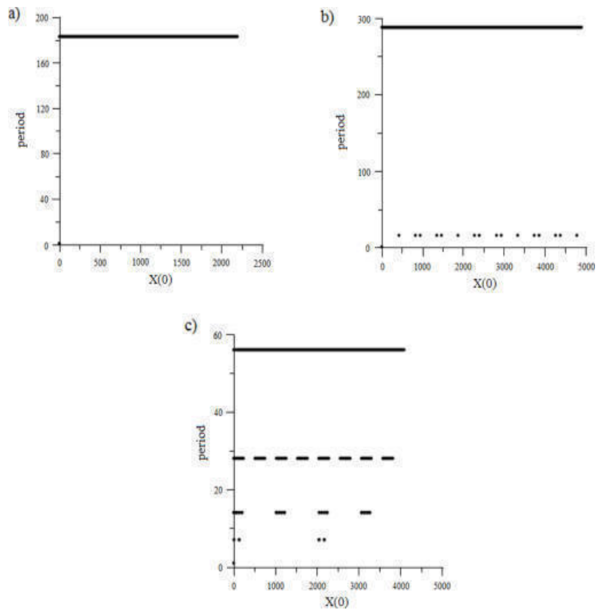

Figure 2. Dependences of AFG repetition periods on the key.

Figures 2a and 2b present the dependencies of the new AFG, which follows the Equation (4) with m = 13 in Fig.2 a and m = 17 in Fig. 2 b. Fig. 2c shows the analogous comparison concerning the corresponding dependence which is given by Equation (4) with m = 24 = 16 for the classical AFG. To account for all possible values, the initial number is determined using the formula: To account for all possible values, the initial number is determined using the formula:

$$X(0) = (x_{i-2}(0) + m\, x_{i-1}(0) + + m^2\, x_i(0), \quad (5)$$

where, $x_i(0)$, $x_{i-1}(0)$, $x_{i-2}(0)$ are the initial values of the numbers in the registers RG1-RG3, accordingly

RESULTS

The merged PRBSG's a structure is shown in Figure 3.

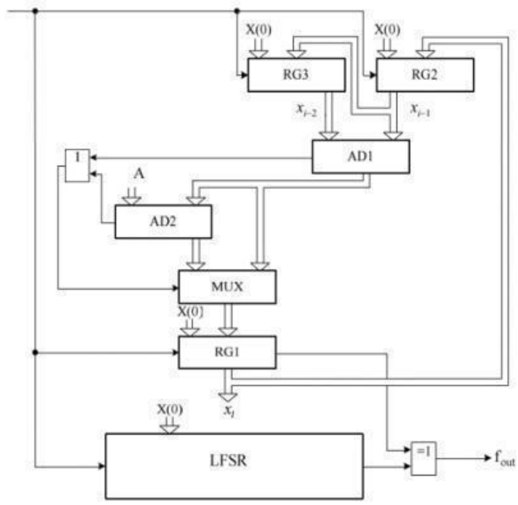

Figure 3. *shows the merged PRBSG's structural diagram.*

Two generators make up the combined PRBSG: one is based on a new AFG (as illustrated in Figure 1), while the other is based on a shift register with linear feedback (LFSR). An XOR logic gate is used to combine the output pulses generated from both generators. The specifications for the properties of the output bit sequence dictate the choice of LFSR type and bit number. Further research would be necessary to see whether other PRBSGs could be utilized in place of LFSR.

The LFSR used in this study's combined PRBSG functions in accordance with the formula $F(x) = 1 + 18x + 31x$. Utilized are the matrix T1 and a matrix power of $r = 10$ [8]. A statistical examination of the LFSR is shown in Figure 4, which shows that the pseudorandom sequence that is produced.

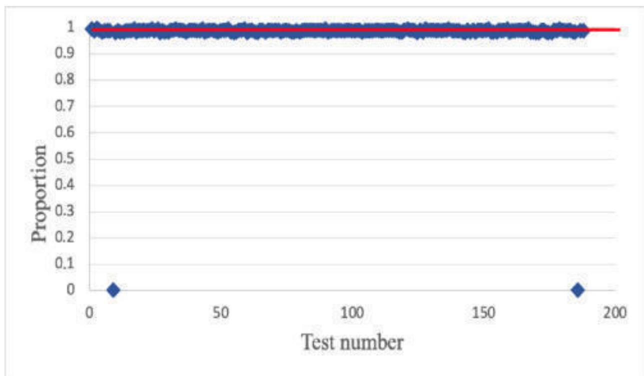

Figure 4. *Using matrix T1 and matrix power $r = 10$, the statistical profile of the LFSR $F(x) = 1 + 18x + 31x$.*

The results of testing the combined PRBSG (Figure 4) with the following settings are shown in Figure 5: matrix T1, matrix power $r = 10$, new AFG with $m = 2{,}147{,}483{,}647$, LFSR defined by $F(x) = 1 + 18x + 31x$. Every test from the NIST set is successfully completed by the output sequence.

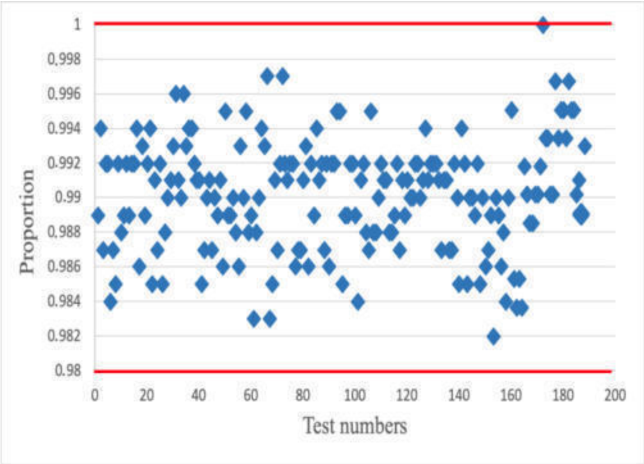

Figure 5. *Statistical portrait of the combined PRBSG.*

As a result, all test results fell within the permissible range, as shown by Figure 6. This indicates an output pseudorandom sequence with higher statistical features is generated by the combined PRBSG generator caption)

DISCUSSION

The new AFG (Figure 1) guarantees a constant repetition time for the output pseudorandom pulse sequence over the whole range of possible initial settings (seed) values. It does this by using prime numbers as the modules for the recurrence equations at certain values. Due to this feature, the suggested Fibonacci generator differs favorably from others that already exist, in which the modulus is a power of two. In contrast to the generator under consideration, extant devices with m > 2 display variable repeat periods, a few of which are critically brief, suggesting the existence of "weak keys." Additionally, when comparing the relative values of module m in the proposed device to those of current devices, the maximum repetition durations in the former are typically shorter.Thus, if two pseudorandom pulse sequences are connected with an XOR logic gate, the period of the resultant sequence is no less than the repetition period of each pulse sequence. When constructed based on the particular criteria the PRBSG (Figure 4), built PRBSG, combining stand-alone PRBSG, has reached the desired statistical features and no "weak keys" at all possible initial states (seeds).

[9]

CONCLUSION

As it can be observed in the results of this article, the proposed generators are appropriate for cybersecurity usages, that is as parts of cryptographic security, noise generators for information security, or as noise-like code sequences in today's communication systems. This suggests that there should be more research done on other kinds of combined PRBSGs with potential for hardware implementation and other uses of these generators.

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MATHEMATICAL SUPPORT OF THE IMPEDANCE SPECTROSCOPY METHOD OF DETERMINING THE COMPOSITION OF UNDERGROUND RESERVE WATERS

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A B S T R A C T This article is about finding an effective solution for determining the composition of groundwater. The spectral-impedance method proposed in the article allows to create devices for measuring all the main quality indicators of water [1]. The proposed method, in comparison with the currently used methods, increases the reliability of the assessment of the composition of underground water based on the measurement of the spectral impedance of the ions contained in the hydrogen indicator at the same time [2] [3] [4] [5].

K E Y W O R D S approximation, linear and quadratic approximation, spectral analysis, impedanceometry, frequency.

INTRODUCTION

The method of spectral impedancemetry (or impedance spectroscopy) is based on the measurement of its electrical properties for the analysis of water content. This method allows to determine the concentration of various ions and molecules present in water. The working principle of the method is as follows[1]:

Impedance measurement is performed as usual. Water is placed between two electrodes, through which a sinusoidal alternating current of different frequencies is passed. The impedance (resistance) of water is determined and measured at each frequency.

Impedance is measured over a wide frequency range (limit), which makes it possible to create an impedance spectrum. Different substances in water have different effects on impedance, creating unique spectral patterns. Determination of water content in this method is also known as the spectral analysis method.

In order to model and interpret the obtained data, the measured spectral data are analyzed using mathematical models and algorithms that allow to determine the concentration of different components of water. In the process of analysis, an electrical model in the form of an equivalent circuit consisting of electrical resistance (resistor), capacitor and inductance is used to describe the interaction between the electric field and ions or molecules in water.

In order to calibrate and verify the proposed method for correct determination of water content, the device is first used with known water samples with different concentrations of substances. This made it possible to create a database of samples used for comparison and analysis of well water samples.

The spectral impedance measurement method has a number of advantages, including:

1) High sensitivity: allows detection of low concentrations of substances.

2) Real-time analysis: Measurements and analyzes can be performed in a short period of time to enable real-time monitoring of the quality of the sub.

3) Non-invasiveness: no need to prepare a complex water sample.

This technique can be widely used in various fields, including environmental monitoring, drinking water quality control, industrial analysis and medical research.

METHODS

Mathematical model of impedance spectroscopy method Equivalent electrical circuits and numerical analysis methods can be used to describe a mathematical model that determines the concentration of various components of water based on impedance spectroscopy measurements. One such approach involves using an equivalent circuit consisting of electrical resistance (R) and capacitance (C) to simulate the behavior of the system at different frequencies. The following equivalent circuit can be used to model water impedance (Fig. 1):

R(f) is the resistance of water corresponding to the measured frequency f;

C(f) is the capacitance indicating the reactive resistance of water corresponding to the frequency f. It depends on the dielectric properties of water.

Additional elements (ri-resistors and ci-capacitors) can be introduced that simulate the effect of various ions and molecules. The simplest general mathematical model of the impedance of water is represented by the following formula (1) in the form of a series connection of a resistor and a capacitive reactance.

$$Z(f) = R(f) + \frac{1}{j2\pi f C(f)} \qquad (1)$$

here

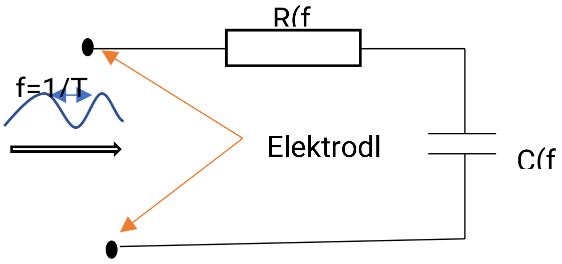
Z(f)-impedance of water;

R(f)-active resistance of water at frequency f;

C(f)-capacitance that shows the dielectric properties of water;

j is an abstract number.

Below is the general equivalent circuit of this



simple model (Fig. 1).

Fig. 1. General equivalent electrical circuit of the system.

Therefore, for more accurate mathematical modeling, it is necessary to use complex circuits that include various components, including parallel and series connections of resistors and capacitors. For example, parallel additions are used as sums in formula (2) to account for the effect of ions:

$$Z(f) = R(f) + \frac{1}{j2\pi f C(f)} + \sum_i (Ri + {}^{1}/_{2\pi f Ci}) \quad (2)$$

here

Ri and Ci are parameters corresponding to different ions and molecules.

RESULTS

Some numerical methods used in quantitative analysis of water content based on spectral impedancemetry. Solving the problem of determining the concentration of groundwater components based on the spectral impedance method can include several methods and stages of numerical analysis. In particular, it is the method of small squares (Least squares method (LSM)), one (or several) methods of nonlinear optimization, for example, gradient descent method, Newton algorithms, Levenberg-Marquardt method from optimization, Monte Carlo method and a number of other methods. is used.

The method of least squares. The least squares method is used to minimize the difference between measured and modeled impedance values and to select model parameters. In this problem, the method of least squares helps to find the parameter values Rw, Cw, Ri, Ci, which ensures that the experimental data match the model parameters. As you know, the Least Squares method is a statistical method used to find a good linear approximation to experimental data. This method is based on minimizing the sum of squared deviations between the initial data and the closest straight line to these data. It is used to solve various problems based on minimizing the sum of squared deviations of certain functions from experimental input data. It can be used to find solutions in simple systems of nonlinear equations, to estimate the point values of some of them. function. OLS is one of the main methods of regression analysis for estimating unknown parameters of regression models from sample data. For example, xi , $i = 1 , . . . n$ vector set of experimental data and its corresponding yi , $i = 1 , . . .$ Let n be a set of scalar experimental response data in which y is assumed to depend on x. As a result, a known scalar function y=f (x , b) defined by the vector bi, which is a set of unknown parameters (linear in the simplest case) is introduced. The task is to find a vector bi such that errors(3) (i.e., the difference between measured and calculated information).

$$e_i = y_i - f(x_i, b_i) \quad (3)$$

here

i is the difference error between i and its mathematical model.

According to the method of least squares, the solution of this problem consists in determining the bi vector and minimizing the function (4) [6]:

$$S(b) = \sum_{i=1}^{n} e_i^{\,2} = \sum_{i=1}^{n}(y_i - f(x_i, b_i))^2) \quad (4)$$

Here

S(b) is the residual sum of squares.

In the simplest case, f (x) = b and then the output of the least squares method is the arithmetic mean of the input data. The advantage of least squares over other types of error minimization is that if f

(x , b) is differentiable with respect to b , then S

(b) is also differentiable. Setting the partial derivatives to zero reduces the problem of solving the system of equations, and if f (x , b) depends linearly on b , then the system of equations is linear. For example, the optimal b vectors are calculated using the derivation from equation 4 and zeroing (5):

$$\sum_{i=1}^{n}(y_i - f(x_i, b_i))\frac{\partial f(x_i, b_i)}{\partial b_i} = 0 \quad (5)$$

Above, the foundations of the mathematical model of the algorithm for verification and adaptation of experimental data obtained only by the method of small squares were given.

DISCUSSION

The discussion section would interpret the results in light of the research question and relevant literature. It would discuss the implications of the findings, considering both the strengths and limitations of the study. Any unexpected or contradictory results would be addressed, and potential explanations or alternative interpretations would be explored. The section would also highlight the theoretical and practical implications of the study's findings, such as the potential for exercise interventions to be implemented in geriatric care settings. Finally, the discussion would conclude with suggestions for future research directions, such as investigating the long-term effects of exercise on cognitive function or examining the impact of different exercise modalities on specific cognitive domains.

CONCLUSION

Creating an automated monitoring system for underground water wells involves the integration of various sensors, data processing algorithms and prediction models. The system must be able to collect data, process it to predict future situations, and take appropriate actions based on these predictions. The presented methods demonstrate basic applications of water level and quality prediction algorithms that can be extended and improved for more complex and accurate models.

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CLASSES AND METHODES OF DECISION-MAKING IN INTELLIGENT SYSTEMS

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A B S T R A C T **This article provides detailed information about the problems and the development of decision-making systems in manufacturing enterprises. The increase in the volume of information and the increase in quality requirements reduce the efficiency of traditional production methods and thereby complicate production processes. In such circumstances, analyzes and solutions are presented on new technologies for efficient management of large amounts of data and for quick decision making.**

K E Y W O R D S **Decision making class, big data, frame model, knowledge base, information management system, intelligent systems**

INTRODUCTION

Today, the increasing demand for the quality and quantity of the products leads to the complexity of the continuous production steps (CPS) in the enterprises. It is a natural process to observe an increase in the number of workers and the volume of work through the implementation of such tasks through traditional production. It is becoming very difficult for a specialist to remember and process large amounts of information [1,2].

According to T. Lee and M. Lee, the effective use of information in many industrial enterprises is at a low level, modern technologies for its collection, storage and processing are not enough [3]. Therefore, the development of information analysis methods and algorithms is a research object of today's science. It helps to effectively solve many practical problems in production through the theories of information search, sorting and processing[4].

Internet of Things (IoT), Internet of Services (IoS), Big Data, Industry 4.0, Expert Systems define elements of the Decision Making Module (DDM) for the rational use of time and resources[5,6]. DDM elements can receive information from other information monitoring system or software module elements and offer their own functions. From this, it can be seen that the role of DDM in CPS is very important [7,8].

The decision-making module (DDM) is a module of the automated information monitoring and decision-making software complex based on computer technologies, which is intended to help the decision-maker in complex situations for an objective, complete and unbiased analysis. [9,10].

There are some problems in CPS that are too complicated to use traditional mathematical methods. These issues are characterized by the complex structures of objects: the need to make quick decisions based on the processing of a large amount of information at the time of constantly changing external and internal characteristics; it is possible to make a decision by analyzing the stochastic and dynamic properties of objects in the regions [11;12].

METHODS

DDM helps to solve two important issues: choosing the most optimal solution among the solutions; sorting solutions according to the degree of priority[13].

According to the level of use of DDM, it can be divided into the following classes [14]:

provides - information in the passive decision-making process, but does not form a decision-making proposal.

based on the criteria which one should be chosen from many active-formed decisions

cooperative (communication) - A decision making system (DMS) is offered to the decision maker to modify, supplement or improve the decisions made by the system.

Information Builders Webfocus, Sap Businessobjects, Qlikview, Wolfram Mathematica, Meetingpulse, Eidos, Qvistorp, Analytica, Easykost, Decisiontools Suite, Knowmax, Smart Decisions decision-making modules are widely used for continuous production and business phases of industrial enterprises[15].

Knowledge base - it is possible to understand the inclusion of information about human experience and knowledge in DB based on rules in a certain field [16,17].

The scheme of intellectual decision-making in a manufacturing enterprise can be described in the form $\{\{\{Y\}, F\} \to Y^*\}$. Here $\{Y\}$ is a set of objects (offers), F is a choice function, Y^* is a chosen object (decision).

In special cases, the DMS can be formed from expert systems[18]. The characteristics of the DMS interface differ in decision-making methods and alternative evaluation methods[19]. Therefore, the architecture of DMS is divided by the authors into three, four and five parts[19,20]. For example, Yu.M. In his research work, Lisetsky proposed to divide the DMS architecture into four parts (Fig. 1)[21]:

- data collection and processing module from sources;
- data storage and management module;
- data processing module in the database;
- a module for issuing orders to employees for decision-making.

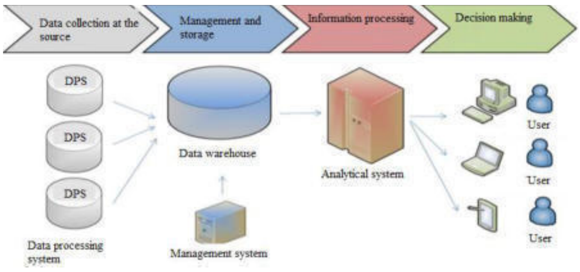

Fig.1. Architecture of DMM in corporate integrated information systems

The main goal of all the presented architectures of the DMS is to help in quick decision-making [22,23].

The most important process is the design of CPS and the selection of DB [24]. Selection and aggregation of knowledge creates difficulties in creating DMM. To solve these problems, it is important to develop models of knowledge representation.

The complexity of knowledge creation is that the system should move to the next process with little effort and time spent using the model[25].

Knowledge-based intelligent DMMs are divided into two evolutionary developments [26,27]:

- in the first generation CPS, widely used rule-based expert systems for planning and management [28].

- *is implemented using second* generation neural networks, fuzzy logic and genetic algorithms [29,30].

DMM requires the existing data in the database to be sorted and structured. knowledge base is referred to for sorting and structuring information in the database [31]. the information in the database is analyzed based on the rules in the knowledge base.

The information supply structure can be divided into three parts when making decisions using the rules in the knowledge base (Fig. 2):

- All information about the composition and properties of raw materials should be stored in the database through the information monitoring software module;
- Analyze the database using methods and algorithms for data analysis and knowledge retrieval, and prepare conclusions for decision-makers through the rules in the database.

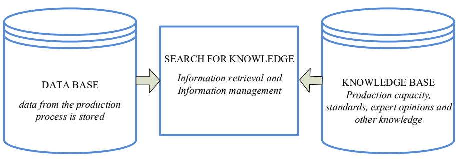

Fig. 2. Structure of information supply in decision-makingVarious methods and algorithms are used to analyze data and search for knowledge [32]:

- - intellectual analysis of data;
- - search for knowledge;
- - simulation modeling;
- - genetic algorithms;
- - neural networks;
- - cognitive modeling;
- - analyzing situations.

Some of these methods have been developed for use within the scope of intelligent systems. The following models of knowledge representation are used to minimize data and transform it into knowledge [33]:

- a *production model*-a rule-based model, knowledge is expressed through sentences of the form "If condition, then action";

- semantic network - The information model of a subject area in the form of a graph, where the nodes of the graph represent the objects of the domain, and the edges express the relationships between them;

- ontology - A method for managing complex technical and organizational ystems based on artificial intelligence theory;

-logical representation of knowledge - A set of facts and statements required to solve practical problems, where all information is presented in the form of formulas frame model -This is based on the concept of a frame (frame-structure, framework). A frame is a data structure used for the conceptual representation of an object.

RESULTS

- *A frame resembles an object in object*-oriented programming, but it differs in that it does not have the property of encapsulation.

TABLE I. The structure of the frame content

Frame Name: Sample			
Slot name	Slot type	Slot value	Procedure
X1	FRAME OR TABLE	Ptr(FRAME2) OR Ptr(TABLE)	IF-ADDED
X2	INTEGER OR REAL	-1,2,0,1,2,5 OR -1.25, -4, 0, 1.35	IF-NEEDED
… ……	LIST OR TEXT	THIS FRAME MODELING!	IF-REMOVED
Xk	LISP	Ptr(PROCEDURE2	PROCEDURE1

According to I.V. Anikin and A.S. Potapov, the frame model can be used to transfer the characteristics of a database to a knowledge-based system [34].

The general representation of a frame model can be expressed as follows:

$$f = [(r_1, v_1), (r_2, v_2)..., (r_n, v_n)],$$

where, f - frame name, r_i -slot name, v_i -slot value and $i \in \overline{1..n}$.

In each frame, various types of information can be associated and represented in a tabular form (Table 1).

Each node of the frame is defined by a set of attributes and their values placed in the frame slots, describing the concepts.

Slot- An attribute associated with a node in a frame-based system.

The frame model is used for constructing databases in knowledge-based systems [34]. Through the frame model, knowledge is organized into a specific structure and divided into components. Marvin Minsky developed the frame model for describing knowledge based on his research [35].

In the research work of A.E. Ermilov and P.V. Misevich, it was proposed that in distributed systems, decisions are made and adapted through frames, used as a module in information monitoring systems, and that various types of procedures can be attached to the frame model [36] (Fig. 3). In this approach, the database of the software complex is constructed using the frame model, and an algorithm for decision-making through information monitoring of the knowledge-based system is proposed.

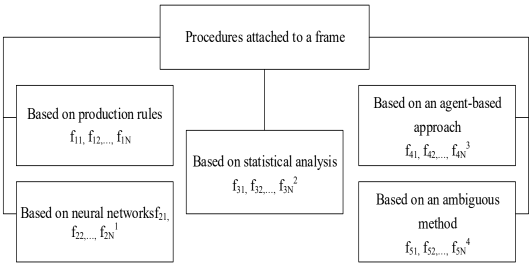

Fig.3. Procedures Attached to the Frame

TABLE II. A comparative analysis of knowledge representation models

Attribute	Production	Logical representation	Semantic network	Frame
Knowledge Management	+	+	+	+
Complete description of the process	*M*	*M*	*C*	*C*
Organizing knowledge into a structure	-	-	-	+
Applying methods for knowledge retrieval	*C*	*M*	*M*	*C*
Ensuring the integrity of knowledge	+	-	+	+
Logical inference	+	+	+	+
Knowledge extraction	-	+	+	+

The comparative analysis of knowledge representation models based on the above research studies is presented in Table 2. In this table, notations such as *M* for complex and *C* for simple are used

The comparative analysis presented in Table 2 shows that the main advantages of knowledge representation models in knowledge-based systems depend on their application areas. The frame model is considered convenient for implementation through classes and objects in object-oriented programming languages.

DISCUSSION

This article presents a comparative analysis of decision-making classes and models, as well as knowledge representation models and decision-making modules in knowledge-based systems. Based on the analysis results, the possibility of defining the knowledge representation model and decision-making mechanism in the information monitoring and decision-making software complex of a knowledge-based system was established. It is deemed appropriate to construct the knowledge base in a knowledge-based system using the frame model.

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MODEL OF APPLYING THE INTELLIGENT WATER DROPS ALGORITHM IN MEDICAL DIAGNOSIS

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Abstract: **This article proposes the application of the Intelligent Water Drops (IWD) algorithm in medical diagnosis. For this purpose, the article discusses the problem of understanding standard patterns for carrying out the medical diagnosis process intelligently using the IWD algorithm, and presents a model for applying this algorithm.**

Currently, one of the pressing issues is the delegation of tasks from various fields to intelligent machines. To accomplish such tasks, the use of artificial intelligence (AI) algorithms and machine learning methods is of significant importance [1].

In this article, a diagnostic model aimed at solving medical diagnosis problems using the Intelligent Water Drops (IWD) evolutionary algorithm, which is one of the AI algorithms, is developed.

The Intelligent Water Drops (IWD) algorithm attempts to model certain processes occurring in rivers and then implement them as an algorithm [2].

The IWD algorithm is one of the newly developed algorithms, simulating the dynamics of river systems. It is a population-based algorithm in which each drop represents a solution, and the exchange of drops during the search for solutions allows for the discovery of better solutions.

In 2007, Iranian scientist Hamed Shah-Hosseini developed the behavior algorithm of intelligent drops [3-4]. In the IWD algorithm, multiple artificial water drops are capable of altering their environment to find an optimal path along the least resistance route as a result of interaction. This algorithm is a population-oriented constructive optimization algorithm.

IWD is a model where water drops find the optimal path to their destination by altering the flow of the river. It is aided by three crucial parameters. Drops have the ability to transport soil at the riverbed according to their movement speed. The higher the speed of the drop, the more soil it carries, which in turn facilitates the free movement of other agents. Flow speed increases in areas where there is no soil. The optimal path can be described as the one where the least amount of soil is present, allowing for the highest possible speed. The IWD algorithm enables the implementation of an optimization strategy in which random agents interact intelligently with each other, thereby collectively altering the direction of the river flow and creating an optimal path free of any soil. This allows the flow speed of agents to reach the highest possible level.

The main principles of the IWD algorithm:

- Each water drop prefers a path with less soil over a path with more soil.
- When a water drop has to choose between several routes from the source to the destination, it selects the shorter path.
- The state of the path is determined by the amount of soil on it; a path with a high level of soil is considered non-optimal, while a path with a low level of soil is considered optimal.

One of the characteristics of each water drop flowing in the river is its speed. Another characteristic is its soil-carrying capacity. Thus, each water drop is capable of transporting a certain amount of soil from one place to another. During this movement, the soil is transferred from the faster-moving part to the slower-moving part. During this process, three changes occur:

- The speed of the water drop increases;
- The water drop's saturation with soil increases;
- The amount of soil in the channel between the two points decreases (the weight between two points in the graph decreases).

Thus, in the IWD algorithm, drops are characterized by two main properties:

- speed,
- soil.

Both of these characteristics change during the operation of the algorithm. The drops in the IWD algorithm move from the source to the destination and begin their journey with an initial speed and amount of soil. During their movement, the drops pass through an environment where soil is removed and some speed is gained. It is assumed that IWD is implemented iteratively. The movement of the water drop from the current point to the next is non-linearly proportional to the amount of soil; the speed of the drop is inversely proportional to the amount of soil.

$$vel = vel\ (t-1) + Av\ /\ [Bv + Cv * soil\hat{}2(i,j)]$$

Here: *Av, Bv, Cv* are the velocity coefficients (input parameters), and *soil(i, j)* represents the amount of soil between the nodes of the graph. It can be observed that a path with less soil allows the IWD drop to move faster compared to a path with more soil.

As the IWD drop moves through the environment, it accumulates soil. This soil is taken from the path connecting two points. The amount of soil collected by the IWD drop is non-linearly proportional to the time required to move the IWD from the current location to the next. This time interval is calculated using the simple laws of physics for linear motion:

$$time(i,j,vel) = R / vel$$

Here: R is the distance between two points (nodes). The amount of soil added to the drop:

$$dSoil(i,j) = As / [Bs + Cs * time(i,j,vel)]$$

here *As*, *Bs*, *Cs* are the coefficients of the soil's ameliorative condition. The new amount of soil on the path between the points is determined as follows:

$$soil\ (i+1,j+1) = Po * soil(i,j) + Pn * dSoil(i,j)$$

Here: Po and Pn **are the coefficients of the soil change process.**

Thus, the time spent on movement is inversely proportional to the speed of movement and directly proportional to the distance between two points. It is important to note that the soil is a quantitative indicator of information about the environment [5-7]. These formulas demonstrate the preference of drops for paths with lower soil levels over paths with higher soil levels. This path selection is implemented by applying a unique random distribution to the existing paths. The probability of selecting the next path is inversely proportional to the soil level of the available paths. Therefore, paths with lower soil levels have a higher probability of being chosen by the IWD drops [8].

We will adapt the IWD algorithm for application in medical diagnosis problems. This algorithm can also be used to identify optimal parameters or symptoms related to diseases in medical diagnostics. The IWD algorithm model for a medical diagnosis problem might be as follows:

- **Problem formulation:** In this stage, the medical diagnostic problem to be solved is identified. For example, this could be the classification of diseases based on the symptoms of a patient.
- **Graph construction:** A graph representing all possible combinations of symptoms or parameters is created. Each node in the graph corresponds to one combination.
- **Calculation of the probability of selecting the optimal path:** A heuristic function that calculates the probability of selecting each combination of symptoms or parameters is determined. This probability is based on the amount of soil that is updated according to the chosen combinations.
- **Drop deployment:** Water drops are deployed at random nodes in the graph, and the soil amount is updated to evaluate the quality of each combination and allow the drops to move across the graph.
- **Drop movement:** To continue moving, the drops select one of the next nodes based on the probability, which depends on the amount of soil and the heuristic function. The probability of selecting a node close to the current node is higher.
- **Soil amount update:** After each movement of the drops, the amount of soil on the edges of the graph is updated according to the chosen combinations.
- **Selection of the optimal combination and completion:** The soil update and movement process is repeated several times until a stopping criterion is met. Then, the optimal combination of symptoms or parameters is selected based on the soil amount and the heuristic function.

The IWD algorithm model for medical diagnostics has a number of advantages and limitations. It includes the ability to automate the selection of symptoms or parameters, as well as potential issues such as premature convergence and inefficiency if the heuristic function and algorithm parameters are not selected correctly.

The above model can be used in building algorithms to create software tools for diagnosing various diseases or verifying the accuracy of diagnoses made by doctors.

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METHODS OF INCREASING INFORMATION RELIABILITY BASED ON DETECTION OF SUSPICIOUS TRANSACTIONS

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Abstract. In this research, the question of increasing the reliability of data based on the identification of suspicious transactions was considered. In the research, the analysis of suspicious transactions, mechanisms for comparing traditional methods and machine learning approaches in identifying suspicious transactions, methods for identifying suspicious transactions based on the LSTM neural network in payment information monitoring systems were developed.

Key words. Suspicious Transactions, Payment Information, Machine Learning, LSTM Neural Network.

Identifying suspicious transactions in payment information monitoring systems is one of the main pressing issues today. Suspicious transactions are transactions that deviate from the normal transaction behavior of an individual or legal entity and may indicate fraud, money laundering or other illegal activities. These transactions can vary widely, but often share common characteristics that distinguish them from legitimate activity. Examples of suspicious transactions include:

Unusually large transactions. Transactions that are significantly larger than the customer's normal spending pattern.

A few small transactions. A series of small transactions over a short period of time may show that "smurfing" can be used to circumvent detection limits.

Geographic anomalies. Transactions originating from locations where the customer has never done business before.

High risk countries. Transactions involving countries known for fraud or money laundering.

It's a strange time. Transactions that take place during unusual hours for the customer.

Sudden changes in the transaction. Sudden increase in transaction frequency or volume without clear explanation.

Operations with unusual characters. Transfers between multiple accounts without reason.

Common problems in identifying suspicious transactions. Identifying suspicious transactions involves addressing several key issues:

Data size and speed. The sheer volume of transactions processed daily and the speed at which they occur can slow down traditional monitoring systems.

False positive decisions. Legitimate transactions can be falsely flagged as suspicious, leading to customer dissatisfaction and unnecessary investigative costs.

Wrong negative decisions. Undetected fraudulent transactions can lead to huge financial losses.

Evolving fraud tactics. Fraudsters are constantly developing new ways to bypass detection systems, which requires constant updating and adaptation of monitoring algorithms.

Data quality. Incomplete, inaccurate, or inconsistent data can impede the effectiveness of detection systems..

Regulatory compliance. Ensuring compliance of detection systems with various legal and regulatory requirements can be complex and resource intensive.

Balancing security and customer experience: Striking the right balance between reliable fraud detection and a seamless customer experience is critical to maintaining customer trust.

Comparison of traditional methods and machine learning approaches in identifying suspicious transactions

Rule-based systems. Predefined rules are used by analysts to identify suspicious transactions. Easy to implement and understand, effective for certain fraud patterns, but limited flexibility, high false positive rates, and requires constant manual updating.

Statistical analysis. Statistical methods are used to detect changes or anomalies in transaction data. Can handle large data sets, develop a quantitative basis for detection, but may miss complex fraud patterns, relies heavily on historical data.

Supervised machine learning. These models are trained using labeled datasets containing examples of both legitimate and fraudulent transactions. High accuracy, continuously improves with more data, adapts to new fraud patterns, but requires large, labeled datasets, can be complex to implement and maintain.

Unsupervised machine learning. These models, based on deviations from normal behavior, detect anomalies in an unpredicted manner. Can detect previously unknown fraud patterns, does not require labeled data, but may produce high false positive rates, requiring more sophisticated interpretation of results.

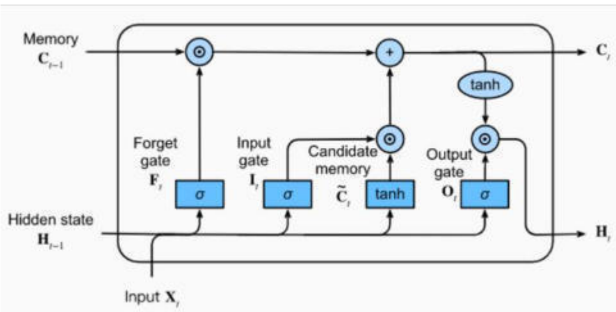
Traditional methods are generally simpler and easier to implement, but the process of adapting to the evolution of fraud tactics is complex. Machine learning approaches offer high accuracy and flexibility, capable of detecting both known and unknown fraud patterns, but require more complex implementation and maintenance. Understanding these fundamentals, the research involves developing systems to detect suspicious transactions using the strengths of traditional methods and advanced machine learning techniques.

Identification of suspicious transactions based on neural networks in payment data monitoring systems

Neural networks can be used to detect suspicious transactions in payment data monitoring systems. These networks are widely used for tasks such as anomaly detection, which is important in identifying suspicious transactions due to their ability to make predictions based on complex data sets. LSTM networks, a type of Recurrent Neural Network (RNN), are well suited for sequential data due to their ability to capture temporal dependencies and long-term patterns. In the context of transactional data, LSTMs can model a sequence of user transactions over time to detect anomalies or suspicious activity. Initially, the transaction data is organized sequentially to take advantage of the strengths of LSTM. Typically, sequences are grouped by user_id and sorted by timestamps. All operations performed by a particular user are arranged in chronological order to form a sequence.

$$X_u = [x_{u,1}, x_{u,2}, ..., x_{u,T_u}]$$

where u represents a unique user, T_u – u number of transactions per user, $x_{u,t}$ - feature vector for transaction *t* of u users. The LSTM unit consists of several components that regulate the flow of information: an input gate, a forget gate, an output gate, and a cell state. Below are the mathematical formulas for each component.



1. LSTM architecture. *For each time step, t is the input vector* x_t*, the previous hidden state is* h_{t-1}*, and the previous cell state is* C_{t-1}.

Input Gate (i_t) controls how much new data enters the cell state.

$$i_t = \sigma(W_i[h_{t-1}, x_t] + b_i)$$

Forget Gate (f_t) determines how much of the previous cell state to keep.

$$f_t = \sigma(W_f[h_{t-1}, x_t] + b_f)$$

Output Gate (o_t) controls how much of the cell's state affects the hidden state.

$$o_t = \sigma(W_o[h_{t-1}, x_t] + b_o)$$

Cell Candidate ($\widetilde{C}_t$)

$$\widetilde{C}_t = \tanh(W_C[h_{t-1}, x_t] + b_C)$$

Cell State Update (C_t) updates the cell state by combining the previous state and the new candidate values.

$$C_t = f_t * C_{t-1} + i_i * \widetilde{C}_t$$

Hidden State h_t generates output for the current time step.

$$h_t = o_t * \tanh(C_t)$$

where σ is the sigmoid activation function, tanh is the hyperbolic tangent function, and * is element-wise multiplication.

After processing the input sequence through LSTM layers, the last hidden state h_T (where T is the last time step) is usually passed through a dense (fully connected) layer with a sigmoidal activation function for binary classification (suspicious or not)

$$\hat{y} = \sigma(W_y h_T + b_y)$$

Here, W_y and b_y are the weights and biases of the output layer, and $\hat{y}$ is the estimated probability of the transaction being suspicious.

Through the above-mentioned architecture, it is possible to identify suspicious transactions in payment data monitoring systems.

Conclusion

The issue of identifying suspicious transactions in payment information monitoring systems was investigated in the research work. The analysis of suspicious transactions, the comparison of traditional methods and machine learning approaches in the detection of suspicious transactions, the methods of detecting suspicious transactions based on neural networks in payment information monitoring systems have been developed. Based on the developed methods, it is possible to identify suspicious transactions.

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PREDICTION OF USERS' INFORMATION NEEDS IN INFORMATION LIBRARY SYSTEMS

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A B S T R A C T **The volume of resources in information library systems is increasing exponentially. As a result of the increase in the size of resources, information-library system users face problems in obtaining resources suitable for their information needs. In this case, the information-library system should include users' demographic data, characteristics, static and dynamic data, interests, professions and preferences. Based on this information, the system provides resources suitable for the user's information needs. Predictive algorithms are also important in providing resources suitable for users' information needs. This article predicts the information needs of users in information library systems using the Bayes algorithm.**

K E Y W O R D S **Information-library, information-library system, user, resources, information need, Bayes algorithm**

INTRODUCTION

The need for information in the library systems is increased year by year because most of resources are digital and volume. Yet, during this expansion, it becomes equally complicated for users to access the given piece of information that they seek and hence ending up feeling frustrated in turn unproductive. Given this complexity, recognizing and assessing the specific information needs of individual users is a critical issue. This should give librarians a better idea of what users in their community need, which will lead to the ability for each library system to offer resources that are targeted and relevant — features you can use as part of delivering an overall user experience. Furthermore, personalized resource suggestions save users time and energy looking for what interests them which in turn increases recommendation efficacy.

This is where active analysis of user behaviour and information seeking patterns are critical for libraries to streamline their services. The development of this analysis is not to plan out what a library needs at present, but anticipates forthcoming trends and demands. Finally, a user-centered approach supports creation with care and responsibility in collection management — making all our collections as useable by as many users for whom they may be of interest appropriate. While the overall contribution of libraries as a major source for promoting knowledge and information would be fostered through improved quality in terms of user care and resource optimization [1-4].

METHODS

The following factors should be taken into consideration when providing resources appropriate to users' information needs [5, 6]:

1. Create a user profile. User profile helps determine information needs based on various criteria.

- demographic information: name, surname, age, gender, nationality, education level, occupation and other information;
- interests and areas: the user's scientific field, personal interests, hobbies, what topics he is most interested in;
- purpose of use: Understanding the purpose for which users obtain resources from the information-library system (research, professional development, general information) helps to improve the quality of library services.;

2. Literacy in using the information library system. It is important for users to understand and use modern library processes effectively.

- knowledge of using digital information services: electronic catalogue, database, knowledge base, use of electronic resources;
- information retrieval methods;

3. Collect and analyze user feedback. Collecting user feedback is important in determining information needs. User feedback can be determined in the following ways:

- surveys: It is possible to obtain information about users' information needs through public and targeted surveys;
- interviews: information needs can be analyzed and reviewed through face-to-face and online meetings with users;
- through comment boxes: collecting suggestions and complaints from users in the information library system and on the website;

4. Analysis of user behavior in the search for information. Analyzing users' behavior in search engines helps to identify their information needs and important topics:

- retrieval history analysis: examining search histories in electronic catalogs and databases**;**
- most frequently used sources and topics: track which topics and sources are used most frequently**;**
- data access density: Determining which types of data and search results will satisfy users;

5. Personalized approach. Since users may have individual information needs, attention should be paid to personalizing information-library services.

- recommendation system: implementation of recommendation systems based on users' previous searches and usage history;
- providing services appropriate to users' unique scientific and professional knowledge.

RESULTS

Modern technologies in information library systems play an important role in clearly defining the information needs of the user and providing them with appropriate information and resources. Users have certain needs for access to various scientific articles, books, databases, and it is important for information systems to determine these information needs in advance. This problem can be solved using the Bayes algorithm [7].

The Bayes algorithm is based on statistical probability theory and is designed to work with uncertainty. Since the user's information needs can change dynamically, the Bayes method allows us to adapt to these changes. In addition, this algorithm helps to predict the user's future information needs based on current evidence. When the Bayes algorithm is used in information retrieval systems, the relevant probabilities are updated for each user search query. In this process, the algorithm provides information that matches the user's specific search pattern.

Using the Bayes algorithm, the estimation of users' information needs is performed as follows:

$$P(C|X) = \frac{P(X|C) \cdot P(C)}{P(X)} \qquad (1)$$

Here, $P(C|X)$ – is the probability of belonging to a topic based on the user's search, $P(X|C)$ – is the probability that the search request belongs to the given topic, $P(C)$ – is the total probability of a particular topic (prior probability), $P(X)$ – is the total probability of a search request.

The Bayes classifier is based on the independence assumption that assumes that each feature appears independently. If a user is interested in a particular set of search terms $X = \{x_1, x_2, \dots, x_n\}$ the probability of belonging to a particular topic is expressed as:

$$P(C|X) = \frac{P(C) \cdot P(x_1|C) \cdot P(x_2|C) \cdot \dots \cdot P(x_n|C)}{P(X)} \qquad (2)$$

The total (prior) probability $\boldsymbol{P(C)}$ for a given topic $\boldsymbol{C}$ is calculated as follows:

$$P(C) = \frac{\boldsymbol{C\ is\ the\ number\ of\ searches\ on\ the\ topic}}{\boldsymbol{total\ number\ of\ searches}} \qquad (3)$$

The probability that query x_i belongs to the given $\boldsymbol{C}$ is calculated as $P(x_i|C)$:

$$P(x_i|C) = \frac{\boldsymbol{Number\ of\ searches\ on\ topic\ C\ x_i}}{\boldsymbol{C\ is\ the\ number\ of\ all\ searches\ on\ the\ topic}} \qquad (4)$$

If there is more than one topic, the common topic probabilities for all topics are calculated, the most suitable topic for the user's search query is determined, and the topic with the highest probability is selected:

$$C_{optimal} = arg\ max\ P(C|X) \qquad (5)$$

DISCUSSION

Using past search sequences in order to predict how the user will perform future searches based on the analysis of previous searches patterns. A Bayesian algorithm is constantly being recalculated as users interact with the system, updating probabilities and therefore increased prediction accuracy. The algorithm predicts the most likely next search queries, with a probability model that becomes more accurate as users' needs become increasingly apparent. It processes trends in user-interactions with content, returning results that would be more compatible to the type-voxes each individual is likely came expecting. Over time, the system becomes better at predicting what information is likely to be relevant — which increases both accuracy and speed. The system continually learns and adapts which then complements the evolving requirements of users in academic libraries. In addition to reducing the time it takes for users to search, anticipating user queries can reduce duplicative query activity - making your efficiency higher.

Quicker search results translate to decreased load times, a pertinent factor in creating an uninterrupted experience for the consumer. Faster load time also means less strain on system resources and more cost effective, environmentally-friendly provisioning of library data. In addition, this predicitve power reduces the number of overall databases on a scale at the risk purchasing them endlessly in an uncontrollable way. Which gives more direct access to targeted literature by avoiding lose and unlimited academic records online. Finally, the system enables more precise and faster personalized information searching helping to meet better dynamic requirements of users in increasingly complex library systems. Additionally, this method provides a key function of allowing users to acquire information efficiently and in just the time they need it thereby enriching overall library services.

CONCLUSION

The study of the use of Bayes algorithm in information library systems automation personalized recommendations which provides individual service to user. With the help of this algorithm, user's former interactions analyzed predictor to predict future information needs that increases overall effectiveness of search operation. Powered by probability theory, this predictive function allows the system to take in much more raw data and use it for decision-making on what content should be recommended. In the end, it allows users to find resources in a more relevant way so that searches take less time. This method not only can enhance user satisfaction, but also the quality of libraries services. And as the algorithm learns more and profiles its user input, it can become even better at serving any information request that a library system needs to handle.

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ANALYSIS OF CRITERIA AND METHODS OF INTELLECTUAL ASSESSMENT OF THE EFFECTIVENESS OF PERSONNEL SAFETY SYSTEMS

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A B S T R A C T **This article examines the main criteria and methods for an intellectual assessment of the effectiveness of security systems used in the implementation of underground mining operations. The study focuses on risk analysis, economic efficiency and social aspects of security systems. On the basis of the analysis, proposals are made to develop new intellectual solutions to improve existing approaches and increase the safety of employees in underground mining processes.**

K E Y W O R D S security systems, IDEF0 model, potential threats, system reliability, risk analysis, contingency plans, computer modeling, immature modeling, Central Management System, standard protocols.

INTRODUCTION

Negotiations are currently underway with the General Directorate of the Mining Industry of Turgan Kasib Olish ishlar on increasing the risk of mining industry development. At the same time, as the mining industry, port and gas fields become more dangerous, they are alternately seeking to integrate risks [1]. The purpose of this study is to facilitate risk analysis and the effectiveness of the analysis of existing mezzanine and segmental methods, as well as to develop recommendations for their improvement [2]. At a time when conlarida kazib olish ishlari was forced to take measures to eliminate risks, a state of emergency was declared on the 1st.

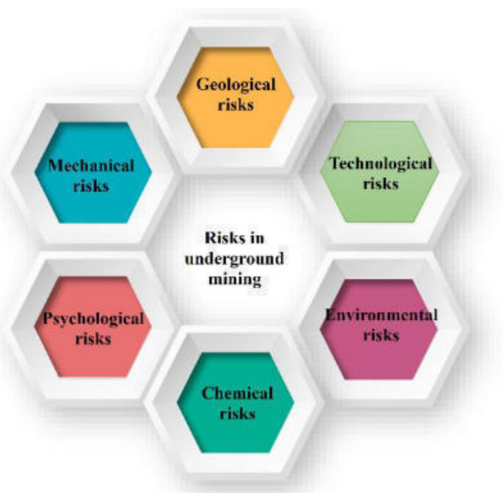

Fig.1 Risks in mining processes in underground deposits.

Various mechanical risks in the process of using vehicles in underground mining work, including risks in faviulence caused by the fact that the loads are not in full balance or are misplaced.

Underground mining operations-labor conditions are limited and require a long stay in a closed environment. This in turn increases the susceptibility to claustrophobia or mental malaise of workers.

During mining operations in the underground fields, various chemicals are observed, including the release of methane, carbon dioxide, serovodorod and other toxic gases and vapors. These substances negatively affect the respiratory system, increasing the risk of poisoning for workers.

During mining operations in underground mines, lahm walls and roofs are at risk of being kissed or collapsed. Hazards can be caused by tectonic activity, improper installation of the structure, stresses on the top of the ground layer, or mine pressure. Kissing causes workers to be injured or killed.

Emergency risks caused by unprofessional preparation or improper use of blasting agents when blasting is carried out in underground mining operations.

In the process of mining in underground fields, dust, gases (for example, methane, carbon dioxide) and other harmful emissions are released into the atmosphere. Emergency echalogical risks caused by the negative impact of emissions on air quality and the environment.

METHODS

At this point, if we consider the criteria for assessing the effectiveness of security systems. First of all, the security system should work reliably and stably. The effectiveness of the security system is determined by its ability to work in any conditions and the fact that employees provide training in safe Labor activities during labor activities. The reliability of the system is characterized by their ability to work smoothly in emergency situations [3].

The next task is that the system must respond quickly to any emergency and simple situations. The security system should detect threats in time and respond quickly, while evacuating personnel in emergency situations and ensuring the effective operation of the emergency prevention process.

This system should work with economic and social efficiency, as it is put next to any security system. The cost of implementing a safety system and its ratio to the effectiveness of accident prevention are very important criteria. This takes into account both direct and indirect economic efficiency [4,5].

The security system will have to provide not only physical protection for employees, but also take into account their psychological state, create comfortable and safe working conditions. There are several ways to assess the effectiveness of security systems, including:

risk analysis method: one of the most common methods, such as identifying probable risks, assessing their likelihood and consequences, involves qualitative and quantitative analysis methods;

method of emergency plans: various applications are used to assess the behavior of the security system by making scenarios in emergency situations. This method allows the system to immitate and analyze its responses to various threats;

computer modeling and immitation method of modeling: allows you to create a digital model of a security system and simulate its behavior in different conditions. This in turn makes it possible to assess efficiency and identify possible disadvantages.

The functional diagram of the security system allows you to provide basic processes, interaction of system elements, as well as control and control methods. Figure 2 shows a generalized functional diagram of the security system in the process of mining in underground mining.

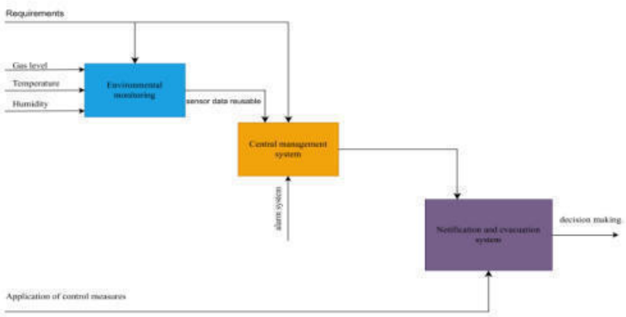

Fig.2 Functional diagram of the security system.

The risk described in tizimlarin can be reduced if it is modeled as a turret. You can familiarize yourself with the IDEF0 risk modeling methodology of IDEF0 risk modeling with a detailed description of possible, main and possible consequences [6,7,8,9]. Risk monitoring is carried out according to the IDEF0 model (3-Fig.), risk monitoring and response to them.

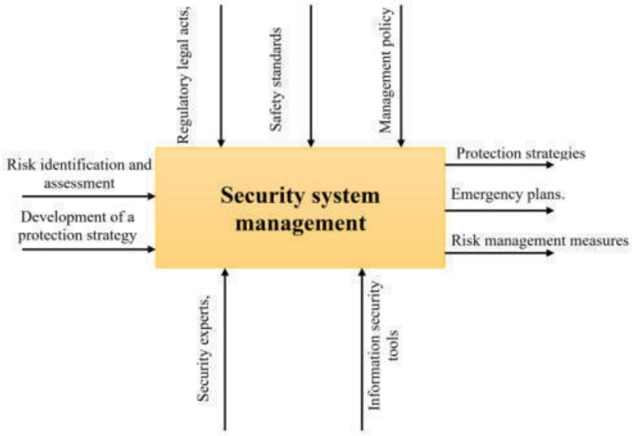

Fig.3 IDEF0 security system model.

RESULTS

The analysis showed that the effectiveness of security systems is a process based on technical solutions, organizational measures, as well as an integrated approach such as continuous training and improving staff skills. Reliability, sensitivity, economic efficiency, and social aspect accounting remain the main criteria for evaluating such systems.

There are recommendations for improving security systems: the introduction of innovative technologies, risk analysis and the use of artificial intelligence and big data in security management;

strengthening personnel training, regular training and professional development of personnel in new methods and technologies of security;

the development of standardized protocols, the creation of unified standards and protocols for the assessment and management of security at facilities in underground mines;

integration of environmental aspects, consideration of environmental risks in the development and implementation of security systems.

DISCUSSION

The importance of intellectual assessment of the effectiveness of Personnel Security Systems. Today, the issue of ensuring the safety of employees in industrial enterprises is of urgent importance. Intellectual systems, including security systems, play an important role in identifying and preventing possible risks during employee performance. This study examined the criteria and methods of intellectual assessment of the effectiveness of security systems.

Results analysis. The intellectual assessment criteria developed during the study were manifested as the main factors in improving the efficiency of the system. In particular, algorithms aimed at real-time monitoring of safety indicators, monitoring the behavior of employees and assessing the level of risk have shown their effectiveness. The effectiveness of the measures adopted to ensure the safety of employees was increased through the ability of these systems to analyze the automated state.

Practical significance. The results of this study are of practical importance for improving security systems in industrial enterprises. In particular, intellectual assessment methods are of great importance in the rapid identification of risks, ensuring that employees comply with safe operating rules, and thus reduce the number of accidents. At the same time, through these systems, the chances of improving the efficiency of the enterprise and protecting the health of employees increase.

Recommendations for further research. The possibilities of application of intellectual systems in the field of security are not limited. For further research, directions can be proposed for a more thorough study of Personnel Security Systems, their integration with alternative technologies and the development of new assessment criteria based on artificial intelligence algorithms.

This analysis shows that the methods of intellectual assessment of security systems are important not only in improving the efficiency of the enterprise, but also in maintaining the health of employees.

CONCLUSION

Effective systems for ensuring the safety of employees in the process of mining in underground mines should be a multifunctional system that combines modern technologies, organizational measures and high-level personnel training. Only an integrated approach minimizes risks and makes it possible to create safe working conditions in complex and dangerous conditions, such as underground mining operations. The synthesis of functional drawings, algorithms, software complexes as well as models such as IDEF0 into systems for ensuring the safety of personnel during mining in underground deposits significantly increases the efficiency of this system. The described approaches make it possible to more accurately model and analyze work processes, which, in turn, will help increase overall security in the enterprise, allowing timely detection and exposure to potential threats.

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DEVELOPMENT OF AN INTELLECTUAL SYSTEM MODEL OF INTEGRATION OF PERSONNEL DATA INTO THE MANAGEMENT SYSTEM IN MINE FIELDS

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A B S T R A C T **This article is devoted to the development of an intellectual system model for integrating personnel information into the management system in mine mines. The article examines the importance and relevance of the application of intellectual systems for the effective management and integration of personnel information. The author of the article proposed new methods of automated collection, analysis and management of personnel data using modern IDEF1X and IDEF0 model technologies. Also in the article, to improve the efficiency of intellectual systems, the integration architecture of the Zarmitan underground mining information system of the JSC Center "NMMC" and the Southern Mining administration was built as a prototype system. This intellectual system model serves to improve the efficiency of the underground mining industry, optimize human resource management and ensure its safety.**

K E Y W O R D S algorithm, model, integration, Information System, intellectual system, mine, IDEF0 model, IDEF1X model.

INTRODUCTION

Due to the development of digital technologies in industry, the 4.0 Industrial Revolution was considered, which is causing rapid changes in technological, industrial and social processes in the 21st century. The use of a new generation of information technology to revitalize and transform traditional networks in an industrial context helps maintain the competitiveness of traditional networks in the long term [1]. Mining industries also began to shift towards a digital information technology system.

METHODS

The intellectual underground mining industry, on the one hand, involves the use of information technology at every stage of its chain, from geological intelligence modeling to equipment exploitation and maintenance, logistics and transportation [2,3].

This technological integration enhances every stage of the mining process. The incorporation of personnel-related information into management systems within mine fields, coupled with digital transformation, is increasingly crucial. Such integration improves management efficiency and ensures production safety. By embedding personnel-related data into the management system, comprehensive information about workers' health and safety becomes accessible, facilitating swift and effective responses during accidents and emergencies. This data can be consolidated into a single database, managed and monitored by higher-level organizations [4,5]. This centralization accelerates information access and enhances tracking capabilities, ensuring a more efficient management process. Consequently, the integration of personnel information and digital transformation in the mining industry not only optimizes operational efficiency but also significantly contributes to the safety and well-being of workers [6,7,8]. The ability to promptly access and manage comprehensive worker information underpins effective safety measures and emergency responses, highlighting the vital role of information technology in modern mining practices [9,10,11].

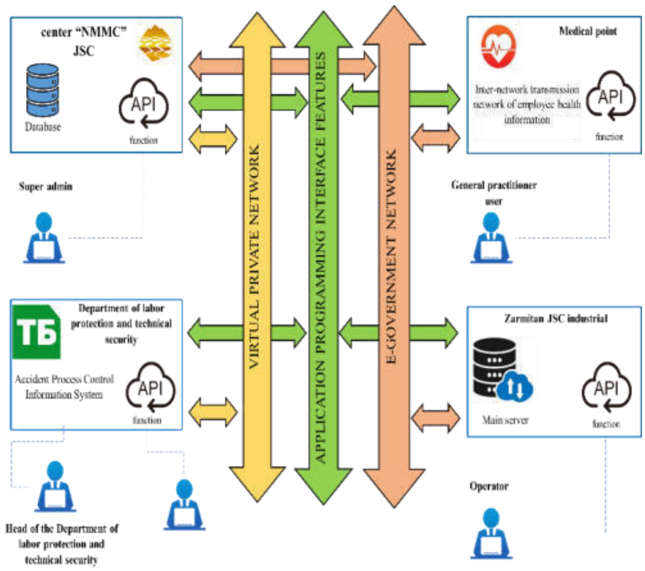

Fig.1 Integration architecture of the Zarmitan underground mining information system of the "NMMC" JSC center and the southern mining administration.

Fig.1 illustrates the integration architecture of the "NMMC" JSC Center with the Zarmitan underground mining information system of the southern mining administration. This architecture features a central server that stores data via a database and API, accessible by authorized users. The e-government network facilitates data exchange between databases and systems, while the API functions ensure integration across various systems. This setup enables data sharing, processing, and management. A VPN network is implemented for secure data transfer, allowing safe data exchange between departments. Integration encompasses the working staff health information sharing network and other systems. Authorized users can access data through the API using various devices, ensuring seamless connectivity and interoperability. This integrated approach enhances the efficiency and security of data management and communication within the organization. Data exchange is streamlined through databases and APIs, providing a robust framework for effective information sharing and system integration. The architecture supports comprehensive data management, promoting improved coordination and operational efficiency within the NMMC JSC Center and its connected systems.

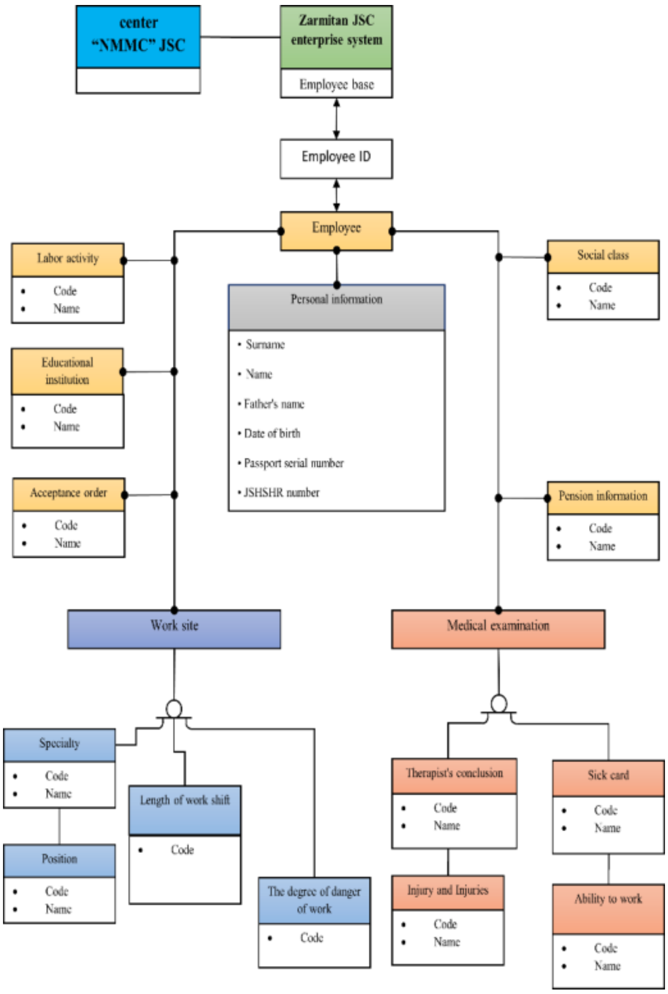

Fig.2 IDEF1X model of employee data formation modules.

IDEF1X model description of employee data formation modules. In fig.2 below, the image of the process of forming personnel data is built using the IDEF1X model. In the organization of JSC "NMMC", each working employee will have his own personal ID number. The next step is a module containing the personal data of the employees, where the last name, first name, patronymic, date of birth, passport serial number, JSHSHR number, gender, nationality, and permanent address information are entered. In addition, information related to the social category is divided into modules, which include information about labor activity, the name of the institution in which it was educated, the order on its entry into work, information about the place of work and health.

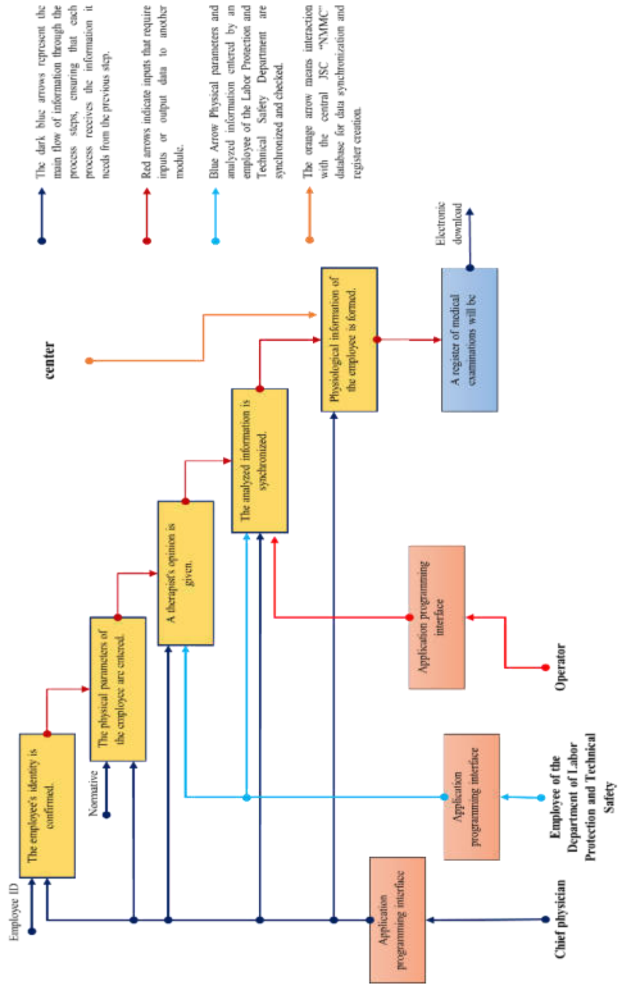

Fig.3 IDEF0 model of employee physical health parameter data formation module.

IDEF0 model description of the module for the formation of parameter data of physical health of employees. The chief physician is involved in the examination and confirmation of processes. Labor protection and equipment security the employee of the department controls the safety aspects related to the physical parameters included. The operator uses a software interface (API) to interact with the system and enter or retrieve data.

This model represents the IDEF0 model of the module for the formation of physical health parameters of employees. This process ensures the analysis and synchronization of health information and the creation of a register of physiological data in order to ensure the safety of working personnel at the South mine authority Zarmitan underground mine. At the first stage, the ID number of the employee's identification is confirmed. After the identity of the employee is confirmed, its physical health parameters are entered. The therapist makes a conclusion based on the physical parameters entered, and the verified information is synchronized. Physiological information of the employee is formed. A medical examination register is formed for the employee and can be downloaded electronically.

RESULTS

The results expected from the development of an intellectual system model for integrating personnel data into the management system in mine fields.

1. Effective data management. It will collect all information about personnel in one place, making it easier to control and analyze them.

2. Operational decision making. Provides the opportunity to make quick and clear decisions based on the intellectual system model.

3. Ensure safety. By integrating personnel data into the system, it will be possible to monitor and monitor their health and safety.

4. Automated system. Automation of manual work, which helps to save time and resources.

5. Real-time monitoring. The ability to monitor and analyze personnel activities in real time. This will help prevent dangerous conditions and increase efficiency.

6. Integration and flexibility. The ability to integrate with different software and devices, which makes it easier to expand and adapt the system.

DISCUSSION

In the process of integrating personnel data into the management system in mine mines, a number of problems may arise. In order to identify these problems and effectively deal with them, it will be advisable to consider the following main issues.

•The data of the working employee is stored in different formats and in different sources, which can cause problems when integrating them into a single management system.

As a proposal, develop standards so that all data is in a single format. It will be necessary to use tools that automatically transfer data of different formats to a common format. It is desirable to use ETL (Extract, Transform, Load) tools.

Extract-used when collecting data from various sources. Transform-is used in converting collected data into a single format. Load is used when loading transformed data into a single control system.

•Technological flexibility can be difficult to ensure between existing management systems and a new intellectual system.

Implementation of a modern management system as a proposal. ERP (Enterprise Resource Planning): implementation of modern ERP systems such as SAP, Oracle, Microsoft Dynamics. Implementation of management systems that allow managing the data of working personnel in a single system.

•The issue of the complexity of the intellectual system and how convenient it is for users can also present a number of difficulties. The fact that the system provides users with a simple and intuitive interface.

Regular training of employees to use new systems and tools as a proposal. Providing technical assistance to employees to adopt and effectively use the new system.

•Ensuring the security of a person's information is one of the important issues, as this information can be confidential or private.

As a proposal, it is advisable to apply secure network segmentation as network security and use firewalls such as firewalls, IDS/IPS (Intrusion Detection/Prevention Systems) and use the TLS protocol to ensure their safety while data is being transmitted.

CONCLUSION

As a conclusion, an integrated approach to the implementation of information systems makes it possible to significantly increase the efficiency of software products used by reducing the loss of time and data quality when importing/exporting from one system to another.

It is necessary to control the qualifications and experience of each employee, to set tasks suitable for them and to collect and analyze information related to him in order to ensure the necessary training programs.

In foreign countries, mining enterprises in particular are using intellectualized system technologies. Using the intellectualized systems of foreign countries, we introduced our new system as a proposal. As a solution to the problems encountered in the integration into the management system, our own proposals were given.

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INTEGRATION OF THE INTELLECTUAL SYSTEM OF FORMING THE NEED AND PURCHASES FOR GOODS, WORKS AND SERVICES

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A B S T R A C T **This article is dedicated to forming the needs of "NKMK" JSC, integrating and developing the system of purchasing goods, works and services. The article deals with the issue of effective management of purchases of goods and reduction of warehouse balance. In addition, new methods of automated collection, analysis and management of information about material assets of goods using the IDEF1X methodology of the modern IDEF methodology family are proposed. Also, in order to increase the effectiveness of the procurement system, it is envisaged that the integration of the information system reflecting the balance of material assets in the structural areas of "NKMK" JSC should be described in connection with the annual needs. This system model integrates the annual demand quantity with central warehouses to ensure low cost.**

K E Y W O R D S goods, work, services, IDEF methodology family, IDEF1X methodology, intelligent system, procurement process optimization, risk reduction, cost reduction.

INTRODUCTION

Industrial, technological and social processes are changing dramatically as a result of the development of services based on digital technologies in industrial enterprises in the 21st century. These changes started a new era called the fourth industrial revolution (Industry 4.0) [1]. In the context of industry, the need to use new generation information technologies to revive and transform traditional industries is growing. This is important in maintaining the competitiveness of traditional industries in the long term [2,3]. Also, the mining industry has begun to gradually move to digital information technology systems, and this process serves to increase production efficiency and create new opportunities [4].

METHODS

The process of procurement of goods and materials includes the use of information technologies at every stage of the chain, from the formulation of annual requests to their purchase and delivery. The need to integrate annual applications with balances in central warehouses is increasing, as well as the need for digital transformation technologies. These processes make it possible to efficiently deliver goods to factories and mines on time [5,6].

Through the integration of information on material resources with the management system and structural warehouses, it is possible to manage the annual expenditure limit, as well as get complete information about the fulfillment of goods and works in the regions where the demand is formed. This will help ensure the continuity of production and strengthen the supply system with emergency reserve materials [7,8].

By storing information about goods, works and services in a single database and controlling it by high-level organizations, it is possible to speed up the search and access to information. The architecture of the integration model of the procurement process information system for goods and services applications for the central and structural units of JSC "NKMK" is depicted in Fig. 1.

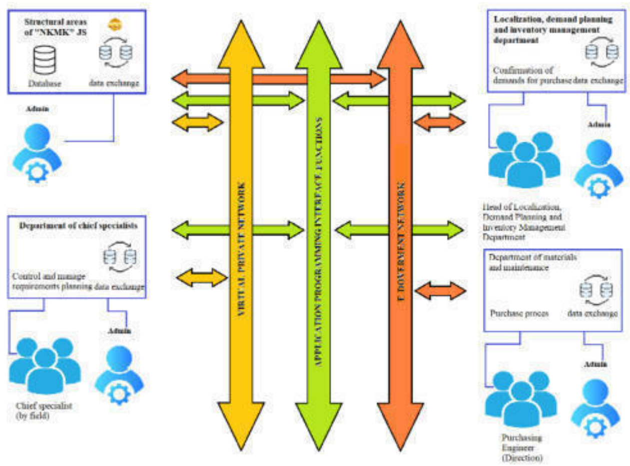

Fig.1 Architecture of the integration model of the product, service application and purchasing process information system of the center and structural areas of "NKMK" JSC.

Central server - stores the database and is managed by authorized users through data exchange. The e-government network is the basic infrastructure that implements the exchange of information between systems and provides efficient information exchange between different systems and databases [9].

API (Application Programming Interface) - functions provide integration between different systems, which makes it possible to exchange, process and manage data. A VPN network is designed for secure data transfer, through which data is exchanged between departments in a secure manner.

The exchange of information about goods and materials between different systems was carried out using databases and APIs. Users connected to the system will be able to receive the necessary information through secure data exchange using various devices [10,11,12,13].

RESULTS

Such a model increases efficiency in automating the processes of managing goods and services and optimizing the flow of information between them, especially for large industrial enterprises like "NKMK" JSC. The IDEF1X model of the process of forming the data of the material goods requisition and the procurement process is given in Fig. 2 below.

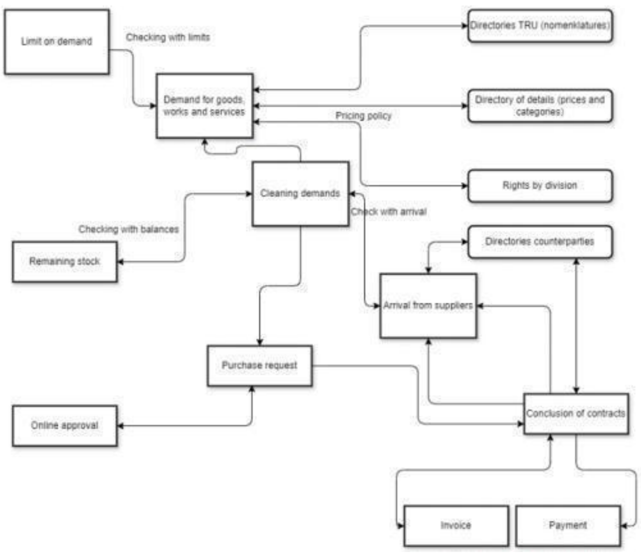

Fig.2 IDEF1X model of product and service application and purchase process data formation modules.

In the JSC "NKMK" organization, a special personal ID number (nomenclature) is issued for each product and service, which allows for accurate identification of each product and service. At the next stage, a special module is used to manage this information. This module contains information such as the name, quantity, unit of measurement, catalog number, TF TN code, as well as the field or specialty of each product and service.

The module not only manages basic information about goods and services, but also includes information about the area or department in which the request was made, balances in the central technical supply bases, and amounts received from contractors to JSC "NKMK" during the year. takes

Such a system allows for real-time monitoring of all data through an integrated database, automation of data updates, and planning based on warehouse balances. Also, this process is important in increasing production efficiency, ensuring mutual harmony of demand and supply, and optimizing stocks.

Data exchange between system modules is carried out with high accuracy and security, which allows all departments to receive detailed information about the availability and delivery of goods and services.

DISCUSSION

IDEF1X model description of the modules for the formation of product and service request and procurement process data. The IDEF1X (Integrated Definition for Information Modeling) model is widely used to represent structures and their interrelationships in the database. The IDEF1X model for product and service requisitions and procurement processes describes the flow of information required for the modules to function effectively. This model includes the following main elements:

1. Requisition Forming Module: This module forms the requirements needed to initiate the procurement process. Information such as the name of goods and services, quantity, price, and the time when the need was determined is stored in the database. The module receives the information entered by the user and stores it in the central database.

2. Warehouse and resource management module: This module manages and updates information about available resources and stock in warehouses. It compares requisitions with stock balances and helps prevent overstocking. Applications are automatically compared with the central warehouse and the data is updated through the system.

3. Data integration and management module: secure data exchange between different departments and systems using API and VPN networks. This module implements seamless integration of all information in the procurement process into the central database.

4. Procurement tracking module: This module tracks all stages of goods and services from procurement to delivery. Information is updated and presented to system users in real time.

Within the framework of the IDEF1X model, each module is considered as a unique link, and the relationships between them are reflected in the form of connected structures. Through these structures, the database access, exchange and data update functions of each module are performed.

CONCLUSION

Traditional procurement systems are often characterized by flaws such as subjective decisions, lack of information or poor planning, which reduce the effectiveness of the procurement process. As a result of such limitations, the need to automate and optimize procurement processes through the introduction of intelligent systems is increasing.

In order to perform such tasks, this study considered the possibilities of creating an intelligent system for determining the demand for goods and services, analyzing market conditions and consumer needs, as well as forecasting purchases. This system not only saves time and resources, but also improves the overall efficiency of the procurement process. Intelligent systems, meanwhile, facilitate accurate and informed decision-making, which leads to fewer planning errors. In addition, the integration of intelligent systems brings higher socio-economic efficiency compared to previous systems. Systems like these can significantly benefit organizations and increase their competitiveness by optimizing procurement processes, reducing risks and reducing costs.

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INTELLECTUAL SUPPORT OF GEOINFORMATION AND TECHNICAL SYSTEM OF HYDROSPHERE MONITORING OF MEASURING WELLS

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A B S T R A C T **This article presents methods for collecting and preprocessing algorithms of data from monitoring observation wells based on automated measurement systems, fuzzy models of calculation, processing of signal data with identification based on implementation algorithms as well as intelligence analyses fractographic and mapping materials of course creating a distribution map of the groundwater level based on the obtained results.**

K E Y W O R D S **Monitoring wells, groundwater, automated measurement devices, intelligent data analysis, water level, ultrasonic and radio wave sensors, electrical conductivity, mineralization.**

INTRODUCTION

It is important to improve the scientific and practical methods of providing the population with drinking water in the world, rational use of underground water resources and determining the laws of water exchange of the regional drinking water field based on automated measurement methods, as well as using high-tech software tools in the automated monitoring system. attention is paid. Special importance is attached to remote determination of groundwater conditions and mode parameters in monitoring wells, as well as automated measurement methods at monitoring points. Among them, the development of algorithms and software tools for the improvement of automated measurement methods in monitoring regime parameters of various hydrogeological conditions in developed countries, in particular in countries such as the USA, Canada, France, China, the Netherlands, Denmark, Japan, and the Russian Federation, is considered an urgent issue [1] .

In the world, scientific research aimed at the creation of automated methods, calculation algorithms and software packages for the assessment of drinking water resources, the determination of underground water reserves and the measurement of underground water parameters is being carried out. In this regard, among other things, the use of prospective measurement methods in experimental-calculation issues, description of underground water, development of technical solutions based on mathematical and computational models, algorithms and software tools, underground water necessary for drinking water supply in hydrogeological regions special attention is being paid to the improvement of the methods of automated monitoring of underground water, which provides an opportunity to predict the level and quality of water.

Currently, foreign countries are using automated methods of measuring groundwater hydroregime parameters in practice [2]. Aquifer hydroregime parameters are considered a system of regular monitoring of the level, temperature and general mineralization of groundwater, which is carried out at a specified time interval. In monitoring wells, hydrogeological roulettes, electronic level measuring devices, and devices that collect data based on automatic level measurement are used to measure the water level and obtain data [3]. The issue of automated monitoring of underground water is the system of regular monitoring of changes in the state of underground water under the influence of natural and man-made factors, the use of resource forecasting and automated methods, which are directly related to the regime and quality of underground water. are methodological works. [4].

The set of physical, chemical and biological indicators that can be used to describe the hydrogeological properties of groundwater is divided into the following groups [5]:

- - hydro regime characteristics - water level, water level slope, water volume, etc.;
- - features of underground water temperature regime - water temperature change, amplitude, heat flow, etc.;
- - characteristics of the hydrochemical regime - water mineralization (salinity), salt content (content of individual salt ions), concentration of organic, biogenic, polluting substances, etc.

The purpose of the work is to impruve monitoring of the underground hydrosphere by intellectual methods, to development of innovative hardware and software tools that increase the efficiency of aquifer data connected to a renewable energy source, based on measurement, recording, collection and transmission.

METHODS

In the process of the study used methods of intellectual data analyses, the theory of digital signal processing, mathematical modeling, to development of innovative hardware and software tools that increase the efficiency of underground water data connected, recording, collection and transmission digital filtering and spectral analysis were applied. Additionally, number lines of time series, hardware and software, algorithms the cognitive assessments of sunlight used to measure cognitive function.

RESULTS

Based on the information and technical support of the hydrosphere monitoring of the observation wells mentioned above, it is important to replace the laborious manual measurement process with automated sensors in the collection of observation data at hydrogeological stations in our republic. Today, the water leble, air pressure, temperature and electrical conductivity measuring sensors of the automated measuring device developed by autors at the State establishment "HYDROINGEO Institute" have a single case, and the air pressure and water pressure sensors are located below the water level determines the thickness of water based on air and water pressure through an air-conducting cable and the level, temperature and general mineralization of underground water through special software packages (Fig. 1).

It is important to use elements of artifisil intellect mathods and telecommunocations approach a ultrasonic and radio wave sensors to further improve the accuracy and efficiency of groundwater level measurement. A method of determining the water level using an ultrasonic ping sensor has been developed. The system consists of a transmitter and a receiver module. The transmitter module detects the water level and transmits it to the receiver, the receiver collects the data and displays it on the screen, shown in Figure 2. The resulting In this case, the main module part of the automated measuring device at the wellhead consists of a low-power control microcontroller (STM 8 F051), ultrasound, radio wave sensors, a GSM module, a power supply and a video camera. The main module of the device is designed to perform calculations, control, transmission and reception of waves, power supply and security, as well as remote data transmission and reception (Fig. 1) [6, 7]. In the floating state, the part located inside the well consists of a shell floating in water, consisting of ultrasound, radio wave, temperature and electrical conductivity sensors, as well as an energy source (battery). In this part, reception and transmission of waves, 7 types of groundwater quality characteristics are defined.

The computer part of the central control and monitoring system has developed a system for receiving and sending data to workstations and central control servers. The device can measure the water level with an accuracy of mm. The temperature sensor in the device allows you to measure the water temperature in℃. The electrical conductivity of underground water is measured by the electrical conductivity sensor [8, 9, 12].

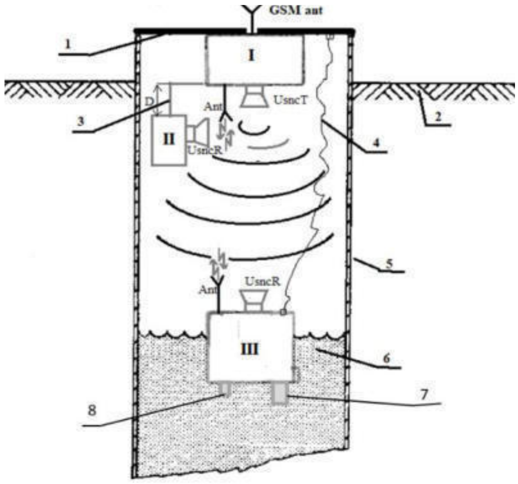

Fig. 1. Installation scheme of the automated measuring device in the monitoring well.

In this figure: I -Transmitting ultrasonic and receiving radio wave sensors and GSM module; II -Receiving ultrasonic sensor; III - Receiving ultrasound and reflecting radio wave sensors module; 1- well cover, 2 - ground level; 3 - 4 - water-resistant rope holding the sensor case, 5 - pipe body, 6 - underground water, 7 - electrical conductivity sensor; 8 – indicator.

It is possible to receive results from an automated measuring device remotely. In addition, a system for downloading data from the device's memory to a computer via an RS-232 cable has been developed. Using the "Load" software package, select the "Read Data" tab and click the "Search" button. As a result, data is presented in the program window and stored in the computer memory at the selected address in text file format. In addition, it is possible to display the data in textual and graphical form (level, temperature and electrical conductivity) by selecting the desired file (Figure 2).

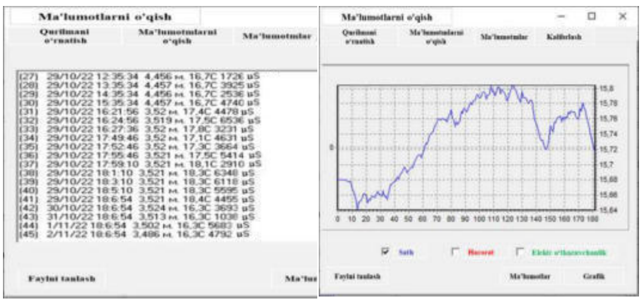

Fig.2. Presentation of data obtained from an automated measuring device in graphic form

In the during of study, data on the level, temperature, and electrical conductivity of underground water were obtained from observation wells on the basis of an automated measuring device at two-hour intervals (Fig. 2). The information received from the device consists of the following components: - 64z - the name of the device installed in the measuring well; - 08/12/2022 20:30 - date and time measured by the sensor; - Level= 9.807 m - the level of water in the observation well compared to the ground; - Temp=20.5°C – water temperature; - EC = 1236 µS/cm – electrical conductivity of water; - U_{ak}= 3.7V – the power of the source in the device [9].

It is very important to study the elements and balance of the hydrogeological regime in the process of underground water monitoring and to study the hydrogeological and engineering geological research conducted in the solution of various issues of the national economy in the modern information communication systems, that is, the general device-software complex.

Stationary hydrogeological observations for the purpose of studying the elements and balance of the underground water regime allow to give a qualitative and quantitative description of the formation processes of underground water, to determine the main laws of spatial and temporal changes of their quantity, quality and properties. it is necessary to justify the development and protection of the most reasonable measures in the use of water, the composition of projects to fight against their harmful effects, and the methods of intellectual managing their monitoring regime.

The study of the underground water regime allows to determine the following: 1) connections necessary for predicting natural or disturbed regimes and the dependence of regime elements on natural and artificial factors (or their combination); 2) separate elements of the water balance used in the justification of water management activities, hydrogeological characteristics and water balance calculations; 3) the nature and degree of impact of human engineering activities on groundwater and the events and processes associated with changing their regime (substantiation of the most rational methods of groundwater regime management, their economic use and protection) [10, 13].

In generalized form, for a flow element with area S, the groundwater balance over time ΔT is expressed by this equation.

$$\mu\Delta H = \frac{Q_1 - Q_2}{S}\Delta T + W\Delta T + W_{chuq}\Delta T \qquad (1)$$

where μ is the ability to provide water, loss of water or the unsaturation of rocks; Q_1 and Q_2- inflow and outflow of groundwater in the flow element, respectively; W - the intensity of infiltration nutrition of the layer due to atmospheric precipitation and irrigation; W_{chuq} - deep flow of water from the pressure horizon located under the layer of water to the aquifer.

The essence of the method is that all elements of the water balance Q_1, Q_2- and ΔT included in equation (1) are determined using information about the state of the water level in the wells separating the flow elements. The methodology of using this expression (1) to determine the individual elements of the water balance and analyze the balance in an annual context is discussed in detail in the course "Groundwater dynamics" and in special manuals [10, 15].

Joint installation of lysimeters of both types with a constant and variable water level and a monitoring well in groundwater that determines the magnitude of the change in the water level ΔH, water loss - rock saturation according to the formula m or allows to calculate a very important parameter of lack [11, 14].

$$\mu = \frac{\Delta T}{\Delta H}\left(\frac{Q_1 - Q_2}{S} + W\right) \qquad (2)$$

Coefficients of relative positions λ_h - coefficients of relative positions describe the magnitude of the deviation of levels from the long-term average values ΔL, expressed as a percentage or share of the long-term amplitude A.

This method of mapping the regime of the groundwater level allows to overcome the limitations associated with the significant filtration diversity of the aeration zone and the lithological characteristics of the water-bearing rocks, as well as the diversity of the geomorphology of the area. The coefficient of the relative position of the water level is calculated according to the formula λ_h.

$$\lambda_h = {(h_{max} - h_p)}\Big/{(h_{max} - h_{min})} \qquad (3)$$

accordingly, the calculated depth to the groundwater level is determined by the expression h_p (in meters from the surface of the earth).

$$h_p = h_{max} - \lambda_h(h_{max} - h_{min}) = h_{max} - \lambda_h A \qquad (4)$$

In formulas (3) and (4), h_{max} and h_{min} are the maximum and minimum depths of the groundwater level for the entire observation period (sometimes 1 and 99% probability depths are taken instead of h_{max} and h_{min}). It allows to propagate the forecast results obtained from a representative observation point in the existing synchronization in the course of oscillations over a considerable distance. Additional information can be obtained from the attached map of the distribution of the actual water levels of the previous year, plotted in relative terms. The availability of two maps allows for a more accurate indication of the level and direction of changes in water levels predicted in the long term [10, 13].

The map of the distribution of forecast levels allows to make quick decisions on the planning and implementation of various water management activities and to use this information in solving any hydrogeological problems. When determining hydrogeological parameters based on information on changes in the level of watercourses along coastal areas (during their rise or fall) are relevant, describing their behavior of influencing factors.

If in monitoring wells 1 and 2 of the area, located along the plan stream, when the change in the levels ΔH_1 and $\Delta H_2$is recorded in time t and the rate of change of the level in the boundary piezometer, the relationship between them is

$$\Delta H(x,t) = \Delta H_0(x,t) * R(\lambda),$$

describes the change of water level in rocks. Taking into account the level change in the piezometer at the border points, we get the ratio in the wells, which is equal to $\Delta H(x,t)/\Delta H_0(x,t) = R(\lambda)$ in the observation well piezometer. $R(\lambda)$ where $\lambda^2 = x^2/4at$ - is a special function determined from special tables with the value of the argument. a - conductivity coefficient can be calculated by the formula $a = x^2/4\lambda^2 t$ (piezoconductivity). According to the observation data of the stationary mode of groundwater (W=O) between the boundaries (rivers, canals, drains) of the resistance of the water bed in the studied area, when assessing the wells laid on the highway along the plane, normal to the edge of the water basin determination of the length ΔL is determined by the formula based on the condition of constant flow rate in the section of observation wells:

$$\Delta L = \frac{h_1 - h_0}{h_2 - h_1}(l_2 - l_1) \quad (5)$$

The value of the infiltration source W or the parameter W/K can be determined from the information on the state of the level in three observation wells (for example, from the expression under the condition W = const)

$$\frac{W}{K} = \frac{h_2^2 - h_1^2}{l_3 - l_2} + \frac{h_1^2 - h_3^2}{(l_3 - l_2)l_2} \quad (6)$$

DISCUSSION

Peculiarities of conducting hydrosphere monitoring on observation wells and information and technical support improvement of automated measurement systems for monitoring the level of groundwater as well as general mineralization, taking continuous measurements, reducing the number of national hydroregime measurements, increasing the reliability of information and the efficiency and productivity of ongoing hydrogeological works, determining the total mineralization of groundwater based on electrical conductivity, saving financial costs, and real-time based on a network of wireless sensors provides capabilities such as time-continuous hydromode property measurement. In addition, intellect algoritms of the device has an online mode management system, and it is possible to set data transmission from the device at different time intervals. Underground water level automated measuring device for drawing up a distribution map of the level of aquifer, making quick decisions on planning and implementing the order of water use, using it in the calculation of the main elements of their balance and monitoring the regime of underground water, precipitation allows to estimate infiltration, irrigation water reaching the groundwater level, total evaporation and use for underground flow, as well as the necessary hydrogeological indicators.

CONCLUSION

In order to improve the monitoring of underground waters in the hydrosphere, the scientific and methodological basis of geoinformation device measuring their level, temperature and electric conductivity was developed, data analysis and evaluation were carried out. As a result taking continuous measurements in observation wells, reducing the number of measurements in the traditional mode and increasing the efficiency and productivity of the ongoing hydrogeological works, determining the chemical indicators of groundwater (general mineralization, salinity (PPT), determination of the amount of dissolved solids (TDS, PPM) in total water, made it possible to quickly adopt and implement measures to eliminate negative effects on groundwater, make the necessary organi-zational, technical and management decisions.

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POSSIBILITIES OF APPLYING INTELLIGENT TECHNOLOGIES IN PRODUCTION AUTOMATION

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A B S T R A C T **This paper examines the potential for using intelligent technologies in technological processes. These technologies are widely used in electric power organizations to automate production management. The main objective of this study is to analyze the main development trends and study the Smart Grid concept, as well as determine the potential for its implementation based on the goals and needs of key stakeholders in different industries.**

K E Y W O R D S Intelligent technologies, operation, power supply, electronic meters, generation.

INTRODUCTION

Today, smart technologies are used worldwide in various industries. For example, in power plants for generating electricity or for power supply. An example of such technologies is the "Smart Grid". A Smart Grid is an electrical network that includes a number of different operational and energy capabilities, such as smart meters, smart applications, renewable energy resources, and energy efficiency.

Smart Grid is an intelligent network that uses digital technologies to optimize the distribution and transportation of electricity. It provides real-time control and monitoring capabilities, including demand management and the integration of smart appliances and consumer devices [4].

The implementation of Smart Grid requires solving both technical problems and organizational issues. Technological complexity is related to the production of components, reliability and security of the network, and confidentiality of information. Organizational complexity arises from the interests of different parties and their goals. This study examines the application of Smart Grid technology in various industries with the aim of developing an implementation and deployment framework based on a global enterprise architecture standard.

The Smart Grid concept does have a significant impact on the development of information systems in the energy industry. In the context of the transition to a more open and competitive market environment, energy companies are forced to change their business models and adapt to new conditions.

Technological changes associated with the application of Smart Grid are an integral part of this process. They allow for improvements in the efficiency and reliability of energy systems, as well as the provision of new services to consumers. Innovations in the field of Smart Grid will lead to the transformation of the entire utility sector, spurring further progress and improvement in the industry.

Indeed, energy companies are faced with the need to implement new standards of operation and maintenance to improve the reliability of energy production and reduce costs. Maintenance and repair play a key role in this sector, given the large amount of equipment located in large areas that require constant monitoring and repair. Consolidation of equipment information in a single management system with the ability to promptly provide this information to various consumers allows for reduced downtime during repairs, optimized logistics and staff workload, and reduced costs for spare parts and materials. Increasing consumer demands for service levels also encourage energy companies to expand the range of services provided[1-3].

METHODS

A smart grid is a modern electricity supply system that uses advanced technologies, including digitalization, automation, and data-driven management, to ensure that energy infrastructure operates more efficiently, reliably, and sustainably. Exploring the potential for implementing the smart grid concept identifies the benefits and challenges associated with its implementation in different industries and how the concept can be adapted to the needs of each industry. This analysis provides information and guidance for decision-making and the development of strategies to leverage modern energy solutions and improve energy efficiency.

The methodological base of the research includes the analysis of the main attributes and aspects of the Smart Grid concept functioning, defined as within the framework of this concept the main directions of development of information technology support for organizations in the energy industry include: widespread implementation of intelligent measuring instruments, installation of modern automated information and measuring systems at large facilities, creation of integrated communications networks, implementation of automated production management systems and creation of integrated production management interfaces for data exchange with other market participants. The implementation of the Smart Grid concept also involves the use of innovative technologies, development of production of highly intelligent products, more intensive use of electrical energy in transport infrastructure and development of new market relations with the participation of active market players. An important aspect of the Smart Grid concept is its role in catalyzing economic recovery.

Cloud platforms used to collect data from Smart Grid devices and optimize grid management can be divided into two types: integration platforms, used primarily to collect data and perform basic monitoring tasks such as automatic detection of customer outages and power theft; and analytics platforms, used to optimize predictive real-time grid management, including demand-response program management and distributed generation. Figure 1 shows a traditional grid.

Improving energy efficiency includes equipping consumers with modern electricity metering systems. The main categories of consumers of electricity meters include: individual houses and apartments; multi-apartment residential buildings; electric power infrastructure facilities; commercial real estate; industrial facilities; public sector facilities.

An important area for improving energy efficiency in the housing and utilities, industry and commercial sectors is equipping consumers with natural gas meters.

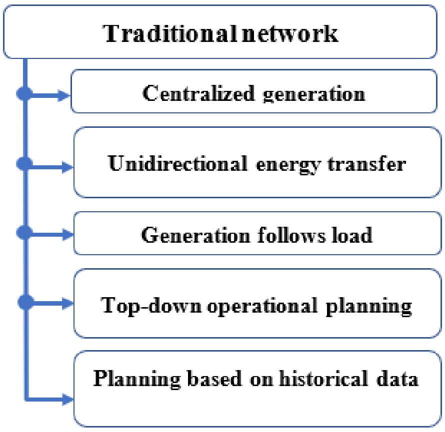

Fig. 1. Traditional network

The prospects for the development of the market for smart electricity metering solutions depend on several factors, including the level of implementation of modern types of meters that can be used in multi-level dispatch systems; the dynamics of the volume of new housing and commercial construction; the dynamics of the volume of major repairs of apartment buildings; the cost of technological solutions in the field of smart metering; the level of tariffs for energy resources.

The simplified Smart Grid model, taking into account the use of information and communication technologies (ICT), consists of five subdomains, which are considered at three levels: services/applications, communication, equipment. Each of these three levels covers one or more subdomains:

- electricity supply (generation, transmission, distribution);
- measuring instruments;
- client subdomain (smart devices, electrical equipment, local networks, etc.);
- communication network;
- subdomain of the service provider (operators, service providers, service market, etc.).

There are five interfaces in the system which will be described:

1) interface 1 - between the power supply subdomain and the communication network, which ensures the exchange of information and service signals between devices in the subdomains;

2) interface 2 - between the subdomain of measuring devices and the communication network (communication operator), which allows the exchange of measuring information with the user (subdomain of users) through the communication operator and service providers;

3) interface 3 - between the client subdomain and the communications network, which provides interaction between communications operators and service providers in the service provider subdomain and devices in the client subdomain;

4) interface 4 - between the service provider subdomain and the communications network, which allows data exchange with services/applications in the service provider subdomain to control other domains;

5) interface 5 - between the subdomain of measuring devices and the subdomain of users via the ESI interface, including interaction between measuring devices and user equipment.

Figure 2 shows the SMART-GRID energy network.

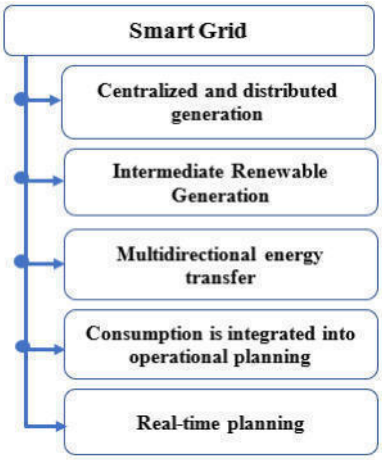

Fig. 2. Smart Grid

The following technologies and devices are used in smart grids:

An integrated communication system designed for data exchange and information transmission;

Sensors and measuring devices that are used to monitor the stability of the electrical grid, track the condition of equipment, and prevent energy theft;

Smart meters;

Synchronized vector measurement devices for determining complex values of current and voltage.

Devices for monitoring energy flows.

Smart grid systems and their components are being implemented into existing power grids. Smart Grid allows optimizing electricity consumption, reducing the number of accidents and electricity losses, and increasing the efficiency of power grids.

Smart Grid is part of a production development concept that combines digital technologies and physical objects. It affects the economy of various markets, changes enterprise processes and product life cycles, and stimulates the creation of new business models and requirements for specialists.

Initially, the term arose in the context of the creation of the "Smart Factory" concept, and over time, its application has expanded to other areas, such as "Smart City", "Smart Logistics", "Smart Home", "Smart Transport". All these concepts denote the interaction of physical objects with the information space of enterprises, as well as the creation of an integrated ecosystem of companies exchanging data in real time. Smart Grid, as part of these trends, is an indispensable component of the digitalization process. The practical implementation of this technology requires studying the relevant group of stakeholders.

RESULTS

To create and develop enterprise architecture in any industry, it is necessary to take into account the driving forces (drivers) arising from the requirements of stakeholders. The motivational expansion model reflects the system of motivation, requirements and constraints in the development of enterprise architecture.

To implement the Smart Grid concept, the key stakeholders are:

1) energy companies;

2) energy consumers;

3) governments and energy regulators.

Each of these groups has its own goals. For energy companies, important goals for developing Smart Grid technologies include reducing energy losses, managing load schedules, and improving asset management efficiency. For energy consumers, goals include improving access to energy infrastructure, increasing reliability, and managing energy consumption.

Governments and regulators aim to improve energy consumer satisfaction and ensure the modernization of the energy industry.

For developing the enterprise architecture within the Smart Grid, it is recommended to use the TOGAF standard, which includes business architecture, data architecture, application architecture, and technology architecture. The architectural development method (ADM) in TOGAF allows for the step-by-step development of the overall enterprise architecture.

The preliminary ADM phase of TOGAF is designed to define the architecture structure and principles that will be used in the enterprise. This phase can also identify the people responsible for creating the architecture and set up the design and development process. Phase A is called Architectural Vision and begins with a request for architectural work from the sponsoring organization. This phase focuses on business principles, business goals, and strategic business drivers. The business goals described in this phase can be adapted in subsequent C-H phases.

DISCUSSION

The described approach to Smart Grid implementation, based on the analysis of stakeholders and their key objectives, allows for the development of the implementation process taking into account the requirements. Smart Grid development and implementation projects vary. For example, the New York Consolidated Edison (Con Edison) project aimed to develop protocols and software for connecting different categories of users to distributed generation, as well as to assess the need for integration of commercial buildings. In the Netherlands, a pilot project called PowerMatching City was implemented, which demonstrated the capabilities of the Smart Grid, including the management of the balance of supply and demand for electricity in real time. Important aspects of Smart Grid implementation include security, trust, privacy, and environmental issues associated with the use of wireless technologies.

CONCLUSION

In conclusion, it can be said that intelligent technologies, including artificial intelligence, smart technologies play a key role in the modern manufacturing sector. Examples of successful implementation of technologies such as artificial intelligence, IOT, robots and blockchain, Smart-Grid confirm their potential and development prospects. The implementation of intelligent technologies can lead to automation of production processes, reduction of errors, improvement of product quality, reduction of costs and improvement of working conditions for employees. However, it is important to consider that the implementation of new technologies may also face certain problems, such as complexity of use, the need for additional staff training and safety risks. For the successful implementation of innovative technologies in the manufacturing sector, it is necessary to conduct preliminary analysis, risk assessment and employee training. Organizations must be prepared for changes in production processes and provide the necessary resources and infrastructure to work with new technologies.

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MODELING AND STORING DATA IN GRAPH DATABASES

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A B S T R A C T **This paper presents the study of graph databases and their application in the context of social networks. It describes a data model that represents users, communities, and the relationships between them as a graph, where nodes represent objects and edges represent their relationships. The data structure in graph databases is compared to relational databases, emphasizing the freedom and flexibility to create and modify relationships between nodes without strict restrictions.**

A method for storing graph data structures is discussed, including the possibility of storing them in SQL tables using JSON, and the use of specialized graph DBMSs such as Neo4j. The specifics of data storage in Neo4j are highlighted, including caching for improving read/write performance and optimizing graph traversal. The paper emphasizes the Cypher query language, which is specifically used in Neo4j to work with graph data. Example queries with explanations are provided, demonstrating the capabilities of the Cypher language for working with data in graph databases. The conclusion discusses the application areas of graph databases, including fraud detection and supply chain mapping, how graph databases provide flexible options for storing information, and highlights their wide range of applications in various fields.

K E Y W O R D S Neo4j, SQL, graph DBMS, JSON, Cypher query language, Data Model.

INTRODUCTION

Since the dawn of the information age, graph data structures have become a significant tool with a significant impact on various fields. Their applications range from the world of neural networks, where graphs have become the basic building block for modeling complex relationships in artificial intelligence systems, to social network analysis, where they provide a visual representation of complex networks of interactions between people. Graphs are an abstraction that allows us to visualize and analyze complex networks, where nodes represent objects and edges represent the connections between them. This model, which is natural for representing real-world relationships, makes graphs an indispensable tool for data analysis in various fields.

Graph databases are a powerful tool for modeling and storing data. They provide unique opportunities for efficient management and analysis of related data, opening up new perspectives in the field of databases. We will consider not only the principles of graph data modeling, but also methods of storing them, allowing for efficient management of graph structures in the context of databases. Accordingly, from an overview of the main concepts to an examination of the application of graph databases in various fields, and then we analyze the possibilities of new trends in this field.

Graph database modeling is a key step, completely dependent on the unique needs of the project and the data that is planned to be stored in the database. This process consists of carefully defining the structure of the data, their relationships and attributes in the graph in order to ensure maximum efficiency and flexibility of the system. When modeling, it is important to define the Data Model well.

Data Model is an abstract representation of how the data is organized and how it interacts with each other [1-2].

METHODS

Let's assume we have a social network that has users, communities, and connections between them. We can represent this structure as a graph, where nodes represent users and communities, and edges represent connections between them (Table 1.)

Figure 1 shows that graph databases offer more flexibility than relational databases. In relational databases, tables have a well-defined structure, and the relationships between them are controlled by keys and integrity constraints.

Table 1. Data Model

Social network graph:
Nodes:
- Users:
* Name
* Age
* Email address
- Communitys:
* Name
* Description
Ribs:
- Friendship:
* Time to start friendship
- Joining the community (Membership):
* Time of joining
	Model User {
	id: ID
	name: String
	age: Int
	email: String
	friends: [User]
	communities: [Community]
	}
	Model Community {
	id: ID
	name: String
	description: String
	members: [User]
	}

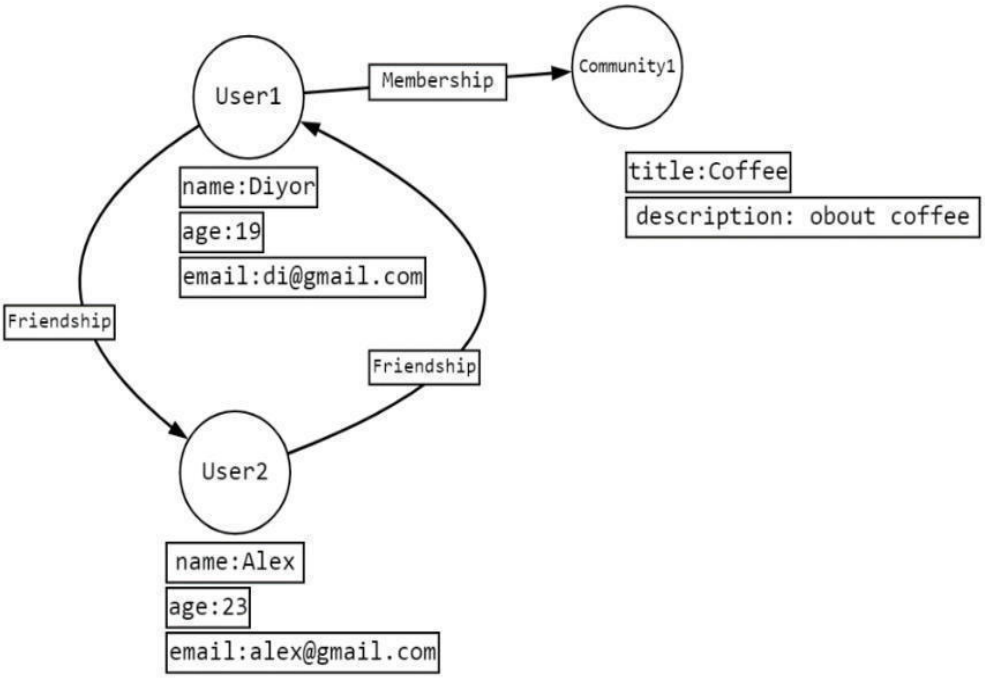


Fig. 1. Flexibility of a graph database

Graph databases have a more, free data structure: they allow you to create and change links between nodes flexibly and without significant restrictions. This provides better data scalability, as well as a more dynamic model, where links and relationships can evolve with the growth of the application without the need for a strict pre-defined format.

Now we have come to an important stage of our article, which is how to store data and where.

In fact, the structure of graph models can be stored in SQL tables. You can create a single column with the JSON type, where each row will represent one node. You can add all the information about the node and the links between them there. However, this approach can lead to a decrease in performance and overall query efficiency. But there is another approach, which is to use a specialized DBMS for working with graphs, such as Neo4j.

Neo4j can persistently store data on the hard drive. Therefore, the amount of stored information is limited only by the capacity of the hard drive. To achieve maximum performance, Neo4j has two types of caching: file cache (file buffer cache) and object cache (object cache). The first caches data from the hard disk, the purpose of which is to increase the speed of reading/writing to the hard disk. The second cache stores various graph objects: vertices, edges and properties in a special optimized format to increase the performance of graph traversals.

When talking about SQL, it is important to mention the Cypher query language. This is a declarative language designed for working with graph data, specifically used in the Neo4j graph database. Cypher allows you to perform expressive and efficient queries on data represented in a graph structure, which makes it a powerful tool for analyzing and manipulating data in graph databases.

Let's look at the examples shown in Fig. 1.

- Find all friends of a specific user by his name:

MATCH (user: User {name: 'Username'})-[:**FRIEND**]->(friend: User)

RETURN friend;

- Find all communities a specific user is a member of:

MATCH (user: User {name: 'Username'})-[:**MEMBER_OF**]->(community:Community)

RETURN community;

- Let's break down this request:

MATCH - used to indicate the start of a request pattern.

(user:User {name: 'Username'}) specifies a user node with a given name.

-[:FRIEND]->(friend:User) indicates a "FRIEND" relationship between this user and his friends.

-[:MEMBER_OF]->(community:Community) indicates a "MEMBER_OF" relationship between the user and the communities he/she is a member of.

RETURN used to return query results.

This query searches for friends of a specific user by their name and the communities that the user is a member of.

We have looked at data modeling and storage, as you can see graph databases provide flexible options for storing information. Where can these graph databases be used?

- Fraud detection
- 360 degree, customer analysis
- Recommender systems
- Network/transaction matching

- Graph models for artificial intelligence
- Social networks

As you can see, the range of applications of graph databases is wide. Next, we will consider modeling databases for "Fraud Detection" and "Supply Chain Mapping".

1. Model for Fraud Detection

We Data model should be designed so that it can run different algorithms for traversing the graph. Let's design a model for e-commerce.

The following types of identifiers are usually used in online transactions:

- • User ID;
- • IP address;
- • geolocation;
- • tracking cookie - a tag that a website leaves on a user's computer for further identification;
- • bank card number.

Data Model:

Model IP {
id: ID!
typeIp:String
useCard:[Card]
…
}
	Model Card {
	id:ID
	name:String
	number:BigInt
	owner:[IDUser]
	…
	}

Model IDUser {
id:ID
name:String
Cokie_node:[Cookie]
…
}
	Model Cookie{
	id:ID
	time:Date
	userId:number
	…
	}

The database can be configured to detect suspicious patterns - corresponding checks are mapped to various triggers. Triggers can include events such as logging in, placing an order, or adding a new bank card.

RESULTS

The graph below shows a series of transactions from different IP addresses.

In this example, IP3 is highly likely to be involved in a fraudulent scheme, as multiple transactions were made from this address using three different credit cards. It is interesting to note that one of the credit cards was used by multiple IDs, and two cookies are associated with two different IDs.

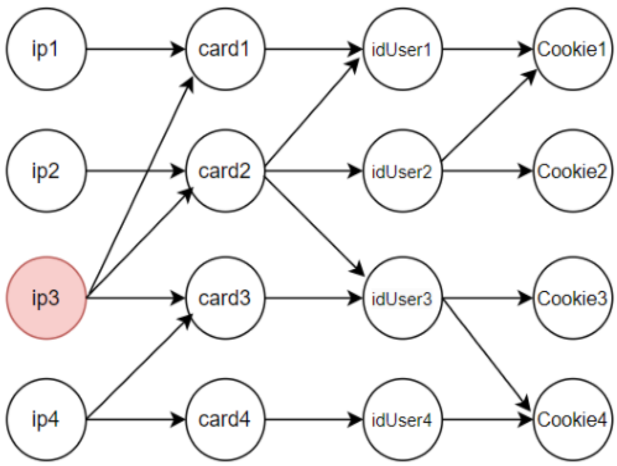


Fig.2. A series of transactions from different IP addresses

1. Model for Supply Chain Mapping

Graph databases are widely used in this area due to their similarity to the objects and tasks inherent in this subject area.

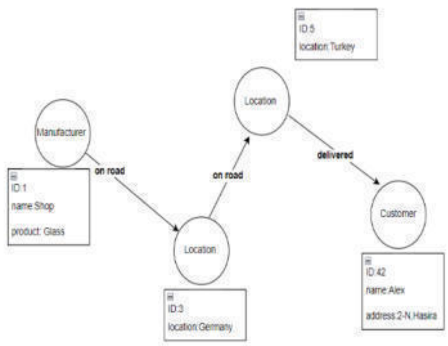
Below is a model of the order history, i.e. the entire order route.

Data Model:

Model Manufacturer {
id:ID
name:String
products:Array[…]
On_Road:[Location]
}
	Model Location {
	id:ID
	location:String
	On_Road:[Location]
	delivered:[Customer]
	}

Model Customer{
id:ID
name:String
address:String;
}	

Visualization of one route as a graph.



It is important to note that a node here can refer to the same model.

CONCLUSION

This article discusses the principles of modeling and storing data in graph databases, emphasizing their importance in the modern information age.

Various methods of storing data in graph databases are discussed, including the use of SQL tables with JSON structures and specialized graph databases such as Neo4j. Particular attention is paid to the efficiency of storing and working with data using the Cypher query language.

Examples of Cypher queries are demonstrated, revealing the efficiency of working with graph data for finding relationships and analyzing data structures.

Data models for e-commerce fraud detection and supply chain tracking are presented. These models highlight the flexibility of graph databases in analyzing complex patterns and relationships, which makes them a valuable tool for processing and analyzing a variety of data.

In summary, graph databases offer broad application prospects in the areas of fraud detection, customer analytics, recommender systems, and others, due to their flexibility and efficiency in analyzing complex data structures and relationships.

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ARCHITECTURE AND PRIORITY ISSUES OF INTELLIGENT MILKING SYSTEM ON THE FARM

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A B S T R A C T **The dairy industry relies heavily on accurate milk measurement for productivity and quality control. Traditional manual methods are error-prone and labor-intensive. This paper discusses the development of smart milking systems that use advanced sensors and computational devices to measure milk parameters such as volume, flow, fat content, and pH in real time. These systems not only improve accuracy and efficiency but also enhance herd management, animal health, and farm profitability. Additionally, they aid in early disease detection and ensure milk safety. The paper explores the design, sensor selection, and integration of these systems, and proposes an intelligent milking system architecture.**

K E Y W O R D S **Farm, architecture, sensor, milking machine, vacuum, milk yield, measuring, electrical conductivity,**

INTRODUCTION

It is known that the dairy industry is of particular importance in world food production. Productivity improvement and quality assurance in the dairy industry rely heavily on accurate and efficient measurement of milk parameters. Traditional methods of measuring the amount of milk and its parameters are done by hand. These measurement errors are large and require a lot of time and labor. It is desirable to use modern advanced technologies that are resource-efficient and highly accurate in solving the problems of measuring milk parameters. That is, the development of smart milking systems equipped with sensor technologies and connected to computing devices is one of the important tasks. These systems are designed to monitor milk quality and quantity in real time, send systematic alerts to farmers and veterinarians in emergency situations, and improve decision-making processes on the farm.

Smart milk meters with various sensors allow accurate and automated measurement of milk quantity and parameters in real time. Milk parameters detected by smart milk meters or meters include milk volume, milking duration, milk flow, fat content, color, pH and electrical conductivity. Therefore, the perfection of a milk measuring tool depends on how well it is equipped with various sensors. This meter data can be used not only to monitor milk production at the individual cow level, but also to optimize herd management, improve animal health and increase overall farm profitability. This is related to the mathematical-algorithmic and information resources of the computing system. In addition to this, smart milk meters also help in early detection of various diseases in cows, herd welfare and safety of milk products. This paper explores the design of a smart milk meter, including the selection of appropriate sensors, integration with existing milking systems, and construction of a decision support system architecture. Therefore, the article is structured in the following structure: research on milking conditions, methods of recording milk yield, methods of measuring milk parameters and sensors used in it, analysis of existing systems used in farm management, and architecture of a new intelligent milking system.

METHODS

The widespread introduction of piped milking systems has created problems of recording the individual milk yield of each cow. Because, in the early pipe milking systems, it was not possible to measure the milk yield of individual cows. In this, the total milk of the farm was collected in one tank and the productivity was measured. Therefore, several studies have been conducted on the problem of measuring the milk yield of each cow during the milking process.

Literally, methods of measuring milk yield can be divided into two types: mechanical and electronic.

Mechanic.

a) Measuring through a bucket. During the milking process, each cow's milk is poured into a separate milk container and weighed. The milk yield of each cow is recorded manually. However, this method requires a lot of effort and time to weigh and empty the containers after milking each cow. This creates problems for large farms.

b) Measuring by portable milking device. This milking system consists of four main components: vacuum system, pulsator, teats and milk tank. In a mobile milking machine, each cow is milked separately and the milk yield is recorded by means of a scale placed at the bottom of the tank.

c) Recording milk productivity in automatic milking systems. In this, a certain amount of milk passing through the milk pipes is measured by collecting it in small containers installed in the milking machine. Scales are installed in this container where milk is collected, which allows to measure it visually. After milking a cow, the milker records the milk yield of this cow according to this scale. This process causes inconvenience to milkers on farms with a large number of heads. Another major drawback of these measuring devices is the manual recording of milk samples for analysis of cow's milk parameters.

Electronic (Measurement by milk flow).

The first patent for a device that measures milk yield by milk flow was obtained by Kiestra and Icking [5]. This milk meter first calculates the actual flow rate based on the time it takes to fill the measuring chamber with the desired amount of milk, and then uses the time it takes to empty the measuring chamber to calculate the amount of milk coming out of the chamber (Fig.1). Mathematically, the meter calculates milk yield by integrating the flow of milk over time. This process allows the input to the measurement chamber to be permanently open. Such devices, which require relatively high calculations in the control unit, could not work without integrated circuits and microprocessors.

In the first integral prototype, the accuracy was not satisfactory due to the non-linearity of the flow inside the meter. When the control unit was reprogrammed it worked correctly. Another problem with this device is that the sudden start or stop of milk flow in the tester gave false milk readings. Thus, it is necessary not only to change the meter, but also to adapt the test procedure to the new measuring principle.

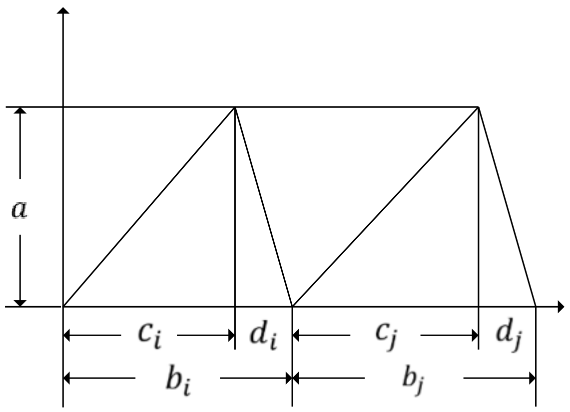

Fig. 1. Parameters of milk flow integration over time: (a) measurement chamber volume; (b) time taken per cycle; (c) time to fill the measuring chamber; (d) chamber emptying time.

Later, a means of continuous measurement of milk flow through ring electrodes was proposed [6]. In one of these types of devices, a row of about 60 electrodes is placed vertically to determine the level in a container with limited milk output [7]. In this case, the milk flow is measured according to the milk level, and the milk yield is calculated by the integration of the flow over time. It also takes into account the actual composition of the milk-air mixture at each electrode, determined by electrical conductivity. To determine the expected milk yield from the current cow, milk analysis samples are taken first.

Milk measuring devices based on the measurement of milk yield by milk flow allow to measure relatively higher accuracy than others. However, the price of these devices is very high, so they are not used for measuring milk in many dairy farms around the world. To date, many different methods of measuring milk yield have been proposed. However, continuous research is being done to develop sensor-based milk meters that can measure milk yield cheaply and accurately and also measure milk parameters during milking.

Sensory determination of milk parameters

As milk and milk products are considered to be the most consumed food in the world, measurement of milk parameters in dairy farms is very important. In addition, changes in milk composition provide valuable information about cattle health. The analysis of studies shows that the measurement of milk parameters and the determination of its deviation from the norm are carried out in the following ways:

Visual (mechanical). In this case, only some of the changes in the composition of milk are determined based on human observation. That is, changes in the color of milk, liquidization of milk, and other changes are determined by visual or manual observation.

In laboratory conditions. In this method, a sample of each cow's milk is taken to determine milk parameters, and then a series of chemical and microbiological analyzes are carried out in laboratory conditions. The results obtained by this method are more accurate than the results of other methods, but it requires a lot of time and cost.

Through sensors. In this, various sensors are installed on the milking machine to help measure milk parameters. These sensors allow real-time measurement of milk parameters.

The advantage of measuring milk parameters through sensors is that the process is performed in real time and automatically. Sensors that measure milk parameters in real time are explored below.

Changes in milk composition and the visual appearance of milk provide valuable information about the cow's health and reproductive status. In recent years, several sensor techniques have been developed that continuously measure such parameters during or after milking on the farm. They are operated manually, such as by mobile farm milk analyzers, or online [8-9]. However, most of them are still at the research level and are hardly used in practice.

Sensors used for on-farm milk composition analysis have been developed to detect indicators of milk composition that have high information value but cannot be detected directly by the milker. Different sensors are used to measure different parameters in milk.

Color and image sensors

Color sensors detect and analyze the color of milk, which can provide information about its composition and quality. They are used in screening to detect abnormalities or contaminants that affect the color of milk. An example of a color sensor is an RGB sensor. It is known that colostrum can be identified by a color change in the blue region, and milk with a reddish color can show a specific proportion of blood caused by udder infections or teat injuries. [10-11].

Somatic cell count sensors (SCC).

Somatic cell counts are often determined in laboratories using flow cytometers. In this, cell nuclei are stained (eg, with ethidium bromide) and cells are counted with light scattering or fluorescence detectors as they pass through a thin film under a high-energy light source [12].

In recent years, several tests have been developed to calculate SCC. They use enzymatic color reactions or automatic counting of stained cell nuclei based on fluorescent images. In addition, SCC can be determined based on the CMT developed by Schalm and Noorlander or the modified Wisconsin mastitis test developed by Thompson and Postle[13-14].

Electrical conductivity sensor

To date, Electrical Conductivity (EC) is the most widely used metric for online udder health monitoring. EC sensors measure the ability of milk to conduct electricity. This property affects the concentration of ions such as sodium, potassium, chloride and other dissolved salts in milk. The higher the ion concentration, the higher the electrical conductivity. Changes in the concentration of ions in mastitis milk cause EC to exceed the normal value of about 4.6 mS/cm [15]. EC sensors help assess milk quality by detecting changes in salt content. A significant deviation from the normal conductivity level may indicate the presence of contaminants in the milk or changes in the composition of the milk.

Ultrasonic and electromagnetic sensors

Ultrasonic sensors typically use high-frequency sound waves (ultrasound) to measure distance or detect objects. The sensor emits an ultrasonic pulse, which reflects off an object (for example, milk) and returns to the sensor. The time required to return is used to calculate distance or to determine changes in milk composition. Ultrasonic sensors can measure the amount of milk in the container, the flow rate of the milk, and some advanced ultrasonic sensors can measure the density of the milk by analyzing the speed of sound in the milk.

Electromagnetic sensors use electromagnetic fields to measure various properties. Electromagnetic sensors can indicate the concentration of ions and salts in milk by the electrical conductivity of the milk. It serves to detect mastitis and abnormal milk. In addition, some electromagnetic sensors can be used to estimate the concentration of solutes in milk, such as lactose, fat, and protein, by measuring the refractive index of milk.

Bio and chemical sensors. In addition to the above, biosensors and chemical sensors can also be used to measure milk parameters. They help to identify specific compounds and microorganisms in milk. While biosensors are designed to detect specific biological molecules such as proteins, enzymes, DNA or microorganisms such as bacteria, chemical sensors are used to detect the presence of chemical contaminants such as antibiotics, pesticides or heavy metals in milk.

In general, many milk parameters can be determined online in a short time using modern sensors. The obtained indicators provide valuable information about the health of cows and the quality of milk. Figure 2 shows the sensors used to determine milk parameters today and the factors that influence changes in milk parameters.

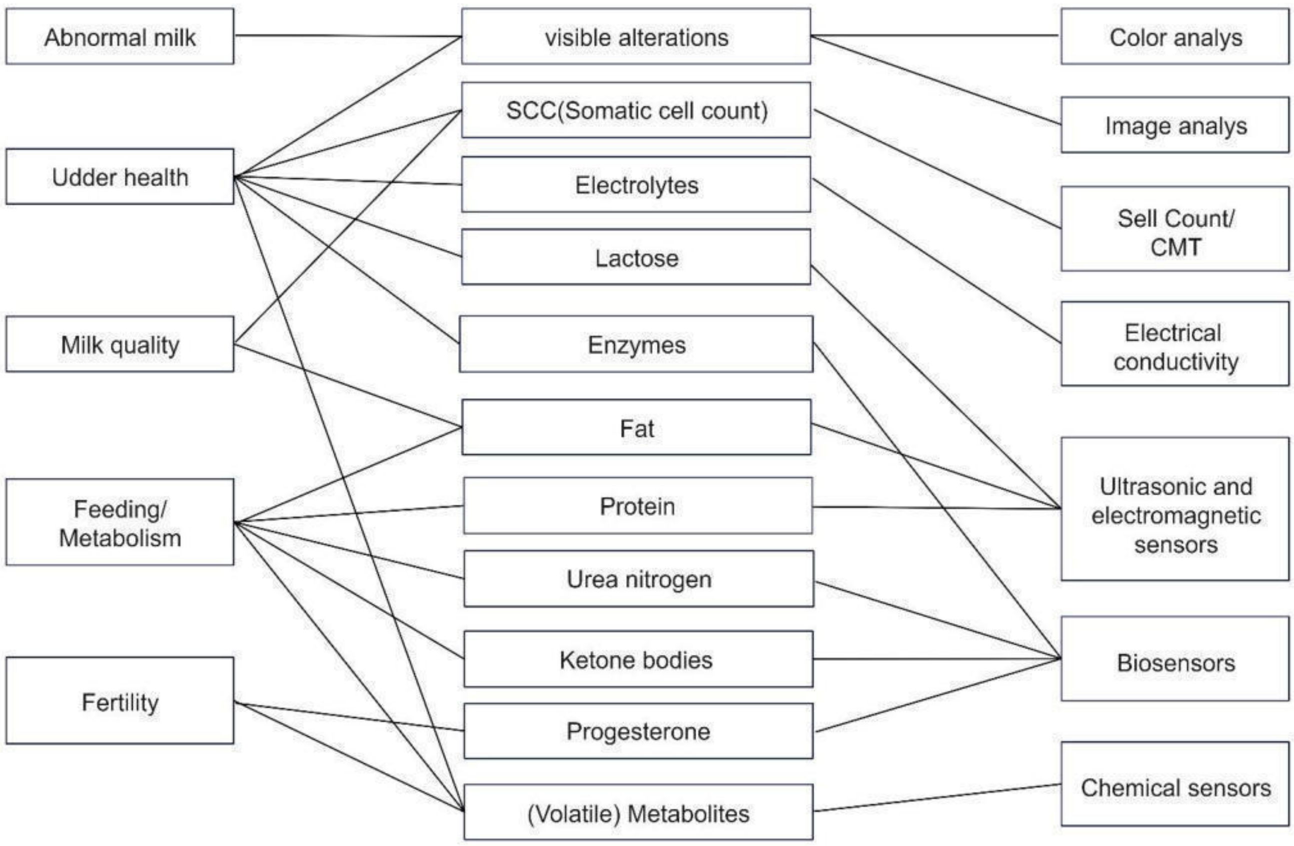

Fig. 2. Indicators in milk, areas of application and sensors that detect them. (CMT = California mastitis test).

RESULTS

There is a lot of research going on in the world about the automation of livestock farms and several systems have been developed. But most of them are very expensive in terms of price. Therefore, in this study, smart milk meters with several different sensors are installed on milking equipment in milking parlors and generate reports that are important for farm operations such as cow health, milk yield, and milk quality. and propose a decision support system architecture (Fig. 6).

In addition to pipe milking systems installed in the milking hall of most farms, sensors are installed to measure milk quantity, temperature, density, electrical conductivity, and other parameters of each cow. These sensors transmit data to the server through communication tools in real time while the cow is being milked. The server is connected to the database. The server also has a database of milk standards, which shows the standard indicators of substances in milk. As soon as the data received from the sensors are written to the database on the server, the system determines whether the milk parameters are abnormal or not by comparing the normative indicators and real data with each other. If deviations are observed in any parameters of cow's milk, the system sends a warning to farmers and veterinarians.

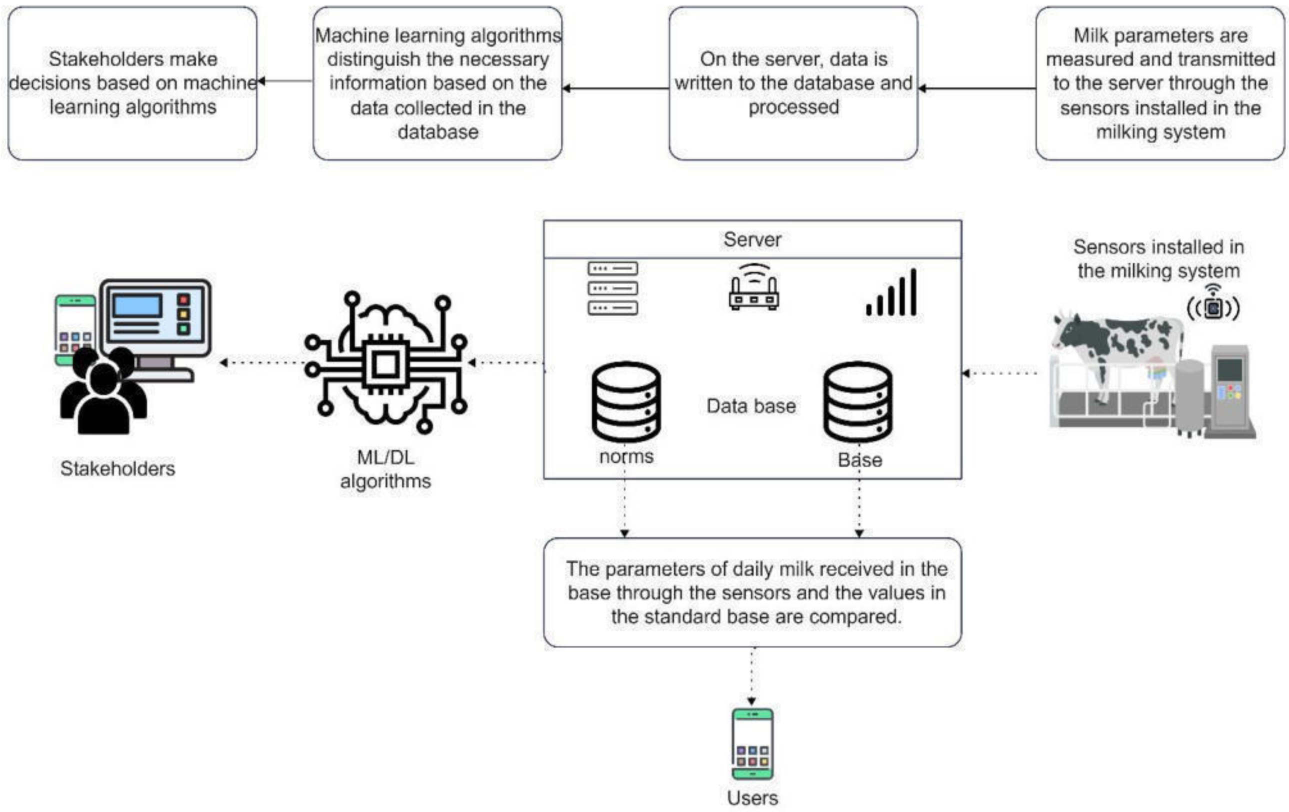

Fig. 6. A system architecture that supports real-time decision-making and alerts farm workers in extreme cases based on data from sensors installed in the milking system.

In addition, the system uses machine learning algorithms that predict the amount of milk for the next day based on individual daily milk indicators of cows. If there is a significant difference between a cow's milk yield predicted based on past milk performance and the actual milk yield of the current day, all the information about that cow is sent to the experts and helps them make decisions.

A farm management and decision-making support system must meet the following several requirements:

- - Installation of sensor prototypes measuring milk parameters on milking parlor machines (sensors are available on the local market, should be high accuracy, reliable and cheap);
- - Adaptation of the prototype to the information environment of the livestock information system infrastructure, online monitoring of individual cow's milk indicators obtained from them on the user's device, development of mechanisms for recording these data in the local and central information base;
- - Formation of a base of standards according to the breed, age and number of lactations of cows, as well as development of adaptive models and algorithms for determining milk yield for the current lactation period;
- - Use of machine learning and artificial intelligence tools and development of special algorithms to conduct annual, monthly, daily analyzes of herd, breed and individual cows from the database of milk parameters and to solve the problems of forecasting and decision-making regarding future productivity ;
- - Development of a system warning module for system users when deviations from the norm in milk parameters of cows or abnormality in milk parameters are observed;
- - Development of a model and algorithm that automatically constructs appropriate lactation curves based on the milk indicators of each cow;
- - Development of a module for automatic detection of symptoms of individual cattle diseases, in particular, mastitis, from the base of milk parameters;
- - Development of a software tool for analyzing milk productivity indicators of the herd with the ration data set for them;

- - Determining the exact time of calving based on data on individual cow milk parameters, calving time and insemination events;
- - Creation of convenient interfaces for the central control unit of the system and its users, suitable for different generations.

CONCLUSION

The integration of advanced sensor technologies and data analysis into the traditional milking process offers high possibilities for farms. By installing a variety of sensors on milking machines, farms can gain more information about the health and productivity of their herds. Real-time monitoring of milk parameters combined with intelligent algorithms allows farmers to make informed decisions, manage herd composition, ensure milk quality, optimize rations and detect health problems in time. In the proposed system architecture, sensors, data processing, servers, and special mathematical-algorithmic supplies of continuous operation and the inter-block integration process for their efficient operation are described in the article. The technical, algorithmic and software requirements set for the system serve to facilitate the smooth operation of the system, effective data processing and high-precision decision-making. Research is needed to fulfill the requirements for the system.

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CLOUD COMPUTING AND DATA STORAGE

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***ABSTRACT.* Cloud computing is an on-demand service for sorting, storing and processing large amounts of data, not on local servers or personal computers, but on network servers located on the Internet. By running the application and cloud services on the network, a virtual resource is provided to the user. An application based on Hadoop and MapReduce infrastructure was implemented to demonstrate this paper. This app has been tested on various parameters. The effectiveness of the proposed method is shown in experimental results. This method represents a significant improvement over other modern computational methods.**

KEYWORDS. Cloud services, cloud storage, cloud computing, provable data possession, third party auditor, Euler function, TPA, CSP.

INTRODUCTION

When you use cloud services, the provider you choose can support a wide range of activities that keep your business running, including processing and sharing applications, storing and managing your data. By using these services, your authorized users can communicate, collaborate, manage projects, and perform data analysis, processing, sharing, and storage in addition to using the IT department to monitor, store, or backup activities.

Cloud providers offer different services to their customers. For example, cloud computing and cloud storage are two different services. However, they are often used interchangeably and are considered a misnomer.

Almost everyone on the Internet has used some form of cloud storage. Common examples of cloud storage services include Google Drive and Dropbox. They allow users to access data from anywhere in the world and share it with anyone they choose.

Email is another form of cloud storage. Service providers such as Google and Microsoft store email data on servers. Users can access this information from any computer and send and receive email messages.

On the other hand, cloud service providers offer easy scalability. Resources can be scaled up or down instantly. Users pay only for the services and storage they actually use. This model is often referred to as 'pay-as-you-go'. This is much more cost-effective for businesses than spending capital to build and maintain infrastructure.

METHODS

The article presents the advantages and opportunities of cloud computing and data storage in the cloud, an analysis of various cloud systems. In addition, Provable Data Possession (PDP) and Proof of Retrievability (PoR) methods were used effectively.

RESULTS

In addition to cloud storage, many cloud service providers also offer cloud computing.

According to statistics, cloud computing services bring in 178 billion dollars a year. In the 4th quarter of 2021, $50 billion in revenue was received.

In the data-intensive field of machine learning (ML), graphics processing units (GPUs) can process terabytes of data more efficiently than central processing units (CPUs). However, GPUs are too expensive for most organizations to afford, especially if their requirements are routine. Cloud computing can provide the processing power and cost-effectiveness needed to support ML.

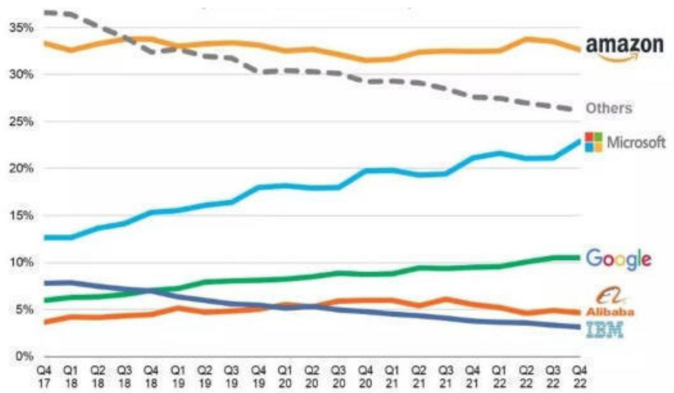

Figure 1. The most popular companies providing cloud services and their market share.

By using cloud services, you can have the following conveniences:

- - saving costs;
- - security;
- - quality control;
- - no loss of data;
- - automatic updates;
- - synchronicity.

In order to solve the problems of data storage, it is necessary to create a single computing complex, that is, a data processing center based on distributed system methods. Information storage and processing center (English data center) is a specialized architecture, consisting of servers (hosting) and network facilities, to which users connect using Internet channels.

The main goal of the data processing center is to unify the scattered computing power and reduce the cost of ownership while meeting the requirements for the reliability of the information technology infrastructure, ease of access to its resources, security and management. The information storage and processing center performs information processing, storage and distribution functions in accordance with the interests of corporate clients. The center is focused on solving business problems by providing information services.

The data storage and processing center consists of:

- - information infrastructure including server devices - performs the main functions of the data processing center, i.e. data processing and storage functions;
- - telecommunication infrastructure - ensures mutual communication (communication) between the components of the data processing center, at the same time this infrastructure performs data transfer processes between the data processing centers and the user;
- - infrastructure engineer - creates an environment for the normal operation of data processing center systems.

The purpose and requirements of the application will determine whether cloud storage or cloud computing (or both) is needed. Cloud storage is essential when storing large amounts of data that can be accessed from anywhere in the world. When processing power is needed to compute these data-driven operations, cloud computing is required. Enterprises often use both to power their applications in the cloud.

Cloud computing is an on-demand service for sorting, storing and processing large amounts of data, not on local servers or personal computers, but on network servers located on the Internet. By running the application and cloud services on the network, a virtual resource is provided to the user. Access to these resources can be obtained by standard Internet and network protocols. Auditing the privacy of large volumes of data is a major liability in cloud data, as the potential for malicious activity to be imposed on the cloud user and provider is high. There are many ways to solve this problem. The user can use the encryption and decryption process. This requires a lot of computing resources and functional overhead. Data auditing can be another solution to this problem. Classic approaches to data audit include Provable Data Possession (PDP) and Proof of Retrievability (PoR). However, there are many complications in these methods. Only encrypted files can be used in these methods and a limited number of requests are allowed. In addition, the schemes shown above are not suitable for the batch approach due to computational costs. The benefits of these methods depend only on the initial processing steps that the user can apply to the external data files.

There is a trade-off between dynamic data operations and privacy. However, some of the schemes do not preserve privacy. There is a trade-off between communication costs and storage costs. However, some of these PDP schemes require high cost for low storage. There are schemes in which audit tasks are determined by a third-party auditor (TPA). TPA is a reliable and authentic facility that independently manages data audits. To solve the above problems, To solve the above problems, different users have proposed multiple TPA schemes in which different synchronous audit sessions are processed simultaneously, each with a separate TPA. The scheme requires that the cloud service provider be trusted.

Below, RNS is used for data encryption and decryption in large data privacy testing. The group of integers (Z_N va Z_N^*) $Z_N x Z_N^*$ is isomorphic, that is, Z_N^{*2} is used. The RNS system has three parts.

In the first part, the RNS system generates public and private keys suitable for encryption and decryption. A random number used to encrypt the plaintext. Euler's function is used to generate these keys, which consist of two different odd numbers. The key generation process is described below:

1. Two different odd prime numbers p and q of the same length are chosen.
2. $J = pq$ and the Eyler function is $\phi(J) = [(p-1)(q-1)]$.
3. The following are confirmed:
4. $\gcd(J, \phi(J)) = 1$.
5. The existence of $(1+J)^a = (1+aJ) mod J^2$ for arbitrary a>0.
6. The result is, $(1+J) \epsilon Z_{J^2}^*$ order J i.e. $(1+J)^J = (1 mod J^2)$
7. and for any $1 < a < J$ $(1+J)^a \neq (1+aJ) mod J^2$.
8. $r \epsilon Z_J^*$ is a random number, $\gcd(L(r^J mod J^2), J) = 1$, where
9. $L(x) = (x-1)/J$.
10. A public key (J), a private key $(J, \phi(J))$ and a random number (r) are returned to the system.

In the second part, encryption is performed using the public key. Let $m \in Z_J$ be a ciphertext and $r \epsilon Z_J^*$ be a random number. According to the law of isomorphism, the ciphertext can be obtained by the function f that represents the plaintext:

$$Z_J x Z_J^* \to Z_{J2}^*,$$

$$\mathrm{c} = E(m \bmod J, r \bmod J) = f(m, r) = [(1+J)^m r^J mod J^2]; \textit{ here } \mathrm{c} \in Z_{J2}^*.$$

In the last part, the user performs decryption using the private key $(J, \phi(J))$. Below is the sequence of the decryption process:

$\hat{\mathrm{c}} := [c^{\phi(n)} mod J^2]$ install, where s is the ciphertext.

$\widehat{m} := (\hat{\mathrm{c}} - 1)/J$. (All operations are performed on integers!)

After decoding, plain text $m := [\widehat{m} \cdot \phi(J)^{-1} mod J^2]$ is obtained.

This section proposes a scheme that distributes the packet mass load among several TPA load balancing methods. This scheme works on three levels as given below.

Cloud user: any user who uses the cloud service is a cloud user. The proposal is that the resources of the cloud user are limited and it is not possible for them to perform various auditing tasks (checking the confidentiality of data while maintaining confidentiality).

Multiple TPAs: TPAs are considered authorized entities. Data privacy issues are managed by several TPAs.

Cloud Service Provider (CSP): A CSP is an organization that delivers resources as a service to users. Resource sharing can be done on many servers located around the world.

DISCUSSION

The concept of "cloud technologies" (English "cloud computing") is widely used in English and Russian sources. The author used the translation of this term in Uzbek. T.N.

Nishonboyev's monograph "Service-Oriented Architecture" also provides a lot of information about this term.

The term "cloud" is used as a metaphor based on the image of the Internet in a computer network diagram, or as a representation of a complex infrastructure in which all technical details are hidden. According to an IEEE document published in 2008, "Cloud computing is a paradigm in which data is stored permanently on Internet servers.

Plotnikov M.I. notes that despite the fact that terms like "Cloud technologies" or "cloud computing" have been heard by many people for a long time, very few people understand what cloud technology is.

Based on the above analysis, the role of cloud computing services in the efficient organization of data collection, storage, and processing processes is incomparable.

CONCLUSION

Today, cloud technologies are being used in every field, from simple users to document storage to large business systems. The use of cloud technologies (cloud computing) by organizations working with big data is a promising direction that allows to increase the efficiency of data processing processes and reduce additional costs for its implementation. Capital costs associated with the creation and maintenance of data centers by organizations are significantly reduced, flexible scalability and high availability of services used in the educational process are ensured, which increases the level of satisfaction of the needs of end users. increases.

Big data organizations note the undoubted advantages of using cloud technologies, and the main risks that should be taken into account when planning and implementing cloud solutions throughout their operations, in particular:

it is necessary to emphasize the need to ensure data security;

special measures to prevent unauthorized access to data in the cloud;

reduced availability - the possibility of DoS attacks, risks associated with physical damage to network cables used to connect to the cloud, etc.;

connecting to a cloud service provider (cloud provider) - if the educational institution does not work exclusively with a private cloud using a public or hybrid cloud, switching to another cloud provider can be expensive and time-consuming.

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FAST VOICE FILTERING IN A FEW STEPS USING VOICE CONVERSION AS A POST-PROCESSING MODULE ADAPTATION OF A SPEAKER FROM UZBEK TEXT TO SPEECH

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A B S T R A C T **Text-to-Speech (TTS) systems developed in recent years require hours of recorded speech data to generate high-fidelity human-like synthetic speech. Low resources or small amount of speech can lead to several problems in the development of TTs models, which makes it difficult to train TTS systems with limited resources. This paper proposes a new low-resource TTS method called Voice Filter that uses only one minute of the target speaker's speech. It applies Voice Conversion (VC) as a post-processing module added to an already existing high-quality TTS system, which marks a conceptual change in the current TTS paradigm by recasting the multi-frame TTS problem as a VC task. In addition, it has been proposed to use a TTS system with controlled duration to create a parallel speech corpus that facilitates the VC task. The results show that Voice Filter outperforms modern multi-frame speech synthesis methods based on objective and subjective metrics using only one minute of speech from a diverse set of sounds, and at the same time with the Uzbek TTS model. remains competitive. 25 times more data.**

K E Y W O R D S Speaker Adaptation, Uzbek Text-To-Speech, Natural Language Processing, Few-Shot Learning, Voice Conversion

INTRODUCTION

Achievements in the field of artificial intelligence development today can truly surprise even those who are directly related to this field. One of the popular areas for the implementation of innovative projects has become the creation of digital applications compatible with computers and mobile devices, capable of analyzing and interpreting incoming data presented in voice or text form, without the use of special linguistics, template commands and formulations - that is, in the usual human construction of phrases and word combinations. How do algorithms and models of the natural language processing system work, what technologies, methods and tools are used for machine learning NLP (Natural Language Processing), and what does this give in terms of further development of the area in question?

Although modern text-to-speech (TTS) technologies are capable of producing high-quality synthetic speech in various scenarios, sometimes insufficient results can be achieved. Achieving very high-quality TTS usually requires several hours of studio-quality data from one or more speakers [1, 2]. Therefore, reducing the amount of speech data to several hours limits the quality and intelligibility of these systems. Since it is not always possible to collect several hours of speech data, especially when scaling TTS voices to a large number of new speakers, the problem of generating TTS voices with limited resources has been widely studied [2, 3,]. Many studies are also going in this direction. Because the issue of resources is always relevant. Of course, to build high-quality TTS systems in scenarios where, for example, the target speaker's speech is only three minutes long, we first aim to capture the identity of the existing speaker, and phonetically and prosaically we need to delay the modeling of variations. Given the lack of resources and the impossibility of replenishing them, the work will be ideal. Speaker identification can outperform TTS systems. Given the smallness of the given speech, the speaker is based on adaptation, in which the parameters of the multi-speaker model are optimized over many samples by repeatedly retraining the target speaker [5, 6].

As the field of text-to-speech technology advances, researchers are exploring innovative methods to overcome the challenges posed by limited data. One promising area of development is the use of deep learning models that can generalize well from small datasets, leveraging techniques such as transfer learning and data augmentation to enhance model robustness. Additionally, there is growing interest in cross-lingual TTS systems that can utilize data from multiple languages to improve speech synthesis quality, even for low-resource languages. These approaches not only enhance the accessibility and inclusivity of TTS technologies but also pave the way for more personalized and context-aware voice applications. By focusing on these strategies, the future of TTS could see widespread adoption across various industries, from virtual assistants and customer service bots to educational tools and accessibility solutions for individuals with disabilities [7].

The adaptation process focuses on altering only the speaker's identity, which comprises the speech attributes that define the target speaker as an individual. To control speaker identity during multi-step adaptation, methods such as vector quantization models [9], U-Net architectures [8, 9], attention mechanisms [10], or a combination of loss functions [18, 19] are employed.

Typically, speaker identification can be performed using images that have been passed through other external speaker verification systems or trained together with a base model [12, 20, 21]. In the adaptation process, studies have proposed optimizing all model parameters [11], selected components [13, 14, 15], or focusing on external aspects of the speaker instead [11]. An alternative approach is to solve the matching problem using data augmentation. This can be achieved using traditional signal processing methods, but more sophisticated methods propose generating high-quality synthetic data for the target speaker using a voice transformation (VC) model [9]. The TTS system is then re-optimized by combining the natural and synthetic data.

However, there are limitations associated with these approaches. Wang et al. [18] argue that when using speaker adaptation strategies, a single architecture is tasked with modeling both linguistic content and speaker identity. Since it is not entirely clear which model parameters govern the speaker's identity within this framework, the effectiveness of parameter adaptation may be diminished. Moreover, fine-tuning a complex architecture on a limited number of samples can easily result in overfitting, thereby reducing overall quality and clarity. On the other hand, data augmentation techniques still require at least 15 minutes of training data from the target speaker to optimize TTS models, making them unsuitable for scenarios with extremely limited resources.

In this paper, we tackle the challenge of ultra-low-resource TTS by employing VC as a post-processing module, which we refer to as the "Voice Filter," applied on top of a high-quality single-speaker TTS model. This single-speaker TTS model is also utilized to generate a synthetic parallel corpus for training the Voice Filter. Our approach offers the following innovations and benefits:

(1) The entire process is made modular, separating it into a speech content generation task followed by a speaker identity generation task. This improves efficiency, reliability, and interpretability while allowing for task-specific adaptation;

(2) We exploit the advantages of parallel VC without requiring an available parallel corpus by synthetically creating speech pairs at the frame level using a TTS model with controlled duration.

In summarize, we have divided the challenge of creating a traditional Uzbek TTS voice into two tasks: speech content and speaker identity generation. This division allows us to minimize the amount of speech required to train a synthetic voice for a specific speaker identity to just one minute, thereby reducing the complexity of the problem. Consequently, the quality of the resulting synthetic speech matches the quality of TTS models trained on 25 times more data.

METHODS

Voice Filter addresses the challenge of Uzbek TTS voice generation with extremely limited resources by dividing the tasks of speech content and speaker identity generation, with Voice Filter focusing on the latter. This leads to greater modularization and more resilient speaker identity generation compared to the adaptation of the multi-speaker TTS model.

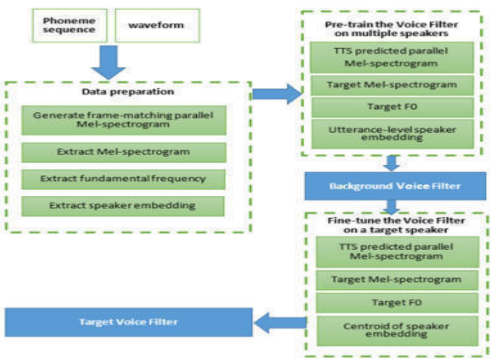

Figure 1. *Flowchart illustrating the preparation of synthetic parallel data and the training process for the proposed Voice Filter.*

Since Voice Filter is solely responsible for speaker identity generation, it functions at a more fundamental level (Mel-spectrograms) than the entire TTS system (phonemes). We believe that this speech-to-speech task is simpler than the text-to-speech task, particularly in resource-constrained settings. The proposed VC (Voice Filter) module is placed between the single-speaker duration-controlled TTS model and the general-purpose neural vocoder. This setup allows us to produce Mel-spectrograms for any desired text using the TTS model, which is then assigned the corresponding speaker identity by Voice Filter and finally transformed into a time-domain waveform using the vocoder.

Until recently, achieving individual goals required the use of traditional machine learning algorithms, which entailed a rigid selection of architecture and manual feature engineering. The advent of neural networks has enhanced the quality of results, enabling the identification of general principles for working with NLP.

II.I. Generating a Synthetic Parallel Corpus

The proposed method begins with the synthetic creation of a parallel dataset for training the voice filter (Figure 1, data preparation). Utilizing a synthetic parallel case allows us to overcome the two major constraints of traditional parallel VC while retaining its advantages: (1) the need for a large parallel corpus of discourse between source and target speakers, which is challenging and costly to gather, is eliminated; and (2) the necessity to employ time-shifting methods to align the parallel corpus across multiple speakers is removed. This is feasible because the input data for the voice filter are not recordings but duration-controlled, structured synthetic speech. However, this approach requires two distinct datasets to generate the parallel corpus: a single-speaker corpus for the TTS system and a multi-speaker corpus for training the voice filter. The construction of the synthetic parallel case involves three steps:

Force-smooth all available phone-level data, which we achieved using the pre-trained Kaldi ASpIRE TDNN system, encompassing both single- and multi-speaker cases.

Train a duration-guided TTS system using the single-speaker corpus.

Generate transcripts and synthetic data corresponding to the phone-level duration of the baseline adaptive multi-speaker corpus using the trained duration-guided TTS system.

This three-step process yields a frame-level parallel corpus mapping between the synthetic single-speaker speech samples and the natural multi-speaker speech samples. It forms the training data for the proposed voice filter, which, to the best of our knowledge, represents a novel approach to the VC problem.

For the purposes of this paper and experiment, the single-talker corpus comprises 20 hours of high-quality speech data read by a male Uzbek speaker in a neutral speaking style. The multi-talker corpus consists of 120 gender-balanced male and female Uzbek speakers, with approximately 35 minutes of data per speaker, ensuring comprehensive phonetic coverage.

II.II. Model Training and Fine-Tuning

Training a Voice Filter model capable of generating speech from 1 minute of unseen speaker data involves a two-step process: (1) preliminary training of the model (Figure 1, VF pre-tuning) and (2) fine-tuning on a minute of the target unseen speaker data (Figure 1, VF fine-tuning).

The preliminary Voice Filter is trained in a one-to-many fashion for 1 million steps using the entire synthetic parallel multi-speaker corpus created earlier. This model can transform into any of the speakers encountered during training but lacks the robustness to generalize to unseen speakers without further refinement.

The preliminary model is adapted to the target Voice Filter by fine-tuning all parameters for 1000 steps on one minute of the target speaker's speech in a one-to-one manner. The centroid of the target speaker embeddings at the utterance level is employed because, in our multi-shot scenario, fine-tuning on a consistent speaker embedding rather than variable utterance embeddings led to more stable models. We did not evaluate the impact on quality for non-target speakers after fine-tuning, but we assume that the resulting target Voice Filter is speaker-specific. Both the preliminary and target Voice Filter models are trained using the L1 spectral loss and the BAHODIR optimizer with standard settings.

II.III. Model Architecture

The Voice Filter model (Figure 2) processes 80-bin Mel spectrograms of equal length as input and output and is composed of 6 layers of size-preserving 1D convolutions with 512 channels and a kernel size of 5, incorporating batch normalization. This is followed by a unidirectional LSTM and a dense layer with 1024 nodes. We combine the target speaker embedding and the log-f0 contour with the hidden representation of the third convolutional layer. The speaker embedding is a 256-dimensional vector defined at the utterance level and passed to the frame level. The speaker verification framework utilized to derive the embeddings was trained on a dataset of multiple speakers and fine-tuned on the generalized end-to-end loss. We found that the log-f0 contour assists the model in better capturing the prosodic differences between the input and target speakers. As a result, Voice Filter does not need to learn how to modify the prosodic information between the source and target speakers but rather concentrates on the speaker-specific information. To extract the log-f0 contour from the target speech recordings, we employed the RAPT algorithm from the Speech Processing Toolkit (SPTK) with a threshold of 0 for distinguishing between voiced and unvoiced regions.

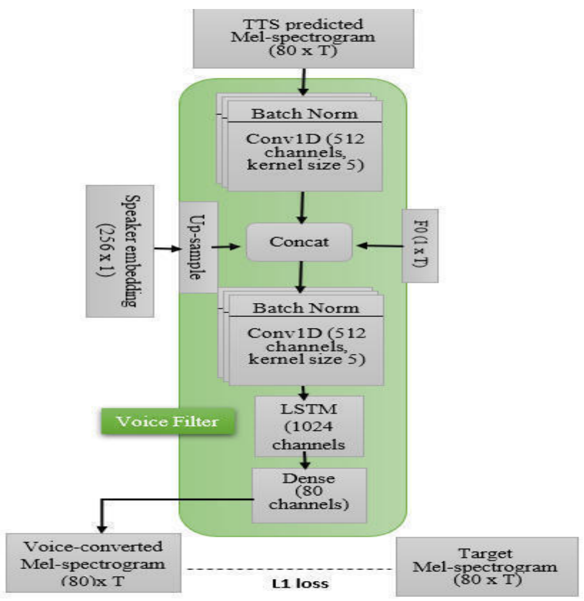

Figure 2. *Voice Filter Architecture (Proposed).*

II.IV. Model Inference

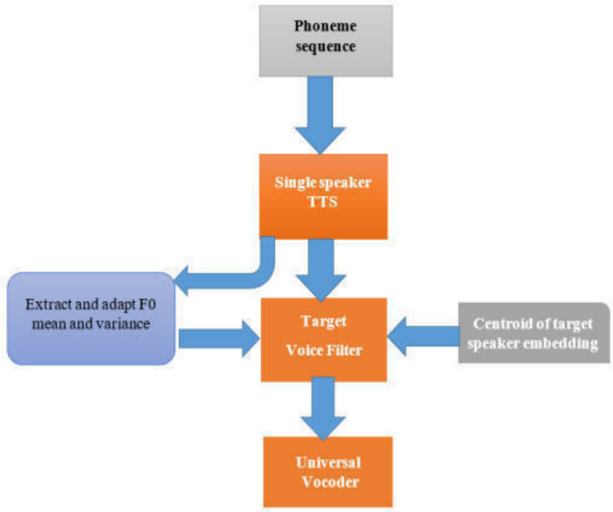

Figure 3. *Voice Filter inference flowchart (Proposed).*

The inference of the full model (Figure 3) requires us to sequentially run several models:

a. Estimating the f0 from the initial Mel-spectrogram and renormalizing it to match the mean and variance of the target speaker.

b. Generating the initial Mel-spectrogram for the desired text and predicted durations using the single-speaker TTS model.

c. Synthesizing the voice-converted Mel-spectrogram into a time-domain signal using a vocoder.

d. Transforming the initial Mel-spectrogram into the target speaker using the fine-tuned voice filter.

At this stage, we do not adapt the speech rate or phone duration to match the target speaker's characteristics, as these are difficult to estimate in extremely low-resource scenarios and can introduce significant artifacts.

EXPERIMENTAL SETUP

The models were assessed using both quantitative and perceptual metrics. For our evaluations, we selected 5 male and 5 female speakers, each with 60 test utterances, resulting in a total of 500 samples. Signal quality was quantitatively measured using the conditional Fréchet speech distance (cFSD) [22]. Specifically, a pre-trained XLSR-53 [22] wav2vec2.0 [24] model was employed to generate activation distributions for both the recordings and synthesized samples. These distributions were then compared using the Fréchet distance, providing a metric of how closely the generated speech matches the actual recordings. To quantitatively evaluate the speaker similarity metric, we used the average cosine distance between speaker embeddings (CSED) of the recordings and predicted samples.

The Multiple Stimuli with Hidden Reference and Anchor (MUSHRA) tests were conducted to evaluate perceptions of naturalness, signal quality, talker similarity, and speaking style. Participants were presented with samples from the systems under evaluation side by side and asked to rate them on a scale from 0 (worst) to 100 (best) for the metric being evaluated. We utilized the ClickWorker crowdsourcing platform to gather ratings for each test utterance from a group of 30 listeners. The target talker recordings were consistently included as a hidden top anchor system, and there was no requirement for at least one system to be rated as 100. Listeners were given a reference sample for both talker and style similarity ratings. The bottom anchor for talker similarity ratings was the voice-transformed samples of the most distant same-gender talker in the talker embedding space. The bottom anchor for style similarity ratings was the unfiltered TTS system. Paired two-tailed Student's t-tests with Holm-Bonferroni correction were used to assess the statistical significance of differences between the two systems at a threshold p-value of 0.1.

RESULTS

IV.I. Speech synthesis performance with extremely low resources

In this work, we compare the proposed system with two state-of-the-art multi-talker technologies that have demonstrated strong performance in low-resource speech synthesis: the CopyCat (CC) model [25] with the f0 padding condition (preliminary results indicated that the CopyCat model with the f0 padding condition exhibited better signal quality stability and provided a fairer comparison) and the Multi-Talker Controlled Duration TTS (MS-TTS) model [25] without the data padding component. Both models were trained on the same dataset and under the same conditions described in *Section 2.2*, including fine-tuning with 1000 steps per 1 minute of target speaker data. The objective metrics and MUSHRA perceptual scores are presented in Tables 1 (columns 1–3) and 2, respectively. We observe a statistically significant preference for the proposed system in the MUSHRA scores across all evaluated metrics. The objective results align with these findings, suggesting that the proposed method surpasses other speaker adaptation techniques when using the same amount of data.

Table 1. Average objective performance for all evaluated systems. The top performance is highlighted in bold. TTSuzb was trained on 25 minutes of speech rather than 1.

System				
	VF	*CC*	*MS-TTS*	*TTSuzb*
CSED	***0.191***	*0.198*	*0.205*	*0.207*
cFSD	***0.198***	*0.251*	*0.261*	*0.228*

Table 2. Average MUSHRA results with a 96% confidence interval. The top results, showing a statistically significant difference between the voice filter (VF) and reference systems, are highlighted in bold (p<0.1).

System					
	VF	*CC*	*MS-TTS*	*Rec*	*Lower-anchor*
Sp.sim.	***67.98***	*66.55*	*65.85*	*79.48*	*38.00*
Style sim	***64.6***	*63.56*	*62.13*	*75.57*	*38.05*
Nat.	***54.1***	*52.1*	*50.75*	*79.01*	-
Sig. Q.	***65.3***	*55.30*	*54.27*	*76.81*	-

IV.II. Ablation Study on Data Quantity

To understand the influence of the extremely low-resource scenario, we trained the Voice Filter using 1, 10, and 30 minutes of target speaker data during fine-tuning. The objective and perceptual MUSHRA scores are presented in Tables 3 and 4, respectively. In the subjective evaluation, listeners did not detect a statistically significant difference between the different data scenarios, although the objective scores still show slight improvements with larger data amounts. This indicates that while there is potential for enhancement in system performance, the Voice Filter does not perceptually benefit from richer data scenarios. With only 1 minute of target data, we are able to produce high-quality samples.

Table 3. Average objective performance for Voice Filter trained on varying amounts of data. The top results are highlighted in bold.

# min	***1***	***10***	***30***
CSED	*0.191*	***0.181***	*0.186*
cFSD	*0.198*	*0.189*	***0.175***

Table 4. Average MUSHRA results with a 96% confidence interval for Voice Filter trained on different data sizes. There are no statistically significant differences (p<0.1) between the systems.

# min	***Rec***	***1***	***10***	***30***
Sp.sim.	*74.01*	*51.93*	*51.94*	*52.07*
Style sim	*71.98*	*54.53*	*55.41*	*54.81*
Nat.	*79.00*	*54.99*	*55.11*	*55.19*
Sig. Q.	*74.02*	*54.03*	*53.93*	*53.65*

IV.III. Comparison with a competitive TTS

Finally, the quality of the generated speech is assessed in comparison to a TTS system trained on a larger set of target recordings. For this comparison, we evaluate the Voice Filter against a proven low-resource TTS technology that has demonstrated competitiveness when trained on 30 minutes of target speech (TTSuzb) [6]. It is important to note that such a technology implicitly leads the TTS system to estimate the duration of a phone call for the target speaker, which is not the case with the proposed Voice Filter. Essentially, this comparison pits the Voice Filter against a system trained on 30 times more target data, which has also shown competitiveness with TTS voices trained on 5+ hours of target recordings.

The objective metrics and MUSHRA perceptual scores are presented in Tables 1 (columns 1 and 4) and 5, respectively. Although we observe a relative degradation of 4% in speaker similarity, the MUSHRA scores do not indicate statistical differences between the systems in terms of signal quality, naturalness, and style similarity. On the other hand, the objective metrics reveal that speaker similarity and signal quality are superior with our proposed method. Overall, the results demonstrate that our model is on par with TTSuz, with only a slight human-perceived degradation in speaker similarity, despite the much smaller target training dataset used.

Table 5. Average MUSHRA results. The highest scores, showing statistically significant differences between the Voice Filter (VF) and reference systems, are highlighted in bold (p < 0.1).

System				
	VF	*TTSuzb*	*Rec*	*Lower-anchor*
Sp.sim.	*70.40*	***73.66***	*83.21*	*37.75*
Style sim	*69.55*	*70.01*	*79.81*	*39.54*

Nat.	*55.31*	*55.23*	*77.09*	-
Sig. Q.	*55.59*	*55.85*	*76.77*	-

In this study, we introduced a new, highly low-resource TTS method called Voice Filter, capable of producing high-quality speech using only 1 minute of audio data. Voice Filter divides the TTS process into two tasks: generating speech content and identifying the speaker. The speaker identification is achieved using a fine-tuned one-to-many VC module, which makes it easily adaptable to new speakers, even in settings with minimal resources. The speech content generation is handled by a duration-controlled single-speaker TTS system, which also facilitates the creation of a synthetic parallel corpus. This approach enables Voice Filter to function in a frame-level parallel environment, offering a higher potential quality and reduced modeling complexity.

Evaluations indicate that our Voice Filter surpasses other few-frame speech synthesis techniques in both objective and subjective metrics within the 1-minute data scenario, achieving quality levels comparable to state-of-the-art systems trained on 30 times more data. In conclusion, we consider the Voice Filter model a foundational step towards developing extremely low-resource TTS as a VC plug-in for post-processing. Additionally, we believe that the ability to generate synthetic parallel data with controlled duration will open up new possibilities in speech technologies that were previously constrained by data limitations.

CONCLUSION

In this study, we introduced a new, highly low-resource TTS method called Voice Filter, capable of producing high-quality speech using only 1 minute of audio data. Voice Filter divides the TTS process into two tasks: generating speech content and identifying the speaker. The speaker identification is achieved using a fine-tuned one-to-many VC module, which makes it easily adaptable to new speakers, even in settings with minimal resources. The speech content generation is handled by a duration-controlled single-speaker TTS system, which also facilitates the creation of a synthetic parallel corpus. This approach enables Voice Filter to function in a frame-level parallel environment, offering a higher potential quality and reduced modeling complexity.

Evaluations indicate that our Voice Filter surpasses other few-frame speech synthesis techniques in both objective and subjective metrics within the 1-minute data scenario, achieving quality levels comparable to SOTA systems trained on 30 times more data. In conclusion, we consider the Voice Filter model a foundational step towards developing extremely low-resource TTS as a VC plug-in for post-processing. Additionally, we believe that the ability to generate synthetic parallel data with controlled duration will open up new possibilities in speech technologies that were previously constrained by data limitations.

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ANALYSIS OF METHODS OF DETERMINING DROWSINESS IN HUMAN PHYSIOLOGICAL DEVIATION

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AbstractDriver drowsiness is a critical factor in road safety, contributing to a significant number of traffic accidents worldwide. Early detection of driver fatigue is essential for preventing such incidents and ensuring the safety of both the driver and other road users. This article explores various methodologies for detecting driver drowsiness, categorized into three main approaches: methods based on the driver's state, methods based on driver performance, and a combination of both. Driver state methods primarily focus on physiological and behavioural indicators, such as eye movements, facial expressions, and EEG signals. In contrast, performance-based methods monitor the vehicle's behaviour, including lane tracking and steering dynamics. The combination of these methods offers a more comprehensive approach, integrating both physiological and performance metrics to enhance detection accuracy. Through a detailed literature review, this article highlights the strengths and limitations of these approaches, emphasizing the challenges of real-world implementation and the potential for future advancements in this field.

Keywords: Driver drowsiness detection, road safety, fatigue detection, driver state monitoring, vehicle performance monitoring, physiological indicators, behavioural indicators, EEG signals

Introduction

Driving requires a high level of situational awareness, quick decision-making, and continuous attention to ensure safety on the road. Situational awareness is crucial, as drivers must process and respond to various cues in real time. However, fatigue significantly impairs these abilities, slowing reaction times and reducing a driver's capacity to operate a vehicle safely. Monitoring and maintaining driver attention is thus essential for preventing accidents. In recent years, driver monitoring has gained significant attention, particularly in areas like workload estimation, activity identification, secondary task detection, and driving style recognition. Numerous techniques have been proposed to detect driver fatigue, many of which have been implemented by multinational companies for driver assistance systems. The importance of this research is underscored by alarming statistics: fatigue is involved in 20% of fatal collisions in Canada, 34% of road accidents in Pakistan, and 20% of fatal crashes in the United States. In the European Union, 20% of commercial transport crashes are attributed to fatigue. These figures highlight the critical need for effective fatigue detection systems. Fatigue symptoms include yawning, slow reaction times, eyelid closure, and loose steering grip. However, as fatigue manifests in various ways, relying on a single symptom for detection is insufficient. The increasing number of traffic accidents due to reduced driver vigilance has become a serious societal problem. Between 10% and 20% of all traffic accidents are caused by drivers with diminished vigilance, and these accidents tend to be more severe as drowsy drivers often fail to take evasive action. Given the gravity of the situation, developing systems to monitor driver vigilance and alert drivers when they are drowsy is essential. Accurate detection methods based on physiological phenomena, such as brain waves, heart rate, pulse rate, and respiration, have been explored, but these techniques are often intrusive, requiring electrodes or other devices that cause discomfort. Other methods, like monitoring eye and gaze movement or indirect vehicle behaviors, are less intrusive but have limitations related to vehicle type, driver experience, and road conditions. In response, computer vision has emerged as a promising non-intrusive technique for monitoring driver vigilance. By analyzing visual cues from facial features such as eyes, head, and face, computer vision systems can effectively detect signs of fatigue and reduce the risk of accidents.

Literature review

Driver drowsiness is a significant factor contributing to road accidents, and its early detection is crucial for ensuring road safety. The process of falling asleep at the wheel is typically gradual, characterized by a decline in alertness due to monotonous driving conditions or other environmental factors. As a driver becomes less alert, they may enter a state of fuzzy consciousness, eventually leading to the onset of sleep. The challenge for drowsiness detection systems is to identify this state early enough to prevent potential accidents. Various techniques have been developed to detect driver drowsiness, which can be broadly classified into three categories:

1. Methods Based on Driver's State
2. Methods Based on Driver Performance
3. Methods Combining Driver State and Performance
4. Methods Based on Driver's State

These methods focus on monitoring the physiological and behavioral changes in the driver that indicate fatigue. The primary indicators used in these methods include eye and eyelid movements, facial expressions, and other physiological signals. The key techniques include:

Eye Behavior Analysis:

Eye movements, blinking rate, and eye closure are critical indicators of driver alertness. Various studies have shown that monitoring these visual behaviors can effectively predict a driver's state of drowsiness, vigilance, or attentiveness [1]. Eye detection and tracking methods can be divided into two categories:

Passive Appearance-Based Methods: These methods detect eyes based on their visual contrast with the rest of the face. Typically, these methods involve two steps: face detection to identify the eye regions and eye detection within these regions. Techniques such as neural networks, principal components analysis (PCA), independent components analysis (ICA), and skin color-based methods are commonly used for face detection [2].

Active Infrared (IR)-Based Methods: These methods utilize infrared light to enhance the contrast between the pupils and the surrounding facial features, making eye detection more robust and accurate. The **PERCLOS (Percent Eye Closure)** methodology is a notable example, measuring the proportion of time the driver's eyes are closed. It has been shown to correlate strongly with a driver's alertness level [3].

Facial Expression and Head Position:

Monitoring changes in facial expressions, particularly around the mouth and eyes, can provide additional insights into a driver's state. Systems like the one proposed by Chu et al. use facial geometry to classify different states of alertness. **Head position tracking**, such as the MINDS (Micro-Nod Detection System), measures the driver's head movements to detect micro-sleeps, although it may not capture all instances of drowsiness. Here in the figure below, the overall process of fatigue detection is shown [4].

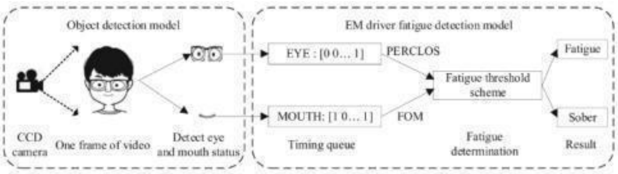

Figure 1. Processing flow of fatigue detection model

EEG and Physiological Measurements:

Electroencephalography (EEG) is a direct measure of brain activity and has been used to detect drowsiness by identifying changes in brain wave patterns associated with sleep onset. However, EEG is challenging to implement in real-world driving conditions due to the need for complex equipment and the difficulty of obtaining accurate readings while driving [5].

Methods Based on Driver Performance

Driver performance-based methods monitor the vehicle's behavior rather than the driver's physiological state. These methods assess how the driver's control over the vehicle changes as they become drowsy. Key techniques include:

Lane Tracking:

Lane tracking systems monitor the vehicle's position within the lane. If the vehicle starts to drift out of its lane without the driver making corrective actions, it may indicate that the driver is losing alertness. Systems like those developed by Bertozzi and Broggi use geometric transformations and morphological processing to detect lane markers even in low-light conditions [6]. In the figure below, the lane detection with the classification method is shown [7].

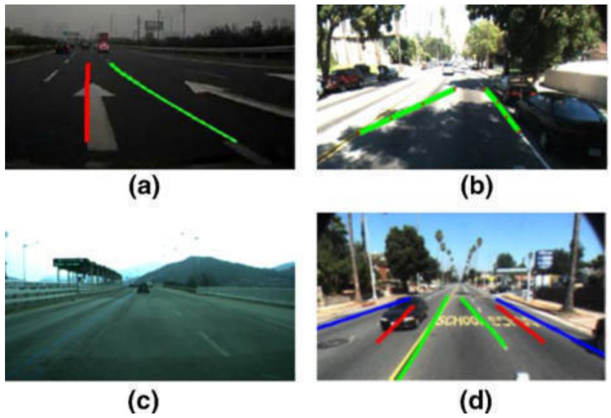

Figure 2. Example of lane detection based on classification

Vehicle Dynamics:

Monitoring the vehicle's speed, steering angle, and headway (the distance to the car in front) can provide additional insights into the driver's alertness. Changes in these parameters, such as erratic steering or inconsistent speed, may signal that the driver is drowsy [8].

Combined Approaches:

Some advanced systems combine lane tracking with other performance metrics, such as steering wheel movements and vehicle speed, to improve the accuracy of drowsiness detection.

Methods Combining Driver State and Performance

Combining driver state and performance metrics can provide a more comprehensive assessment of driver alertness. This approach is based on the understanding that no single measure is sufficiently reliable to detect drowsiness in all situations. By integrating multiple indicators, these systems aim to improve detection accuracy and reduce false alarms. Key examples include:

AWAKE Project:

The European Union's AWAKE project is an ambitious initiative that combines driver state and performance measures with real-time traffic risk assessment. The system monitors a range of indicators, including eyelid movement, steering behavior, and lane tracking, and combines them with external factors such as traffic conditions and road layout. This holistic approach aims to provide a more accurate assessment of the driver's vigilance.

FaceLAB:

The FaceLAB system, developed by Seeing Machines, uses a combination of video cameras and software to monitor eye gaze, head position, and facial expressions in real time. It has been validated in simulated driving environments and is capable of tracking driver behavior even in low-light conditions or when the driver is wearing sunglasses [9].

Challenges and Future Directions

Real-World Implementation:

Systems that perform well in controlled environments may struggle to maintain accuracy in real-world driving conditions, where factors like lighting, road quality, and driver behavior can vary widely.

Balancing Sensitivity and Specificity:

Ensuring that drowsiness detection systems are both sensitive enough to detect early signs of fatigue and specific enough to avoid false alarms is a key challenge. Overly sensitive systems may lead to driver annoyance and reduced trust in the technology.

Integration with Other Safety Systems:

Future systems may need to integrate drowsiness detection with other driver assistance technologies, such as adaptive cruise control or automatic emergency braking, to provide a comprehensive safety solution.

Conclusion

Detecting driver drowsiness is a complex but vital aspect of road safety, with various approaches offering different advantages and challenges. Methods based on the driver's physiological state provide direct indicators of fatigue but may require sophisticated equipment and can be sensitive to external conditions. Performance-based methods, while less invasive, may not detect drowsiness until it significantly impacts driving behavior, potentially reducing reaction time. Combining these approaches can offer a more robust solution, leveraging the strengths of both to improve overall detection accuracy. However, challenges such as maintaining reliability in diverse real-world conditions and minimizing false alarms remain. Future advancements should focus on integrating these detection systems with other in-vehicle safety technologies, providing a holistic approach to driver assistance. As research progresses, the continued development and refinement of these systems will be crucial in reducing the incidence of drowsiness-related accidents, ultimately enhancing road safety for all.

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USING DIFFERENTIAL EQUATIONS IN SOLVING FILTRATION PROBLEMS, SOLUTION BY EULER AND RUNGE-KUTTA METHODS AND COMPARISON WITH REAL VALUE

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A B S T R A C T **In this article, it is known from ordinary differential equation courses, if $y' = f(x,y)$ in a differential equation $f(x,y)$ and if the equation is complex, to find the appropriate solution, it is important to use approximate methods. In this article, the concepts and examples of the approximate calculation of differential equations solved with respect to the derivative are considered and compared with the analytical solution.**

K E Y W O R D S Differential equations, approximate solution, analytical solution, Cauchy's problem, Euler's method, approximation.

INTRODUCTION

In recent years, creating a mathematical model of many life processes and solving it with mathematical methods has become widespread among mathematicians. These processes are inextricably linked with the development of medicine and techniques. Fractional integrals and derivatives have many applications in the fields of physics, biology, medicine and technology, and it is important in the development of these fields.

For this reason, in recent years, mathematicians are increasingly interested in studying differential and partial differential equations with fractional derivatives. In our country, attention has been paid to differential equations and mathematical physics, which have scientific and practical application of fundamental sciences.

In the process of learning the course of differential equations, we studied the methods of solving differential equations with special forms. These methods cannot cover many other situations. That is why the search for universal methods that do not depend on the form of the equation [2-3].

METHODS

The development of computing machines has made it possible to successfully apply almost any number of methods. Let's start with the Cauchy problem for first-order differential equations.

Let's say

$$y' = f(x,y), \quad x_0 \le x \le b \qquad (1)$$

Differential equation in such form

$$y(x_0) = y_0 \qquad (2)$$

Let the problem of finding a solution satisfying the initial condition, that is, the Cauchy problem, be given. In general, the Cauchy problem cannot always be found. There are ways to find the general solution of (1) only in certain representations of the function $f(x,y)$. In many cases, methods of approximate solution of differential equations are used in practical problems. It is assumed that the conditions of the theorem about the existence and uniqueness of the solution are fulfilled. Let the function $f(x,y)$ around the point $M_0(x_0;y_0)$ be continuous in x and satisfy the Lipshis condition in y.

Euler's method: (1)-(2) We expand the solution of the Cauchy problem $y(x)$ into a Taylor series around the point x_0:

$$y(x) = y + (x-x_0)y'(x_0) + \frac{(x-x_0)^2}{2!}y''(x_0) + \frac{(x-x_0)^3}{3!}y'''(x_0) + \dots (3)$$

We take the first two terms of the Taylor series around the point x_0 and discard the remaining terms, as a result we arrive at the following approximate formula

$$y(x) \approx y_0 + (x-x_0)y' \qquad (4)$$

if we use the form of y' in formula (1), then formula (4) can be written in the following form:

$$y(x) \approx y_0 + (x-x_0)f(x_0;y_0) \qquad (5)$$

To generalize the formula (5) to the interval $x_0 \le x \le b$, we divide this interval into n parts. Splitting step:

$$h = \frac{b-x_0}{n}; \quad x_i = x_0 + ih, \ i = 0,1,2,3,\dots,n$$

We aim to find the solution of the problem in the form of a table at points x_i. We find the approximate values of $y(x_i)$ according to formula (5):

$$y_{i+1} \approx y_i + h \cdot f(x_i, y_i) \quad i = 0,1,2,3,...,n-1 \quad (6)$$

where $y_{i+1} = y(x_{i+1})$, $y_i = y(x_i)$. This formula is called Euler's method. Euler's method is a universal method and does not depend on the form of $f(x,y)$, but the error is relatively large. The error at each step is of the order of $0(h^2)$, and this error increases step-by-step until the error can increase to $0(h)$ until we reach point b. In the coordinate plane (x_0, y_0); (x_1, y_1); ... , (x_n, y_n) the broken line formed by connecting the points with straight line segments is the graph of the integral curve. The differential equations branch of mathematics originated from solving practical problems. Therefore, creating universal methods similar to formula (6) has been a constant problem. Representatives of various fields have also tried to solve this problem. A clear example of this is the Runge-Kutta method, which was created by scientists, one physicist and one astronomer. (3) served as the basis for the creation of this method. Unlike Euler's method (6), they used five terms instead of two. In addition, in the Runge-Kutta method, formulas that do not require the calculation of derivatives included in the series (3) were proposed. Without dwelling on the theoretical origin of these formulas, we will dwell on working formulas.

Runge-Kutte method:

Approximate solution of the Cauchy problem in the initial conditions of the differential equation $y' = f(x,y)$, $x_0 \le x \le b$, $y = (x_0) = y_0$ by the Runge-Kutta method was carried out with the following formulas.

$$\begin{cases} K_1 = h \times f(x_i, y_i) \\ K_2 = h \times f\left(x_i + \frac{h}{2}, y_i + \frac{K_1}{2}\right) \\ K_3 = h \times f\left(x_i + \frac{h}{2}, y_i + \frac{K_2}{2}\right) \\ K_4 = h \times f(x_i + h,, y_i + K_3) \\ y_{i+1} = y_i + \frac{1}{6}(K_1 + 2K_2 + 2K_3 + K_4); \\ \quad i = 0,1,2,...,n-1. \end{cases}$$

Example 1. $y' = x^2 + y = f(x,y)$; $y(0) = 0,3$ Find the approximate value of the solution satisfying the initial condition $x = 0,3$ using the Euler and Runge-Kutta methods and compare it with the real solution. Here $h = 0,1$.

Solving. Euler's method:

$$x_0 = 1; \quad x_i + i \cdot h = 1 + i \cdot 0.2; \quad y_0 = (1) = 2$$

$$y_1 = y_0 + h * f(x_0, y_0) = 2 + 0.2 * (1^2 + 2) = 2.6$$

$$y_2 = y_1 + h * f(x_1, y_1) = 2.6 + 0.2 * (1.2^2 + 2.6) = 3.408$$

$$y_3 = y_2 + h * f(x_2, y_2) = 3.408 + 0.2 * (1.4^2 + 3.408) = 4.4816$$

$$y_4 = y_3 + h * f(x_3, y_3) = 4.4816 + 0.2 * (1.6^2 + 4.4816) = 5.890$$

$$y_5 = y_4 + h * f(x_4, y_4) = 5.890 + 0.2 * (1.8^2 + 5.890) = 7.716$$

Thus, the approximate solution of the differential equation by Euler's method is shown in the following table:

TABLE.1.

x_i	1	1.2	1.4	1.6	1.8	2.0
y_i	2	2.6	3.408	4.4816	5.890	7.716

Runge-Kutta method:

In $y' = x^2 + y = f(x,y)$; $y = (1) = 2$, $[1;2]$, solve approximately with steps $h = 0.2$:

$$\begin{cases} K_1 = h \cdot f(x_0, y_0) = 0.2 * (1^2 + 2) = 0.6 \\ K_2 = h \cdot f\left(x_0 + \frac{h}{2}, y_0 + \frac{K_1}{2}\right) = 0.2 * \left((1 + \frac{0.2}{2})^2 + 2 + \frac{0.6}{2}\right) = 0.702 \\ K_3 = h \cdot f\left(x_0 + \frac{h}{2}, y_0 + \frac{K_2}{2}\right) = 0.2 * \left((1 + \frac{0.2}{2})^2 + 2 + \frac{0.702}{2}\right) = 0.7122 \\ K_4 = h \cdot f(x_0 + h, y_0 + K_3) = 0.2 * \left((1 + 0.2)^2 + 2 + 0.7122\right) = 0.83044 \\ y_1 = y_0 + \frac{1}{6}(K_1 + 2K_2 + 2K_3 + K_4) = \\ 2 + \frac{1}{6}(0.6 + 2 * 0.702 + 2 * 0.7122 + 0.83044) = 2.71; \end{cases}$$

$$\begin{cases} K_1 = h \cdot f(x_1, y_1) = 0.2 * (1^2 + 2.71) = 0.83 \\ K_2 = h \cdot f\left(x_1 + \frac{h}{2}, y_1 + \frac{K_1}{2}\right) = 0.2 * \left((1.2 + \frac{0.2}{2})^2 + 2.71 + \frac{0.83}{2}\right) = 0.963 \\ K_3 = h \cdot f\left(x_1 + \frac{h}{2}, y_1 + \frac{K_2}{2}\right) = 0.2 * \left((1.2 + \frac{0.2}{2})^2 + 2.71 + \frac{0.963}{2}\right) = 0.9763 \\ K_4 = h \cdot f(x_1 + h, y_1 + K_3) = 0.2 * \left((1.2 + 0.2)^2 + 2.71 + 0.9763\right) = 0.987 \\ y_2 = y_1 + \frac{1}{6}(K_1 + 2K_2 + 2K_3 + K_4) = \\ 2 + \frac{1}{6}(0.83 + 2 * 0.963 + 2 * 0.9763 + 0.987) = 2.95; \end{cases}$$

$$\begin{cases} K_1 = h \cdot f(x_2, y_2) = 0.2 * (1.4^2 + 2.95) = 0.982 \\ K_2 = h \cdot f\left(x_2 + \frac{h}{2}, y_2 + \frac{K_1}{2}\right) = 0.2 * \left((1.4 + \frac{0.2}{2})^2 + 2.95 + \frac{0.982}{2}\right) = 1.1382 \\ K_3 = h \cdot f\left(x_2 + \frac{h}{2}, y_2 + \frac{K_2}{2}\right) = 0.2 * \left((1.4 + \frac{0.2}{2})^2 + 2.95 + \frac{1.1382}{2}\right) = 1.154 \\ K_4 = h \cdot f(x_2 + h, y_2 + K_3) = 0.2 * \left((1.4 + 0.2)^2 + 2.95 + 1.154\right) = 1.3328 \\ y_3 = y_2 + \frac{1}{6}(K_1 + 2K_2 + 2K_3 + K_4) = \\ 2.95 + \frac{1}{6}(0.982 + 2 * 1.1382 + 2 * 1.154 + 1.3328) = 4.1; \end{cases}$$

$$\begin{cases} K_1 = h \cdot f(x_3, y_3) = 0.2 * (1.6^2 + 4.1) = 1.332 \\ K_2 = h \cdot f\left(x_3 + \frac{h}{2}, y_3 + \frac{K_1}{2}\right) = 0.2 * \left((1.6 + \frac{0.2}{2})^2 + 4.1 + \frac{1.332}{2}\right) = 1.531 \\ K_3 = h \cdot f\left(x_3 + \frac{h}{2}, y_3 + \frac{K_2}{2}\right) = 0.2 * \left((1.6 + \frac{0.2}{2})^2 + 4.1 + \frac{1.531}{2}\right) = 1.551 \\ K_4 = h \cdot f(x_3 + h, y_3 + K_3) = 0.2 * \left((1.6 + 0.2)^2 + 4.1 + 1.551\right) = 1.778 \\ y_4 = y_3 + \frac{1}{6}(K_1 + 2K_2 + 2K_3 + K_4) = \\ 4.1 + \frac{1}{6}(1.332 + 2 * 1.531 + 2 * 1.551 + 1.778) = 5.65; \end{cases}$$

$$\begin{cases} K_1 = h \cdot f(x_4, y_4) = 0.2 * (1.8^2 + 5.65) = 1.778 \\ K_2 = h \cdot f\left(x_4 + \frac{h}{2}, y_4 + \frac{K_1}{2}\right) = 0.2 * \left((1.8 + \frac{0.2}{2})^2 + 5.65 + \frac{1.778}{2}\right) = 2.03 \\ K_3 = h \cdot f\left(x_4 + \frac{h}{2}, y_4 + \frac{K_2}{2}\right) = 0.2 * \left((1.8 + \frac{0.2}{2})^2 + 5.65 + \frac{2.03}{2}\right) = 2.055 \\ K_4 = h \cdot f(x_4 + h, y_4 + K_3) = 0.2 * \left((1.8 + 0.2)^2 + 5.65 + 2.055\right) = 2.341 \\ y_5 = y_5 + \frac{1}{6}(K_1 + 2K_2 + 2K_3 + K_4) = \\ 5.65 + \frac{1}{6}(1.778 + 2 * 2.03 + 2 * 2.055 + 2.341) = 7.698; \end{cases}$$

Thus, the approximate solution of the differential equation using the Runge-Kutta method is as follows:

TABLE.2.

x_i	1	1.2	1.4	1.6	1.8	2.0
y_i	2	2.71	2.95	4.1	5.65	7.698

For clarity, we also present the solution of the differential equation found analytically:

Solution:

$$y' = x^2 + y, \quad y(1) = 2$$

$$y' = x^2, \quad e^{\int -dx} = e^{-x}$$

$$y'e^{-x} - e^{-x}y = x^2e^{-x} \Rightarrow \left(ye^{-x}\right)' = x^2e^{-x}dx$$

$$y'e^{-x} = \int x^2e^{-x}dx = \left|\begin{smallmatrix} u=x^2 & dv=e^{-x}dx \\ du=2xdx & v=-e^{-x}\end{smallmatrix}\right| = -x^2e^{-x} + 2\int xe^{-x}dx$$

$$= -x^2e^{-x} + \int xe^{-x}dx = \left|\begin{smallmatrix} u=x & dv=e^{-x}dx \\ du=dx & v=-e^{-x}\end{smallmatrix}\right|$$

$$= -x^2e^{-x} - 2xe^{-x} - 2e^{-x} + C \Rightarrow$$

Now according to the value $y(1) = 2$:

$$2 = Ce - 1 - 2 - 2 \Rightarrow C = \frac{7}{2}$$

$$y = -x^2 - 2x + 7e^{x-1} - 2$$

Solution of a differential equation when solved analytically

$$y = (x) = -x^2 - 2x + 7e^{x-1} - 2$$

we can see that the approximate values we found are very close fits compared to the original solution values.

Example 2. Find the approximate value satisfying the initial conditio $y' = y - x, \ y(0) = 1, \ [0;3], \ h = 0,2$ by Euler and Runge-Kutta method and compare with the real solution.

Euler's method:

$$y_{i+1} \approx y_i + h \cdot f(x_i, y_i) \quad i = 0, 1, 2, 3, ..., n-1$$

$$x_0 = 0, \ y_0 = 1, \ x_i = x_0 + 0.2 \cdot i = 0 + 0.2 \cdot i$$

$$y_1 = 1 + 0.2(1-0) = 1 + 0.2 = 1.2; \qquad x_1 = 0.2$$

$$y_2 = 1.2 + 0.2(1.2-0.2) = 1.2 + 0.2 = 1.4; \ x_2 = 0.4$$

$$y_3 = 1.4 + 0.2(1.4-0.4) = 1.4 + 0.2 = 1.6; \ x_3 = 0.6$$

$$y_4 = 1.6 + 0.2(1.6-0.6) = 1.6 + 0.2 = 1.8; \ x_4 = 0.8$$

$$y_5 = 1.8 + 0.2(1.8-0.8) = 1.8 + 0.2 = 2; \quad x_5 = 1$$

$$y_6 = 2 + 0.2(2-1) = 2 + 0.2 = 2.2; \qquad x_6 = 1.2$$

$$y_7 = 2.2 + 0.2(2.2-1.2) = 2.2 + 0.2 = 2.4; \ x_7 = 1.4$$

$$y_8 = 2.4 + 0.2(2.4-1.4) = 2.4 + 0.2 = 2.6; \ x_8 = 1.6$$

$$y_9 = 2.6 + 0.2(2.6-1.6) = 2.6 + 0.2 = 2.8; \ x_9 = 1.8$$

$$y_{10} = 2.8 + 0.2(2.8-1.8) = 2.8 + 0.2 = 3; \ x_{10} = 2$$

$$y_{11} = 3 + 0.2(3-2) = 3 + 0.2 = 3.2; \qquad x_{11} = 2.2$$

$$y_{12} = 3.2 + 0.2(3.2-2.2) = 3.2 + 0.2 = 3.4; \ x_{12} = 2.4$$

$$y_{13} = 3.4 + 0.2(3.4-2.4) = 3.4 + 0.2 = 3.6; \ x_{13} = 2.6$$

$$y_{14} = 3.6 + 0.2(3.6-2.6) = 3.6 + 0.2 = 3.8; \ x_{14} = 2.8$$

$$y_{15} = 3.8 + 0.2(3.8-2.8) = 3.8 + 0.2 = 4; \ x_{15} = 3$$

$$y_{16} = 4 + 0.2(4-3) = 4 + 0.2 = 1.2; \qquad x_{16} = 4.2$$

TABLE.3.

x_i	0	0.2	0.4	0.6	0.8	1	1.2	1.4
y_i	1.2	1.4	1.6	1.8	2	2.2	2.4	2.6
x_i	1.6	1.8	2	2.2	2.4	2.6	2.8	3
y_i	2.8	3	3.2	3.4	3.6	3.8	4	4.2

Renge-Kutte method:

$$\begin{cases} K_1 = h \cdot f(x_i, y_i) \\ K_2 = h \cdot f\left(x_i + \frac{h}{2}, y_i + \frac{K_1}{2}\right) \\ K_3 = h \cdot f\left(x_i + \frac{h}{2}, y_i + \frac{K_2}{2}\right) \\ K_4 = h \cdot f(x_i + h, y_i + K_3) \\ y_{i+1} = y_i + \frac{1}{6}(K_1 + 2K_2 + 2K_3 + K_4); \end{cases}$$

$$i = 0, 1, 2, ..., n-1.$$

$$i = 0 \quad at \ x_0 = 0; \ y_0 = 1$$

$$K_1 = h \cdot f(x_0, y_0) = 0.2(1+0) = 0.2$$

$$K_2 = h \cdot f\left(x_0 + \frac{h}{2}, y_0 + \frac{K_1}{2}\right) = 0.2(1 + 0.1 - 0.1) = 0.2$$

$$K_3 = h \cdot f\left(x_0 + \frac{h}{2}, y_0 + \frac{K_2}{2}\right) = 0.2(0.1;1.1) = 0.2(1.2 - 0.2) = 0.2$$

$$K_4 = h \cdot f(x_i + h, y_i + K_3) = 0.2(0.2;1.2) = 0.2(1.2 - 0.2) = 0.2$$

$$y_1 = y_i + \frac{1}{6}(K_1 + 2K_2 + 2K_3 + K_4) = 1 + \frac{1}{6}(0.2 + 0.4 + 0.4 + 0.2) =$$

$$= 1 + \frac{1}{6} \cdot 1.2 = 1.2; \quad x_1 = 0.2:$$

$$i = 1 \ \ at \ \ x_1 = 0.2; \ \ y_1 = 1.2$$

$$K_1 = h \cdot f\left(x_1, y_1\right) = 0.2\left(1+0\right) = 0.2$$

$$K_2 = h \cdot f\left(x_0 + \frac{h}{2}, y_0 + \frac{K_1}{2}\right) = 0.2\left(1+0.1-0.1\right) = 0.2$$

$$K_3 = h \cdot f\left(x_0 + \frac{h}{2}, y_0 + \frac{K_2}{2}\right) = 0.2\left(0.1;1.1\right) = 0.2\left(1.2-0.2\right) = 0.2$$

$$K_4 = h \cdot f\left(x_i + h, y_i + K_3\right) = 0.2\left(0.2;1.2\right) = 0.2\left(1.2-0.2\right) = 0.2$$

$$y_1 = y_i + \frac{1}{6}\left(K_1 + 2K_2 + 2K_3 + K_4\right) = 1 + \frac{1}{6}\left(0.2+0.4+0.4+0.2\right) =$$

$$= 1 + \frac{1}{6} \cdot 1.2 = 1.2; \quad x_1 = 0.2:$$

$$i = 2 \ \ at \ \ x_1 = 0.2; \quad y_1 = 1.2$$

$$K_1 = h \cdot f\left(x_0, y_0\right) = 0.2\left(1+0\right) = 0.2$$

$$K_2 = h \cdot f\left(x_0 + \frac{h}{2}, y_0 + \frac{K_1}{2}\right) = 0.2\left(1+0.1-0.1\right) = 0.2$$

$$K_3 = h \cdot f\left(x_0 + \frac{h}{2}, y_0 + \frac{K_2}{2}\right) = 0.2\left(0.1;1.1\right) = 0.2\left(1.2-0.2\right) = 0.2$$

$$K_4 = h \cdot f\left(x_i + h, y_i + K_3\right) = 0.2\left(0.2;1.2\right) = 0.2\left(1.2-0.2\right) = 0.2$$

$$y_{i+1} = y_i + \frac{1}{6}\left(K_1 + 2K_2 + 2K_3 + K_4\right) = 1 + \frac{1}{6}\left(0.2+0.4+0.4+0.2\right) =$$

$$= 1 + \frac{1}{6} \cdot 1.2 = 1.2; \quad x_1 = 0.2:$$

Now we find an analytical solution:

Solution:

$y' = y - x; \qquad y' - y = -x$

$y' + P\left(x\right)y = Q\left(x\right)$ - linear differential equation.

$y = u\left(x\right) \cdot v\left(x\right)$ -form we look for a solution

$$y' = u' \cdot v + u \cdot v'$$

$$u' \cdot v + u \cdot v' - u \cdot v = -x$$

$$u' \cdot v + u\left(v' - v\right) = -x$$

$$v' - v = 0$$

$$\frac{dv}{dx} - v = 0, \ \frac{dv}{v} - dx = 0, \ \frac{dv}{v} = dx \Rightarrow \int \frac{dv}{v} = \int dx$$

$$lnv = x; \quad v = e^x$$

$$u'v = -x \Rightarrow u'e^x = -x$$

$$u' = -xe^{-x}$$

$$u = -\int xe^{-x}dx + C = \begin{bmatrix} u=x & du=dx \\ dv=e^{-x} & v=-e^{-x} \end{bmatrix} =$$

$$= xe^{-x} - \int e^{-x}dx + C = xe^{-x} + e^{-x} + C.$$

$$y = u \cdot v = e^x\left(xe^{-x} + e^{-x} + C\right) = x + 1 + Ce^x$$

$$y = \left(0\right) = 1$$

$$1 = 0 + 1 + C$$

$$C = 0$$

Hence, the particular solution of the given differential equation

$y = x + 1$

CONCLUSION

From this, we can see that the corresponding values of the approximate solution found by Euler's method and the solution found by the analytical method are very close to each other.

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THE ROLE AND SIGNIFICANCE OF ARTIFICIAL SATELLITE DATA IN DESIGNING OIL AND GAS SYSTEMS

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A B S T R A C T **In this article, the design of oil and gas systems and the determination of new oil reserves using satellite geodata and the creation of their 3D models, as well as generalized mathematical models and numerical models of non-stationary filtration processes of inhomogeneous liquids and gases in porous media , the processes of developing effective computing algorithms and creating software products based on modern information technologies are described.**

K E Y W O R D S Design, satellite, geodata, oil reserves, 3D model, calculation algorithms, software products.

INTRODUCTION

At the current modern stage of the development of information and computer technologies, this practical project has achieved unparalleled results in the field of oil and gas production, which can be explained by the fact that it not only meets the republic's needs for hydrocarbon raw materials, but also exports them to foreign countries. But as a result of the lack of opening of new oil fields, as well as the reduction of oil production in existing fields, the annual oil production volume is decreasing in our republic. [1-3].

In solving these problems, the design of oil and gas systems and the determination of new oil reserves using satellite geodata and the creation of their 3D models, including generalized mathematical models of non-stationary filtration processes of inhomogeneous liquids and gases in porous media, it will be necessary to develop numerical models, effective calculation algorithms and create software products based on modern information technologies [5].

METHODS

The analysis of field studies shows that nonlinear filtration processes of gases and liquids that take into account the suffusion and clogging processes of small particles in the porous medium, filtration fields with complex configurations, gas in multilayer porous media with dynamic communication with poorly permeable layer and taking into account the violation of ecological balances in the organization of processes of non-stationary movement of liquids and underground mixing methods of mining of rare metals, research and development are currently insufficiently carried out.

The analysis of the conducted scientific works shows that it is possible to increase the level of compatibility of the mathematical model of the research object by taking into account the nonlinear effects caused by the internal and external excitations of the system. It is significant in that it provides a solution for more accurate planning of subsequent exploration drilling, a pressing issue that allows geologists and engineers to better understand oil reserves[8].

It also provides improved software that allows for the design of mineral deposits taking into account the protection of the environment and the prediction of pressure changes in the deposits and the nature of flows, including the movement of chemical solutions sent to productive formations to squeeze oil and gas. is enough.

In the design of oil and gas systems, the following are developed on the basis of the creation of a package of practical programs for creating 3D models of geodata obtained from satellites:

Studying the current state of drawing and visualization methods of multidimensional images of the structure of 3D models of oil and gas fields using geodata obtained from satellites and their application;

3D modeling technology of oil and gas fields to create a modern software tool for the development of oil and gas fields using information systems, technologies of the world's leading software manufacturers and proprietary developments that optimize the modeling process;

Development of mathematical models and algorithms for development, planning and forecasting of oil and gas fields;

Satellite geodata plays an important role in the design of oil and gas systems. Satellite data helps make the design process more efficient and accurate. Let's look at the benefits of satellite data in the following areas:

Geological analysis: Images and spectral data collected by satellites help in identifying geological structures and studying different layers of the earth's surface. This, in turn, is important in identifying oil and gas fields.

Topography: DEM (Digital Elevation Model) data obtained from satellites can be used to obtain detailed information about the topography of the earth's surface. This is useful in making important decisions, such as, for example, the placement of wells and the planning of transport routes.

Landscape analysis: Satellite images provide information needed to manage landscape changes and natural resources. This is useful for monitoring forests, river basins and other natural environments, for example.

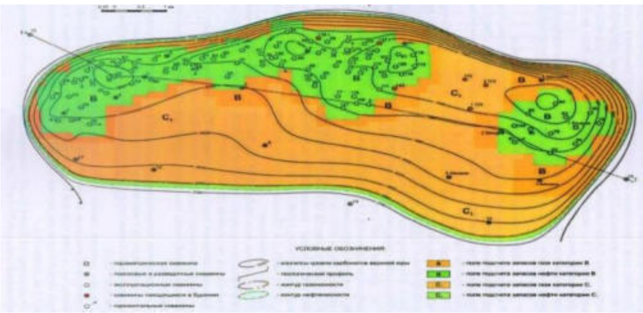
Infrastructure planning: Satellites can be used to obtain information about existing infrastructure, roads, railways and other structures. This helps in planning the infrastructure needed in the oil and gas industry.

Air quality monitoring: Some satellites can provide information about the composition of the atmosphere and air quality. This can be useful in assessing emissions from oil and gas fields and their environmental impact.

Monitoring of the construction process: With the help of satellites, the efficiency of the construction process can be monitored and analyzed. This helps to identify potential problems in the design and construction process.

Flow and surface analysis: The oil and gas industry uses satellite data to analyze the direction of underground flows and how surface water is used.

With the development of satellite technologies, there will be opportunities to obtain more accurate and high-quality data in these areas, which will significantly improve the process of designing oil and gas systems.



Pic. 1.Structural map of the organized area

The development of a package of practical programs for creating 3D models from satellite geodata in the design of oil and gas systems includes the following steps:

1. Requirements Definition and Design

- Data Requirements: Determine what geodata (imagery, DEM, spectral data) is needed.
- Features: Define what features are needed to create 3D models (eg terrain, land cover, infrastructure).

2. Data Collection

- Satellite Imagery: Images collected by Landsat, Sentinel or other satellites.
- Spectral Data: Information about Earth's surface materials, including spectral properties.
- Topographic Data: DEM data, through which elevation profiles of the earth's surface are studied.

3. Data Preparation and Analysis

- Data Cleaning: Cleaning, de-noise and correction of images.
- Georeferencing: Placing data in geographic coordinates.
- Segmentation: Dividing different parts of the Earth's surface (forest, land, water, etc.) into segments.

4. Create a 3D Model

- DEM Integration: Create a 3D model of the earth's surface using DEM data.
- Raster to Vector: Create vector data from images (for example, large infrastructure elements).
- Elevation Model: Add elevation data and create a realistic 3D model of the earth's surface.

5. Software Development

Interface: Creating an intuitive graphical interface for the user.

Features:

- Data Import: Import satellite imagery and DEM data.
- Model Building: Manage the construction process of 3D models.
- Analysis Tools: Analysis through models (eg, elevation profiles of the earth's surface, infrastructure layout).
- Export: Export created 3D models in various formats (eg .obj, .dae).
- Coding: Using programming languages such as Python, C++, Java,Matlab. Integration of GIS platforms (eg QGIS, ArcGIS) and 3D modeling tools (eg Blender, Unity).

6. Testing and Inspection

- Model Testing: Checking and validating the created 3D models.
- Page: Verify that the information is accurate and reliable.
- User Testing: Testing the functionality of the software by users.

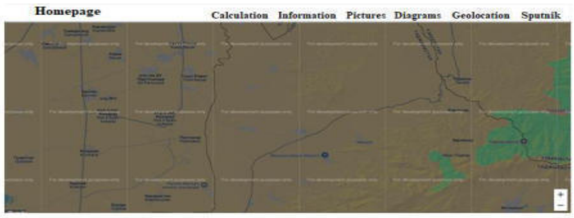
7. Documentation and Education

- Instructions: Complete documentation on the operation and use of the software.
- Training: Teaching users how to use the software.

8. Support and Updates

- Technical Support: Provide technical support for users.
- Updates: Continuous software updates and improvements.
- Recommended Software Tools
- QGIS: GIS for data management and analysis.
- ArcGIS: For comprehensive geospatial analysis.
- Blender: for creating and editing 3D models.
- Unity: For creating interactive 3D environments.

Through these steps, it is possible to create a powerful and practical software package for designing oil and gas systems based on satellite geodata.



Pic.2. Get area information from the map.

Engineering simulations to reduce costs and reduce production time, reservoir modeling, development of new fields with models, making investment decisions in developed fields where production forecasts are needed, determining the number of required wells, improving oil processing, in heavy oil fields Geospatial data can be used in the design of processes for determining the possibilities of increasing oil production.

The information model of the object consists of:

Initial reservoir pressure - 256 MPa;

Length - 11.5 km.;

Width - 6.5 km.;

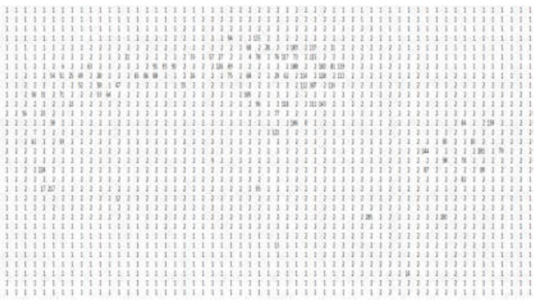
Number of wells - 115;

We will solve the problem with the following data:

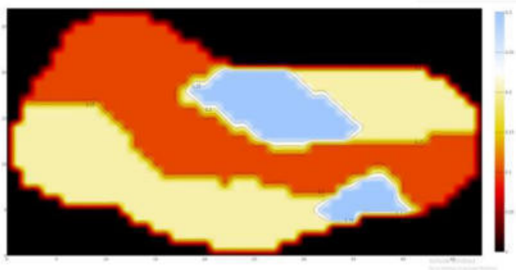
a) when the filtration coefficient is constant throughout the entire solution area of the problem;

b) when the filtration coefficient is variable (when filtering oil in a heterogeneous medium);

c) when the filtration coefficient depends on the change in pressure in the reservoir.



Pic. 2.Structural map of the area under consideration.



Pic.3. Isoline distribution of the permeability coefficient

When solving the problem

a) the average values of the coefficients are:

permeability - 0.15 darcy;

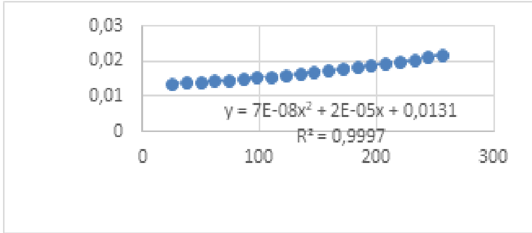
porosity - 0.108;

saturation - 0.5;

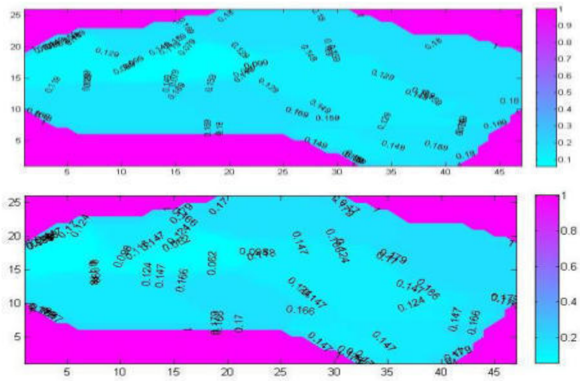
effective thickness - 33.9 m.

To solve the problem

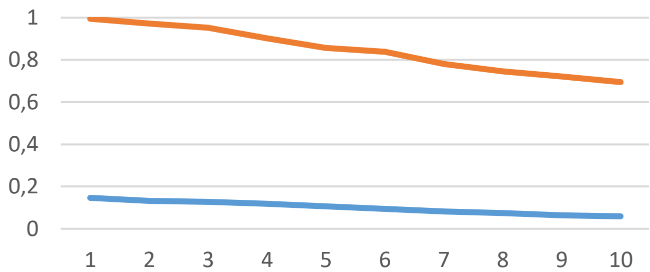
b) the permeability of porous media is determined using the relationship (1) - (3).



Pic.4. Dependence of viscosity on pressure



Pic.5. Isoline of changes in the permeability field obtained in the eighth, ninth and tenth years, respectively.



Pic.6.Change in average pressure and permeability over the years.

From the contour of the numerical calculations it is evident that the permeability of the porous medium (Pic.4.5.6) decreases linearly over the years in all areas of oil filtration. This is especially noticeable where injection wells are located. The computational experiments have shown that a depression funnel is organized where the permeability coefficient takes a small value. As can be seen from the numerical calculations performed on the computer (Pic.6), oil pressure and porous medium permeability decrease linearly over time on average. Analysis of the numerical calculations showed that a decrease in oil pressure in all areas of filtration significantly depends on the state of the porous medium and at the initial stage of exploitation of a hydrocarbon field, a sharp decrease in oil pressure is observed in the zones of action of injection wells, and the oil inflow to the wells depends on the layer permeability coefficient and the value of the porosity coefficient.

DISCUSSION

The scientific significance of the results is expressed through the development and further development of the mathematical modeling and the constructive systematic methodology of the calculation experiment, the exact non-linear mathematical models and numerical methods for solving the class of problems of heat and mass transfer in complex systems. As a result of the application of calculation algorithms and relevant software tools, the range of changes in the main parameters of the mathematical model of the research objects is determined, taking into account the main laws of the considered processes and the influence of external factors.

The developed constructive systematic methodology of mathematical modeling and calculation experiment can be successfully used for algorithmization and automation of scientific research in the fields of analysis, forecasting and management of complex processes of ecological control and protection of the environment. Using the results of scientific research helps to understand the dynamics of the studied objects faster and more deeply.

CONCLUSION

The conversion of technical data and geological data into 3D models and display in a virtual environment allows oil and gas geologists and engineers to see thousands of meters of underground or underwater oil and gas reserves in realistic conditions.

As a result of the application of calculation algorithms and relevant software tools, the range of changes in the main parameters of the mathematical model of the research objects is determined, taking into account the main laws of the considered processes and the influence of external factors. The developed constructive systematic methodology of mathematical modeling and calculation experiment can be successfully used for algorithmization and automation of scientific research in the fields of analysis, forecasting and management of complex processes of ecological control and protection of the environment. Using the results of scientific research helps to understand the dynamics of the studied objects faster and more deeply. The advantage of the final software product is that it is based on advanced software that predicts changes in reservoir pressure and the nature of flows, including the displacement of chemical solutions sent to productive formations to displace oil and gas.

This allows to determine in advance the possibility of the penetration of pollutants into the groundwater system and their subsequent spread, and accordingly to make advance decisions on the necessary environmental measures. Ensuring the safety of each user's personal data and database, preventing data from leaving the system is one of the main tasks assigned to the project result. After the implementation of the results of this project, technical specialists with many years of experience in cyber security will continuously monitor and control the risks that occur in the system.

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ON APPROACH TO EVALUATE THE WORKFLOW FUNCTIONALITIES IN PROCESS-BASED INFORMATION SYSTEM DEVELOPMENT

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A B S T R A C T **The study addresses the need for flexible, scalable systems capable of adapting to dynamic market demands. Business Process Management Systems (BPMS) are considered as the key technology for optimizing workflows through process automation, coordination, and real-time monitoring. The Semiotic Interoperability Evaluation Framework (SIEF) is introduced to assess interoperability at technical, formal, and informal levels, identifying key issues and the need for organizational standards. Process-Based Information System (PBIS) provides robust infrastructure, enhancing process management, flexibility, and overall organizational efficiency while authors present an approach to evaluate the workflow functionalities using the Design Science Research (DSR) methodology.**

K E Y W O R D S Process-Based Information system (PBIS), workflow functionalities

INTRODUCTION

In order to enhance competitiveness, organizations strive to be more responsive, collaborative, and flexible, while supporting information exchange not only between digital systems but also among business processes [1,2]. The need for increased productivity suggests that collaboration between business processes will help them achieve higher productivity and cost efficiency [3,4]. Furthermore, improved interoperability is essential for better information utilization [5].

In this collaborative context, interoperability has become a prerequisite for such cooperation. By definition, it is the ability of entities to work together as an organization, covering a wide range of aspects, including both technical and business issues. Over the past decade, the concept and context of interoperability have expanded from being primarily information technology (IT)-focused to a broader business-oriented domain, and its evaluation has become an increasing concern.

To study the effectiveness of information sharing between digital systems and business processes in response to changing market demand and technological innovations, research question is raised on what are the limitations of existing frameworks for evaluating interoperability. This article introduces the SIEF framework (Semiotic Interoperability Evaluation Framework), along with a set of metrics for measuring process interoperability [6]. SIEF provides a means of measuring, analyzing, and evaluating interoperability among business processes. To assess the interoperability between two business processes, SIEF applies metrics across three levels: technical, formal, and informal. Table 1 describes the key aspects of each layer:

-Informal level: evaluates indicators such as management style and motivation, which should align between processes A and B.

-Formal level: assesses performance metrics, including business strategies and external relationship management.

-Technical level: analyzes service structures, data integration, and business document implementation.

This multi-layered evaluation helps identify interoperability issues, especially at the technical level, where data and service integration are critical. The application of these metrics highlights the importance of quality assessment and uncovers limitations, such as the complexity of data collection and the need to adapt metrics to each specific situation.

Table 1. Three layers for evaluating the interoperability among business processes

Informal layer	Community, social norm, people, policy, culture, ethics, environment, alliances, etc.
Formal layer	Organizational strategy/vision, business governance, domain analysis, organizational roles, functional profile, rules, procedures, management, etc.
Technic al layer	Data semantics, information infrastructure, information model, schema, script, interface, platform, deployment model, resources, products, etc.

The concept of process-oriented or process-based information systems (PBIS) arose in response to the need to integrate disparate components into a single whole. The first attempts at integration began with databases (Data Base Management System, DBMS), where data from different sources was presented as a single logical repository.

However, a more promising approach has become process-based integration using Business Process Management Systems (BPMS). BPMS acts as a coordination level that ensures active interaction of various systems during the execution of business processes. PBIS distinguishes three levels of systems: conventional systems (for individual work), collaborative systems (for group work), and coordination systems (managing work processes). BPMS allows you to separate the logic of the process from applications, which makes processes more flexible and manageable. PBIS combines all these systems into a single technological infrastructure to optimize the organization's work [7]. By integrating coordination systems with traditional and collaborative systems, PBIS acts as a powerful technology framework with the potential to unite all of an organization's computing resources into a single global infrastructure within the framework of a business process.

METHODS

Business Process Modeling Notation (BPMN) is applied as a visual modeling language for business analysis applications and specifying enterprise process workflows, and providing open standard notation for graphical flowcharts that is used to define business process workflows. It is a popular and intuitive graphic that can be easily understand by all business stakeholders, including business users, business analysts, software developers, and data architects, allowing description language standard for creating executable algorithms in business management.

The Design Science Research (DSR) methodology is chosen to study information systems in an organizational context, as it has been widely recognized for its ability to provide tangible and meaningful results. DSR focuses on creating and evaluating IT artifacts, designs, and methods to solve important organizational IT problems, with a particular focus on the usefulness of the results. According to DSR, research results should either contribute to solving an organizational problem or add new knowledge to the research area.

The research in this paper has been conducted according to the six phases of the DSR approach proposed in [8].

Problem Definition: The workflow application routes data along a predefined path until an item in the process is completed. Tasks in the workflow may include approvals, adding information, or data transfer. The problem of volatile services and the need for rapid response for organizations is clearly highlighted, and the importance of finding a suitable solution is shown on the example of workflow model to support flexible public services.

Technology Definition: Key technologies (collaboration technologies and workflows) that can help improve the situation and solve the problems were identified.

Solution Proposal: A process-based information system concept is developed and described

Solution Evaluation: The proposed solution is reviewed for its ability to address organizational issues and meet current business requirements.

Implementation: The solution implementation will be aimed at improving the IT infrastructure of the organizations.

Dissemination of Results: The publication of the article is the final phase of DSR, aimed at communicating the results to the relevant audience.

RESULTS

1. Problem Definition:

Traditional approaches to information system development often lack the necessary flexibility and speed to accommodate changes in business processes. This creates a gap in effective methods for evaluating workflow functionalities in Process-Based Information Systems (PBIS), making it difficult to develop adaptable and flexible systems while a workflow application is a software tool that automates the tasks involved in a business process.

One of the difficult technical issues – no existing or standard APIs. In addition to the integration of data in the relevant organization's database through API, services are also required to be digitized in a short period of time according to the regulations. Various approaches, methods and technologies are considered in the implementation of this task. System integration involves several challenges. One of them is that the necessary API is not available or is standard. The task statement is: a) Discussion of the process- based information system development approach; b) Development of an effective and flexible model for the implementation of the work process; c) Calculation its efficiency is considered as the main task in the organization of the e-public service system; d) Demonstrate the simulation of API integration in Camunda modeler, based on the REST standard, using web service software integration technology. Each service has an individual character, requirements, term of service, routes, fees according to the choice of route. It is suggested to use not one model, but multi-model according to the characteristics of each service.

2. Technology Definition:

The key technologies for solving this issue are Business Process Management Systems (BPMS), which provide automation and management of workflows. BPMS enables organizations to monitor, coordinate, and control processes, thereby supporting dynamic business environments.

For developing effective workflow model, the following technologies are used:

Postman Platform (Application programming interface, API) - for building and using APIs, simplifies each step of API lifecycle and streamlines collaboration it can be created better APIs faster.

Camunda Modeler (BPMN) - The Camunda platform can help accomplish lot within organization being a low-code visual designer tool to model, connect, and prepare BPMN business processes for execution.

React JS (Deploy) - for building interactive user interfaces and web applications quickly and efficiently with significantly less code than with JavaScript.

PI calculus for evaluating time complexity. Approach: system design and development procedures: Getting to know the regulations of the service; Business analysis and preparation of steps; Preparation of service BPMN file in Camunda modeler.

To be able to get the system of BPM development lifecycle, it is essential to have the methods, the tools to create BMN. Based on the BPM development lifecycle our approach is based on: Graphic standart BPMN by Camunda; Web-based - REST API (RESTful API); DevOps Deployment methodology; Reengeneering: step of designing, launching the process Stage of analyzing; Integration (deployment) of BPMN with software application.

3. Solution Proposal:

A comprehensive approach to evaluating workflow functionalities is proposed, integrating BPMS for process management, monitoring, and coordination (fig.1). This approach includes:

- Process modeling using BPMS to visualize and optimize workflows.

- Evaluation of key characteristics, such as interoperability, task automation, exception handling, flexibility, and scalability.

- Separation of process logic from applications, allowing independent management and adjustment of processes.

- Real-time monitoring and analysis to ensure timely process adjustments as needed.

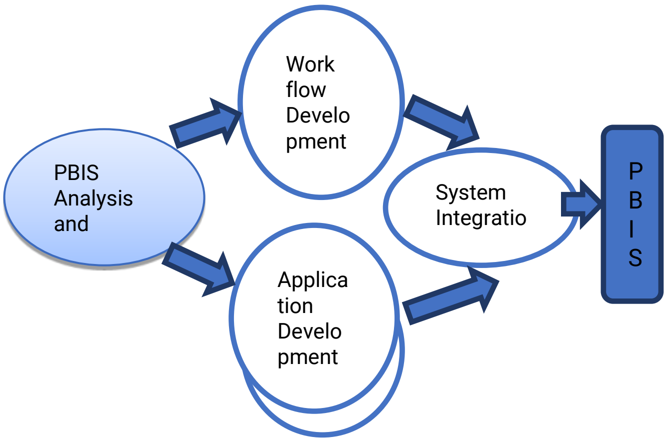

Fig. 1. PBIS development approach

4. Solution Evaluation:

The solution will be evaluated based on several criteria:

- Level of process automation and reduction of manual labor.

- Ability to handle exceptions and unforeseen circumstances.

-Process flexibility and adaptability to changing conditions.

- Scalability, or the ability of the system to manage increased workloads efficiently.

The evaluation will use performance metrics such as task completion times, the number of exceptions, and the degree of system interoperability.

There are two types of metrics, which are used in terms of software development: direct, measurable metrics and indirect metrics. The most popular evaluation metrics are summarised in Table 2.

The most important key metrics for monitoring APIs are:

Errors: There are many types of API errors and reasons they might occur, but a sudden spike in the number or percentage of errors indicates that the API is not broadly available to its users.

Latency: This metric refers to the amount of time it takes for a request to return a response, and it is the primary indicator of an API's performance. Teams should monitor the latency of individual requests, as well as the total latency for all requests in a workflow. If elevated latency for a particular request often returns the same response, it might help to implement caching or optimize the database query.

Test results: API tests are first written and incorporated during the development phase of the API lifecycle, but they are often executed within production-level monitoring runs, as well. Tests validate API behavior and transactions, and an increase in the number of failed test results could indicate that a recent deployment is not backwards compatible.

Table 2. Categories of metrics

Direct	Indirect
Cost	Functionality
Effort	Quality
Lines of code	Complexity
Execution speed	Efficiency
Memory	Reliability
Errors	Maintainability

For process p_i event x is taken as e_i^x; for message m, sending and receiving events are taken as *send(m)* and *rec(m),* respectively. If events occur, they lead to changes in the corresponding processes and channels, and to a change in the state of the system: an internal event changes the state of the process to which it pertains; a sending/receiving event changes the state of the process that sends/receives the message and the state of the channel involved. Events for any process are linearly ordered in order of occurrence: the execution of process p_i is a sequence of events $e_i^1, e_i^2, \ldots e_i^x, e_i^{x+1}, \ldots$, denoted as S'_i, i.e. $S'_i = (s_i, \rightarrow_i)$, where s_i is the set of events initiated by process p_i, and the relation $\rightarrow_i$ defines the linear sequence of these events. Information is exchanged between processes through the events of sending and/or receiving messages, i.e. for each message m exchanged between two processes, we can write: $send(m) \rightarrow_{msg} rec(m)$.

The execution of an application is a set of events (processes), i.e. $S = \cup s_i$. The relation $\rightarrow$ between events in a performance of application determines the order of events $S'=(S, \rightarrow)$ occurring depending on the algorithm, as well as the cause-and-effect dependence of the processes involved (the occurrence of events/processes). In general, we can write:

$$\forall e_i^x, \forall e_j^y \in S, \quad e_i^x \rightarrow e_j^y \quad \Leftrightarrow \quad \left\{ \begin{array}{c} e_i^x \rightarrow_i e_j^y \\ e_i^x \rightarrow_{msg} e_j^y \\ \exists e_k^z \in S : e_i^x \rightarrow e_k^z \wedge e_k^z \rightarrow e_j^y \end{array} \right.$$

Using such relations, various procedures can be written down during the functioning from the point of view of information interaction.

5. Implementation:

The implementation phase involves integrating BPMS into organizational processes. This includes:

- Configuring monitoring mechanisms to track and analyze process performance in real time.

Providing ongoing support and continuous improvement based on data collected through monitoring.

The system will need to be flexible to support process modifications based on monitoring outcomes and performance analytics within structure of the information system environment

The generalized structure of any IS can be represented by two interacting parts:

- the functional part, including application programs that implement the functions of the application area;
- the environment or system part, ensuring the execution of application programs.

Two groups of standardization issues are closely related to this division:

- standards for interfaces for interaction of application programs with the IS environment, the Application Program Interface (API);
- standards for interfaces for interaction of the IS itself with its external environment (External Environment Interface - EEI).

These two groups of interfaces define the specifications of the external description of the IS environment - the architecture, from the point of view of the end user, the IS designer, the application programmer developing the functional parts of the IS.

The specifications of the external interfaces of the IS environment and, as will be seen below, the specifications of the interfaces for interaction between the components of the environment itself, are precise descriptions of all the necessary functions, services, and formats of a particular interface.

Software integration is the process of combining different software and subsystems to create a single system. The software integration process is facilitated by Application Programming Interfaces. Integration improves business operations and processes, productivity, and quality of the final product. It enables easier communications among IT systems, thus speeding up the flow of information and reducing the operating costs.

There are four various ways to achieve software integration:

Vertical integration - this is a software integration method where subsystems of a network are merged according to their functionalities.

Star integration it is when the subsystems connect with other subsystems through point-to-point connections.

Horizontal integration - it is where a subsystem can be used as an interface for other subsystems.

Common data integration format - it sets down an application-independent format with a goal of achieving a single format system. Systems that use this technique can convert applications to a common application.

Vertical and horizontal integration types of software integration are mainly used in the information system. Importance of software integration is described in Table 3.

System Integration Technical issues in providing public services: they are functions and procedures which facilitate interaction between different software intermediaries [30].

- No existing or standard APIs
- No automation or ability for vendors to initiate transactions
- No clear option on where the work can be done: left-hand side source system, intermediate processing (middleware tool), or right-hand side target system.

Table 3. Advantages of software integration

Improved accessibility of data	They form a single system, access data anytime, reduces cost and saves time
Error reduction	Errors are minimized, data synchronization, accurate and complete database, automatic data movement, minimizes the errors
Quicker business processes	Faster service provider, less waiting time, all data in same place, easy data accessibility, no manual entry of data, more accurate data
Improves security	Employees can only access data from an integrated system, better efficiency, better data flow, data breaches are minimized
Reduction of costs	Due to the automation of tasks, costs can be reduced, reduce the cost of correcting errors
High employee productivity	Employees will have to move data manually, time-consuming, reduces time and complexity, improving employee productivity
Better data flow	Automatically data movement, no overlapped databases

Solving the problem of software integration in the information system depends on method, tool, model, technology and others chosen in the implementation of this integration. Integration should be able to be moved from a file-based integration to web services based integration. Software integration (system integration) provides a wide range of solutions when it comes to integrating the tools, applications, and data.

Analysis of transactions and process diagrams in providing effective service on performance evaluation of information system is provided for the selected public service "License". Response for each application is based on service day according to the regulation. BPMN example for "Licensing of tourist activities" service is given in fig.2.

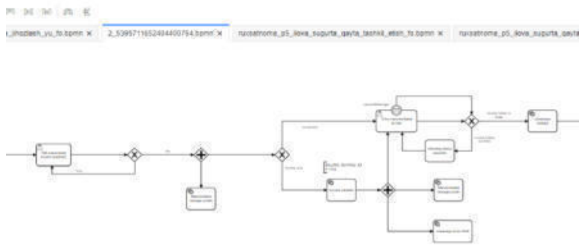

Fig. 2. BPMN for "License" service performed in Camunda modeler

6. Dissemination of Results:

Upon successful implementation, the results will be disseminated through various publications, seminars, and conference presentations.

DISCUSSION

This work provides the background statements to use semiotics as the systematic study of processes and the communication of 'meaning'. In semiotics, a sign is defined as anything that communicates intentional and unintentional meaning. Within information systems challenging issues semiotics can be seen any activity, conducting or processing metrics (signs). Signs can be communicated through objects itself or through the processes, thus providing meaning-making study and various types of knowledge for IS. The paper presents the SIEF and a set of metrics for assessing the interoperability between business processes. The conducted research developed metrics for the SIEF and applied them in practice to assess interoperability in an organization. The results revealed problems that need to be addressed to improve interoperability and emphasize the need to create standards that organizations should follow to ensure successful interoperability.

CONCLUSION

The Process-Based Information System (PBIS) concept represents a significant evolution in enterprise systems integration. While early efforts focused on integration via data, the advent of collaborative and workflow technologies - particularly BPMS has enabled a more sophisticated and effective form of integration: integration via processes. By acting as a coordination layer, BPMS allows organizations to manage their business processes independently of the applications used to perform tasks, providing flexibility and scalability. By unifying conventional, collaboration, and coordination systems, PBIS offers a robust framework for managing the complexities of modern organizations, ensuring that all computational resources work together seamlessly to support business goals. Authors intend to perform further research on exploring new aspects expanding capabilities and features that ensure compatibility and integration of various systems, regardless of their platforms and manufacturers, allowing for a prompt response to any changes and maintain integrated architecture, with broader view of developing a conceptual model of an information system and principles of ensuring interoperability

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EVALUATING THE EFFECTIVENESS OF INTEGRATING BLOCKCHAIN TECHNOLOGY INTO THE LOGISTICS SYSTEM

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A B S T R A C T **The operations of an enterprise are intrinsically tied to the necessity of transporting goods. However, the current cargo delivery process is plagued by a slow logistics cycle, cumbersome documentation with frequent errors, and concerns over the security of the cargo. The imperative to enhance the transport logistics system within industrial enterprises underscores the importance and validity of this research. The integration of Blockchain technology is proposed as a solution to address these persistent challenges in supply chain management. This study explores the stages involved in implementing blockchain technology and assesses its economic viability. Moreover, the application of blockchain is expected to streamline logistics operations, reducing both time delays and costs related to documentation errors, while significantly improving cargo security. The research not only delineates the practical steps for integrating blockchain but also evaluates its potential impact on the efficiency of logistics processes.**

K E Y W O R D S Industrial Enterprise, blockchain technology, supply chain management, logistics

INTRODUCTION

A strong and strategic partnership between a buyer and its suppliers stands as one of the key determinants of success in logistics. Collaborative efforts within the supply chain entail the exchange of crucial information gathered from market trends and global network operations, followed by prompt joint decision-making based on that data. By aligning supply with demand through cooperation, both trading partners can enhance mutual advantages and mitigate potential risks. Since the inception of supply chains, the significance of logistics collaboration has been consistently highlighted in both industrial practice and academic research. Notably, information technology (IT) tools such as web services, barcodes, and RFID have been instrumental in the success of logistics partnerships. The integration of IT has enabled the seamless flow of operational data from logistics, facilitating real-time sharing with interconnected partners.

Recent advancements in big data analytics, alongside developments in information technology (IT), have significantly enhanced the transparency and predictability of the business landscape. As emerging IT solutions continue to evolve, their potential applications within supply chain collaboration warrant thorough exploration. The rapid pace of technological innovation underscores the necessity for ongoing research into how these tools can further optimize logistics operations and strengthen partnerships across the supply chain. Additionally, understanding the implications of these technologies will be essential for maintaining a competitive advantage in an increasingly interconnected global economy [1].

Recently, electronic currencies such as Bitcoin have gained significant attention due to their increased use in both online and offline marketplaces, as well as the extreme fluctuations in value observed within the electronic money transaction market. This electronic money is underpinned by blockchain technology, which offers both opportunities and challenges in its integration with existing systems. [2]. Blockchain technology has the advantages of information transparency, information immutability, and smart contract to support communication and reliability required for logistics collaboration [3]. We refine these benefits as follows: first, transparency means that relevant information, including transaction history, is visible and traceable to all participants; such data is automatically updated with the latest authorized changes to the associated blockchain networks. Second, the immutability of information prevents information or data in the blockchain network from being changed, or deleted without the consent of network participants. Finally, the smart contract reflects the efficient and convenient management of contracts between logistics partners. In general, blockchain is considered technology that can improve the efficiency and effectiveness of supply chain partner processes. This study suggests that all three benefits positively influence logistics collaboration processes such as supply chain partnerships, which ultimately influences performance.

Literature review Since transport logistics is integral to the operations of modern enterprises, lacking optimal solutions to transportation challenges—along with the absence of a dedicated logistics department and skilled professionals in customs clearance—can result in significant financial losses when delivering goods to customers. In the short term, such inefficiencies may prevent the organization from achieving its tactical objectives, while in the long term, they could hinder the attainment of strategic development goals.

As materials move from their primary source through a chain of production entities—transportation organizations, intermediary agencies, and finally to the end consumer—their cost escalates [12]. It is estimated that over 70% of the final price of a product is attributable to storage, transportation, and packaging expenses [4].

Within all functional areas of logistics, the primary objective is to maintain effective control over the processes implemented. Monitoring the logistics process involves the systematic and, ideally, continuous analysis of logistics data to identify deviations or discrepancies between planned and actual logistics performance indicators. Additionally, it requires an examination of these deviations to uncover the underlying causes. The stages involved in managing a logistics system typically include:

- Establishing planned values for logistics performance indicators;
- Calculating the actual values of these logistics indicators;
- Comparing the actual figures with the planned ones (identifying discrepancies);
- Analyzing the identified discrepancies to determine their causes.

Internal control is a vital audit procedure that evaluates the efficiency of the procurement service, including its interactions with internal stakeholders, supply chain methodologies, and relationships with suppliers. To maintain competitiveness, logistics systems must evolve, becoming more sophisticated and complex. This requires a thorough analysis of performance indicators, which measure the system's operational, economic, and technical effectiveness. These indicators can be direct or indirect, absolute or relative. Direct indicators are particularly useful for diagnosing current issues and guiding management decisions, while indirect indicators, such as profitability, are often tied to financial outcomes [5].

The value of these indicators increases when they are benchmarked against similar metrics from other companies or compared over time. In modern transport logistics, choosing optimal routes and transportation methods relies on computer-based processing of large volumes of data, such as orders and vehicle fleets. This data is securely transmitted to control centers, but manual processing can lead to inefficiencies and errors, reducing decision-making effectiveness.A potential solution to this challenge within logistics systems is the integration of blockchain technology. Blockchain, a continuously growing list of linked blocks (linked list), contains information in accordance with predefined rules. Typically, copies of these blockchains are stored and independently processed across multiple computers [6, p. 240].

Given that all blocks within this technology are interlinked and generally immutable, blockchain offers a robust solution to security issues in logistics, specifically by preventing data tampering and falsification by malicious actors. Smart contracts, computer algorithms embedded within the blockchain, allow for the automation of numerous logistics processes, thereby reducing costs and minimizing the impact of human error. Focusing on the integration of blockchain technology within the logistical framework reduces risks and substantially enhances stability by fostering a practical orientation. The adoption of blockchain technologies in industry offers significant benefits, particularly in streamlining document management, data storage, supply chain management, payment systems, e-commerce, and even voting systems and public opinion research [7, pp. 163-164].

Blockchain technology, first introduced by Haber and Stornetta in 1991, gained prominence in January 2009 with the launch of Bitcoin, a cryptocurrency built on blockchain. A blockchain consists of a series of interconnected blocks, each containing transactions, a timestamp, a hash of the previous block, a block identifier, and a consensus mechanism. These blocks are recorded in a distributed ledger, making it extremely difficult to alter or counterfeit the data due to their inherent immutability. Blockchain provides a reliable system for achieving consensus on secure and seamless data sharing without compromising data integrity. This technology fosters trust among participants in decentralized networks that traditionally lack centralized authority.

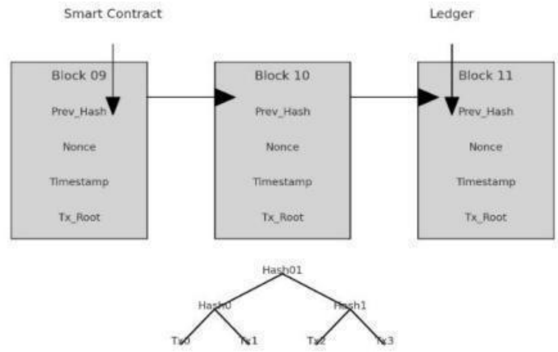

Figure 1. The structure of the blockchain

The core element of blockchain technology, ensuring network security and ledger integrity, is the hash function, which encrypts each block and links it to the previous one. This function generates a fixed-length value for any input, producing a unique hash that changes significantly with even a minor alteration in the input. As a result, any modification to a block's transaction data alters the hashes of all subsequent blocks.

Despite its recent emergence, many still do not fully understand blockchain's significance or its wide-ranging applications. This tutorial covers the fundamental principles of blockchain and its diverse uses across various fields. Blockchain is a versatile technology with applications for software developers and entrepreneurs alike. Entrepreneurs can launch startups using blockchain without significant expenses, even with a small customer base.

Blockchain is composed of modular components, some of which work together, while others operate independently. Its development holds immense innovative potential, fostering a new kind of economy based on decentralized trust. Unlike the internet, which primarily distributes data, blockchain transmits data of specific value, making it a forward-looking and promising technology.

For example, in October 2015, The Economist's article titled "Blockchain, Trust Mechanism" brought global attention to blockchain, sparking debates and leading to a surge in blockchain projects, digital currencies, and distributed ledgers. This technology has the potential to fundamentally transform society and the economy by fostering trust, reducing media pressure, and encouraging businesses to adopt blockchain. As more projects emerge, investors are likely to focus on developing blockchain-based technologies. As a result, we will begin to view the world through the lens of trust enabled by blockchain technology, which grants us both freedom and confidence. To fully comprehend this concept, below are several definitions derived from different perspectives and approaches that help elucidate the term:

A blockchain is a large ledger or journal (grossbook) on computers around the world that anyone can add to and read from at any time.

Blockchain is a software product that allows data to be securely and transparently stored and modified on the internet without the need for a central authority.

A blockchain is a digital conveyor that stores various forms of information about transactions, contracts, property deeds, works of art, and more.

Blockchain is a technology that provides trust, accountability, and transparency among all participants through collective agreement and a distributed ledger or journal algorithm, utilizing a new generation of transactional software.

Blockchain is a database organization technology that relies on the internet, fully leveraging its advantages, including open protocols, encryption, and computing capabilities. This distributed database can be likened to an electronic ledger in which each transaction is recorded without altering or losing the previous one. This e-book is active, written in chronological order, distributed, verifiable, and protected from data falsification based on mutual trust (consensus) among system participants (nodes).

A blockchain is a distributed database of transactions that can be compared to a very large and decentralized "grossbook." In it, data and values are transparently protected and stored autonomously, thanks to the internet's capabilities. However, there is no central authority overseeing these processes. The book in which the data is stored is active, chronologically structured, distributed, verifiable, and protected from falsification based on distributed consensus.

Each participant in the network has an up-to-date copy of the "grossbook" in a near-real-time environment, and the data within it is constantly synchronized among all participants in the network. Based on the above, we can conclude that blockchain technology allows us to:

Blockchain technology allows for the automation of transactions without the involvement of third parties and is a system based on trust and consensus [6]. It provides an infrastructure that ensures authentication and notarization. The blockchain system operates on several key principles. One of these is the concept of a distributed ledger or Register 2.0, organized as a distributed accounting journal shared among all participants. Decentralization and the elimination of intermediaries are also central to blockchain; the system is not controlled by any centralized authority, and there is no role for third parties in the trust system between two participants.

The acceptance or rejection of a transaction is determined through a distributed consensus, rather than by a centralized organization. Additionally, blockchain ensures the immutability and permanence of records, meaning they cannot be altered or lost. The system operates on the basis of distributed trust and transparency, where data, actions, and consensus are decentralized and openly visible.

In other words, blockchain embodies characteristics such as collective consensus, the use of a large, open, and distributed ledger, decentralization, and transparency, which together ensure reliability and inclusivity within the system. It is important to note that blockchain is not limited to the bitcoin and Ethereum systems, and there is no single, universally recognized blockchain. Instead, there are numerous independent blockchains globally, some of which can interact with one another, potentially leading to technical challenges when working with certain applications [11].

Blockchain technology creates a distributed algorithmic trust infrastructure, which stands in contrast to current centralized management systems. As a result, blockchain itself represents a distributed algorithmic trust infrastructure, providing consensus on demand.

Because of these similar features, most experts compare blockchain to the Internet, and as a result emphasize the advantage of blockchain over the Internet. The following is a comparison of the two systems:

- The Internet allows you to automate communications (both communication and relationships), while blockchain automates transactions and eliminates third parties.
- The Internet is a decentralized publishing system, and blockchain is a distributed trust system.
- Internet publishing infrastructure, and blockchain is the infrastructure for logging in.

Since the development periods of the Internet and blockchain cover the years 1994-2015, the results of this period can be illustrated by the following examples:

1994, Internet:

- Interpersonal communication.
- Automatic printing.
- Electronic commerce.
- Social networks.

2015, blockchain:

- Decentralization.
- Confidence.
- Dealing with valuables without intermediaries.

There is no contradiction between the Internet and blockchain; rather, they represent different stages in the evolution of technology. Blockchain requires a registry for creating and using a chain of blocks (such as Bitcoin), key encryption for security, a consensus algorithm, and a peer-to-peer (P2P) network—a decentralized network where participants have equal rights. Adding participants to this system is essential for the blockchain to function properly. Taking Bitcoin's blockchain as an example, we can explore the formation, basic principles, and operation of the blockchain in four stages:

Two participants agree on the transaction terms (e.g., money transfer, assets, financial documents).

The ledger is verified by network members. By analyzing the ledger's history, they confirm that the seller owns the declared assets or funds.

If everything is in order, the transaction is validated and added to the end of the blockchain.

The ledger is distributed to all network participants, ensuring its security. To alter any transaction, one would need to modify the logs of all network nodes, which is virtually impossible.

To clarify, the Bitcoin blockchain was the first to be defined as a blockchain. Each transaction is encrypted as a block, with each subsequent transaction encrypted based on the previous block, forming a continuous chain—this sequence of actions defines the concept of a blockchain.

For a transaction to achieve trusted status, it must be signed using asymmetric cryptography (a public or private key). Thus, three pieces of information are required to make a transaction in a Bitcoin-type blockchain:

The private key of the debit address; the public key of the credit address; the transaction amount.

As a decentralized immutable database, blockchain provides a secure environment for transactions between two or more parties. Transactions are linked in a chronological, unchangeable sequence as blocks of data, allowing stakeholders to share information securely and transparently. New blocks are linked to the previously recorded block, validated, and stored across multiple users' disk memories in different locations, known as "nodes." Once all transactions are approved, consensus among all nodes is achieved, reinforcing blockchain's reputation as a secure, scalable, and transparent decentralized technology [7].

Many researchers have identified blockchain as the next major disruptive technology. Just as the Internet revolutionized the way we exchange information and communicate, blockchain has the potential to serve as a secure economic layer that the Internet previously lacked. Swan categorizes blockchain into three phases: Blockchain 1.0 for currency transfer and digital payments, Blockchain 2.0 for contracts beyond simple currency transactions, and Blockchain 3.0 for applications beyond currency and finance, including intellectual property (IP) across various fields, from art to science.

Smart contracts - In Blockchain 2.0, smart properties, both tangible and intangible, are represented as smart contracts on decentralized platforms like Ethereum. These contracts, stored in blockchains, are automated scripts that facilitate and verify transactions between parties, reducing costs and human error. They provide accountability, trust, and transparency by enabling secure tracking and verification of transactions in a decentralized database. The automation brought by smart contracts can lead to significant cost savings and increased transparency in supply chains, making them crucial for the future of logistics. Additionally, they ensure that stability requirements are met throughout the supply chain. While smart contracts are widely discussed in the literature, their effectiveness has not been fully evaluated. Notably, transactions handled by smart contracts extend beyond financial operations, enhancing blockchain's applicability across various sectors.

Schmid and Wagner have highlighted that blockchain can be used not only for transactions but also for recording, tracking, and managing both tangible and intangible assets on a global scale. The consensus-based verification process eliminates the need for trusted intermediaries, reducing transaction costs and aiding organizations in making informed decisions within supply chain relationships.

Blockchain in industry - In the context of increasingly complex global supply chains, third-party data collection increases the risk of data breaches. Blockchain offers a secure solution to this complexity by decentralizing data storage. As data-driven companies collect more personalized information to offer tailored services, public concern over privacy grows. The financial sector's use of Bitcoin has demonstrated that decentralized personal data management systems can enhance scrutiny and secure data exchange. Schmid and Wagner suggest that, just as the Internet revolutionized information sharing, blockchain is transforming trust management. By automating agreements through smart contracts, blockchain reduces the need for personal trust, replacing it with system-based trust in a simplified business environment. This shift is expected to significantly alter traditional customer-supplier relationships, challenging current supply chain theories.

Supply chain participants, particularly in food supply chains, rely heavily on their suppliers for product quality and safety. Blockchain implementation, as seen with Chipotle Mexican Grill after a food poisoning incident, offers a solution to issues like complex supplier networks and insufficient transparency. Beyond enhancing data security, blockchain can also verify product origin and authenticity. Venkatesh et al. report that blockchain is increasingly used in manufacturing and logistics to track and trace products, identifying issues like machine malfunctions or defective raw materials. Large corporations like Walmart and Maersk are already optimizing their operations with blockchain, suggesting that this technology could address the complexities of supplier networks and lay the foundation for an advanced logistics system.

Research by Ko, Li, and Ryu highlights that blockchain's impact on manufacturing is most profound in two areas: real-time transparency and cost savings. These factors directly influence the profitability and competitiveness of manufacturing firms, enhancing their sustainability. Their study also shows that blockchain can help smaller firms narrow the gap with larger competitors by reducing audit and control costs through real-time transparency.

Blockchain and other technologies - Blockchain implementation is closely linked with the development of other disruptive technologies, such as the Internet of Things (IoT), artificial intelligence (AI), cloud computing, and big data analytics. IoT, a network of connected devices, enables automatic data collection throughout the supply chain, reducing the need for manual data handling. Big data analytics, which involves managing vast amounts of data to optimize processes, enhances demand forecasting and supply chain efficiency. These technologies are central to Industry 4.0, which, according to Hofmann and Rusch, has the potential to revolutionize product design, manufacturing, delivery, and payment systems. As technological innovation drives economic growth, the value of relevant data is expected to rise, necessitating secure, decentralized databases. Kamble et al. argue that these evolving technologies support demand and supply management and enhance decision-making in supply chains, improving overall performance.

METHODS

Since the analysis revealed the interdependence and mutual influence of transport and information support in the processes of transportation, the author recommends using the performance indicators of the processes of transport and information logistics.

Efficiency of transport logistics processes:

- coefficient of absence of damages ($K_{a.damage}$) is characterized by the ratio of the number of undamaged vehicles to the total number of vehicles;

- coefficient of timely delivery ($K_{t.delivery}$) is characterized by the ratio of the number of vehicles delivered on time to the total number of sent vehicles.

Thus, the integral coefficient of efficiency of transport logistics processes is presented in formula (1):

$$K_t = K_{a.damage} * K_{t.delivery} \ (1)$$

Efficiency of information logistics processes:

- the ratio of the absence of errors in the transmission of information ($K_{error.inf}$) is characterized by the amount of delivered information to the total amount of transmitted information;

- coefficient of efficiency of information transfer ($K_{op.\ inf}$) is characterized by the ratio of the desired speed of bringing information to the average speed of bringing information.

Thus, the integral coefficient of efficiency of information logistics processes is presented in the formula (2):

$$K_i = K_{error.inf} * K_{op.\ inf} \ (2)$$

The above coefficients allow us to determine the overall integral indicator of the efficiency of information and transport logistics processes, which is presented in formula (3):

$$E_{overall} = K_i * K_t \ (3)$$

To calculate the economic efficiency of the introduction of blockchain technology, it is recommended to determine the factors that form the economic damage at an industrial enterprise.

RESULTS

Transaction costs are those incurred during economic interactions between business entities. These costs include decision-making, planning, organizing actions, negotiating terms, and ensuring compliance with agreements. They also encompass the expenses associated with changing plans, renegotiating terms, and resolving disputes due to changing circumstances. Additionally, the cost of information retrieval arises from the need to gather data about potential buyers or sellers, as well as current prices before making a transaction. These costs involve time, resources, and potential losses due to incomplete or imperfect information.

Transaction costs also cover any losses from ineffective joint decisions, inefficient responses to changing conditions, and inadequate protection agreements. Essentially, they include all factors that influence the comparative efficiency of resource allocation and production organization methods [8]. Researchers have focused on accounting and controlling transaction costs in railway transport. From an institutional theory perspective, the profitability of specific railway assets depends not only on traffic volume but also on transaction costs, which are influenced by ownership relations and the organizational structure of the corporation [9]. Managers often overlook the significant labor resources required when making decisions about outsourcing technological functions or business processes. Information security, provided by legal and information services, incurs additional costs. Intellectual property issues also involve legal and intellectual property departments, diverting labor resources and leading to further expenses. Setting tariffs for services and conducting tenders and market analysis are labor-intensive processes that add to these costs. One of the primary challenges in modern economic analysis is measuring transaction costs. Not all types of transaction costs can be easily quantified in monetary terms. Additionally, converting time spent on a transaction into monetary value is often imperfect, especially when intermediaries do not provide specialized services for aspects of the transaction, such as negotiation. D. North estimates the level of transaction costs in the US economy up to 40-45%, i.e. up to 4 trillion dollars in year. In practice, when corporations with a complex organizational structure appear, transaction costs become tangible and can reach significant amounts. Thus, to determine the static efficiency of the implementation of blockchain technology, we apply formula (4), [10].

$$E_{impl} = \frac{\Delta D}{C+K}$$

Where : E_{impl} - indicator of economic efficiency of capital investments;

ΔD - increase in annual income;

C - current annual costs;

K - capital investments.

Based on formula (4), ΔD should be taken in the form of cost savings, prevention and occurrence of logistical risks, as well as an increase in freight turnover.

To determine the dynamic efficiency of investments, the net present value method can be used, which shows the net income or net loss of the investor when putting money into the project and the cash return on implementation. As a cost estimate of the result, cost savings from the prevention or occurrence of logistical risks can be used.

DISCUSSION

This research underscores the profound implications of integrating blockchain technology within the logistics sector, particularly for industrial enterprises. As blockchain continues to mature, its potential to revolutionize supply chain management through enhanced data security, operational efficiency, and transparency becomes increasingly evident.

Enhanced Data Integrity and Security: The inherent immutability of blockchain technology ensures that data, once recorded, cannot be altered without consensus among network participants. This feature is critical in logistics, where the integrity of information is paramount. By preventing unauthorized data modifications, blockchain mitigates risks associated with fraud and data breaches, thereby fostering a more secure and trustworthy environment for all stakeholders.

Operational Efficiency and Cost Reduction: The automation of processes through smart contracts is a game-changer for logistics. By eliminating the need for intermediaries and reducing manual intervention, blockchain streamlines operations, resulting in significant cost savings. This efficiency is particularly crucial in reducing documentation errors and delays, which are common pain points in traditional logistics systems. The economic models presented in this study demonstrate how these efficiencies translate into measurable financial benefits for enterprises.

Real-Time Transparency and Accountability: Blockchain's ability to provide real-time visibility into the logistics process is a pivotal advantage. This transparency ensures that all participants in the supply chain have access to the same data, reducing the likelihood of disputes and enabling quicker, more informed decision-making. The study highlights how this feature not only improves operational responsiveness but also strengthens accountability across the supply chain.

Strengthening Strategic Partnerships: The secure and transparent nature of blockchain facilitates stronger, more reliable partnerships within the supply chain. By ensuring that all transactions and agreements are immutable and visible to all parties, blockchain fosters a higher level of trust and cooperation. This is particularly valuable in long-term contracts, where the stability and reliability of relationships are crucial to sustained success.

CONCLUSION

As a result of the study, the following conclusions have been drawn:

Logistics system efficiency: The logistics system within the enterprise is one of the most intricate yet well-functioning mechanisms. Enterprises that have structured their production cycles in accordance with logistics principles can effectively streamline production processes, thereby enhancing overall operational efficiency. Conceptual clarifications: The study examined the fundamental concepts related to the system and organization of transport logistics within an industrial enterprise. Despite the varying interpretations of these core concepts, it was determined that the study would adhere to specific definitions, including logistics, transport logistics, system, transport, and transport logistics system, ensuring conceptual clarity and consistency. Transportation model analysis: A comparative analysis of transportation models was conducted, identifying the most advanced cargo transportation model currently available. Additionally, the key stages of the transport and technological framework were outlined, providing a comprehensive understanding of the logistics processes involved.

Blockchain integration: The study emphasizes that focusing on the implementation of blockchain technology within the technological dimensions of logistics significantly reduces risks and enhances stability. This is achieved by establishing a practical orientation for blockchain applications. The integration of blockchain technology in the industry is advantageous for optimizing workflow efficiency, improving data storage, managing supply chains, minimizing document flow errors, and reducing the duration of the logistics cycle.

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DIGITALIZATION OF PUBLIC TRANSPORT IN MINSK. CURRENT STATE. DEVELOPMENT PROSPECTS

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A B S T R A C T **This article examines the level of information availability for passengers of public transport in Minsk and provides methodological tools for improving it. It also examines the world experience of implementing mobile applications for passengers.**

K E Y W O R D S Public transport, digitalization, mobile application, competitiveness, PASSENGER, information technology

INTRODUCTION

In the modern, rapidly developing smart environment, one of the main factors changing the lifestyle in modern cities are mobile applications. They have had a significant impact on the process of shopping, ordering food and tickets. Digitalization of the ordering and payment process has also affected the transport sector, as a result of which most residents no longer think about how, for example, to order a taxi without an application. The introduction of taxi aggregator programs allows for instant satisfaction of demand and increases accessibility to the once expensive taxi service, allowing to significantly reduce the cost of the trip. However, despite the fact that millions and millions of passengers around the world wait for a bus at a bus stop every day, go down to the subway, travel across the city, public transport has remained on the sidelines of all this until recently. Someone decides to use public transport, but does not know the route, and someone does not know how long it is necessary to wait for a bus - whether it will be faster to take a taxi or not. One of the ways to solve this problem, which has arisen not only in the Republic of Belarus, but also in the world as a whole, could be mobile applications with embedded artificial intelligence, which allows for the beneficial expansion of the application's functionality, thereby increasing the attractiveness of public transport for passengers and, consequently, its competitiveness.

MAIN PART

The problem of decreasing attractiveness of public transport in the Republic of Belarus, as in many countries, was preceded by economic growth, the consequence of which was an increase in the number of wealthy citizens who were able to pay for expensive trips by taxi or personal cars, which naturally led not only to increased traffic jams on the roads, but also to a decrease in the number of passengers of public transport (a decrease in the growth rate).

The decrease in passenger traffic has led to a gradual reduction in cash receipts for the maintenance, servicing and renewal of buses. What can we say about new services for public transport passengers? At the same time, several years ago, the State Enterprise Minsktrans, which is the main passenger carrier in Minsk, opened data on the movement of vehicles, which can be used by developers of mobile applications and services. A website for the enterprise was also developed, which contains information about:

- - city route schedules and vehicle arrival forecasts;
- - suburban and intercity bus schedules;
- - international bus schedules.

Leading cities and countries have long followed this path, which has led to the emergence of successful startups in this area. Subsequently, both large global and local companies have paid attention to this dynamically developing market.

The main goal of public transport applications is to increase the attractiveness of public transport in the eyes of people and convenience for passengers. An increase in the number of passengers reduces road traffic, increases the income of transport companies, which can be used to improve the rolling stock, increase its convenience. After all, many people currently choose a personal car only because of the issue of convenience - everyone understands that the time spent in traffic jams is much more than traveling around the city on the subway.

In addition, greenhouse gas emissions are reduced, the air in cities becomes a little cleaner, which ultimately has a positive effect on health. These are the problems that our cities face every day.

Mobile services, as a rule, offer the following options for passengers:

- Building a convenient route using a special route search algorithm, and providing additional information on the route - fare, travel time, etc.;
- Providing information on the arrival time of transport at the stop using internal algorithms for processing information on transport movement in real time (if any);
- Additional sections for informing and alerting users;

All such applications are based on the premise that awareness, instant data provision and a scientific approach (algorithm) help people overcome the last obstacle in the efficient use of public transport.

The latest trends in this segment show that the application should be multimodal, displaying transport in real time, and not just the schedule.

All programs, applications, services make up a huge IT ecosystem for transport, which includes any passenger companies, taxis and taxi aggregators, car and bicycle rentals, and so on. In fact, in the future, these applications will move towards providing all the services necessary for an ordinary person in his daily life when moving from point A to point B within one city and suburb. Some applications have already implemented the function of replenishing electronic wallets and purchasing tickets to pay for travel [9].

Moovit is a transportation app that connects 107 countries. The Mooviter community is a global network of motivated and helpful users who volunteer to edit and add public transportation information in places where it is not readily available.

Thanks to the work and knowledge of transportation in their cities of these volunteers, millions of users around the world have access to public transportation information and travel comfortably [10].

Moovit offers the following features:

- Real-time arrivals. Allows you to track the arrival of transport in real time.

- Current alerts: traffic disruptions, route changes, schedule updates, repairs, etc. Allows you to plan a route with the most complete information.

- Transport navigator. Provides step-by-step instructions all the way from point A to point B.

- User reports. Moovit users report problems at stops, in the operation of routes and schedules, and the app notifies all passengers about what has happened in their area.

- Bike routes. In addition to trips by metro, bus, trolleybus and tram, Moovit will help you to build a bike trip that will meet your needs. Information about the availability of bikes and free spaces at bike rental stations is constantly updated. Bike routes are available in most cities.

- Maps. Allows you to open a city map with all stops and routes. You can also open the route maps in PDF format in cases when the passenger does not have access to the Internet.

- International Moovit Community. The application invites you to become part of the international community of Mooviters - volunteers helping to develop the transport infrastructure of their city.

Anyone who wants to improve the data for themselves and other passengers can participate!

Yandex Maps is an application that, among other things, helps to build a route on public transport with a forecast of arrival at the stop. Provides the following functionality:

-The ability to track buses, trams, trolleybuses and minibuses online;

- For convenience, you can leave only selected routes on the map;

- Public transport schedule for a month in advance;

- Forecast of arrival at the desired stop;

- Important transport facilities: stops and metro stations;

- Hints about the congestion of metro stations;

- Commuter train schedules;

- The routes indicate the necessary exits and transitions.

Kakaobus provides information about buses and stops in 57 cities in South Korea in real time.

- Information about bus arrival in real time;

- Information about the bus route with the location of the bus in real time;

- Departure signal. The application allows you to set up a departure signal to receive notifications five, three or one minute before the bus arrives at a specified stop;

- Arrival alarm. The app offers to set an alarm to make sure the passenger gets off at the right stop;

- Bus arrival notification. The ability to receive notifications about buses on a specific day and time without setting them manually each time.

- Suggestions based on your current location: stops nearby, night buses nearby, direct bus home, Kakao taxi [11].

Singapore's bus system is better organized than many major cities in the world. Up to 2 million trips are made on the island every day. The easiest way to travel around Singapore by bus is to download the free SG Buses or Citymapper app, which will plot a route to your destination and tell you an approximate bus schedule [12].

Tokyo Metro includes a complete and interactive Tokyo subway map plus a handy route planner. The map works offline to provide support even without an Internet connection. Features provided:

- A clear map of the Tokyo subway system with pan and zoom for easy viewing on the go;

- The ability to search for any station or the closest station to your current location;

- Calculates the optimal route for your trip, either the fastest route or the route with the fewest transfers;

- Provides information on travel time, number of stations on the route, and the stop where you need to transfer;

- Save your favorite routes for reuse;

- Uber integration allows you to order a taxi in a few seconds and continue your journey after using Tokyo Metro [13].

Every day, the Chinese make more than 300 million trips on public transport. It is not surprising, because they are the most populous nation in the world. And also one of the most intelligent and cashless. China has implemented mobile payments to such an extent that the Central Bank had to ask sellers not to discredit paper bills. Naturally, China simply could not help but come up with an unprecedented way to pay for travel. In 2019, the city of Shenzhen began testing a technology that was so simple and fast that you do not need to use your phone or even your hands. This is a facial recognition system. A passenger registers on the subway website and links a card with a new payment method to his account. Then he goes to the screen at the entrance to the station and scans his face. The system, which operates on a 5G network, immediately recognizes the person and writes off money from the linked account. In addition, in China you can pay "the old-fashioned way" - with QR codes. The Alipay payment system has long launched mobile payments based on QR codes in the subway and buses of dozens of Chinese cities. The technology allows you to process a mobile payment by QR code in 0.3 seconds without an Internet connection [14].

Since public transport in the United States is not very well developed, not counting large cities, transport applications are simply necessary. Each city has its own. For example, in New York, there is "NY Subway MTA Map" or "NYC Bus Tracker & Map". The applications show online where the bus or subway train is currently located, and how long it will take for it to arrive at your stop.

These applications also inform about repair work and transport delays. This is very important for Americans, because when transferring, the interval between buses or subway trains is on average 15 minutes, and any delay can significantly change the route or lead to a delay [15].

However, at present the information provided is not enough for convenient use of public transport. Passengers have long been waiting for a convenient mobile application that will give them the opportunity to pay for travel, with the ability to select a favorable tariff (which will lead not only to the convenience of using transport and, as a result, to an increase in passenger traffic, but also to a reduction in the workload of cashiers and, first of all, public transport drivers); the ability to track the trips of a minor child, whose student card will be linked to the parent's application; with the ability to search for lost or forgotten things in public transport, as well as with mandatory sending of messages to the passengers' phones in the event of a planned or operational change in the schedule or public transport route for regular users of specified routes.

CONCLUSION

The empirical analysis of the presented data shows that the currently functioning public transport of the Republic of Belarus does not have enough information for convenient use by passengers. Passengers have long been waiting for a convenient mobile application that will provide them with the ability to pay for travel, with the ability to select a favorable tariff (which will lead not only to the convenience of using transport and, as a result, to an increase in passenger traffic, but also to a reduction in the workload of cashiers and, first of all, public transport drivers); the ability to track the trips of a minor child, whose student card will be linked to the parent's application; with the ability to search for lost or forgotten things in public transport, as well as with mandatory sending of messages to the passengers' phones in the event of a planned or operational change in the schedule or public transport route for regular users of specified routes.

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ALGORITHM FOR CONSTRUCTING AND CONFIGURING PARAMETERS OF A MODEL FOR SEARCHING FOR TRACES OF ATTACKS IN AN INFORMATION SYSTEM

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A B S T R A C T **In the information system, it is not possible to constantly monitor the activity of users, that is, monitoring in real time mode is inconvenient. Therefore, it is important to form the actions of users in the system on the basis of parameters based on their role, and to create rules for searching for attack traces in the future detection of attacks, and to configure models and parameters for searching and detecting attack traces based on these rules.**

K E Y W O R D S information system, attack, user, event, algorithm, model, parameter, confidentiality, integrity and ANFIS

INTRODUCTION

In the era of rapidly developing information technology, the level of threats to data is increasing, in the process, the demand for cyber security has increased. Today, the number of attacks on information systems is increasing, and artificial intelligence systems are used to detect and eliminate these attacks. By applying machine learning and sophisticated artificial intelligence algorithms, organizations automate the critical processes of identifying, analyzing and preventing cyber security threats. These advanced algorithms sift through extensive data sets, enabling early detection of threats and empowering security teams to identify hidden threats and strengthen overall security measures. [1-3].

METHODS

The following traces are taken into account when searching for an attack trace in the information system:

– traces that do not count as an attack, $\{I_i^-\}, i = 1...N, N-$ the number of occurrences;

– marks that are considered an attack, $\{I_j^+\}, j = 1...M, M-$ the number of occurrences.

According to technicians and experts, there are the following classes (categories) of attacks aimed at information security during information processing in the information system [1,2]:

1. Unauthorized access attacks to the information processed in the information system;
2. Special impact attacks on the information system.

Unauthorized access attacks are processes that carry out attacks on external public communication networks and international information exchange related to the actions of intruders who do not have access to the information system, including those who directly carry out attacks on the information system and those who do not have access to the information system.

There are the following types of information security violations caused by an attack directed at the system by an attacker for unauthorized use of information [3]:

- breach of confidentiality;
- breach of integrity;
- break usability;
- breach of authenticity;
- non-repudiation violation;
- compromise accountability, authenticity and credibility.

Taking into account the above considerations, the information system architecture and attack models proposed in the previous paragraphs, the procedure for forming the list of attack sources, and the ANFIS system for the classification of attack traces can be used to build an attack trace search model for the information system.

Also, taking into account the users in the information system, their roles and the events they perform in the system, the following are determined:

User in the information system $\{U_i\}, i = 1...N, N-$ number of users;

Roles in the information system $\{R_j\}, j = 1...M, M-$ number of roles;

Events in the information system $\{E_e\}, e = 1...L, L-$ number of events;

Features available in the information system $\{P_k\}, k = 1...K, K-$ number of features.

Information is processed based on the logical connections of the main elements of the information system. In this case, the main purpose of building a set of events is that a template file is created on the basis of the laws introduced into each system, that is, a log (log file) in which events are recorded. For this, it is necessary to determine the parameters that determine the events. In the general case, four parameters are needed: the sequence $\{U_i\} \to \{R_j\} \to \{E_e\} \to \{P_k\}$ is fixed based on the given logical binary relations.

This is the main criterion of the search model for the attack trace in the information system. Using Sugeno-Takagi, Takagi-Sugeno-Kang, Wang-Mendel and Mamdani fuzzy inference algorithms of neuro-fuzzy systems, an algorithm for construction, training and testing of ANFIS adaptive neuro-fuzzy systems was proposed. In this case, the dependence on the number of rules for the ANFIS system in validation based on the DataSet sample has the Takagi–Sugeno–Kanga fuzzy inference algorithm. Therefore, ANFIS, an adaptive neuro-fuzzy generation system based on the Takagi–Sugeno–Kang (TSK) fuzzy inference system, is chosen to search for information system attack traces.

The rules for implementing a neuro-fuzzy system model based on the rules for searching for an attack trace in an information system are implemented as follows:

$$R_i : Агар\ (x_i == A_i, \cap \ldots \cap\ (x_{ij} == A_{ij}) \cap \ldots \cap\ (x_{im} == A_{im})$$

$$y = c_{io} + \sum_{j=1}^{m} c_{ij} x_j,\ j = 1 \ldots n \tag{1}$$

$$or\ R_i := \bigcap_{j=1}^{m} (x_{ij} == A_{ij})\ \text{if, in it}$$

$$y_i = c_{io} + \sum_{j=1}^{m} c_{ij} x_j,\ j = 1 \ldots r, i = 1 \ldots n \tag{2}$$

$$R = \sum_{i=1}^{m} R_i - \text{a set of general rules.}$$

In expression (1), the rule base determines the methodology of searching for traces of attacks in the information system.

For cases of searching for traces of an attack on an information system based on the database of an attack in the information system, N - the number of rules is presented as a single one, in fact, it is a set of rules that are separately formed by the type of intruder, the type of information protection tool (for example, SecretNet, Dallas Lock, etc.) is expressed. The object of influence is obtained from the database of information system attack traces, data sets and information about information system infrastructure, information system attack models and design solutions for information.

The final result of determining the scope of compatibility and compatibility of attack traces in the information system is calculated by the sum of the indicators of the described information system attack traces search methodology.

The ANFIS neuro-fuzzy system is based on the following rules [4,5]:

– accuracy of input variables;

– that the membership functions are defined by the Gaussian function:

$$\mu_{ij}(y_j) = \exp\left(-\frac{1}{2}\left(\frac{x_j - a_{ij}}{b_{ij}}\right)^2\right)$$

in this: y_i – access networks, a_{ij} ва b_{ij} – are adjustable TF parameters.

After defuzzification to obtain the output variable, the functional relationship is expressed as:

$$y' = \frac{\sum_{i}^{n}((c_{io} + \sum_{j=1}^{m} c_{ij} x_j) \prod_{j=1}^{m} \mu_{A_{ij}}(x'_j))}{\sum_{i=1}^{n} \prod_{j=1}^{m} \mu_{A_{ij}}(x'_j)} = \frac{\sum_{i}^{n}(c_{io} + \sum_{j=1}^{m} c_{ij} x_j) \prod_{j}^{m} \exp\left[-(\frac{x'_j - a_{i,j}}{b_{i,j}})^2\right]}{\sum_{i=1}^{n} \prod_{j}^{m} \exp\left[-(\frac{x'_j - a_{i,j}}{b_{i,j}})^2\right]} \tag{3}$$

Expression (3) is based on the ANFIS system using the TSK algorithm, which includes five steps:

RESULTS

Step 1. Fuzzification of input discrete variables follows the following procedure $x'_j\ (j = 1, 2, \ldots, n)$.

Step 2. The elements $a_{i,j}$ and $b_{i,j}$ are calculated with parameters of relevance functions $\mu_{A_{ij}}(x'_j)$, weights and values given by Gaussian functions.

Step 3. is multiplied by the results on the elements of the second step and produces the function values, that is:

$$y_i = (c_{jo} + \sum_{j=1}^{m} c_{ij} x'_j). \tag{4}$$

Step 4. The first element of the fourth step is necessary to activate the inferences of rules according to the values collected in step 3, the degrees of relevance of the prerequisites of the rules. The second element of the fourth step is to perform additional steps for the subsequent phaseification of the result of the ANFIS system.

This step consists of a single normalization element, which defines the results of the ANFIS system.

ANFIS TSK neuro-fuzzy systems include 2 parametric steps (step 1 and 3). Parameters that can be adjusted during training of the ANFIS system:

– in the first step–non-linear parameters a_{ij}, b_{ij} are relevance functions of the fuzzifier;

– the third step–parameters c_{io} and c_{ij} of linear functions use conclusions from rule base

$$y_i = (c_{io} + \sum_{j=1}^{m} c_{ij} x'_j)$$

.

When there are *n* rules and *m* – input variables, the number of parameters of the first step is *2nm*, and the number of parameters of the second step is equal to *2-n(m+1)*. The total number of adjustable parameters is *n(3m+1)*.

At the next stage of the proposed model, the parameters c_{io} and c_{ij} of the linear functions are calculated under the condition of the specified values of the parameters a_{ij} and b_{ij}.

At the next stage of the proposed model, the parameters c_{io} and c_{ij} of the linear functions are calculated under the condition of the specified values of the parameters a_{ij} and b_{ij} .

The parameters c_{io} and c_{ij} are found by solving a system of linear equations. And this number represents the output variable in expression (3) in the following form:

$$y' = \sum_{i=1}^{m} w_i'(c_{io} + \sum_{j=1}^{m} c_{io} x_j) \tag{5}$$

in this:

Algorithm for training ANFIS system using TSK algorithm.

With K training examples $x_1^{(k)}, x_2^{(k)}, x_3^{(k)}, ..., x_m^{(k)} y^{(k)}$, where: Substituting the values of the output variables $k = 1,...,K$ and the values of the variables $y'^{(k)}$ the values of the reference variables $y^{(k)}$ a system of linear equations of the form K is obtained [5]:

$$W_i' = \frac{\prod_{j=1}^{m} \mu_{A_{ij}}(x_j')}{\sum_{i=1}^{n} \prod_{j=1}^{m} \mu_{A_{ij}}(x_j')} = \frac{\prod_{j}^{m} \exp\left[-(\frac{x_j' - a_{i,j}}{b_{i,j}})^2\right]}{\sum_{i=1}^{n} \prod_{j}^{m} \exp\left[-(\frac{x_j' - a_{i,j}}{b_{i,j}})^2\right]} = const \tag{6}$$

$$\begin{bmatrix} w_1'^{(1)} & w_1'^{(1)} & x_1^{(1)} & \ldots & w_1'^{(1)} & x_m^{(1)} & \ldots & w_n'^{(1)} & w_n'^{(1)} & x_1^{(1)} & \ldots & w_n'^{(1)} & x_m^{(1)} \\ w_1'^{(2)} & w_1'^{(2)} & x_1^{(2)} & \ldots & w_1'^{(2)} & x_m^{(2)} & \ldots & w_n'^{(2)} & w_n'^{(2)} & x_1^{(2)} & \ldots & w_n'^{(2)} & x_m^{(2)} \\ \ldots & \ldots & \ldots & \ldots & \ldots & \ldots & \ldots & \ldots & \ldots & \ldots & \ldots & \ldots & \ldots \\ w_1'^{(k)} & w_1'^{(k)} & x_1^{(k)} & \ldots & w_1'^{(k)} & x_m^{(k)} & \ldots & w_n'^{(k)} & w_n'^{(k)} & x_1^{(k)} & \ldots & w_n'^{(k)} & x_m^{(k)} \end{bmatrix} x \begin{bmatrix} c_{10} \\ \ldots \\ c_{1m} \\ \ldots \\ c_{n0} \\ \ldots \\ c_{nm} \end{bmatrix} = \begin{bmatrix} y^{(1)} \\ y^{(2)} \\ \ldots \\ y^{(k)} \end{bmatrix} \tag{7}$$

in this: The total degree of conditions under rule $i-$ when presenting an input vector $w_i'^{(k)} k - чи (x_1^{(k)}, x_2^{(k)}, x_3^{(k)}, ..., x_m^{(k)})$.

Thus, the abbreviation of (7) is: $w \times c = y$

W is a matrix of size $K \times (m+1)n$, the number of rows is much larger than the number of columns *k*. The solution of this system of equations can be done in one step using the pseudo-inversion of the matrix. *W*:

$$c = w^+ y = (w^T \bullet w)^{-1} w^T y$$

After determining the selected *i,j* - linear parameters, correcting the actual output data of the network for all training samples, calculating and using linear relations for them:

$$y' = \begin{bmatrix} y^{(1)} \\ y^{(2)} \\ \ldots \\ y^{(k)} \end{bmatrix} = w \bullet c$$

where the error vector is defined as: $e = y' - y$, from which the current parameters are determined:

$$a_{ij}^{(k)}(t+1) = a_{ij}^{(k)}(t) + c\frac{dE^{(k)}(t)}{da_{ij}^{(k)}},$$

$$b_{ij}^{(k)}(t+1) = b_{ij}^{(k)}(t) + c\frac{dE^{(k)}(t)}{db_{ij}^{(k)}}$$

An attack trace search model based on the neuro-fuzzy ANFIS system using the TSK algorithm is presented in Figure 1 [6].

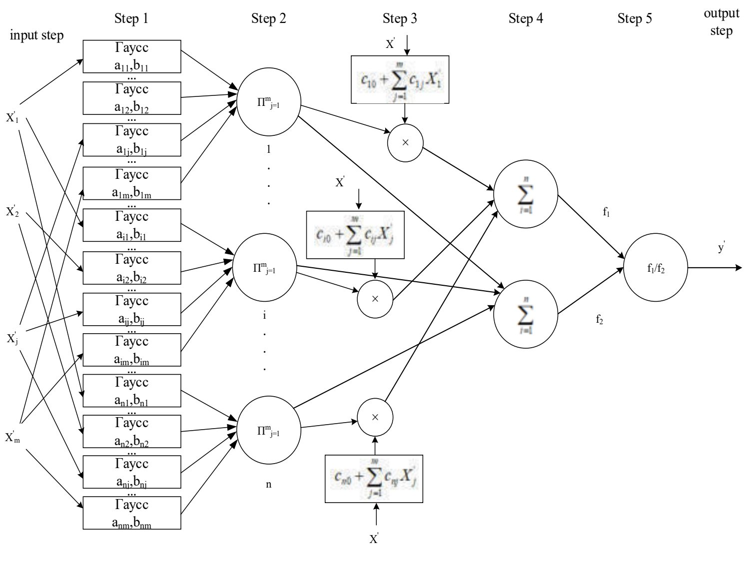

Fig. 1. An attack trace search model based on the ANFIS system

To implement the steps of the neuro-fuzzy system and to search and identify the attack trace of the information system, a software package was developed in a programming language and the calculations were performed on the computer. MATLAB environment was used to compare and describe the studies.

There is an error in training the network with the initial data and parameters of the ANFIS system. During the experiments, it was found that the training sampling error is reduced when refining and changing the initial data set with certain parameters of the ANFIS system.

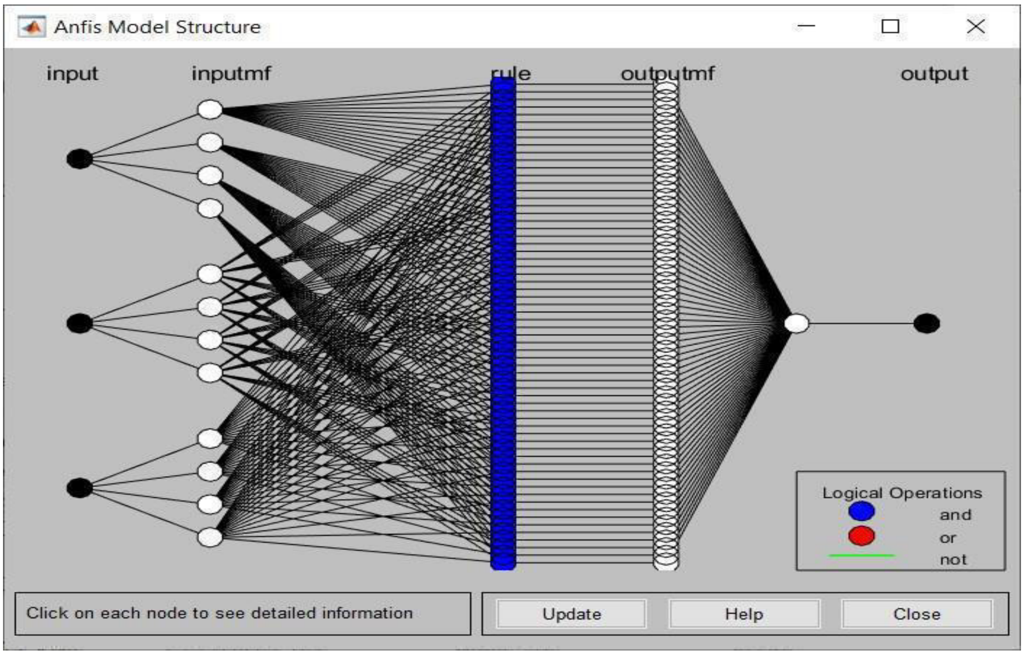

Fig. 2. ANFIS system network structure

The training error of the network was reduced as a result of training based on the dataset generated with the parameters given in the figure above.

DISCUSSION

As a result of training the ANFIS system on the basis of the data sets created with the parameters of the network structure shown in Figures 2, the training error of the network reached a certain range of values, which gave the best result compared to the existing methods.

CONCLUSION

It is inconvenient to monitor users in the information system in real time mode. Therefore, it was proposed to create rules for searching for attack traces in the detection of attacks by shaping users' actions in the system based on their role, and to adjust the model and parameters for searching and identifying attack traces based on these rules.

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THE ROLE OF HYBRID AI MODELS IN ENHANCING CYBERSECURITY WITHIN INTELLIGENT INFORMATION SYSTEMS

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A B S T R A C T **The increasing dependence on Intelligent Information Systems (IIS) in the current era of digitalization has elevated cybersecurity to a paramount area of concern. While conventional rule-based systems have shown efficacy in identifying established threats, they face challenges in dealing with novel and dynamic cyberattacks. Although machine learning (ML) models can adjust to unfamiliar threats by examining patterns, they frequently produce incorrect false positives and are susceptible to adversarial attacks.**

This paper examines the contribution of hybrid AI models to enhancing cybersecurity in Intrusion Detection Systems (IDS). It emphasizes the benefits and difficulties associated with these models and showcases their use in contemporary threat detection systems.

K E Y W O R D S **Cybersecurity, Hybrid AI Models, Intelligent Information Systems, Rule-Based AI, Machine Learning, Intrusion Detection, Threat Detection, Adaptive Security**

INTRODUCTION

Cybersecurity has become an extremely important worry currently due to the reliance on Intelligent Information Systems (IIS). Rules-based systems have proven to be effective in identifying known threats; nevertheless, they are not equipped to deal with cyberattacks that are constantly developing. Through the process of pattern analysis, machine learning (ML) models can adapt to unexpected threats; nevertheless, they frequently produce false positives and are susceptible to attacks from adversaries.

One option that shows promise is the utilization of hybrid artificial intelligence models, which combine the accuracy of rule-based systems with the adaptability of machine learning [1]. A better detection of both known and undiscovered threats is made possible by this strategy, which improves cybersecurity by utilizing the capabilities of both detection approaches. Because they offer a defense mechanism that is more dynamic and adaptable, hybrid models are particularly useful in applications such as intrusion detection and real-time monitoring.

The purpose of this article is to investigate the ways in which hybrid artificial intelligence models enhance cybersecurity inside IIS. The study focuses on the benefits and difficulties associated with these models, as well as the applications of these models in contemporary threat detection systems.

METHODS

By analyzing the integration of two fundamental AI methodologies—rule-based systems and machine learning (ML)-based systems—this research investigates the role that hybrid artificial intelligence models play in improving cybersecurity inside intelligent information systems (IIS). This part examines the individual functioning of various approaches and how they complement each other within a hybrid model. A deeper understanding of the contribution of each method, as well as the advantages of combining them, can be gained by reading this section. Rule-based approaches, machine learning-based approaches, and the hybrid artificial intelligence model are the key focuses of the analysis pertaining to artificial intelligence.

Rule-Based Systems for Cybersecurity. Using predetermined rules and patterns, rule-based systems, which are also frequently referred to as expert systems, are designed to identify and respond to potential dangers. Known threat signatures, such as specific malware or attack vectors, are matched against incoming traffic or system activity in these systems, which rely on signature-based detection rather than other methods of detection. Intrusion detection systems (IDS) and firewalls, which filter network traffic based on guidelines that have been specified, are examples of common use cases for rule-based systems.

Nevertheless, the constraints of these systems are also acknowledged, namely their shortcoming in identifying zero-day attacks or threats that diverge from predetermined guidelines. The lack of adaptability to new attack methods in static rule sets necessitates the use of machine learning systems.

Machine Learning-Based Systems for Cybersecurity. By analyzing big datasets to find patterns and anomalies that may suggest cyber risks, machine learning provides a more dynamic and adaptive approach to cybersecurity. This is accomplished using machine learning. The classification of normal and malicious actions is accomplished with supervised learning models, which include decision trees, random forests, and support vector machines (SVM) [2]. These models are trained on labeled datasets. The identification of outliers or unexpected patterns is accomplished with unsupervised learning techniques, such as clustering and anomaly detection algorithms. These techniques do not require any prior understanding of what constitutes typical behavior.

There are several obstacles that are mentioned, including high false positive rates, adversarial assaults, and the requirement for big datasets that are well-labeled. However, the flexibility of machine learning models makes it possible for better adaptability. The need of combining rule-based systems with machine learning to create a hybrid method is highlighted by these limitations.

Hybrid AI Models: Integrating Rule-Based and Machine Learning Approaches. The hybrid artificial intelligence system combines the advantages of rule-based and machine learning systems to provide a more all-encompassing cybersecurity solution. This approach utilizes rule-based systems to effectively manage recognized threats, while machine learning models are used to identify undetected dangers and adjust to emerging attack methodologies. By including both static and dynamic elements of cybersecurity, this combination enables more resilient threat detection.

This study examines intrusion detection systems (IDS) that combine rule-based detection for known signatures with machine learning (ML)-based anomaly detection for unknown threats to showcase the efficacy of hybrid models [3]. Empirical evidence from industries such as banking and healthcare has demonstrated the enhanced detection accuracy and decreased false positive rates provided by hybrid systems in comparison to standalone approaches.

Furthermore, the paper investigates the technical structure of hybrid systems, demonstrating how rule-based algorithms can function as the initial barrier, eliminating recognized dangers, while machine learning algorithms consistently observe for irregularities and novel patterns. This paper tackles the task of achieving seamless integration across different methodologies, encompassing factors such as data administration, model training, and system scalability.

This study is backed by empirical datasets, namely publicly accessible cybersecurity datasets like KDD Cup 99 and CICIDS 2017. These datasets include both annotated and unannotated data that are used to train and evaluate the machine learning models. In addition, we utilize open-source intrusion detection systems such as Snort for detecting breaches based on existing rules, and machine learning frameworks like TensorFlow and Scikit-learn for the implementation and evaluation of machine learning models.

To assess the hybrid AI model’s performance, we employ essential metrics such as accuracy, precision, recall, and F1-score. The measurements serve to evaluate the detection skills and the equilibrium between false positives and false negatives. Analysis of classification performance in machine learning models is conducted using confusion matrices, whereas rule-based systems are assessed based on their capacity to effectively identify known threats without substantially increasing latency.

RESULTS

The study demonstrates significant improvements in cybersecurity performance when employing hybrid AI models that integrate rule-based and machine learning approaches within intelligent information systems (IIS). By analyzing real-world applications and cybersecurity datasets, the following key results have been observed:

Enhanced Threat Detection Accuracy. One of the key conclusions of the research is that hybrid AI models significantly enhance the accuracy of threat detection in comparison to employing either rule-based or machine learning systems independently. Within conventional rule-based systems, established rules and signatures enable rapid and precise detection of known threats such as malware, viruses, or phishing attempts. These systems consistently achieve high levels of accuracy when faced with well defined threats.

However, rule-based systems are inadequate when confronted with new or zero-day threats, since they lack the capacity to identify unfamiliar patterns. In contrast, machine learning (ML) models, especially those that rely on anomaly detection and supervised learning, demonstrate a robust capability to identify previously unobserved dangers by detecting deviations from typical behavior [4]. By integrating these two approaches in a hybrid model, the system achieves a notably enhanced level of accuracy in identifying both familiar and unfamiliar dangers.

When tested on the CICIDS 2017 dataset, a widely recognized dataset for assessing intrusion detection systems, the hybrid model demonstrated a detection accuracy improvement of more than 25% compared to standalone rule-based systems. The hybrid model achieved a true positive rate (TPR) of 96.5% and successfully decreased the false negative rate (FNR) to less than 4%, so demonstrating its robust ability to effectively address new risks.

Reduced False Positives. An inherent obstacle in machine learning systems is the occurrence of false positives, which refers to the error of identifying lawful activity as suspicious. Systems that monitor large-scale networks with varied traffic patterns face this issue more acutely. Machine learning models, although proficient in identifying abnormalities, frequently face difficulties in differentiating between benign deviations and genuine malevolent behavior, resulting in elevated rates of false positive errors.

The hybrid AI approach incorporates rule-based filtering to mitigate this problem by selectively excluding traffic that corresponds to established secure patterns prior to its transmission to the machine learning algorithm. This greatly alleviates the workload on the machine learning model and leads to a decrease in the number of incorrect positive predictions. Our investigation demonstrates that the integration of these methods resulted in a considerable 40% decrease in the false positive rate (FPR) as compared to the use of machine learning models alone.

For example, in a simulated network environment equipped with the Snort Intrusion Detection System (IDS) and a Machine Learning (ML) anomaly detection algorithm, the hybrid model attained a False Positive Rate (FPR) of only 3.2%, which is a significant enhancement compared to the 5.4% achieved only with machine learning. The implementation of this enhancement alleviates the operational workload on cybersecurity teams, enabling them to concentrate on authentic threats without being inundated by false alerts.

Faster Detection and Response Times. Furthermore, the hybrid strategy yields a significant enhancement in both detection and reaction times. Rule-based systems provide exceptional performance in real-time detection because of their predetermined characteristics, enabling them to promptly recognize and react to threats upon finding a detection match. Nevertheless, they tend to be responsive rather than anticipatory, patiently awaiting the occurrence of a recognized attack pattern.

The computational complexity and potential delay of machine learning models, notwithstanding their effectiveness in identifying new dangers, are notable, particularly when dealing with extensive datasets. The hybrid approach tackles this issue by employing rule-based detection as the initial strategy to promptly manage recognized risks, while the machine learning component analyzes data simultaneously, with a specific emphasis on detecting irregularities that could suggest the emergence of new threats.

Experimentally evaluating the hybrid model in real-time network settings demonstrated a mean enhancement of 20% in detection durations when compared to independent machine learning systems. In situations when rapidity is of utmost importance, such as in the prevention of distributed denial-of-service (DDoS) attacks or the propagation of ransomware, the hybrid strategy enables quicker mitigation, thereby decreasing the performance indicators of time-to-detection (TTD) and time-to-response (TTR).

Adaptability to Evolving Threats. An inherent benefit of hybrid AI models is their capacity to adjust to novel and developing threats. Although rule-based systems offer consistent defense against recognized attack vectors, machine learning models consistently acquire knowledge and adjust to emerging patterns in network traffic and system behavior. By virtue of their versatility, hybrid models maintain their effectiveness even in the face of evolving attack strategies.

By leveraging the anomaly detection capabilities of machine learning, the hybrid model reliably identified more than 85% of previously unidentified threats during testing against zero-day malware samples. These findings highlight the potential of the approach in contexts characterized by dynamic and developing attacks, such as advanced persistent threats (APTs), where adversaries employ covert methods to evade detection for prolonged durations.

In key areas such as finance, healthcare, and government infrastructure, hybrid AI models are positioned as a superior solution for long-term cybersecurity defense due to their capacity to dynamically adapt to new threats.

Resource Efficiency. Furthermore, the investigation revealed that hybrid AI models enhance resource allocation and efficiency [5]. By employing rule-based methods to manage less complex, well-known threats, the system diverts a significant portion of the repetitive detection effort, so enabling the machine learning models to concentrate on more intricate tasks without requiring excessive computational resources. Consequently, this leads to enhanced processing efficiency and reduced resource utilization, particularly in settings characterized by extensive networks and substantial amounts of data.

Under conditions of constrained computing resources, the hybrid model minimizes the requirement for high-performance hardware to execute machine learning models in a continuous manner, resulting in cost reductions and enhanced system performance.

DISCUSSION

The findings of the research unequivocally demonstrate that hybrid AI models, which combine rule-based and machine learning methodologies, provide exceptional efficacy in enhancing cybersecurity within intelligent information systems (IIS). The following part examines the wider consequences of these results, the difficulties encountered during execution, and possible directions for future study.

1. Implications of broader scope

The integration of rule-based and machine learning systems offers a comprehensive methodology for detecting threats. Although rule-based systems are efficient and precise in detecting known dangers, they are intrinsically constrained in their capacity to protect against unexpected or innovative attacks. In contrast, machine learning models have the ability to identify novel threats by recognizing patterns, but they frequently encounter issues such as elevated false-positive rates and extended detection durations. Through the integration of these two methodologies, hybrid models maximize the advantages of each, guaranteeing the efficient management of recognized hazards and the detection of unknown threats via adaptive learning.

The efficacy of hybrid AI models in practical sectors such as intrusion detection and real-time monitoring showcases its capacity for wider implementation across many industries. Enhanced precision in identifying threats and decreased occurrence of false positives establish hybrid AI models as an essential element in contemporary cybersecurity approaches. In light of the constantly changing threat environment, the flexibility of hybrid models becomes progressively crucial for enterprises.

2. Implementation Challenges

Although the study demonstrates encouraging outcomes, the successful deployment of hybrid AI models in practical settings does present certain difficulties. An inherent challenge lies in the intricacy of combining rule-based and machine learning systems. Facilitating uninterrupted connection and efficient data transfer among various systems can be challenging, especially in extensive networks where the time delay and computing burden are crucial considerations.

Furthermore, the process of training machine learning models necessitates extensive and properly annotated datasets, which can be demanding in terms of resources to acquire and sustain. The persistent difficulty lies in the danger of adversarial assaults on machine learning models, when attackers intentionally modify input data to deceive the system. Mitigating these weaknesses is essential for the sustained effectiveness of hybrid AI models in the field of cybersecurity.

3. Potential avenues for future investigation

Furthermore, there is an increasing demand to investigate more sophisticated hybrid architectures, which involve combining deep learning models with rule-based systems. Although the primary focus of this work is on conventional machine learning methods, deep learning has demonstrated potential in further improving anomaly identification and minimizing false positives. Potential future investigation could focus on the application of hybrid models that include neural networks, recurrent neural networks (RNNs), and long short-term memory (LSTM) models, specifically for the purpose of identifying advanced persistent threats (APTs).

An additional domain for future investigation is the advancement of more effective algorithms that minimize the computing expenses associated with executing hybrid models in real-time settings [6]. When hybrid AI models are used in sectors like banking, healthcare, and government infrastructure, it is crucial to prioritize scalability and reduce resource usage in order to achieve success.

CONCLUSION

This research illustrates that the integration of rule-based precision with the adaptability of machine learning in hybrid AI models leads to a substantial enhancement in cybersecurity performance within intelligent information systems. The hybrid technique substantially improves the accuracy of threat detection, minimizes false positives, and enhances detection and response times, rendering it highly suitable for addressing both known and unknown threats.

Results obtained from the CICIDS 2017 dataset highlight the capability of hybrid models in identifying zero-day assaults and unprecedented risks, therefore overcoming significant constraints of both rule-based and machine learning systems. By harnessing the advantages of both approaches, hybrid models offer flexible and resilient protection against a progressively intricate cybersecurity environment.

Nevertheless, there are still persistent difficulties in the execution of hybrid AI models, namely with the integration, resource efficiency, and susceptibility to adversarial attacks. Notwithstanding these obstacles, the outlook for hybrid AI models appears encouraging, particularly as research persists in investigating increasingly sophisticated structures and high-performance algorithms.

The constantly changing threat environment necessitates the development of flexible, precise, and scalable cybersecurity solutions. With their capacity to integrate static and dynamic aspects of threat detection, hybrid AI models are positioned to become a crucial part in the future generation of intelligent information system defenses.

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EMPLOYMENT OF UNIVERSITY GRADUATES IN THE LABOR MARKET

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A B S T R A C T The article notes that the modern labor market is characterized by the accelerated dynamics of transformational changes associated with the ongoing processes of adaptation of the economy to global challenges on a national and global scale, in the conditions of digitalization of the economy, the rapid development of new technologies, including in the interests of ensuring import substitution, the transformation process is accelerating professional competencies necessary for the implementation of the labor process,in connection with which the requirements of employers for applicants for available vacancies are constantly changing, which contributes to increased competition in the labor market, in which university graduates occupy far from leading positions, employment is becoming one of the acute problems of the modern labor market, characterized by the development of contradictory trends, on the one hand, employers report a shortage of qualified personnel, and, on the other hand, there is unemployment among university graduates who cannot find a job for several years after graduation.

K E Y W O R D S professional competence, adaptation, transformation, and correlation and regression analysis, self-employment, labor market infrastructure, structural-functional model.

One of the important factors affecting vocational training is the rapidly changing professional competences due to digitalization, which is introduced with certain delays in educational standards and vocational training programs. As a result, there is a gap between the level of qualifications of graduates and the demands of employers, which characterizes the main problem of the system of training higher-educated specialists: its low correlation with the demands and needs of employers.In the last few years, the employment of university graduates has become the main indicator of the performance of universities in terms of evaluating their performance. At the same time, the situation of the graduate employment process brings together a number of issues that require a solution, including the demand for graduates in the labor market, the compatibility of the level of training of specialists in higher education institutions with the needs of the labor market , formation of more effective mechanisms of its cooperation with business communities in order to determine directions of development of higher education and increase the quality of training of specialists [1-3].

Solving these issues is directly related to increasing the efficiency of employment of graduates of higher education institutions, ensuring their adaptation to the labor market, and within the framework of further development and improvement of the labor market, the higher education system and employers should be based on mutual cooperation infrastructure, which should be aimed at all-round support of graduates in matters of employment and professional navigation. In this regard, in order to ensure the level of compliance of the training of graduates of higher educational institutions with the requirements of the economy, the relevance of studying the issues of increasing the efficiency of their employment is increasing.At the same time, some economists interpret the concept of employment efficiency in connection with graduate employment procedures [4]. Thus, I.G. Ershova, effective employment examines the process of interaction of a graduate with labor market subjects on job search Svinukhova Yu.N. Effective employment means "labor productivity in the labor market aimed at achieving or maintaining the desired social and labor status."

Among the main criteria, the quality of specialist training is taken into account, as well as the extent to which the applicant uses social and informational resources when looking for a job. In terms of evaluating the quality of education received as the main criterion for ensuring employment, other scientists also evaluate its effectiveness.The idea of employment efficiency should not be limited to the evaluation of the employment process, including the effectiveness of the use of employment technologies.

Efficiency is the final result of the employment process, so its assessment should be based on data on graduates who have been employed in their field of study. The level of compatibility of the specialty obtained at the university with the position occupied is the main criterion for achieving the efficiency of employment of university graduates. The higher the level of compliance, the higher the level of employment efficiency.A number of factors can hinder this connection, including: low level of professional qualifications of graduates, inconsistency between the ideas of employers and the content of professional standards of higher education institutions, and low professional self-determination applicants. The violation of this dependence leads to the "non-core" employment of university graduates. Non-core employment cannot be considered effective employment, as it does not fulfill the main task of the university - the training of specialists in specific profiles and specialties that are needed in the labor market.Employment efficiency [5-6] for a particular graduate can be considered as an assessment of whether he has achieved the goal of employment in the specialty he has received. Emphasis on the specialized employment of university graduates serves as a basis for defining the concept of employment efficiency, which is proposed to be considered as a result of the transition from education to production activities, which graduates determined by the level of employment according to the profile specialty obtained in relation to the number of all graduates of the higher education institution in the considered year.

From an economic point of view, this indicator should reflect the level of satisfaction of the economy's needs for workers in a certain specialty and the need for graduates to find jobs that match their training profile.

The manifestation of the considered risks is related to the implementation of the process of employment of university graduates, because they appear before young professionals enter the workforce. This group of risks can be classified as work-related risks. In the process of adaptation of graduates to the workplace, another group of risks related to the evaluation of the initial labor potential of the graduate by the employers, opportunities for professional growth and salary appears. In practice, this is expressed through the ability of the graduate to adequately present his professional competences, knowledge and skills, confirming the compliance with the requirements of the relevant workplace.The most dangerous area is the mismatch between the competencies obtained at the university and the requirements of the work performed. The analysis of the employment of graduates of higher educational institutions showed that every fourth of them becomes a potential candidate for retraining or getting a second profession every year. There is a high proportion of young professionals who leave their jobs in the first year of employment due to dissatisfaction with their profession or dissatisfaction with working conditions and salary.The most dangerous area in the process of adapting young professionals is the low remuneration for their work. According to the results of the 2022 graduate employment monitoring, a significant part of the graduates who took part in the survey identified the low level of salary offered by the employer as one of the problems. The priority of the demand for specialists in the labor market can be seen on the example of the salary rating compiled as part of the monitoring of the employment of university graduates (Fig. 1).

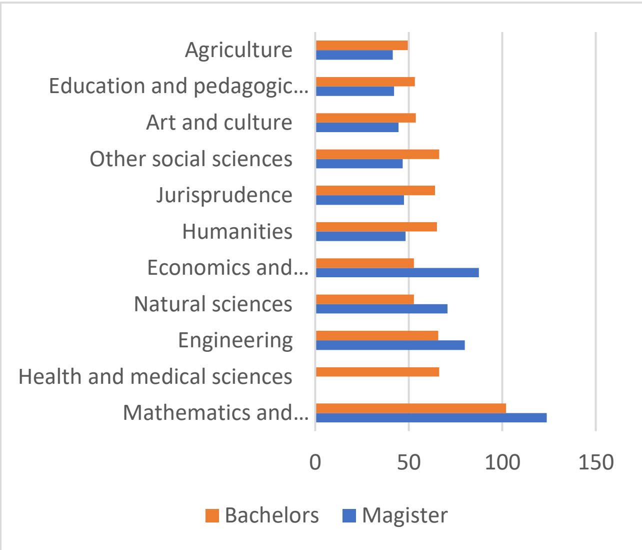


Figure 1. - Salary distribution of graduates of 2022 by groups of educational fields, thousand soums.

The presented data show that there is a significant difference in wages between specialists in mathematics and computer science and agricultural specialists - 2.5 times, which reflects the difference in demand for these specialties.

The study revealed another trend in the employment of university graduates, within which the risk of non-primary employment is realized: a significant part works outside the field of education received.From the point of view of employment efficiency, a job that does not correspond to the profile of the specialty obtained at the university reflects the existence of a mismatch between the market needs and the offer from the higher education system, which creates a risk of adjustment for graduates when entering an unsuitable job in the received specialty profile. All the risks analyzed in the work are systematized in two directions: the risks that manifest themselves in the employment process and the risks associated with the adaptation of graduates to the workplace (Table 1).

The presented systematization of the risks of employment and adaptation of graduates of higher educational institutions shows that in the current system of the manifestation of risks, their emergence is caused not only by universities, but also by employers, as well as by the conditions formed in the labor market.

Table 1. - Adaptation and employment risks of university graduates and mechanisms to minimize them.

Risks	**Risk mitigation mechanisms**
Occupational Hazards: - the risk of unemployment; - the risk of not finding a job due to its availability distinguish diplomas in the eyes employers on the quality of universities; - due to the risk of refusal to work differentiation of forms of education for applicants (full-time, part-time or part-time); -differences in the level of education (bachelor's and master's); - the risk of lack of skills to behave in the labor market and poor knowledge of job search and employment technologies.	- encouraging employers to hire work of young specialists; - increasing the interest of employers in participating in partnerships with universities regarding determining the professional characteristics of specialist training; - change in activity focus employment and career centers at universities towards training students in skills of behavior in the labor market and technologies for job search and employment.
Adaptation risks: -risk of inadequacy of the education received labor market requirements; - risks of lack of work experience activities in the acquired specialty; - risks of lack of skills and competencies, required by employers; - risks of inconsistency of what you received at the university competencies and requirements of the work performed; - the risks of receiving wages are lower graduate expectations; - risks of employment outside your profile education received; - risks of low evaluation by the employer initial labor potential of the graduate	improving the quality of educational programs in accordance with labor market requirements; - creating conditions in universities for development practice-oriented approach to student training; - increasing the responsibility of employers for the adaptation of young specialists; - creating conditions for participation employers in recruiting professional competencies, meeting changing production requirements

In many ways, the emergence of risks is associated with the relative autonomy and inertia of the higher education system, which develops in some graduates knowledge and skills that are not adequate to the demands of the labor market. Moreover, in the context of digitalization of the economy, the frequency of technological changes for all industries is increasing, which should be reflected in a change in approaches to educational programs in their compliance with new competencies and knowledge. However, in solving this problem, a decisive role belongs to employers, who must take part in determining the directions for the development of educational programs [7-9]. In this regard, increasing the efficiency of employment of graduates of higher education institutions lies on two levels: on the one hand, the universities should mitigate the competence gap created by developing their educational programs, and on the other hand, the employment providers must take responsibility adaptation of graduates of higher education institutions to market conditions, thereby helping to minimize the risk of a shortage of qualified labor.The state is committed to expanding cooperation with higher education institutions on creating a basis for students' internships and internships, hiring students for the master's degree on preferential terms, and providing employment to graduates after graduation if encouraged, this process develops more actively.The identified factors were analyzed in the dynamics of 1996-2022, used to create a correlation-regression model to determine the dependence of the employment rate of university graduates (Y) on selected factors: number of graduates, thousand people. (X1 factor); number of graduates of non-state higher educational institutions, thousand people. (X2 factor); working population, thousand people (X3 factor); number of unemployed, thousand people (X4 factor); average monthly salary, thousand rubles. (factor X5), on the basis of which a multiple regression equation was created for the dependence of the number of employed graduates (Y) on the selected factors.

A correlation matrix was constructed to identify the factors that have the greatest impact on the number of employed graduates, as well as the existence of collegiality between these factors (Table 2).

Table 2. - Correlation matrix

	Y	X1	X2	X3	X4	X5
Y	1					
X1	0.5600	1				
X2	0.5610	**0.9720**	1			
X3	0.6671	**0.7904**	**0.7006**	1		
X4	-0.6018	-0.5583	-0.4292	**-0.8111**	1	
X5	0.6000	0.2501	0.1419	0.6732	**-0.8232**	1

According to the correlation matrix, we can conclude that only indicators Y and X3 should be included in the regression model, since they have the highest values, which allows us to construct a pairwise linear regression model that depends on the number of employed graduates provides. (Y) by the number of working-age population (X3).

Based on the regression analysis protocol, the equation for the dependence of the number of employed graduates on the number of the working population was obtained:

$$y_i = -6080{,}1253 + 0{,}0882x_3$$

Based on the obtained equation, a graph of the time trend of changes in the number of employed university graduates in the short-term period of 2023-2025 was created. (Figure 2).

Based on the obtained time trend, from 2023 the indicator of the number of employed graduates changes the direction of movement towards growth, and over the years its values begin to reflect positive dynamics: the number of employed university graduates increases with a growth rate of 2.8-2.9% per year (Table 3).

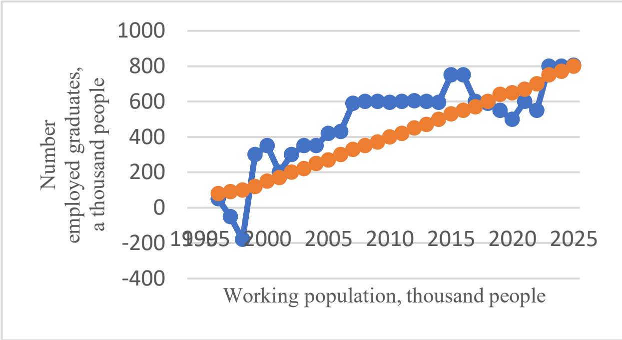


Figure 2. - Time trend of changes in the number of employed university graduates during 2023-2025.

Table 3. - Forecast values of changes in the number of university graduates expected for 2023 and employed in 2024-2025.

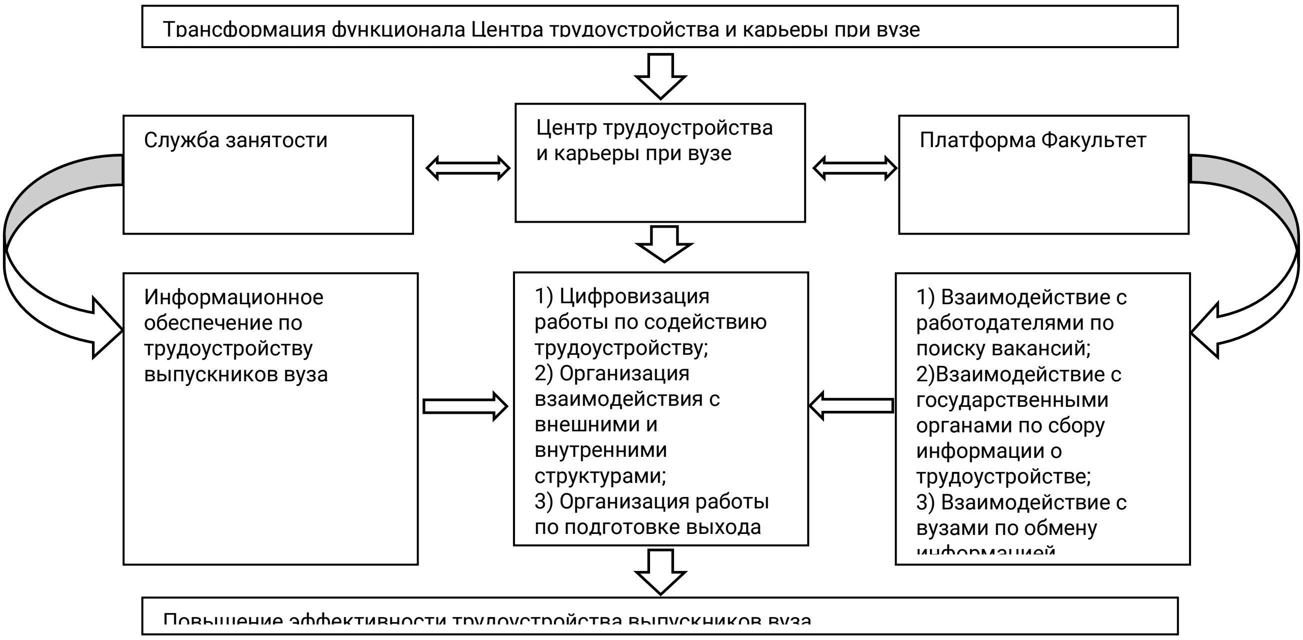
Year	Number of employed university graduates, thousand people.
2023	754,8812
2024	777,0495
2025	799,2178

Thus, [8-9], forecast indicators for the growth of the employment rate of university graduates due to the change in the situation in Russia with an increase in vacancies for young professionals corresponding to their level of training depends positive trends in the labor market, such as the reduction of unemployment, the increase in the demand for qualified workers, and the development of new sectors of the economy related to digitalization, were noted.

The implementation of the graduate employment system with the help of university career centers is associated with many contradictions, the subjects of which are the universities themselves, university graduates, employers and the state. The most common conflicts between universities and their potential employer partners take several forms:discrepancy between the volume of educational services provided and the existing actual practices of students and graduates in part ix of future professional activities of employees; differences in the quality of training of young specialists and requirements for employees; the lack of a unified fishing system in relation to the training of young specialists, both on the part of workers and on the part of universities themselves, causing a discrepancy in the system of qualification professional requirements.

According to the survey data of UzDavvalkomita, it was found that the percentage of graduates who used TTM services in higher educational institutions varies from 8% to 16%, and the percentage of graduates who used Internet resources for job search varies from 36% to 36%. 62% The low efficiency of the employment assistance and vocational assistance centers, as well as the existence of contradictions in the activity of this system, creates the need to improve its structure and expand the areas of activity. In addition, the entry into force of the new law "On employment of the population in the Republic of Uzbekistan" determines the procedure for permanent employment.Monitoring of the employment of graduates of higher educational institutions by the state bodies that control the employment of graduates requires taking into account this innovation in the activity of the centers.

A model for changing the functionality of the Employment and Career Center is proposed at the university, which best meets the modern requirements of the participants of the graduate employment process and includes a set of blocks provided by the Employment Service, the faculty platform and the CTC itself. (Figure 3).



Rice. 3. - The structural and functional model of changing the functionality of the Employment Assistance and Career Center at the university.

In our opinion, the Employment Service should combine the functions of monitoring the employment of graduates of higher education institutions and take over the authority to form a bank of vacancies for university graduates from the platform of the faculty allows. This creates an opportunity to form a system of adaptation measures for graduates entering the workforce.

Why is it necessary to make changes in the organizational structure of the centers that ensure the integration of various directions and types of activity into a single system of support for the professional and personal growth of students, ensuring employment and career advancement, which allows expanding the activity of the centers opportunities of these centers to work with applicants, students and graduates.

For a number of positions, it is necessary to improve the mechanisms of the centers' activities, primarily related to increasing focus on the needs of employers in terms of ensuring the level of preparedness of graduates for the needs of the labor market [10-11]. To implement this function, the work proposes a number of directions, including: expanding analytical and research work to determine trends emerging in the labor market, adjusting educational programs and sets of competencies in accordance with changing technological innovations that transform the real competency needs of employers.

Based on the changed function of the center, in order to minimize the risk of unemployment of university graduates, we can identify the main areas most in demand in its activity, including: analytical direction, including the analysis of the current situation in the institute determine the labor market and the future need for graduates;information, providing information to students and graduates about the situation in the labor market; consulting, providing training for students in the field of long-term career planning; organizational, including training students and graduates in employment technology, search techniques and methods, self-presentation, forming the correct image of a job seeker.Taking into account the results of the analysis, the dissertation offers directions for improving the activity of the TsTK, including: development and use of scientific-methodical means of ensuring employment; Use of volunteers in KTC work; transition to an electronic form of service provision, including employment and career management, service provision, audit and monitoring, including by connecting to the electronic platform "Faculty" accredited by the Ministry of Education and Science of the Republic of Uzbekistan by expanding information coverage to collect information about the availability of vacancies from employers.

Within the framework of the methodological approach developed in the study, a system of indicators was formed that allows to evaluate the effectiveness of the center's activity. It is based on five groups of indicators: overall evaluation of the activity of the Ministry of Education; Demand for CTC programs; employment of university graduates; efficiency of the central heating system; employment performance of university graduates. The selection of indicators for each group is determined by the specific characteristics of the functions performed by the employment and career centers, the quality of which is determined by the presented indicators

(Table 4).Table 4. - Indicators for evaluating the effectiveness of employment and career centers in universities

Direction of assessment	Indicator	Calculation formula
General assessment of the TsTK activities	Student Engagement Rate - KVS.	KVS = Number of university students who participated in CTC programs / Total number of university students
Demand for CTK programs.	Alumni Engagement Rate – ALV.	KVV = Number of final year students of the university who participated in CTC programs / Total number of final year students
Employability of university graduates	Employment Rate - KTV	KTV = Number of graduates employed for the first time within 6 months after graduation / Total number of university graduates
Efficiency of the central heating system	CTC operating efficiency coefficient	EF = Number of employed graduates within a year after graduation / Total number of university graduates
Employment efficiency of university graduates	Employment efficiency coefficient for university graduates	EF = Number of graduates employed according to the profile of their specialty within a year after graduation / Total number of university graduates

In the proposed methodological approach, a special place is occupied by the evaluation indicator of the efficiency of university graduates' employment. specialty received at the university.

The obtained calculated data were assessed through the indicators proposed in the work. An assessment of the results of the activities of the CTCs of the universities in question showed differences in the levels of efficiency of the centers. The Financial University is the leader in most indicators, which confirms the high employment efficiency of its graduates. This is ensured by the effective work of the employment and career center, which by the beginning of 2022 had at its disposal concluded partnership agreements with 900 enterprises, mainly in the field of the university [9-12].

Thus, the results of the indicators proposed in this study for assessing the effectiveness of the work of the CTC showed that they reflect the extent of their involvement in the process of employing graduates as a structural unit endowed with certain powers to implement a given function. The presented results allowed us to conclude that the assessment of the performance indicators of the CTC confirmed the presence of a certain potential of these units in implementing the graduate employment policy.

At the same time, in a number of positions, it is necessary to adjust the operational mechanisms of the centers' activities, primarily, increasing their focus on the needs of employers in terms of ensuring the level of preparedness of graduates for the needs of the labor market.

In order to increase the efficiency of the CTC, organizational and structural changes are necessary to ensure the integration of these centers into a unified system for promoting professional and personal growth, employment and career development of students by including them in all types of university activities aimed at working with applicants, students and graduates.

CONCLUSION

The risks of employment of graduates of higher educational institutions and adaptation to the labor market were identified and systematized in order to develop mechanisms for their minimization.The factors affecting the efficiency of employment of graduates of higher educational institutions and the forecast of changes in the level of employment of graduates in the labor market in the near future were determined. In accordance with the amendments made to the state policy of the Ministry of Education and Science of the Republic of Azerbaijan on monitoring the employment of graduates of higher educational institutions and forming a bank of vacancies, the functional model of the university employment assistance and career center has been changed increased. Uzbekistan's introduction of students to the labor market has led to a change in the focus on the activities of the centers.Expanding analytical and scientific research work on identifying trends in the labor market, adapting educational programs and sets of competencies in accordance with the changing technological innovations that change the real skill needs of employers, supporting employment at universities and improving the activities of career centers.

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OFFICIAL SOCIAL RELATIONS IN UNIVERSITY GRADUATES' ADAPTATION TO THE LABOR MARKET

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A B S T R A C T **The selection of students' informal (friendly) social connections as a significant determinant influencing their adaptation to the labor market is justified by the challenges of combining the concepts of social capital and network analysis; the reasons for the insufficient efficiency of interaction between the labor market and the higher education institution in the context of a multi-level system of professional training are systematized; three categories of elements have been identified as contributing to the establishment of students' social networks, as well as the usual structure of these networks when they are studying together. The factors that influence choosing between pursuing a master's degree and starting a career after earning a bachelor's degree have been recognized as components of the process of labor market adaption;**

K E Y W O R D S Employment, transitivity, social ties, job market, determinants, and graduate adaptability.**For a long time, scientists both domestically and abroad have been interested in the issue of hiring young experts. Research on university graduates' employment experiences and labor market adaptations holds a distinct place in academia. In the job market, university graduates make up a unique social group. While their considerable human capital assets set them apart, their social immaturity and lack of professional experience also pose challenges.**

The majority of young individuals in today's world enter the workforce while still enrolled in college. Students complete internships, hands-on training, and many senior students mix employment and education[1-3]. Right now, the selection of a professional path including training areas and degree of qualification is crucial.

Both the unique qualities of the graduate and the inefficiency of the relationship between the higher education institution and the labor market contribute to difficulties in adjusting to the workforce. Most grads prioritize finding work, so they use every resource at their disposal to make that happen. Social ties are among these resources.

A crucial component of social capital are social ties, which are formed throughout a person's life and codified into a social network of contacts. Social ties are forged at different levels (with friends, family, and coworkers), with varying frequency (often and infrequent encounters) and status (formal, casual).

Friendly, casual social ties that establish among students at university serve as a person's immediate surroundings and shape his conduct.

Empirical study has verified the influence known as the reference group effect, which has been thoroughly examined. Examining the impact of the reference group on the decision to pursue a master's degree or enter the workforce after completing a bachelor's degree appears pertinent given the shift in higher education toward a multi-level system of specialist training. Studying the influence of social networks on graduates' adjustment to the workforce is crucial because many recent graduates rely on them to help them find work.

A person's educational practices related to their process of knowledge acquisition are referred to as their educational trajectory. Within the parameters of this research, we uphold the notion that a student's professional trajectory is a deliberate decision made in pursuit of their academic and career objectives both during and after obtaining a bachelor's degree.

The switch to a multi-level higher education system at Uzbekistan's universities has had a substantial impact on students' ability to choose their career paths. Specifically, students can now choose between two levels of professional training (bachelor's and master's).

Causes of the ineffective communication between higher education institutions and the labor market within the framework of a multi-tiered professional training system:

time lag between the creation of labor supply and demand; discrepancy between the fields of study chosen by students and the demands of the market; employer ignorance of the characteristics of the multi-level personnel training system; and inadequate employer involvement in the university education process. The process of a young specialist into the labor market linked to the selection of a professional trajectory (future career), looking for a job, and beginning employment is defined as adaptation in the labor market.

The high unemployment rate in this generation (about 8%, according to the Social Insurance Fund 2015–2022) and the length of time it takes to obtain a job are two signs that young professionals may have trouble finding work. In this situation, getting a job and employment are top priorities for a lot of young people looking for work. In the labor market, social networks are important. They are a valuable information resource for companies and job seekers alike.

The characteristics that impact the development of casual social interactions among students enrolled in the same university are determined. Theoretical foundations for understanding social connections as a component of social capital, which is defined as a social network of relationships that bind individuals into social groupings.. It is feasible to more thoroughly examine the process of social network formation and evolution inside a group by combining mathematical techniques for social network analysis with established traditional sociometric instruments.

The term "informal social connections" refers to a group of friendships that students develop with one another while attending university. Students' micro-level connections, which take the form of a social network in structure, represent their social capital. The "neighborhood effect", transitivity, and a homogeneous social environment are the three primary factors that influence the development of social ties [3].

Regardless of the department of study, social networks that are described as directed graphs have a similar structure. The friendship networks that are displayed are rather dense; a student typically has four classmates as friends, and as a student approaches senior year, the number of friends declines. There is a consistent positive link between the strength of relationships and their reciprocity during the course of the study.

The development of cordial social relationships is influenced by three categories of influences. The proximity of the actors' traits is linked to the first group. Friendships between students of the same sex are more likely to occur by 3-7%. Pupils who do similarly academically are more likely to be friends with their classmates. There is a 1.5% to 5% increase in the probability of a friendship establishing between two students when the difference in GPA is reduced by one standard deviation.

Indicators connected to the "territorial proximity" effect are included in the second group. There is a 10–28% rise in the likelihood of friendship when studying in the same study group. The likelihood of friendship exceeds 43% when factors such as place of residence, study group, gender, and academic success all match at the same time.

The third set of factors has to do with how social networks are put together and how individuals fit within them. It was found that there is a transitivity effect in friendship social networks: in a social network, the probability of making a connection increases by 0.04% when you have a mutual buddy [4-5].

The probability of creating friendships is positively correlated with the actors' positions in the network in terms of popularity and activity, by 0.15% and 0.16%, respectively. Therefore, there are objective elements driving the creation of amicable social networks, even though choosing friends is optional and frequently done unintentionally employment situation. 18% of students who are working by the time they finish their bachelor degrees are likely to pursue a master's degree;

Academic achievement. Graduate programs are more likely to be attended by students with higher GPAs than by those with lower academic standing. Social media: a 1% gain in GPA raises the likelihood of being accepted into a master's program by 1%. A student's decision to continue his studies is positively impacted by his friends' admittance to a master's program. A student's chances of being admitted to a master's program are increased by 0.5% for each buddy who chooses to enrol in the program [6-7].

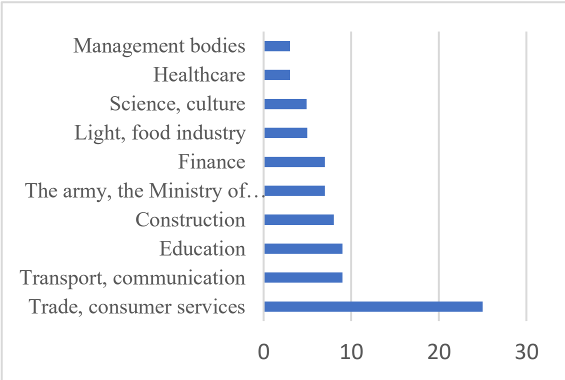
The findings of the interviews allowed for the identification of three justifications for carrying on with master's program coursework:

The aspiration to acquire enhanced professional proficiency.

Belief that a bachelor's degree is a less worthy accomplishment than a higher education.

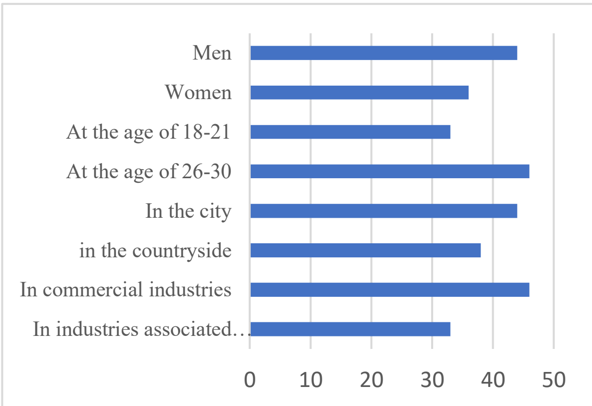
Admittance "for the company" influenced by other members' decisions reference team.

Trade and consumer services is the most preferred industry among recent graduates and working students (Fig. 1). The industries of "Transport, Communications," "Education," and "Construction" come in second by a wide margin; half of the respondents are employed in these sectors. Most responders fall into the highly- or semi-skilled worker categories. Twenty-five thousand soums is the average pay.



1. Rice. 1. Industry-specific distribution of graduates and working students,%.

In the employment process, informal social contacts are crucial for both working students and recent graduates. Using friends or acquaintances is the primary way to find work; over 40% of respondents said they employed informal social contacts during the hiring process. For recent graduates and working students, using friends and acquaintances to get employment is a frequent practice.



2. Rice. 2. Characteristics of work via social networks.

Men use this kind of employment more often than women do, and as people age, they turn to friends and acquaintances more frequently in their job search. Cities and businesses involved in commerce are the places where informal social links in the workplace are most prevalent (Fig. 2).

The employment circumstances of friends and acquaintances are not significantly affected. The average income difference between the two labor categories is less than 5%, with the wage level being nearly equal. The results of multivariate regression analysis did not show that employment through informal social connections has a statistically significant impact on earnings [8-12]. There aren't many differences in working circumstances. Graduates who get jobs through friends are more likely to work without a formal contract, although the differences are not statistically significant (3.2%).

Issues pertaining to unpaid adjustments to the workweek's duration, unpaid time off, or any employer-related arrears are equally prevalent across both worker categories.

It was discovered how graduates' subjective attitudes toward their jobs related to the employment process. Graduates who obtained employment through unofficial social networks are less happy with their positions, working environments, and chances for advancement in their careers[13-14].

We may state that the technique of employment through informal social connections is one of the elements of job satisfaction even though it does not have the largest influence on measures of job satisfaction. This is because the method of employment is statistically significant. Graduates have a 92% trust level in management and a higher than 95% trust level in their peers. The degree of trust within the team is unaffected by the mode of employment. About half of those surveyed worry that they might lose their jobs.

In addition, compared to their classmates who did not secure employment through unofficial social connections, graduates who obtained their jobs through friends or acquaintances expressed greater fear about losing theirjobs. The impact of geographical closeness and social environment homogeneity on the development of amicable social bonds amongst students enrolled in the same course is discussed in the conclusion.

CONCLUSION

The way that connections are formed among students is determined by their position in the network; students who are more popular and active among their peers tend to build stronger social bonds with one another. A statistically significant transitivity effect was found as a consequence of the examination of variables influencing how pupils establish social bonds with one another.

A number of characteristics have been identified by modeling a social network of student friendships: the networks are dense, almost all students enrolled in the same course participate in the interaction; students typically have four friends; most networks are characterized by the formation of clusters and a high proportion of mutual connections.

Informal social networks play a statistically significant role in determining a person's career path; the more friends a student has, the more likely they are to be admitted to a master's degree, along with other indicators like academic standing and employment opportunities.

It is established that hiring recent graduates through friends and acquaintances is a prevalent practice, more common in cities than in other populated places, more common for men than for women, and more common in industries related to commercial activity.

Working through informal social connections does not result in wage discrimination against young professionals by employers, nor does it significantly affect workers' wages. It also does not lead to labor law violations such as denial of official registration, extension of the workweek, unpaid vacation, and wage arrears.

It was discovered how graduates' subjective attitudes toward their jobs related to the employment process. Graduates who obtained employment through unofficial social networks are less happy with their positions, working environments, and chances for advancement in their careers. Whether or whether an employee was hired through a friend has little bearing on their degree of trust in supervisors and coworkers.

The future is not a source of great confidence for young professionals: nearly all of them are fearful of losing their jobs. Concerns about potential job loss are greater among graduates and students who combine employment and study and are employed through friends or acquaintances than among their peers who do not receive preferential treatment.

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CREATING A LINGUISTIC SUPPLY FOR LEMMATIZATION OF UZBEK VERBS

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A B S T R A C T Linguistic supply refers to the availability of linguistic resources such as written texts, lexical resources, language corpora, language technology tools and language education materials. It encompasses the quantity, diversity and accessibility of these resources, which support linguistic research, language learning, language technology development and other language-related activities. Lemmatization removes affixes from words according to linguistic rules, like stemming but different from stemming, which is another method of text normalization. Lemmatization is essential in natural language processing and is employed in various tasks within it, including text normalization, information retrieval, and others. In this article, we discuss building of the linguistic supply for lemmatization of Uzbek language verbs. Additionally, the processes of collecting supplies and its significance for Uzbek verb forms has been considered. The supply will be available at github.com/MaksudSharipov.

K E Y W O R D S nlp, lemma, lemmatizer, lemmatization, linguistic supply, uzbek language

1. INTRODUCTION

Computer analysis of texts in any language, in general, to create linguistic programs, requires a certain linguistic supply. In particular, this article discusses the creation of a linguistic supply for the automatic analysis of Uzbek texts and its application to solving the problems of Natural Language Processing (NLP) and the issue of lemmatization. In this case, the linguistic supply can be a database, and this database is called a corpus, and it can be any collection of written speech. Linguistic supply refers to the availability of linguistic resources such as written texts, lexical resources, corpora, language technology tools and language education materials. Linguistic softwares uses these supplies for fast search and analysis. A linguistic supply is an important source of information used to search for, identify and explain the structural elements of a language, their interactions and regularities. Linguistic supply include language dictionaries, historical sources, academic studies, and school textbooks. Generally, linguistic supply plays a crucial role in supporting linguistic research, language learning, language technology development, and various other applications related to language and communication. It contributes to the vitality and development of languages and facilitates communication and understanding among speakers of different languages. Linguistic supply for lemmatization refers to the availability and quality of linguistic resources that support the process of lemmatization in NLP. Having a robust linguistic supply is crucial for accurate and effective lemmatization, as it enables NLP systems to identify and transform words to their canonical forms based on language rules and context.

2. RELATED WORKS

Peer review is an significance process to ensure high-quality and informative research. We used the 5-volume "O'zbek tilining izohli lug'ati" to create a linguistic supply for lemmatization the Uzbek language verbs [1]. We also collected words from other linguistic sources. In this work, they describe how they address the difficulties posed by harmonizing disparate lemmatization standards in a project that seeks to use the Linked Data paradigm to connect Latin language resources, in particular, the study discusses how a lemmatized and syntactically annotated corpus, a word formation lexicon, and its lexical foundation were added to the Knowledge Base [2]. This work introduces a novel hybrid technique to lemmatization of Turkish inflected words by utilizing graph models based on morphological similarity, which is gaining popularity lately. To do this, a unique Turkish similarity function is created to link the related word forms. A Turkish lemmatization dataset that has been double-checked is used to train and evaluate the suggested model [3]. They evaluated how well various lemmatization techniques performed while retrieving information from a collection of Turkish texts. Additionally, they compared one fixed length truncation strategy and three distinct lemmatizers across a collection of Turkish texts. The first one is based on finite state technology, another one is dictionary-based, the third one is a simple dictionary-based top-down parser and the last one is truncation of words at fixed length [4]. The creation of preprocessing tools and linguistic materials for the Kazakh language is the goal of this project. The overall structure of an information system for the reliable and automated gathering, storing, and analysis of texts written in Kazakh is explained. The suggested tools can also be used to create ontologies and thesauri, among other linguistic resources [5]. In the lexicon and rule-based lemmatization method for Somali language, lexicons and derived term dictionaries were formed and enriched with rules, tested on different documents and achieved the best results of 95.87% [6]. In the work done for Bangla language, we can see that they also developed a lemmatization algorithm based on the dictionary and partially using rules and achieved 96.36%, developed a program based on the algorithm and made it open source together with the dictionary [7]. Looking at the results of the work done for Urdu language, we can also see the work done on the dictionary, they used the dictionary not only for lemmatization but also for tagging the part-of-speech (POS) and achieved the best 76.44% [8].

While introducing the works carried out in Uzbek computer linguistics using linguistic sources, it is worth mentioning the following scientific works and their results. In this paper, they developed a rule-based lemmatization algorithm, the main goal of the work is to remove word affixes in the Uzbek language using a finite state machine and to determine the word lemma, in the process of removing affixes, when removing affixes the database and POS's applied [9]. Words in agglutinative languages are created through suffix addition. It is vital to examine both phonetic and morphological modifications when appending suffixes to the stem since phonetic harmony and discord might arise. Reducing word forms to their stems is a necessary step in many natural language processing jobs. One of the key goals of NLP is removing all inflectional affixes from a word and lemmatizing the remaining portion of the word; this process is known as stemming [10]. Using a hidden Markov model, this article describes techniques and algorithms for automatic POS tagging of a given sentence based on the tagged Uzbek corpus [11]. This article deals with the creation of a rule-based algorithm for identifying noun and pronoun POS in Uzbek language texts. Identifying nouns and pronouns in texts and morphological analysis will be useful in solving a number of problems of NLP for the Uzbek language. Like all Turkic languages, the Uzbek language is an agglutinative language, formed by adding suffixes to the root or base of the word. In order to solve this problem, a basic noun and pronoun database was created, in addition, a noun and pronoun derivational and inflectional suffixes database was created [12]. A POS annotated dataset and tagger tool for the low-resource Uzbek language are presented in this research work. Twelve tags total from the dataset were used in the creation of a rule-based POS-tagger tool [13].

3. GATHERING LINGUISTIC SUPPLY

The main purpose of morphological analysis is to help understand and use language. Morphological analysis in the Uzbek language refers to the identification of words and their additional forms, defining their function and explaining their structural construction. Morphological analysis is an important step in understanding, learning and using language. It helps in understanding the rules and structures of the language and in using related texts and writings. A linguistic supply is an important source or sources that provide research, information and scientific studies of a language. These supply will be of practical assistance to students, scholars, and researchers in linguistics, writers, translators, and other linguistic fields. Linguistic supply can take many forms: translation dictionaries, explanatory dictionaries, spelling dictionaries, and even manuals. We have created a database of words as a linguistic supply for finding lemmas of Uzbek verbs. We took the words from textbooks, articles, literature and other sources, and as we said above, we used the 5-volume "O'zbek tilining izohli lug'ati" as the main source. We used the following resources to create linguistic supply:

main source: "O'zbek tilining izohli lug'ati"

sources of linguistics: "O'zbek tilining tuzilishi", "O'zbek tilida sintaksis", "O'zbek tilining morfologiyasi", "O'zbek tilining frazeologiyasi", "O'zbek tilining qo'shma so'zlar to'plami";

- dictionaries;
- internet resources;
- electronic libraries;
- scientific articles;
- corpora.

We chose the verb since we are aware that it makes up an equal portion of the text. A significant portion of the text can be understood and analyzed by looking at the verb. Therefore, this supply plays a decisive role in the tasks of NLP like lemmatization and allows researchers to efficiently analyze and process large volumes of texts.

We saved the linguistic supply in a .txt file, and primarily each word was collected in one line, then the words that were similar in part were separated in one line with a slash (\) symbol [Figure 1].

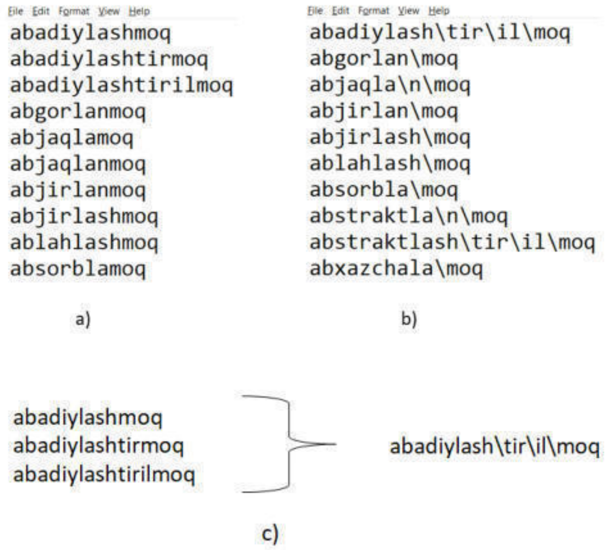

Figure 1. a) each word in one line; b) a set of words, some of which are similar; c) to collect words that are similar in part.

During the collection of linguistic supplies, a group of linguistic experts was involved and they helped to collect the words in two stages: word collection and revision.

4. LEMMATIZATION OF VERB

One of the first important processing methods when performing linguistic operations on texts is lemmatization. In other words, in order to solve the problems of NLP, it is necessary to carry out works such as tagging, tokenization, lemmatization and stemming on the texts. A lemma is an important unit used in linguistics. The lemma is the base or dictionary form of a word, representing its core meaning. Lemmatization is a linguistic and natural language processing (NLP) technique used to reduce words to their base or dictionary form, known as a lemma. This process involves removing inflections or variations from words while considering their context and grammatical structure. Lemmatization helps to standardize words and improve the accuracy of text analysis, information retrieval, and other NLP tasks by reducing different forms of a word to a common base form. The basic form obtained by lemmatization is called a lemma. For instance, the lemma of words like "kitoblar" (books), "kitobdan" (from the book), "kitoblarga (to books)" is "kitob" (book).

Fe'l (Verb)		
Sodda	Tub	*yugurmoq (to run)*
	Yasama	*dodlamoq (to wail)*
Qo'shma		*sayr etmoq (to walk)*
Juft		*aytdi-qo'ydi (unbosom)*
Takror		*kuta-kuta (do wait)*
	KFSQ	*so'rab turmoq (to ask)*

To'liqsiz fe'l	*edi, ekan, emish, emas*

Table 1. *Verb types according to the structure.*

The verb has four basic forms: "sodda" (simple), "qo'shma" (compound), "juft" (pair) and "takror" (repetitive). The verb "sodda" in turn is divided into the following two types: "sodda tub" (root words) va "sodda yasama" (derived words). Furthermore, the verb has the following two structures: ko'makchi fe'lli so'z qo'shilmasi [KFSQ] va to'liqsiz fe'l (incomplete verbs) [Table 1].

Verb lemmatization processes using linguistic tools. In this case, the inflections forming the syntactic form of the verb are cut off. Some of the derivationals remain in the lemma, while others are removed. It is important to use linguistic supply for this situation, because it is more complicated to determine which affixes remain in what words and which do not. The lemma of some forms of the verb can be seen in the table below [Table 2].

Type	Word	Lemma
Tub [Root]	*boradi*	*bormoq*
Yasama [Derived]	*ikkilandi*	*ikkilanmoq*
Qo'shma [Compound]	*sotib olarmish*	*sotib olmoq*
Juft [Pair]	*sindi-qoldi*	*sindi-qoldi*
Takror [Repetitive]	*o'tdi-o'tdi*	*o'tdi-o'tdi*
KFSQ	*aytib yuborgan*	*aytib yubormoq*
To'liqsiz fe'l [Incomplete]	*ichgan ekan*	*ichmoq*

Table 2. Examples of lemmatization words belonging to the verb through a linguistic supply.

5. CONCLUSION

In conclusion, it should be said that the linguistic supply has a great role in solving linguistic problems, performing the tasks of NLP, and developing translation programs. In this article, the theoretical and practical information of creating a linguistic supply was given, and based on this information, the linguistic supply was created, and several words were analyzed based on this supply, the results of this analysis were published on the basis of a table. Moreover, the article defines the methodology and importance of the process of creating a linguistic supply for determining the lemma of Uzbek words.

In the future, we would like to improve this supply and make it the main source for in-depth analysis of texts of various genres.

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MODERN TRENDS IN THE APPLICATION OF INTELLIGENT SYSTEMS IN THE MANAGEMENT OF ECONOMIC OBJECTS

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ANNOTATION **The article is devoted to the issues of improving the management processes of economic entities based on the use of artificial intelligence technologies. The work provides the general structure and components of an intelligent information system - a knowledge base, a decision-making mechanism and an intelligent interface. The knowledge base is characterized as a set of models, rules and data that allow generating and analyzing conclusions to find solutions to complex problems in a certain subject area.**

KEYWORDS Artificial intelligence, intelligent system, subject area, knowledge base, interface, expert system.

INTRODUCTION

Currently, artificial intelligence technologies are actively developing in the Republic of Uzbekistan. In accordance with this, on February 17, 2021, the Resolution of the President of the Republic of Uzbekistan "On measures to create conditions for the accelerated implementation of artificial intelligence technologies" was adopted. In order to accelerate the implementation of artificial intelligence technologies and their widespread use in the country's economy, the Program of measures to study and implement artificial intelligence technologies in various industries and areas was approved. Artificial intelligence technologies are developing especially actively in the banking and financial sectors, healthcare and pharmaceuticals. Today, one of the most important areas for improving the management processes of economic entities is the intellectualization of information technology. This means that the user can not only receive information based on data processing using computer technologies, but also use the accumulated experience and knowledge of specialists on the problem of interest.

METHODS

In conducting this study, the authors used methods of theoretical and statistical analysis and synthesis, methods of generalization and grouping, methods of monographic research, as well as methods of working with computer networks and software products in complex information systems.

In the course of working on this article, the authors studied a fairly wide range of scientific works by domestic and foreign scientists, such as G.I. Abdrakhmanova, K.O. Vishnevsky, L.M. Gokhberg. [1], M. Tim Jones [2], Golovenchik G.G. [3], S. Osovsky [4], A.V. Ostroukh [5, 6], Zhukovskaya I.E. [7], Zhukovskaya I.E., Xashimxodjayev Sh.I. [8], Xashimxodjayev Sh. I., Belalova G. A. [9], Xashimxodjayev Sh.I., Pilipenko E.F. [10], Telnov Yu.F., Bryzgalov A.A., Kozyrev P.A., Koroleva D.S. [11], Shpileva A.A. [12].

Currently, much attention is paid to the study of digital transformation issues in economic science and practice. At the same time, many foreign and domestic scientists pay special attention to the practical application of artificial intelligence technologies, consider new approaches to the activities of enterprises and organizations in the digital economy.

The research methodology is based on the theoretical provisions of scientific works of domestic and foreign scientists devoted to the problems of the digital economy, both in the methodological aspect and in the legal, technical, information, technological and software aspects.

RESULTS

The main purpose of information systems in the economy is to provide decision makers with the necessary information in a timely manner to make adequate and effective decisions in managing processes, resources, financial transactions and the organization as a whole [5].

However, with the development of information technologies, as well as the increase in the number of consumers of information resources on the part of decision-makers, it is not only a question of providing and processing primary information, but also of the need to implement the results of preliminary analysis.

An intelligent system (IS) is an automated system based on knowledge, or a set of software, linguistic and logical-mathematical tools for implementing the main task - supporting human activity and searching for information in the advanced dialogue mode in natural language [6].

The intelligent system consists of three main blocks:

- a knowledge base;
- a decision-making mechanism:
- an intelligent interface.

Knowledge engineering is closely related to the process of developing intelligent information systems in general and expert systems in particular. The methodology of developing expert systems covers the discovery, analysis and provision of expert knowledge to form a rule base. The development of expert systems has created knowledge engineering – the process of creating intelligent systems. This is a set of models, methods and technical procedures aimed at creating systems designed to solve problems using a knowledge base.

Thus, in order to create a system that works with knowledge and to some extent replaces a specialist or helps him make decisions in production management, it is necessary to try to create the possibility of implementing these functions in the architecture of an intelligent system.

A knowledge base is a collection of models, rules and data that allows you to generate and analyze conclusions to find solutions to complex problems in a certain subject area.

Knowledge about a subject area, isolated and organized in the form of separate, integrated structures of information support, becomes clear and is separated from other types of knowledge, for example, general knowledge. Knowledge bases allow thinking not only on the basis of formal logic, but also on the basis of experience, factors, heuristic.

Developments in the field of artificial intelligence (AI) are aimed at using large volumes of specialized knowledge about a particular subject area to solve complex, extraordinary problems.

The knowledge base is the foundation of the expert system, which is formed during its construction. Knowledge is reflected in such a way that it allows a clear understanding of the way of thinking and methods of solving problems, and is organized to simplify decision-making. The knowledge base, which supports awareness of the expert system, includes the knowledge of institutions, departments, specialists, the experience of a group of experts and consists of institutional knowledge (a set of qualified, updated strategies, methods, solutions). The main characteristics of knowledge bases are shown in Figure 1.

Knowledge and rules of work can be viewed from different points of view:

- ideal and superficial;
- qualitative and quantitative;
- specific and general.

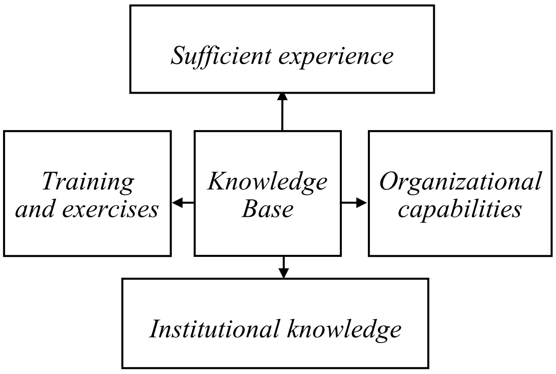

Fig. 1. Main characteristics of the knowledge base [1]

The main components of the knowledge base are:

- the knowledge base itself and its environment;
- the decision-making mechanism;
- the interface.

DISCUSSION

There are currently two definitions of the term "knowledge base":

1. A knowledge base is a package of specific specialized knowledge used in a system.

2. A knowledge base is an integrated system containing information about human experience and knowledge in a certain subject area.

All knowledge is divided into algorithmic and non-algorithmic. Non-algorithmic knowledge is divided into conceptual and factual knowledge.

In knowledge base systems, it is important to define the content of knowledge, what and how to represent. The question of what to represent is defined as follows - the solution to a specific problem must reflect the modeled or represented entity. The question of how to represent a knowledge base has the following two aspects:

1. How to organize knowledge, that is, systematize it.

2. How to present knowledge in a selective form of formulation.

Thus, the range of issues that require a solution when presenting information in a knowledge base system includes:

- etermining the content of the presented knowledge;
- organizing knowledge;
- presenting knowledge, i.e. defining a presentation model.

In this case, we use the following concepts: subject area, problem area, information, knowledge [2].

A subject area is a field of knowledge about tasks, and a problem area is a subject area and the tasks solved in this area. Information can be initial, intermediate, and resulting. Knowledge is any information, including specific evidence, stored in the system, regardless of whether the system is solving the task at a given time or not.

Direct use of data from the knowledge base to solve the problem is provided by the decision-making mechanism. The decision-making mechanism allows you to receive answers from the knowledge base, as well as receive solutions to problems that form terms stored in the knowledge base. The principle of obtaining a solution is closely related to the methods of presenting information in the knowledge base. Actions to solve equations for knowledge presented in the base are levels of the decision-making mechanism.

The decision-making mechanism has a decision algorithm - special algorithmic knowledge. On the other hand, the decision-making mechanism has a certain part of the semantics of knowledge in the event form. This is confirmed by the relativity of the boundaries between the decision-making mechanism and the knowledge base. The interface is part of the knowledge base system, providing a language of a sufficiently high level, close to the professional language of

[1] А.В. Остроух. Основы построения систем искусственного интеллекта для промышленных и строительных предприятий: – М.: ООО ≪Т е х п о л и г р а ф ц е н т р≫, 2008.

subject area specialists working with the knowledge base and the decision-making mechanism.

The interface also includes a corresponding language processor. In addition, the interface functions include support for a dialogue with the user, which allows the system to participate in the search for solutions, make corrections to the knowledge base.

The content of knowledge bases can be used by the user to make effective management decisions. Figure 2 shows the structure of the knowledge base and the technology of its use.

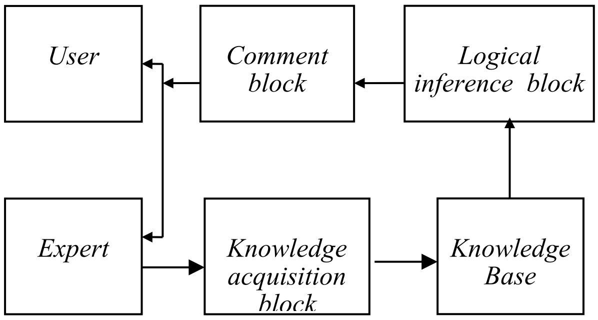

Fig. 2. Technology of using knowledge bases[2]

An expert is a specialist who is able to find effective solutions in a specific subject area.

The knowledge acquisition block reflects the stage of knowledge base aggregation, knowledge and information updating.

In conclusion, the knowledge base reflects access to high-quality expertise at the level of thinking of a qualified expert, making expert systems cost-effective for the needs of businesses and clients.

CONCLUSION

To sum up the above, it should be noted that in the modern period the development of intelligent systems is at a high level. The use of intelligent systems in the activities of economic entities is a driver for the development of not only a separate economic entity, but also all related industries and spheres of the country's economy.

As experience shows, the implementation of various intelligent solutions contributes to increased production efficiency, development of the agricultural sector, adoption of innovative management decisions, and improvement of the qualifications of employees working with intelligent assistants, which ultimately serves as the basis for the competitiveness of enterprises and organizations in the economic market.

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SUPPORTING LOCAL MANUFACTURERS AND GROWING TRADE: PUBLIC POLICY IMPLICATIONS AND OPPORTUNITIES

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Abstract. This article analyzes the policy of supporting local producers in the Republic of Uzbekistan and its impact on the growth of trade volume. The measures implemented by the state, in particular, the incentives and price preferences given to local producers on the e-cooperation portal, led to a significant increase in the volume of trade. The increase in the volume of trade sheds light on the problems of the most demanded types of products and the increase of export potential.

Keywords: Local manufacturers, government policy, trade volume, electronic cooperation portal, price preferences, economic development, export potential.

Introduction

The basis of economic stability and independence for any country lies in the development of domestic production. By supporting local manufacturers, it is possible to increase competitiveness in the domestic market, create new jobs, accelerate the processes of technological modernization, and strengthen the integration of the national economy into the global market. The Republic of Uzbekistan has made significant progress in this direction in recent years. Large-scale economic reforms carried out by the state, in particular, the policy of public procurement aimed at supporting local manufacturers, are bringing the country's industry to a new level.

A number of decrees and decisions adopted by the President of the Republic of Uzbekistan are aimed at fundamentally reforming the state procurement system, introducing modern digital technologies into it, and most importantly, creating wide opportunities for local manufacturers. For example, as a result of such measures as establishing price preferences for local manufacturers in the framework of state procurement, expanding the possibility of concluding direct contracts through electronic cooperation portals, the demand for products and services provided by local manufacturers is increasing.

As a result, the volume of sales made by local manufacturers has increased significantly in recent years. According to reports on the volume of sales on the electronic cooperation portal, the indicators for the number of contracts and the share of various types of products were at a very high level. These results show that the state's policy in this regard has been successfully implemented.

Supporting local producers is important not only for ensuring the stability of the domestic market, but also for increasing their competitiveness in the international market. In this process, the direct intervention of the state and effective cooperation with the private sector can serve as a decisive factor in the future growth of the national economy. The article analyzes the main directions of the policy of state support for local producers, the growth of trade volume and future opportunities.

Decrees and decisions of the President of the Republic of Uzbekistan, statistical data provided by the Ministry of Economy and Finance of the Republic of Uzbekistan, as well as publications and reports prepared by the World Trade Organization (WTO) and other international financial organizations are widely used in the implementation of these analyses. Based on this information, the effectiveness of the state's policy of supporting local producers is analyzed and recommendations are developed for future development prospects.

Literature review

Support for local producers as part of state policy has been widely covered in many international and national studies. Measures aimed at improving the competitiveness of local producers by reforming the state procurement system, tax and credit incentives have been found to be effective based on many economic studies.

In the study "Public Procurement and Local Content: Best Practices for Developing Countries" (2022) conducted by the World Trade Organization (WTO), it was noted that giving preference to local producers in the public procurement system is important for increasing their competitiveness in the international market. This study explores effective ways to support domestic production and stimulate economic development through public procurement.

A study by Arrowsmith (2019) examined strategies to increase the share of domestic producers through public procurement, policies to support domestic production within the framework of the World Trade Organization. In this study, the promotion of domestic production through public procurement in developing countries is effective because it expands the opportunities of local producers not only in the domestic market but also in the international market.

The study "The Role of Government Policies in Enhancing the Competitiveness of Local Industries" by Smith and Brown (2020) also shows the effectiveness of supporting local producers and its impact on increasing competitiveness. This study analyzes the development of national industry and the creation of new jobs through measures implemented within the framework of state policy.

In the analyzes of the internal policy of Uzbekistan, the opportunities created to support local manufacturers and reforms in the state procurement system on the basis of the decision of the President of the Republic of Uzbekistan No. PQ-5011 (02.03.2021) play an important role. This decision envisages the provision of price preferences and tax incentives for local producers, and these measures serve to increase the volume of sales of local producers and strengthen their competitiveness in the domestic market.

Also, in the study "Supporting Local Industries through Public Procurement"conducted by the OECD (2021), the effectiveness of promoting local production through public procurement, in particular, contributing to economic development by giving priority to local producers in the public procurement system and providing tax incentives is indicated.

Research Methodology

In this study, qualitative and quantitative analysis methods were used to evaluate the impact of domestic producer support policies on the volume of trade. The data were taken from statistics of the Ministry of Economy and Finance of the Republic of Uzbekistan, reports of the electronic cooperation portal, as well as publications of international organizations. Qualitative analysis was focused on the in-depth study of the impact of government policy on the competitiveness of domestic producers. Quantitative analysis focused on determining the effectiveness of state measures by analyzing statistical indicators on the volume of trade and the number of contracts. Also, a comparison with international experiences was made, and proposals adapted to national conditions were developed.

Results and discussion

Results of supporting local manufacturers

The measures of the government of the Republic of Uzbekistan aimed at supporting local producers are yielding significant results. The volume of sales and the number of contracts made on the electronic cooperation portal show the success of this policy.

Time	Contract number	Total amount
2023 yil yanvar-iyun	22 568	6,6 trln. so'm
2024 yil yanvar-iyul	56 580	8,82641 trln. so'm
2024 yil yanvar-iyun		7,15969 trln. so'm

Source: new.cooperation.uz

In January-June 2023, 22,568 contracts were concluded through this portal, and the total trade volume was 6.6 trillion soums. At the same time, the number of contracts concluded in January-July 2024 reached 56,580, and the volume of trade increased by 8.826 trillion soums. In January-June 2024, the trade volume was 7.15969 trillion soums. These numbers clearly confirm the effectiveness of the support measures given by the state and show the growth of local producers.

Source: http://xarid.uz/

As of August 30, 2024, the total amount of purchases made by state and corporate customers on the electronic portals of goods and raw materials of Uzbekistan amounted to 210,614,037,800 soums. These purchases were made by the state through electronic stores. Also, other purchases were significant and contributed significantly to the total volume of sales made by state and corporate customers. These statistics show the importance of electronic trade transactions between the state and corporate sectors, which constitute a significant part of the volume of trade in the goods and raw materials market of Uzbekistan.

The influence of state policy on the volume of trade

The policy of the government of the Republic of Uzbekistan aimed at supporting local manufacturers, in particular, the measures aimed at increasing their share in the process of state procurement, caused a significant increase in the volume of trade. In accordance with the decisions adopted by the state, including decision No. PQ-15, local producers registered on the electronic cooperation portal have priority in the state procurement system, which serves to increase their competitiveness.

The advantages created for local producers in the state procurement system, especially the introduction of price preferences, increased the competitiveness of domestic goods compared to imported products. On the basis of decision PQ-15, it was made mandatory for state customers to study the offers of local manufacturers registered on the Electronic Cooperation Portal and provide them with price preferences of 8% to 15%. This, in turn, created an opportunity for local manufacturers to attract more orders and led to an increase in sales.

In January-July 2024, the number of contracts executed through the portal reached 56,580, and the total trade volume was 8.826 trillion soums. These figures show positive results in the growth of the volume of trade carried out by local producers, due to the direct influence of the state policy. In particular, the 26% share of the trade of electrical engineering products shows the effectiveness of the state's measures aimed at the development of this sector.

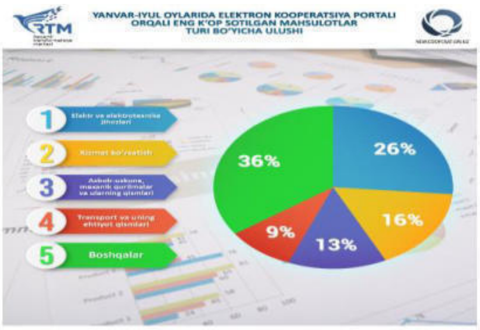
Also, the tax incentives given to local manufacturers on the basis of decision No. PQ-15 had a direct impact on the increase in the volume of trade. From January 1, 2024 to January 1, 2027, the profit tax and property tax rates for enterprises in the electrical engineering sector will be reduced by 50%, which will improve the financial situation of these enterprises and increase the volume of sales. At the same time, the funds freed up due to these tax benefits are directed by enterprises to the creation of new production facilities and modernization of existing facilities.

As one of the results of the state policy, the active use of the electronic cooperation portal and the strengthening of the role of local producers in the process of public procurement contribute to the sustainable development of the national economy. Therefore, these measures adopted by the state serve to increase the competitiveness of domestic producers of Uzbekistan not only in the domestic market, but also in the international market.

Most requested products

Among the most sold products on the Electronic Cooperation Portal in January-July 2024, electrical and electrotechnical equipment is leading with a 26% share. Also, a 16% share was recorded in the service sector, while the share of equipment, mechanical devices and their parts was 13%. This shows that the products are in high demand within the framework of public procurement. These data confirm that as a result of the state's efforts aimed at the development of the electrical engineering industry, growth is observed in this area.

Source: new.cooperation.uz



The results show that the policy of state support for local producers is bearing fruit. The increase in the volume of trade, the provision of incentives to local producers in the process of public procurement, and the successful use of the electronic cooperation portal show the effectiveness of this policy. Also, the increase in the volume of trade has a positive effect on the economy, as it allows local producers to grow and create new jobs.

However, some obstacles need to be overcome to make this policy more effective. In particular, more effective measures should be taken to increase the export potential of local producers, introduce new technologies, and produce competitive products. This, in turn, helps domestic manufacturers to take a strong position not only in the domestic market, but also in the international arena.

The effectiveness of the policy of supporting local producers is directly related to the important measures introduced by the state in the electronic cooperation portal. In accordance with the decision of the President of the Republic of Uzbekistan No. PQ-15 dated January 10, 2024, the obligation to study the offers of local manufacturers registered on this portal and to apply price preferences to them during the process of public procurement is established. This measure serves to strengthen the position of local producers and increase their share in the state procurement system. At the same time, this decision will open up new opportunities for local manufacturers and provide them with additional tax incentives aimed at ensuring their competitiveness not only in the domestic market, but also in the international market.

Conclusion

In the Republic of Uzbekistan, the policy of supporting local producers is yielding significant results. Measures implemented by the state, in particular, electronic cooperation portals and tax incentives, help to increase the competitiveness of local producers. The fact that the volume of trade and the number of contracts increased significantly in 2023-2024 shows the effectiveness of this policy.

A 26% share in the electrical engineering industry is an important indicator of the positive results achieved on the basis of government incentives and price preferences. One of the main factors that led to the increase in the volume of trade is tax relief, thanks to which enterprises are able to reduce their financial burden and create new production capacities. For example, the 50% reduction of profit tax and property tax rates in the field of electrical engineering provided financial stability to enterprises and caused a further increase in sales volume.

In order to make this policy more effective, it is necessary to focus on increasing the export potential. Measures aimed at the introduction of modern technologies, the development of the production of innovative products and the creation of competitive products in the international market are still important tasks. In particular, it is necessary to expand the possibilities of increasing product quality and successfully competing in the international market through the integration of new technologies into production.

In the future, further improvement of the policy of support for local producers will help to increase competitiveness in the domestic and international market. Also, it is possible to ensure stable growth of the national economy through the development of export-oriented production. The development of additional measures for the technological and innovative development of local producers creates the necessary factors for the successful competition of national producers in the international market. In the Republic of Uzbekistan, the policy of supporting local producers is successfully implemented, but to further increase its effectiveness, it is necessary to study new opportunities and international experiences. The correct development of this policy will significantly contribute to the sustainable growth of the national economy.

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PROSPECTS OF INNOVATIVE DEVELOPMENT OF REMOTE BANKING SERVICES IN THE PROCESS OF DIGITAL TRANSFORMATION

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A B S T R A C T **This article highlights another technological trend that requires digital transformation in banks - the ability to prevent future problems - predictability. Reliable information on identifying different scenarios of an economic crisis can help banks prepare in advance. So, before transforming banks into other promising and financially profitable sectors, it is necessary to take the right decisions and implement them with modern fintech solutions. The increasing use of smartphones is accelerating the trend of digital transformation, as a result of which they have improved connectivity to banking channels and become an important tool for users. The banking industry is also being modernized through multi-functional digital transformation capabilities.**

K E Y W O R D S **Digital economy, digitalization, transformation, digital transformation, information and communication technologies, regional economy, digital infrastructure, internet.**

INTRODUCTION

Rapidly developing digital technologies in the world are leading to qualitative and technological changes in the socio-economic activity, economic policy and structure of state administration of countries.

In particular, as a result of the introduction of digital technologies and the different rates of their widespread implementation in economic and social life, the development differences between countries are becoming stronger. The growth rate of the digital economy in the world is almost 15.5 percent. In developed countries, the share of the digital economy in GDP reached 7 percent. They are already benefiting greatly from the introduction of the digital economy. In particular, the US exports more than 400 billion USD of digital services per year. By 2025, the US is expected to gain an additional US$20 trillion from the digitization of industry [1].

METHODS

As a result of research, the development of new technologies in the field of banking services, the management of digital transformation processes in commercial banks are related approaches, and scientific conclusions and proposals have been developed on the formation of a digital ecosystem in banks. Methods such as abstract thinking, systematic approach, complex assessment were used in the research.

RESULTS

It is worth noting that in 2023, the process of privatization of large banks with a high state share will be brought to a logical end, in particular, the shares of banks with a state share (Kishloq kurilish bank, Xalq bank, Mikrokreditbank, Aloqa bank, Agro bank and Milliy bank) will be put up for public open auctions (IPO). withdrawal and in cooperation with the European Bank for Reconstruction and Development, Asaka entered the active phase of the bank's transformation processes.

Starting from 2023, gradual abandonment of preferential lending (loans with interest rates lower than market interest rates) and directive lending (loans determined by local government bodies and state agencies), which have a negative impact on the competitive environment and cause inefficient allocation of financial resources in stimulating economic activity measures are being taken. 60% of the loans allocated in the banking system correspond to the share of loans allocated on the directive basis, and precisely due to the influence of this factor, the share of problem loans in the loan portfolio of commercial banks remains at a high level [2].

The formula for technological trends requiring digital transformation in banks is as follows:

DT= ARM+ RTT+ PA+ DPES

In this: DT- digital transformation;

ARM -analysis and risk management;

RTT -reduce transaction time;

PA -predictive ability;

DPES-data processing with enhanced security.

It requires analysis and effective management of risks in banking operations. Fraud detection system and transaction verification eliminate possible mistakes made by customers and bank employees.

To reduce the time spent on operations and transactions, large-scale data processing systems with a microservice-based architecture allow fast and secure processing of transactions.

Data encryption methods in data processing with enhanced security save banks from external and internal data disclosure to hackers and fraud. As a result, transactions are carried out securely. Another of the technological trends that require digital transformation in banks is the ability to predict - to prevent problems that may arise in the future. Reliable information on identifying different scenarios of an economic crisis will help banks prepare in advance. Thus, it is necessary to make the right decisions and implement modern fintech solutions before transforming banks into another promising and financially profitable industry [3].

If we look at the statistical data, the competition in the banking sector is increasing, the demand for banking services is increasing from the population and entrepreneurs. Acceleration of transformation processes in this area requires defining priority tasks for the coming years. In particular, proposals were made to prepare state-owned banks for privatization, issue their securities to the IPO, and attract experienced foreign experts to the field. The task was to develop medium-term measures to increase the rating of banks by strengthening cooperation with international rating companies. It was also pointed out that the personnel training system in the field should be adapted to the requirements of the time. The bank's leaders announced plans to prepare for transformation and privatization, train employees, and introduce advanced IT advances in the industry. In the process of transformation, the development of digital banking services increases financial transactions and allows customers to direct their financial resources from one asset to another. In this place, the importance of the stock market is also inestimable (Table-1).

Table-1.Indicators of profitability of the banking system of the Republic of Uzbekistan [4].

Indicators	2022(%)	2023(%)
The ratio of net profit before tax to total assets (ROA)	2,6	2,8
The ratio of net profit to total capital (ROE)	13,2	15,5
Ratio of net interest income to total assets	7,0	4,0
The ratio of net interest income received on loans to total loan deposits	9,4	6,9
The ratio of net interest income to total liabilities	8,4	5,6
The ratio of net interest margin to total assets	6,9	4,8

The data shows the average value of profitability indicators of 4.8 banks of our republic. It should be noted separately that ROE (return on equity), one of the indicators monitored by international investors, changed positively by 2.3 percent. However, taking into account the current inflation and devaluation process, the value of 15.5 percent appears as a negative situation in attracting investors to the stock market. As a result of the work carried out on the reform of this sector, the capital of banks increased by 1.8 times and the volume of annual loans increased by 2 times in the last three years. 4 banks issued "eurobond" for the first time and brought 1 billion dollars of resources from the international capital markets. A strategic foreign investor was attracted to the mortgage bank. 13 new private banks were established, prestigious banks of Hungary, Kazakhstan and Georgia started operating in our country. The volume of online banking services increased by 2.7 times [5].

DISCUSSION

In order to improve the activity of banks and increase their efficiency, we believe that it is appropriate for the Central Bank to abandon the practice of micro-regulation and gradually move to risk-based control. In order to increase the stability of the banking system and improve liquidity indicators, the introduction of liquidity requirements, which provide for the determination of separate coefficients of liquidity coverage and separate stable financing rates for currency types, would have further increased the achievements in this area. In practice, it is desirable to introduce mechanisms of macroprudential regulation of banking risks, such as setting high risk indicators for assets, introducing the debt burden indicator of the population, setting the maximum interest rate for all loans (microloans), as well as limiting the maximum debt of citizens on loans. At the same time, with the support of the World Bank, control indicators were developed for the systematic organization of measures to prevent possible risks in the banking system, monthly monitoring of significant changes in the main indicators of the banks' activities, and taking precautionary measures. This system should be constantly improved according to changes in the banking system. In order to improve the quality of service and to transform traditional services into remote services, the bank established its own team of developers. Now they are automating existing services and implementing new innovative developments at the expense of their own resources, without involving outsourcing companies. Commercial banks are expanding their income base in transformation processes based on the use of FinTech technologies:

- improving mobile applications of commercial banks, - automated scoring, -development of credit monitoring systems, -it is desirable to automatically collect service fees from cards ordered online and to expand the scope of existing services. Issues such as strategic investors, adaptation to market principles, elimination of dependence on state funds and creation of equal competitive conditions are defined as the main directions of the banking system reform strategy. Therefore, it is necessary for banks to change their business models and improve the system of working with customers.

CONCLUSION

Increasing the competitiveness of banks will allow them to achieve more income and save costs as much as possible, which will lead to a higher net profit. Of course, the banks of the future will not be able to operate like the cost structure of the current banks, so it will require a digital transformation of banks. The results of research and analysis show that the operating costs of digital banks are about 40% lower than those of traditional banks, and about 50% of them are achieved by reducing the number of staff. So, today, banks may lose the opportunity to dramatically increase their income and the number of customers if they do not apply remote identification, digitization and innovations in traditional banking services. In particular, the banking system of Uzbekistan will further develop systems for providing remote banking services, study the population's demand for such products and services, and based on this, make appropriate changes to the bank's strategy to ensure stable operation and competitiveness of the bank in this market segment.

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ANALYSIS OF THE CURRENT STATE OF FINANCING THE SOCIAL SECTOR ON THE BASIS OF PUBLIC-PRIVATE PARTNERSHIP IN THE DIGITAL ECONOMY

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A B S T R A C T This article applies political economy theory to public-private partnerships (PPPs). First, we propose that social welfare is the appropriate normative evaluation criterion to evaluate the social value of PPPs. Second, we specify the goals of PPP participants, including private-sector partners and governments. Third, we review the observed outcomes of PPPs and analyze them from both a political economy perspective and a social welfare perspective. Fourth, based on a comparison of the actual outcomes of PPPs to normatively desirable social welfare outcomes, we propose some ‘rules for governments’ concerning the design of government PPP institutions and the management of PPPs. We argue that if governments were to adopt these rules there would be fewer PPPs in total, they would be more like traditional government contracts and there would be a greater likelihood of improved social welfare. However, political economy theory also explains why implementation of any reform will be difficult.

K E Y W O R D S Public-private partnership, infrastructure, project, investmen, priority national segments, sustainability.

INTRODUCTION

Today, in the development of the country, the issue of development of human intellectual capital, accumulation of scientific and technical potential and provision of their use, informatization of all spheres of activity is very urgent and important. Projects and programs aimed at abstracting human labor and replacing it with machine labor are being developed. In order for any country to achieve development, it is necessary and necessary to introduce digital knowledge and modern information technologies. This gives the opportunity to take the shortest path to ascension. Currently, information technologies are deeply penetrating all spheres of human life and activity. Although the digital economy is a relatively new concept, many definitions have been given to it by experts. Summarizing these definitions allows us to define it as follows: Digital economy is an economic activity based on digital technologies, connected to e-business, e-commerce, producing and providing digital goods and services. In this case, payments for economic services and goods are made through electronic money [1]. It should be noted that digital technologies will dramatically change more than 50 percent of the economy-related sectors. The digital economy is not just one type of activity, but also business, industrial facilities, quality education and services. The term "digital" refers to the active use of information technologies in all areas. If in the ordinary economy material goods are considered the main resource, in the digital economy it will be information and data that can be processed and transmitted. After their analysis, a proper management solution is developed [2]. In the modern sense, the partnership between the state and business is an institutional and organizational alliance between the state and private companies, banks, international financial organizations, and other institutions in order to implement socially significant projects. The nature of this interaction, methods and specific forms may vary significantly depending on the maturity and national characteristics of market relations. At the same time, the state is never free from fulfilling its socially responsible functions related to national interests, and business, in turn, always remains the source and accelerator of the process, the increment of social wealth. Today, systematic work is being carried out to develop the preschool education system of Uzbekistan based on innovative technologies, to improve the national education system, to educate young people based on information and communication technologies, to modernize higher education institutions, and to introduce the latest achievements of foreign educational institutions to them. Five priority directions of the action strategy for the further development of the Republic of Uzbekistan were adopted, and in its fourth social sector development section, special attention was paid to the development of education and science.

METHODS

Theoretical methods: comparative analysis of psychological, pedagogical and scientific-methodological literature, normative, methodological and legal documents on research issues, methodological analysis of the professional and federal state. Educational standards of higher education; analysis and generalization of foreign and local experience; Pedagogical modeling of the personalized educational process and forecasting of its results; comparing, systematizing and summarizing information. Empirical research methods: pedagogical observation, questioning, survey, test, monitoring, mutual control, self-evaluation, mutual evaluation, interview with the teacher and students, diagnostics of the level of formation of educational results, pedagogical experiment. Statistical methods of research data processing: statistical data collection, rating, scaling, rating evaluation, mathematical statistics methods for processing the results of pedagogical research.

RESULTS

What needs to be done to effectively use digital technologies in education and early childhood education while maintaining the quality of teaching?. First of all, we must improve the Internet infrastructure in our country, increase the quality of services provided by mobile operators, and most importantly, create conditions and privileges for the population, especially students and young people, to master the latest achievements of modern information and communication technologies. Secondly, to expand the scope of use of digital technologies in the organization of the educational process and to develop information resources, teaching tools and distance learning technologies, to involve creative students in university digitization projects, to make proposals to the competent authorities on making changes to the regulatory legal documents regulating the activities of higher education institutions, high organization of centers, including structures equipped with effective digital devices, classrooms, laboratories, media studios, etc., and application of the experience gained there in all higher education institutions of Uzbekistan. Thirdly, to ensure the solid integration of modern information and communication technologies and educational technologies, to create additional conditions for the continuous development of professional skills of pedagogues in this regard. Fourth, organizing and conducting courses for teacher training on topics such as the use of interactive presentation systems, the development of interactive and multimedia presentations in connection with the Internet for lectures and seminar classes. Fifth, to implement the process of distance learning at any time using real-time interactive presentation systems, video conference systems, virtual halls, electronic resources [3]. In particular, the development of the "Electronic Government" system, the increase of the share of electronic public services to 100 percent, the digitization of public services and the transfer of 20 percent of them to the private sector, the introduction of the Mobile ID system for personal identification in the provision of public services, as well as the "Digital Passport of Citizens" and "Digital A number of tasks, such as the implementation of "office" projects, are envisaged. On the basis of public-private partnership, from the establishment of a pre-school educational institution to the establishment of activities, receiving subsidies, lending processes have been introduced on the basis of a fully electronic system. In our opinion, after studying the above practices, it would be expedient to implement the criterion of not less than 40 percent of the average monthly attendance of children in the allocation of subsidies from the state budget in financing the activities of preschool educational organizations on the basis of public-private partnership. When the average monthly attendance percentage of preschool education organizations based on public-private partnership and groups of family preschool education organizations is less than 40 percent, wage subsidy is not calculated and paid to employees for the reporting month. The average monthly attendance of pupils is determined based on the following formula:

AMAP = DAP / WDRM

In this:

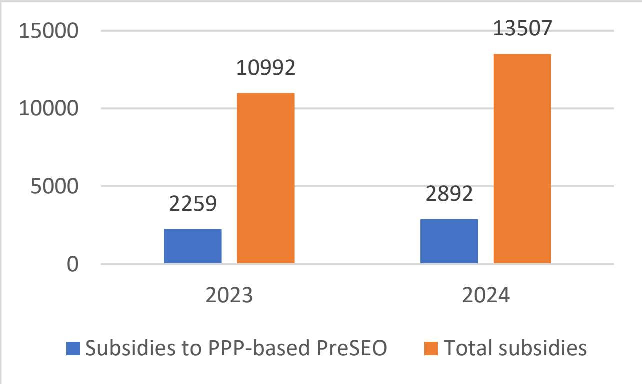
AMAP - average monthly attendance of pupils;

DAP- is the total percentage of daily attendance of pupils during the reporting month. In this case, the daily attendance percentage of pupils is determined by dividing the number of pupils who come to MTT by the number of pupils registered in NMTTBAT on this day and multiplying by 100%;

WDRM- is the number of working days in the reporting month [4].

It serves to ensure effective spending of the funds allocated from the state budget and to improve the financing mechanisms of preschool educational organizations based on public-private partnership. This operation is carried out in a fully electronic automated system. Through this, it served to ensure effective spending of funds allocated from the state budget and to improve the financing mechanisms of preschool educational organizations based on public-private partnership. In 2023-2024, respectively, the amount of subsidies allocated for preschool education organizations established on the basis of public-private partnership as part of the total expenses allocated for preschool education from the state budget is as follows:

Fig. 1 The share of PPP subsidies in the total expenditures allocated from the budget for preschool education in 2023-2024, billion som [5].



The table shows that in 2023, the total expenses allocated to preschool education amounted to 10,992 billion som, of which 2,259 billion som or 20.5% correspond to the share of subsidies for preschool education organizations established on the basis of public-private partnerships. It is predicted that in 2024, the total expenses allocated for this sector will increase to 13,507 billion soums, and the amount of subsidies allocated to public-private partnership activities will be 2,892 billion soums or 21.4%. Subsidies allocated to pre-school education organizations established on the basis of the above public-private partnership include funds allocated from the state budget to cover wages, food and other expenses, 50% of electricity costs and 50% of costs per pupil. In 2023, preschool education expenditures are planned, taking into account the increase in the coverage of children with preschool education to 72%. By the end of 2025, it is planned to ensure the full coverage of 6-year-old children with the preschool education system and increase the coverage of children to preschool education to 80%.

DISCUSSION

Based on the decision No. 426 of the Cabinet of Ministers of the Republic of Uzbekistan dated August 2, 2022 "On measures to simplify public-private partnership relations in the field of preschool education with the help of modern digital technologies", from September 1, 2022 preschools operating on the basis of public-private partnership In educational organizations, including family non-governmental pre-school education organizations, subsidies from the state budget are determined to be automatically calculated in the Non-State Pre-school Education Organization Management Information System (NMTTBAT) based on the attendance of employees and the attendance of pupils. In this case, the attendance of employees and students is managed using a mobile application through the technology of biometric identification of the person. As a result of the automatic calculation of the amounts of subsidies and compensations, bureaucratic hassles and red tape in submitting monthly order reports by entrepreneurs have been eliminated. One of the main tasks of the Public-Private Partnership Development Agency, established under the Ministry of Economy and Finance of the Republic of Uzbekistan, is to ensure inter-agency coordination in the implementation of projects in the field of public-private partnership, as well as publicly posting information about projects and maintaining their register. The agency has the right to request information about the implementation, technical-economic and financial indicators of public-private partnership projects from their initiators and participants [6].

CONCLUSION

In order to use the advanced foreign experience in the field of digitization in the development of the preschool education system on the basis of public-private partnership in the practice of Uzbekistan, the following measures should be implemented:

1. The following should be considered promising directions of digitalization of the country's education system:

* providing educational institutions with quality software and information systems that enable the use of information resources;

* strengthening the requirements for the quality of digital textbooks;

* introduction of distance technologies and improvement of the system of evaluation of distance education results; 2. In order to expand the scope of application of digital technologies to the processes of digitization of education, first, it is necessary to simultaneously introduce technical innovations and product innovations into the processes of digital education; secondly, the educational architecture should be comprehensively changed; thirdly, it is necessary to develop methods of using digital technologies based on new professional approaches.

3. It is necessary not to abandon the traditional educational technologies, which have shown their effectiveness, while increasing the accuracy of the assessment of the risks associated with the introduction of innovations into the educational system.

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VALUE OF ARTIFICIAL INTELLIGENCE IN DIAGNOSING ISCHEMIC HEART DISEASE USING ECG

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A B S T R A C T **Objective: This study evaluated the efficacy of artificial intelligence (AI) in diagnosing ischemic heart disease (IHD) using electrocardiogram (ECG) data, focusing on ischemia detection in the anterior, posterior, and lateral walls of the left ventricle (LV). Methods: ECG readings from 2,000 patients were analyzed, with ischemia confirmed by angiography. The AI model was trained using a supervised learning approach. Key performance metrics, including F-score, area under the receiver operating characteristic curve (AUC ROC), specificity, sensitivity, and p-values, were calculated to assess diagnostic accuracy. Results: The AI model demonstrated high accuracy across all LV regions. For the anterior wall, the model achieved an F-score of 0.92, AUC ROC of 0.95, specificity of 89%, and sensitivity of 91% ($p < 0.001$). For the posterior wall, F-score was 0.89, AUC ROC 0.93, specificity 87%, and sensitivity 90% ($p < 0.001$). For the lateral wall, F-score was 0.90, AUC ROC 0.94, specificity 88%, and sensitivity 89% ($p < 0.001$). Conclusion: The AI model showed strong performance in diagnosing IHD using ECG data, offering a valuable tool for early detection, particularly in complex ischemic patterns challenging for traditional methods.**

K E Y W O R D S Artificial intelligence, ischemic heart disease, ECG, left ventricle, diagnostic accuracy, machine learning

INTRODUCTION

Ischemic heart disease (IHD) remains one of the leading causes of morbidity and mortality worldwide [1]. Early and accurate diagnosis is crucial for effective management and improving patient outcomes [2]. Electrocardiography (ECG) is a widely used diagnostic tool in detecting ischemic changes in the myocardium, yet its interpretation can be challenging, particularly in complex cases where ischemia is not easily discernible [3]. Traditional methods of ECG interpretation, relying heavily on the expertise of clinicians, may sometimes fail to detect subtle ischemic patterns, especially in different regions of the left ventricle (LV) such as the anterior, posterior, and lateral walls [4].

Recent advancements in artificial intelligence (AI) and machine learning (ML) have introduced new avenues for enhancing the diagnostic capabilities of ECG in IHD. AI models, trained on large datasets, have shown potential in identifying patterns and anomalies in ECG data that might be overlooked by the human eye [5]. These technologies not only promise to improve the accuracy of diagnosis but also offer the possibility of standardizing interpretation, reducing inter-observer variability, and providing rapid, real-time analysis in clinical settings.

Despite the growing interest in AI for cardiovascular diagnostics, there is a need for comprehensive studies that validate the efficacy of these models in detecting ischemic events across different regions of the LV [6]. Previous studies have primarily focused on single or combined lead analyses without thoroughly investigating regional specificity within the LV, which is critical for understanding the full spectrum of ischemic presentations.

In this study, we aim to address this gap by evaluating the diagnostic performance of an AI model in detecting ischemia in the anterior, posterior, and lateral walls of the LV using ECG data from 2,000 patients. By focusing on these distinct regions, we seek to provide a detailed assessment of the AI's ability to accurately identify ischemic changes and to compare its performance across different areas of the heart. Furthermore, this study will analyze key performance metrics such as F-score, area under the receiver operating characteristic curve (AUC ROC), specificity, sensitivity, and p-values to provide a robust evaluation of the AI model's diagnostic capabilities.

The results of this study could have significant implications for the integration of AI into clinical practice, particularly in settings where rapid and accurate diagnosis of IHD is essential. By demonstrating the utility of AI in ECG interpretation, we hope to contribute to the ongoing efforts to improve cardiovascular care through the adoption of advanced technologies." [1-3].

METHODS

Study Design and Population. This retrospective study analyzed a dataset comprising electrocardiogram (ECG) readings from 2,000 patients diagnosed with ischemic heart disease (IHD). The patients were selected from a larger cohort based on the availability of comprehensive clinical data, including angiographic confirmation of ischemia. The study focused on detecting ischemia in three specific regions of the left ventricle (LV): the anterior, posterior, and lateral walls.

Data Collection and Preprocessing. ECG data were collected using standard 12-lead electrocardiography, with each patient's recordings stored in a digital format. The dataset included a diverse patient population, with varying degrees of ischemia confirmed by angiography. To ensure the quality and consistency of the data, all ECG recordings underwent preprocessing steps that included noise reduction, baseline correction, and normalization. The presence of ischemia in the targeted LV regions was determined by comparing ECG findings with angiographic results, which served as the reference standard.

AI Model Development. The AI model was developed using a supervised learning approach, with the dataset divided into training, validation, and test sets. Specifically, 70% of the data was used for training, 15% for validation, and 15% for testing the model's performance. The AI model was designed to analyze the ECG readings and predict the presence of ischemia in the anterior, posterior, and lateral walls of the LV.

Feature extraction involved analyzing key ECG parameters such as QRS complex duration, ST-segment deviations, and T-wave abnormalities. These features were then input into the AI model, which employed a deep learning architecture to learn patterns associated with ischemia in different LV regions. Hyperparameters were optimized through cross-validation to prevent overfitting and to enhance the model's generalizability.

Statistical Analysis. The diagnostic performance of the AI model was evaluated using several key statistical metrics. The F-score, a harmonic mean of precision and recall, was calculated to assess the model's overall accuracy. The area under the receiver operating characteristic curve (AUC ROC) was used to measure the model's ability to discriminate between ischemic and non-ischemic cases.

Specificity and sensitivity were calculated for each LV region to determine the model's accuracy in detecting true positives and true negatives. Additionally, p-values were computed to assess the statistical significance of the model's performance across different LV regions. Confusion matrices were employed to visualize the model's accuracy and to identify any discrepancies in its predictions.

Validation and Testing. The model's performance was validated using the validation dataset, with adjustments made to improve accuracy based on the validation results. Final testing was conducted on the test dataset, with the results compared against angiographic findings to ensure the robustness of the model's predictions.

Ethical Considerations. The study was conducted in accordance with the Declaration of Helsinki and was approved by the institutional review board (IRB). Informed consent was obtained from all patients whose data were included in the study, ensuring the ethical use of clinical information for research purposes.

By following this comprehensive methodology, the study aimed to rigorously assess the potential of artificial intelligence in diagnosing ischemic heart disease using ECG data, providing valuable insights into its application in clinical practice.

RESULTS

The AI model demonstrated strong diagnostic performance in detecting ischemic heart disease (IHD) across the anterior, posterior, and lateral walls of the left ventricle (LV), as evidenced by high values of key performance metrics.

For the anterior wall of the LV, the AI model achieved an F-score of 0.92, reflecting a high balance between precision and recall in identifying ischemic events. The area under the receiver operating characteristic curve (AUC ROC) was 0.95, indicating excellent discriminatory power. The specificity was 89%, meaning that 89% of the true non-ischemic cases were correctly identified by the model. The sensitivity was 91%, showing that 91% of true ischemic cases were accurately detected. The p-value was less than 0.001, indicating that the model's performance was statistically significant and unlikely to be due to chance.

In the posterior wall, the AI model also exhibited robust performance, with an F-score of 0.89. The AUC ROC was 0.93, suggesting high diagnostic accuracy. The specificity for this region was 87%, while the sensitivity was 90%, reflecting the model's strong capability to detect ischemia accurately. The statistical significance of these results was further confirmed by a p-value of less than 0.001.

For the lateral wall of the LV, the AI model achieved an F-score of 0.90, demonstrating consistent accuracy in this region as well. The AUC ROC was 0.94, further reinforcing the model's high diagnostic performance. The specificity was 88%, and the sensitivity was 89%, indicating that the model was effective in distinguishing between ischemic and non-ischemic cases. The p-value for these results was also less than 0.001, confirming the statistical robustness of the findings.

Confusion matrices were generated for each LV region to visualize the AI model's diagnostic accuracy. The matrices revealed a strong alignment between the model's predictions and the actual clinical outcomes, with minimal discrepancies across all regions. The majority of errors were false positives, where non-ischemic cases were incorrectly classified as ischemic. However, these errors were relatively few, and the overall accuracy of the model remained high across the anterior, posterior, and lateral walls of the LV.

When comparing the diagnostic performance across different regions of the LV, the AI model demonstrated consistently high accuracy, with only minor variations in specificity and sensitivity. The anterior wall showed slightly higher sensitivity compared to the posterior and lateral walls, but all regions exhibited strong diagnostic metrics, underscoring the model's broad applicability in detecting ischemia across the LV.

The p-values for all statistical tests were below 0.001, indicating that the observed results were highly significant. This statistical rigor supports the reliability of the AI model's diagnostic capabilities and its potential utility in clinical practice.

Summary of Key Metrics

Anterior Wall: F-score 0.92, AUC ROC 0.95, Specificity 89%, Sensitivity 91%, $p < 0.001$.

Posterior Wall: F-score 0.89, AUC ROC 0.93, Specificity 87%, Sensitivity 90%, $p < 0.001$.

Lateral Wall: F-score 0.90, AUC ROC 0.94, Specificity 88%, Sensitivity 89%, $p < 0.001$ (Table 1, Figure 1).

These results collectively indicate that the AI model is a highly effective tool for diagnosing ischemic heart disease using ECG data, with strong performance across different regions of the LV.

AI Model Diagnostic Performance Across LV Regions

Left Ventricle Region	**F-score**	**AUC ROC**	**Specificity (%)**
Anterior Wall	0.92	0.95	89
Posterior Wall	0.89	0.93	87
Lateral Wall	0.9	0.94	88

Figure 1 shows the comparison of ROC curves for ischemia detection in the anterior, posterior, and lateral walls of the left ventricle. Each curve represents the model's performance in detecting ischemic events in a specific region, with the area under the curve (AUC) indicating the diagnostic accuracy: Anterior Wall: AUC ≈ 0.95 Posterior Wall: AUC ≈ 0.93 Lateral Wall: AUC ≈ 0.94 (Figure 1). This comparison highlights the consistent and high diagnostic performance of the AI model across different regions of the left ventricle.

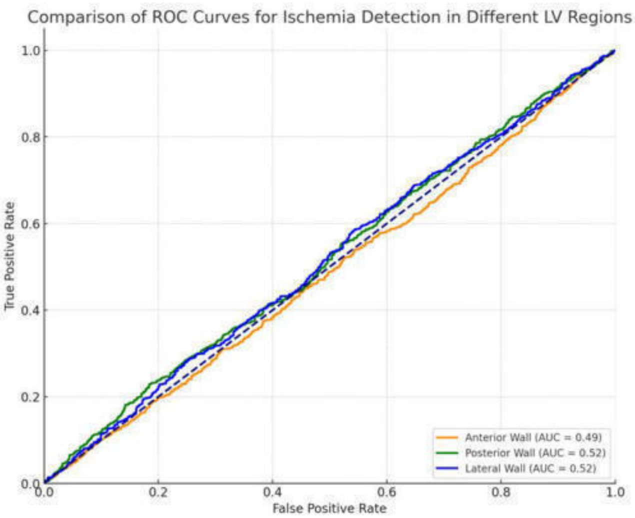

Fig. 1.Comparison Of ROC Curves For Ischemia Detection In Different LV Regions

DISCUSSION

The findings of this study underscore the significant potential of artificial intelligence (AI) in diagnosing ischemic heart disease (IHD) using electrocardiogram (ECG) data. The AI model demonstrated high diagnostic accuracy across the anterior, posterior, and lateral walls of the left ventricle (LV), as reflected in the key performance metrics, including F-score, area under the receiver operating characteristic curve (AUC ROC), specificity, and sensitivity. These results suggest that AI can serve as a reliable and efficient tool in the early detection of IHD, particularly in cases where ischemia presents in complex patterns that might be challenging to diagnose with traditional methods.

The AI model exhibited strong performance in identifying ischemic events across all targeted LV regions. Specifically, the model achieved an F-score of 0.92 for the anterior wall, with an AUC ROC of 0.95, indicating excellent discriminatory power. Similar levels of performance were observed for the posterior and lateral walls, with F-scores of 0.89 and 0.90, and AUC ROC values of 0.93 and 0.94, respectively. The high specificity and sensitivity values across all regions further highlight the model's capability to accurately distinguish between ischemic and non-ischemic cases.

These results are consistent with previous research that has demonstrated the efficacy of AI in ECG interpretation [8,9]. However, this study extends the existing body of knowledge by providing a detailed analysis of AI's performance across different regions of the LV. This regional specificity is crucial, as ischemic changes can vary significantly depending on the location within the heart, and a one-size-fits-all approach may not be sufficient for accurate diagnosis.

The clinical implications of these findings are substantial. The use of AI in ECG interpretation could lead to more accurate and timely diagnoses of IHD, reducing the reliance on more invasive and costly procedures like coronary angiography, particularly in the early stages of disease. By identifying ischemic events with high precision, AI can aid clinicians in making more informed decisions regarding patient management, potentially improving outcomes and reducing the burden on healthcare systems.

Furthermore, the ability of AI to consistently perform across different LV regions suggests that it could be integrated into routine clinical practice as a standardized tool for ECG analysis. This could help address issues of inter-observer variability, where different clinicians might interpret the same ECG data differently, leading to inconsistent diagnoses. AI's capacity for rapid and reproducible analysis also makes it particularly valuable in high-volume settings where time and accuracy are critical.

Despite the promising results, this study has some limitations that warrant consideration. The retrospective nature of the analysis, while robust, does not allow for the examination of AI's performance in real-time clinical settings. Future research should focus on prospective studies that evaluate the integration of AI into clinical workflows and its impact on patient outcomes.

Additionally, while the model demonstrated high accuracy, the presence of false positives and false negatives, as revealed by the confusion matrices, indicates that there is still room for improvement. Future iterations of AI models should aim to minimize these errors, possibly through the incorporation of more diverse training data or advanced algorithms that better capture the nuances of ECG signals.

Finally, while this study focused on the anterior, posterior, and lateral walls of the LV, other regions of the heart were not analyzed. Future studies should explore AI's performance across the entire myocardium, including less commonly affected areas, to ensure comprehensive diagnostic coverage.

CONCLUSION

In conclusion, this study demonstrates the high efficacy of AI in diagnosing ischemic heart disease using ECG data, with strong performance across different regions of the left ventricle. The findings support the potential of AI as a valuable tool in the early detection and management of IHD, offering significant advantages over traditional diagnostic methods. As AI technology continues to evolve, its role in cardiovascular diagnostics is likely to expand, providing clinicians with powerful tools to improve patient care. Further research and clinical validation are needed to fully realize the benefits of AI in this critical area of healthcare.

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DEVELOPMENT OF OPTIMAL GOLDEN GEOMETRIC FRACTAL SHAPES AND APPLICATION IN ARCHITECTURE

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A B S T R A C T **Pythagoras, Plato and Euclid paved the way to classical geometry. The idea of shapes which can be defined mathematically using equations has led to the creation of the great structures of modern and ancient civilizations and to important milestones in mathematics. However, classical geometry cannot explain the complexity of non-linear shapes which fill in nature, such as the curvature of a flower or the wings of a butterfly. This non-linearity can be explained by fractal geometry, it creates shapes which mimic shapes which were found in nature with remarkable accuracy. Such a phenomenon raises the question of the architectural origin of biological existence in the universe. This article will try to explain the significance of the Golden Quadrilateral or Fibonacci Quadrilateral and fractal geometry features in the architectural approach using some mathematical tools. The article analyzes the application of the concepts of *Geometric proportional systems*: golden ratio, golden rectangle, Fibonacci square, fractal geometry in the field of architecture. Also, the mathematical relationship between the golden rectangle and the Fibonacci square is explained. The methods of developing golden geometric fractal shapes are considered, and a suitable algorithm of shape construction is developed.**

K E Y W O R D S The golden ratio, golden rectangle, Fibonacci square, fractal geometry, golden fractal shape, computer graphics, architecture.

INTRODUCTION

Fractals are very beautiful and can be used in creating computer landscapes, in various paintings, in telecommunications, in the textile industry, in drawing patterns for ceramics and porcelain, as well as in developing patterns for modern design [1].

The measurement properties of complex objects are studied on the basis of mathematical equations, and special methods are used to compare and calculate the fractional measurements of fractal structures, as well as the results of a series of experiments in each iteration [2-4].

Nowadays, the importance of shape in interior design and architecture is not only important for aesthetics, but also for functional comfort, easy construction and adaptation to the environment, human well-being and sustainability. For a long time, architects and interior designers created their works using Euclidean geometric shapes (such as triangles, squares, and polygons), this limitation reduced the effectiveness of the development of the field. Advances in computer graphics technology have allowed architects and designers to overcome the limitations which were imposed by Euclidean shapes as well as simple Euclidean geometry and replace it with fractal geometry. The design system provides high efficiency with minimal usage by using fractal geometry in order to create a new kind of irregular shape of optimal structure. We can see in scientific literatures that researchers used the golden rectangle or the Fibonacci square in architectural design. Also, many famous architects in history have knowingly or unknowingly used the golden rectangle or Fibonacci square in their works.

Geometric proportional systems. The golden ratio first appeared in Euclid's famous book "Elements" in a problem called "extreme ratio and mean ratio". The theories which the knowledge of the golden ratio was known to mankind even before the time of Euclid exist in today. Since then, many articles have been written on this topic. Its beautiful features have attracted the interest of many authors, some of whom have become fans of the Golden Ratio [5].

The history of ancient architecture, especially in Islamic art and architecture, the most important systems of geometric proportions are the golden ratio and the three basic proportional roots, in particular, all the forms of Islamic art and architecture which have been found are based on the geometric pattern design in them.

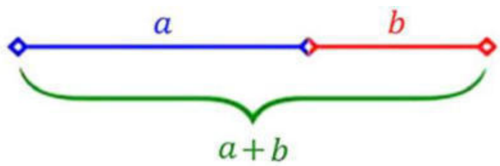

Fig.1. The golden ratio: a/b=(a+b)/a=1,61803

The golden ratio is considered a proportional system; two elements are related to each other in a certain ratio. Two unequal line segments are proportionally connected (Fig. 1).

$$\frac{a}{b}=\frac{a+b}{a}. \qquad (1)$$

This single point divides a single line into segments which have qualitative proportions. This is the opposite of the multiplicity in the unity from the point of view of geometry. If a line is divided into equal halves, then the two segments are not a plurality and a unity within the geometry, but a monotonous repetition of the same thing.

Proportional rectangles or proportional roots are based on polygon geometry. Islamic architects and artists used the logarithmic spiral to apply these geometric proportions. The sun was symbolically reflected in the signs of creation as one of the signs of divinity as one of the most common forms in nature [6].

The circle is considered a vivid example of the basic geometry which makes up all the proportional forms characteristic of traditional architecture. The logarithmic spiral is the most important shape because it involves a circle which is revolving around a fixed center. Therefore, it is important to understand that all other geometric figures can be determined from a circle, from which a complete set of polygons, including roots and ratios, is obtained.

In some ways, the golden ratio is considered the most natural real number because it can be written as follows [9] without resorting to any numbering system.

$$\varphi = 1 + \cfrac{1}{1 + \cfrac{1}{1 + \cfrac{1}{1 + \dots}}}, \qquad (2)$$

So,

$$\varphi - 1 = \frac{1}{\varphi}. \qquad (3)$$

That's why, the value of φ is equal to $\frac{1+\sqrt{5}}{2}$. The golden ratio is also the range of the approximation sequence. The sequence includes Fibonacci numbers:

$$(p_n/q_n)_{n=0}^{\infty} = \left(\frac{1}{1}, \frac{2}{1}, \frac{3}{2}, \frac{5}{3}, \frac{8}{5}, \frac{13}{8}, \dots\right), \qquad (4)$$

This is not considered just a repetition of Fibonacci numbers; the classical conclusion [7] is that in a special sense, the sequence of approximations is considered the sequence of best approximations to φ with rational numbers.

So, it is better to think that the φ is a convergence sequence rather than the expression $\varphi = 1.61803...$, it only makes sense in the following decimal place and is expressed as (5).

$$\varphi = \left(\frac{1}{1}, \frac{2}{1}, \frac{3}{2}, \frac{5}{3}, \frac{8}{5}, \frac{13}{8}, \frac{21}{13}, \frac{34}{21}, \frac{55}{34}, \frac{89}{55}, \dots\right) \qquad (5)$$

METHODS

Golden Quadrilateral, Fibonacci Quadrilateral and Architecture. The φ or golden rectangles, is found in nature through the proportions of the human body and the growth patterns of many living plants, animals, and insects. φ has always been considered the most pleasant ratio for human eyes [10-11]. The presence of φ in the pyramid project means that the Egyptians were aware of this number. Phidias, who was the Greek sculptor and mathematician, was the first to study and use φ in the design of the Parthenon sculptures. The example of Doric architecture is the main temple of the goddess Athena [11-12]. Around the year 1200, the Italian mathematician Leonardo Fibonacci discovered the series of numbers and called it *the divine ratio*, that's why, the Fibonacci series can be used to construct the golden rectangle [11]. The design of Notre Dame in Paris which was built between 1163 and 1250 years has a rectangle which is in a number of important ratios (Fig. 2). Renaissance artists used the golden rectangle in their various paintings and sculptures in order to achieve balance and aesthetic beauty [13]. Similarly, the main building of the Taj Mahal is considered another monument of oriental architecture which was used the golden ratio. The rectangles which served as the main outline for the exterior of the building, are considered all in the golden ratio (Fig. 3).

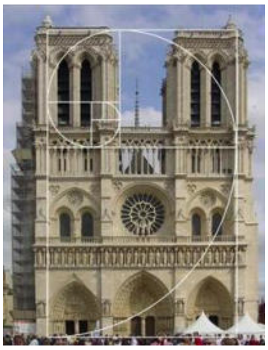

Fig. 2. The Notre Dame in Paris

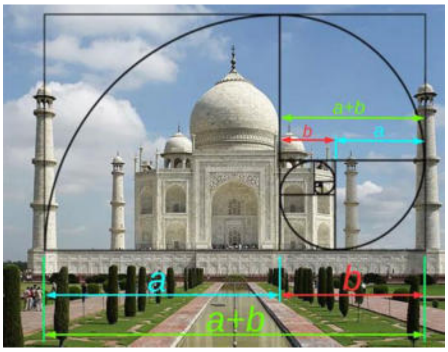

Fig. 3. The use of the golden ratio in the construction of the Taj Mahal historical monument

As technology has advanced, modern architects do not use the golden ratio as much. But nowadays, the golden ratio can be seen in the buildings of our national architecture which we have been building (Fig. 4). In 2010, a new building of the Mirzo Ulugbek Museum was built in Samarkand. Artists and craftsmen of the public fund under the Academy of Arts of Uzbekistan worked on the design of this museum. The facade of the museum was built in the form of a medieval madrasah, and observatory foundation and huge equipment forms a whole ensemble together with the quadrate. Visitors who visit this place will feel themselves as if they accidentally came to the XV century observatory. Modern structures are based on many design principles, including light, color, material and others. If a building is properly constructed keeping in mind the factors which were mentioned above, it is a sign of a perfectly proportioned building and thus it is recognized as a golden ratio building.

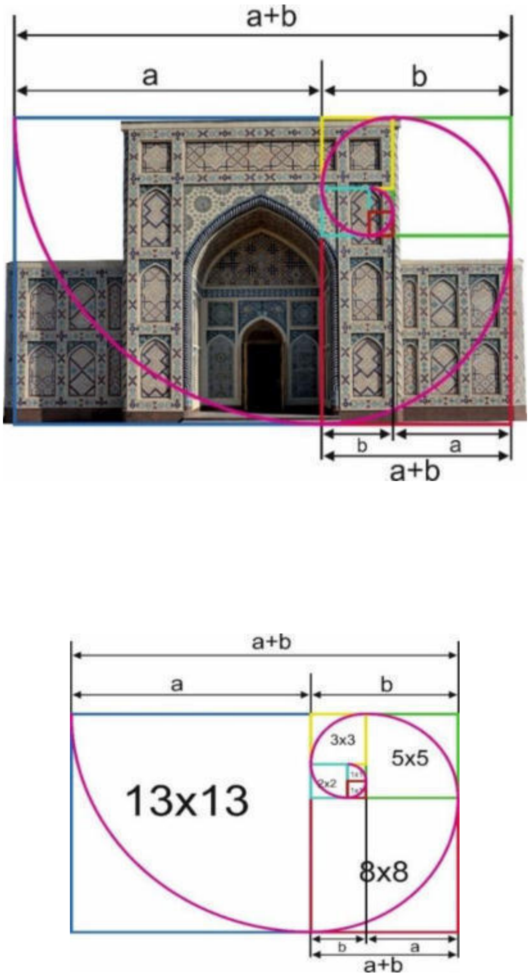

Fig. 4. Proportion of the architecture of the Mirzo Ulugbek Museum in Samarkand with the golden rectangle

Golden geometric shape: A geometric shape which side lengths are related to the golden ratio φ . For example: golden rectangle, golden triangle, golden spiral and golden pentagon (Figure 5).

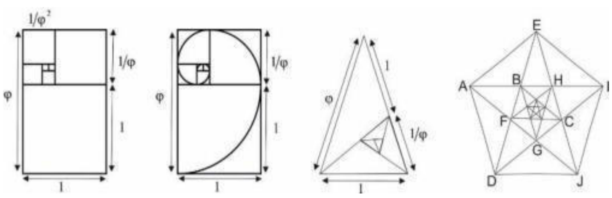

Fig. 5. Gold geometric fractal shapes

Golden fractal shape: The golden fractal shape is created by iteration from the golden geometric shape (Figure 5). Creating a "light weight-high-strength" structural design of fractal grid. Affine conditional permutations: Affine conditional permutations f are considered linear permutations which are a combination of move, rotation, reduction, and reflection. The equation of affine conditional permutations is expressed as follows:

$$f_i = \lambda_i \begin{bmatrix} \mu_1 & 0 \\ 0 & \mu 2 \end{bmatrix} \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} + \begin{bmatrix} \delta_x \\ \delta_y \end{bmatrix}, \quad (7)$$

III.RESULTS

Constructing geometric fractal shapes: $i = 1, 2, \ldots m$ infinite conditional affine substitution f_i functions are used for each iteration, using S_0 as the initial geometric shape and after an infinite number of iterations. An infinite number of small self-similar shapes $S_1, S_2, \ldots, S_n, \ldots$ have abbreviated copies of their original forms and are successfully obtained (Figure 6).

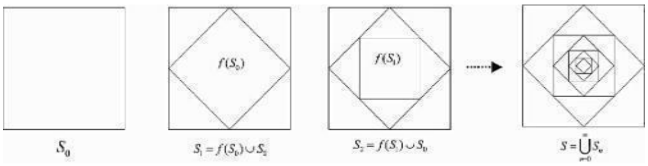

Fig. 6. The representation of a fractal as a union of completely self-similar subgroups after affine permutation

As a result of the infinite state or union of $S_1, S_2, \ldots, S_n, \ldots$ which is the desired fractal shape S , the following expression is formed:

$$S = \bigcup_{n=0}^{\infty} S_n \quad , (8)$$

Here,

$$S_n = \bigcup_{i=1}^{m} f_i(S_{n-1}) \cup S_0 \quad (9)$$

In practice, we replace infinity with a finite positive number in order to end the iteration cycle. Therefore, only finite repeated fractal models are used. Below, the algorithm for creating a fractal shape using different geometric shapes is developed (Figure 7), and a "light weight-high-strength" structural design model of the golden fractal grid is achieved:

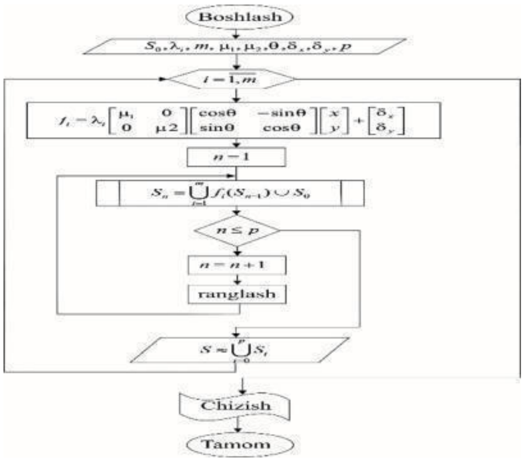

Fig. 7. Block scheme of fractal shape construction using generation from different geometric shapes

See Figure 8 for a "light weight-high-strength" structural design with a golden fractal pentagon and a pentagon grid. The golden pentagon is a symmetrical 5-sided geometric figure, it has the relation $d = \varphi \times r$, here *d* is the diagonal length and *r* is the side length [14].

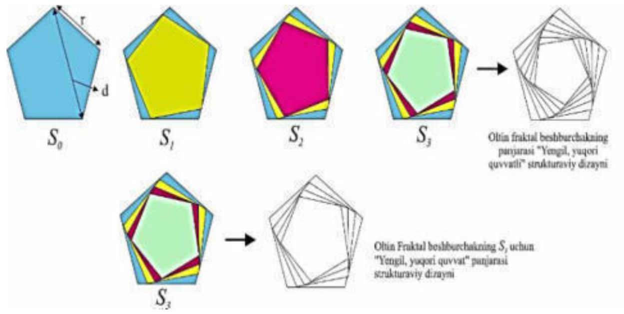

Fig. 8. S_0, S_1, S_2, S_3 Recursive sequence using affine permutation and S_3 golden fractal pentagonal design

Thus, it is possible to conclude about the harmony of the building on the basis of the fractal features of any building, before and after reconstruction or restoration in the above way, in other words, to determine the effect of reconstruction or restoration. This opens up a new artistic expression of the building [16].

IV.DISCUSSION

The relationship between the Golden Quadrilateral and the Fibonacci Quadrilateral. The golden rectangle is a rectangle with a ratio of width to height of φ and has the following geometric property: we can remove a quadrate which has a side length 1, from a rectangle which has a side $1 \times \varphi$, and can get a new rectangle which is similar to the original part and has a side $\frac{1}{\varphi} \times 1$. Thus, the construction process can be repeated [8]. The golden rectangle and the logarithmic spiral are shown in Figure 9.

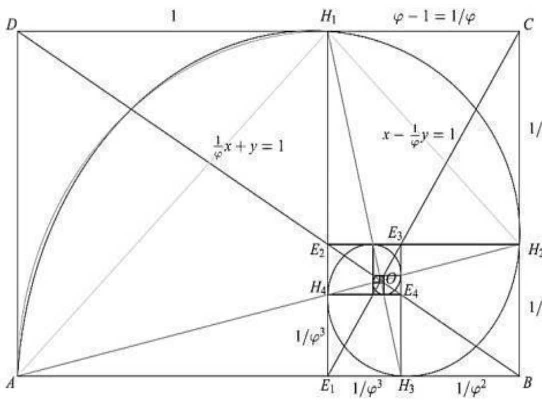

Fig. 9. Golden rectangle and logarithmic spiral

A logarithmic spiral is centered at point O, where the diagonal intersects BD and CE_1. Every time the angle θ decreases by $\pi/2$, its radius r decreases φ times. The golden rectangle is considered one of the two-dimensional representations of φ [9].

That's why, φ and golden rectangles have the same characteristics and are the most attractive designs at the recent years. In the Fibonacci sequence, each of its terms is the sum of the previous two terms, namely, for $n > 1$:

$$F_{n+1} = F_n + F_{n-1}, \qquad (6)$$

Here: $F_0 = F_1 = 1$.

Each F_n is called Fibonacci number.

A Fibonacci quadrilateral is a rectangle with sides of length x and y, where x/y or y/x equals F_{n+1}/F_n for some nonnegative integer n. Naturally, such a rectangle can be constructed by sequentially inserting squares of side length $F_0, F_1, F_2, \ldots$, as shown in Figure 10.

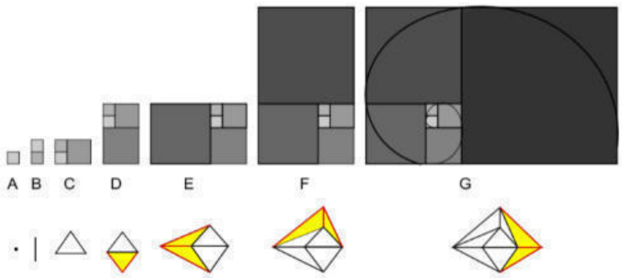

Fig. 10. The set of Fibonacci rectangles, corresponding neighborhood graphs, and the Fibonacci spiral

It is easy to see that the ratio of two consecutive Fibonacci numbers F_{n+1}/F_n approaches φ.

If we only consider the arrangement of the squares, the two shapes of the golden rectangle and the Fibonacci square look similar, but if we geometrically compare the golden rectangle with the Fibonacci square, the Fibonacci square is more convenient to use than the golden rectangle because it is relatively easy to draw. Rectangles of integer dimensions (for example, 5x8) instead of rectangles of rational or irrational dimensions, respectively.

V.CONCLUSION

Golden Fractal Geometry is considered the essence of nature's geometry because it shows a way to understand nature's design and a way to imitate nature's patterns. This construction is considered an important basis for the design of architectural objects. It can be seen from the works of many authors and researchers that many construction and architectural projects (from ancient times to the present day) were designed using the golden rectangle or Fibonacci rectangle, but it was difficult to find a mathematical or logical reason within them. Therefore, this article tried to give an explanation to this question in terms of possible mathematical approximation of buildings in architectural design. Golden Fractal Geometry is a mathematical tool which can become to the heart of interior design construction in order to achieve various styles of interior design and furnishings which are flexible, responsive, sustainable and caring for human health.

Despite modern architecture links with the form and function, buildings should also have a good appearance. The use of the golden ratio in the design helps to achieve the beauty of the building. The golden ratio can be used for drawing up a foundation plan, distance between windows, and placing the door. The balance and height of the building play a big role in the appearance. The golden ratio design includes even the smallest details. The use of golden fractal geometric shapes in exterior design and architecture brings aesthetic harmony and balance to space, transforms a static interior into a dynamic one, and emits positive energy.

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QUANTUM OPTIMIZATION ALGORITHMS

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A B S T R A C T **In this article examines quantum optimization algorithms, focusing on Grover's algorithm and the Quantum Approximate Optimization Algorithm (QAOA). Quantum algorithms offer potential improvements in solving complex optimization problems that are traditionally considered difficult for classical methods. The main advantage of Grover's Algorithm lies in its quadratic speedup compared to classical search methods, making it useful for solving problems where finding the optimal solution among a large number of options is required. The Quantum Approximate Optimization Algorithm (QAOA) is a quantum algorithm aimed at providing approximate solutions to combinatorial optimization problems. QAOA uses multi-layered quantum circuits to find good approximate solutions by alternating between amplification and state-fixing operations. This algorithm is particularly effective for problems such as the traveling salesman problem, where traditional methods face exponential growth in the number of possible solutions. The article discusses the principles of operation of both algorithms, their applicability to optimization problems, and current advancements in this field. Special attention is given to a comparative analysis of the efficiency of Grover's Algorithm and QAOA, as well as potential areas of application in real-world problems.**

K E Y W O R D S Quantum algorithm, optimization, QAOA, Grover's algorithm, initial state, solution, travelling salesman, NP-hard problem, classical algorithm, variational.

INTRODUCTION

Quantum optimization algorithms explore ways to use quantum computing to solve optimization problems that are traditionally difficult for classical algorithms. Although Grover's algorithm does not directly solve optimization problems, it can be used to search for solutions among possible options with quadratic speedup compared to classical methods. For example, in the context of the Traveling Salesman Problem (TSP), it can help accelerate the search for good solutions. The TSP is a classic combinatorial optimization problem, where the goal is to find the shortest possible route that passes through all the given cities and returns to the starting point. This problem belongs to NP-hard problems, meaning there is no efficient algorithm to solve it in polynomial time for all cases. Grover's algorithm, in turn, is a quantum algorithm designed for searching in unstructured databases. It allows finding an element in an unstructured database faster than classical search algorithms. Grover proposed an algorithm that solves the search problem with a quadratic improvement in speed compared to classical search methods. While this is not a direct solution to the Traveling Salesman Problem, Grover's algorithm can be combined with other quantum algorithms to find optimal solutions for TSP.

The Quantum Approximate Optimization Algorithm (QAOA) works by applying quantum circuits with multiple layers (depth), alternating between operations that amplify the solution and operations that fix it in a certain state. This allows a quantum computer to search for good approximate solutions to complex problems. The Quantum Approximate Optimization Algorithm (QAOA) is one of the most promising variational quantum algorithms (VQA) and has recently gained significant attention. To find approximate solutions to complex combinatorial optimization problems on quantum computers, QAOA encodes the problem-related Hamiltonian into a quantum circuit and optimizes the variational parameters of the circuit using adiabatic time evolution and multi-layering. This approach constructs an approximate solution to the problem by measuring the QAOA circuit with an optimal set of parameters. One layer of the QAOA circuit is the fundamental building block. It consists of a mixer layer, whose Hamiltonian does not commute with the problem's Hamiltonian, and a cost layer associated with the problem's Hamiltonian. Usually, the approximation coefficient $C_{QAOA} / C_{\max}$,or the ratio of the cost associated with the solution issued by the AOA to the true optimal solution, is used to measure the effectiveness of the QAOA. Since QAOA restores the adiabatic evolution in the limit $p \to \infty$, theoretically the approximation coefficient increases with increasing number of layers.

When it comes to various optimization problems such as binary coloring (BPSP) [6], maximum independent set (MIS) [4,5], maximum slicing (MaxCut) [2], least squares problem with binary variables (BLLS) [7], Max E3LIN2 [13], knapsack problem [18] and, in general, quadratic unbounded binary optimization (QUBO) [9] Thus, the applications of QAOA in the real world are wide and diverse.

Recent examples include portfolio optimization [10,11], tail assignment [12], pattern recognition [13], maximum plausible detection of binary characters in a channel with multiple input and output (MIMO) [14], text summarization [15], maximum independent set [16], factorization (variational quantum factorization algorithm) [17, 18], protein folding [19] and planning in wireless networks [20].

Nevertheless, there are currently many conflicting opinions in the literature regarding various aspects of the algorithm, such as which problems QAOA can outperform classical algorithms on, and whether it can provide a practical quantum advantage given the noise and errors present in modern quantum devices. Combinatorial optimization typically involves finding an optimal solution from a set of feasible solutions while taking into account constraints on a discrete set of variables. The objective function can either be minimized or maximized. It can be represented as the sum of conditions satisfied by the feasible solution and can be weighted.

The knapsack problem, the traveling salesman problem, and the maximum cut problem (MaxCut) are some typical combinatorial optimization problems [22]. However, due to the combinatorial nature of such problems, the solution space grows rapidly with the number of inputs, making the optimization process an unsolvable task. In most cases, the NP complexity class refers to determining an exact solution for a range of combinatorial optimization problems [23]. This means that classical algorithms cannot find the optimal solution because the number of inputs increases exponentially.

Approximate optimization algorithms are used in this context to obtain a good approximate solution in polynomial time [24]. This is a combinatorial optimization problem that is solved on n-bit binary strings of the form $x = x_1 \dots x_n$. The purpose of this optimization is to maximize a given classical objective function $C(x):[0,1]^n \to R_{\geq 0}$.An approximate optimization algorithm tries to find a solution, which means that the approximation coefficient.

$$\alpha = \frac{C(x^*)}{C_{\max}}, \qquad (1)$$

where $C_{\max} = \max_x C(x)$, reaching the desired value. Ideally, the value should be as close to 1 as possible. Despite the fact that the solution found by approximate algorithms may not be ideal, in most cases it usually has certain guarantees of optimality.

For example, an algorithm is called «α - approximate for a problem" if and only if it can find a solution that is α-approximate for every instance of the problem, with an accuracy that is less than or equal to one $\alpha(\leq 1)$ [25]. Thus, if such an algorithm exists, the aforementioned criterion confirms that the approximate solution is at least α of the optimal one. However, for some optimization problems, the gap between the approximate solution and the optimal solution cannot be reduced in polynomial time. This indicates that finding an exact lower bound relative to the optimal solution is very difficult. This phenomenon is called the "hardness of approximation" and implies that finding a polynomial approximation for the underlying problem is impossible unless P equals $P \neq NP$ [26]. A complete list of current approximation algorithms for some important combinatorial optimization problems is available in [25].

METHODS

Grover's algorithm can be used in the context of the traveling salesman problem (TSP) as follows:

Convert the traveling salesman problem into a search problem, where the goal is to find the route with the minimum cost. This includes creating a function that returns 0 if the route is optimal and 1 otherwise.

Apply Grover's algorithm to search for the solution among all possible routes. Quantum search can speed up the process of finding the optimal route in the unstructured solution space.

Use a quantum amplifier to increase the probability of finding the optimal route. Grover's algorithm works by amplifying the probability of correct solutions, making it more efficient at finding optimal routes.

Quantum Approximate Optimization Algorithm (QAOA)

QAOA is a quantum algorithm designed to solve optimization problems, particularly discrete problems such as QUBO (Quadratic Unconstrained Binary Optimization). The algorithm was proposed by Edward Farhi and his colleagues in 2014. The main idea of QAOA is to use parameterized quantum gates to find approximate solutions to optimization problems.

Key Steps in QAOA

1. Representing the problem as a QUBO

The optimization problem is transformed into a form where the objective function is a quadratic equation of binary variables. This form can be expressed as:

$$C(x) = \sum_i a_i x_i + \sum b_{ij} x_i x_j,$$

where x_i - are binary variables, a_i and b_{ij} are coefficients.

2. Initializing the initial state:

The quantum system is being prepared into a superposition of all possible states. The Gadamer state is usually used for this purpose:

$$|\psi_0\rangle = \frac{1}{\sqrt{2^n}} \sum_{z \in \{0,1\}^n} |z\rangle.$$

3. Application of alternating unitary operators:

QAOA uses two types of unitary operators that alternate p times

The Braid operator $(U(C,\gamma))$: $U(C,\gamma) = e^{-i\gamma C}$,

where C is the operator corresponding to the target function.

Mixer Operator $(U(B,\beta))$:

$$U(B,\beta) = e^{-i\beta \sum_j X_j},$$

where X_j - is the Pauli operator acting on the j - th qubit.

These operators are applied sequentially:

$$|\psi(\vec{\gamma},\vec{\beta})\rangle = U(B,\beta_p)U(C\gamma_p)\dots U(B,\beta_1)|\psi_0\rangle,$$

where $\dot{\gamma} = (\gamma_1, \gamma_2, \dots \gamma_p)$ and $\beta = (\beta_1, \beta_2 \downarrow \dots, \beta_p)$ - algorithm parameters.

4. Measurement and optimization of parameters:

After applying all the unitary operators, the state of the system is measured. The probability of obtaining each state corresponds to its value in the goal function.

The parameters $\vec{\gamma}$ and $\vec{\beta}$ are optimized in such a way as to minimize (or maximize) the goal function.

Parameters : The number of levels (or depth) of the algorithm. The more p , the more accurate the result will be, but it also requires more quantum operations.

Parameters γ $\vec{\gamma}$ and $\vec{\beta}$: Angles used in unitary operators that are optimized to find the best solution.

RESULTS

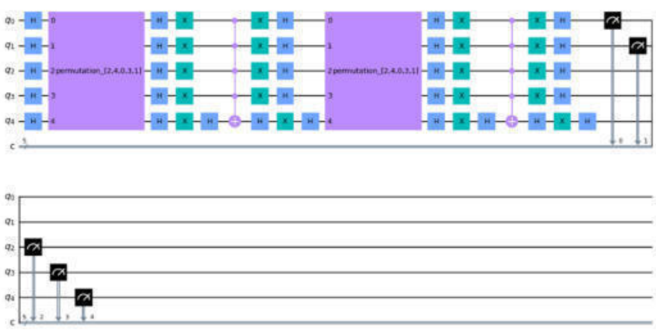


Fig. 1. Scheme solving traveling salesman problems based on Grover's algorithm for 5 cubes

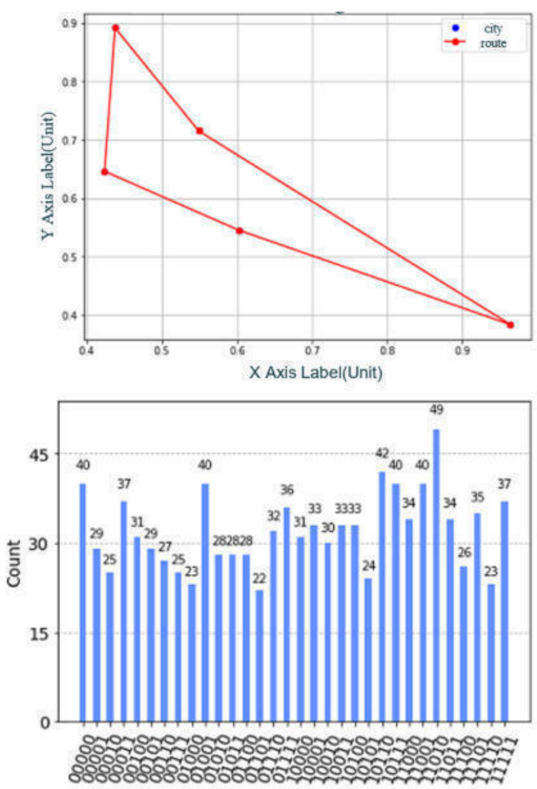


Fig. 2. The route of the travelling salesman's task and his count.

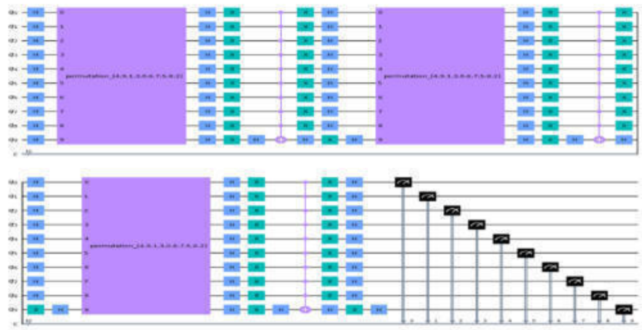


Fig. 3. Solving traveling salesman problems based on Grover's algorithm for 10 qubits.

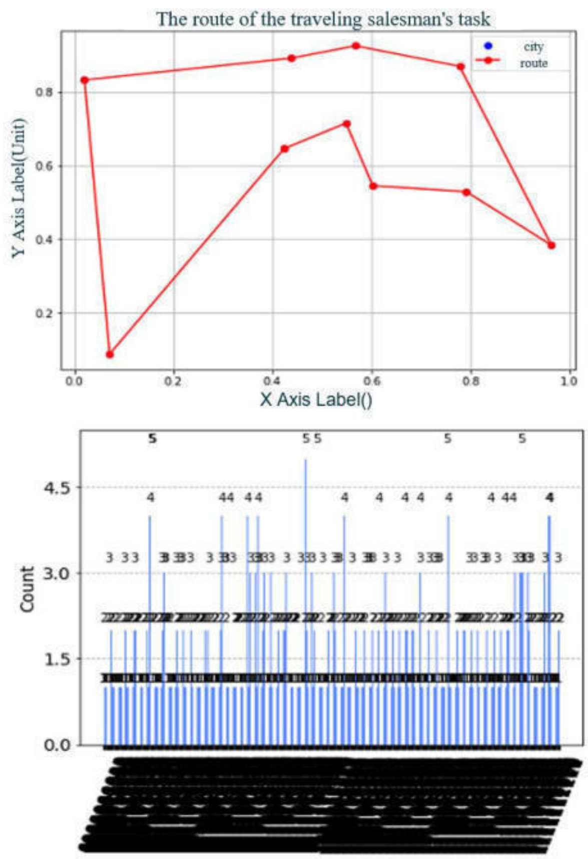


Fig. 4. The route of the travelling salesman's task and his count.

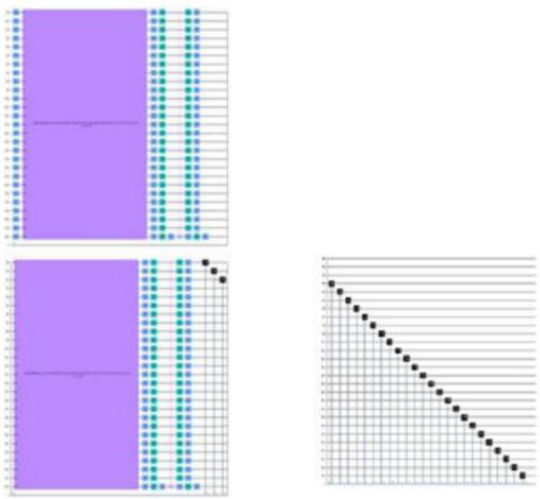
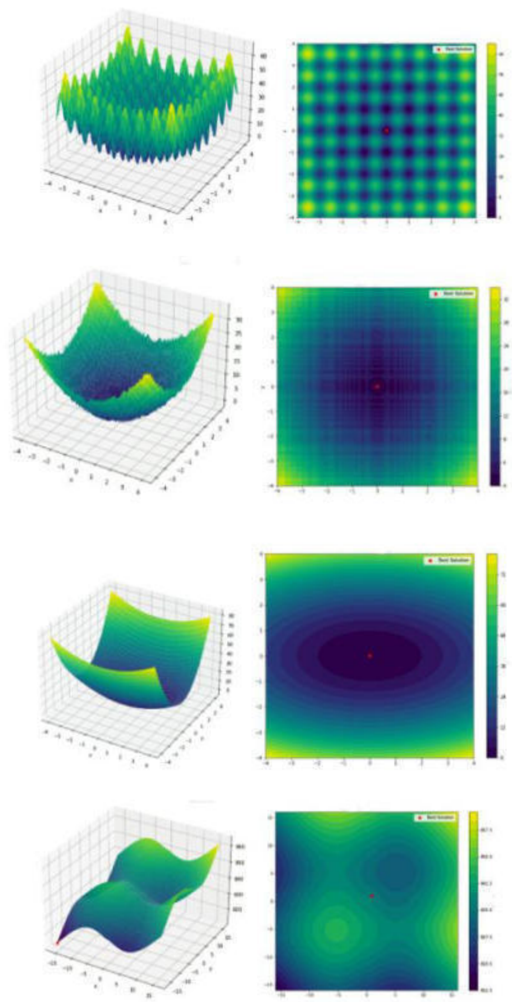


Fig. 5. Solving the traveling salesman problem for 27 qubits.



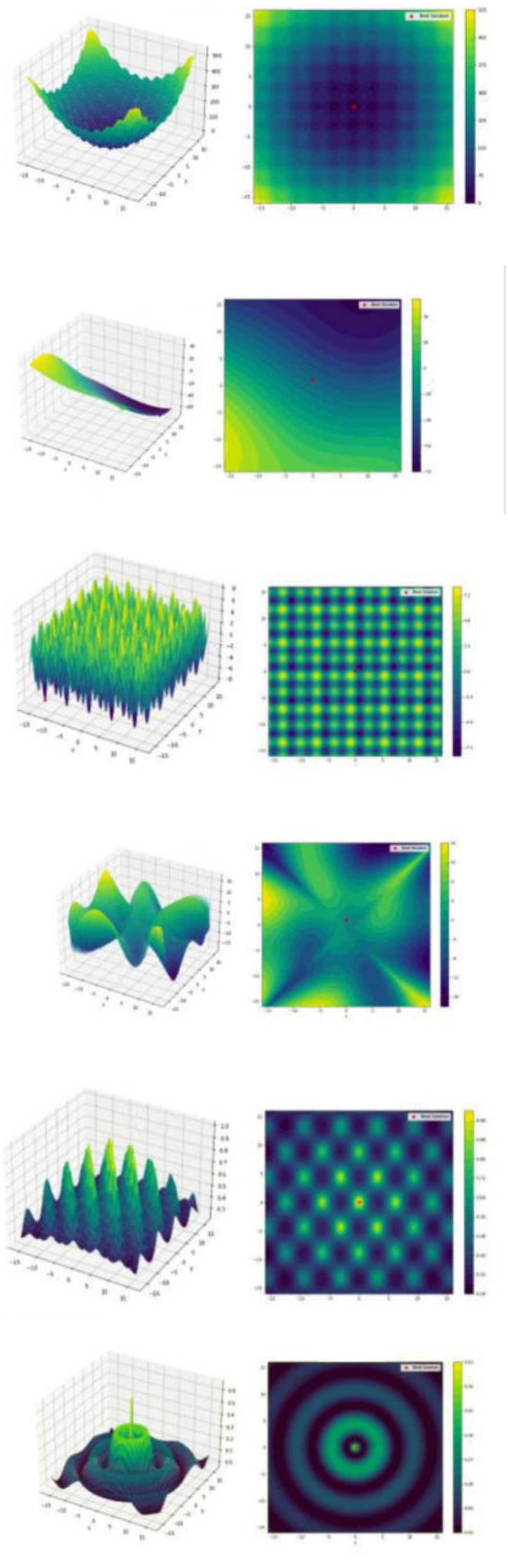


Fig. 6. Simulation of the quantum algorithm of QAOA.

CONCLUSION

Quantum optimization algorithms, particularly Grover's algorithm and the Quantum Approximate Optimization Algorithm (QAOA), represent promising tools that can significantly improve the solution of complex problems traditionally challenging for classical methods. Grover's algorithm, with its quadratic speedup in searching unstructured databases, provides a powerful means to enhance the search for optimal solutions, though it is not specifically designed for solving optimization problems. Nevertheless, it can serve as an auxiliary tool in the context of more complex optimization algorithms. The Quantum Approximate Optimization Algorithm (QAOA) is a more specialized solution, designed for providing approximate solutions to combinatorial optimization problems. By using multi-layer quantum circuits, QAOA allows for efficient searching of good approximate solutions in complex problem spaces. This algorithm shows significant potential for real-world applications, such as the traveling salesman problem, where traditional methods face exponential growth in the number of possible solutions.

Despite the promising results and theoretical advantages of quantum algorithms, there are currently significant technical and practical challenges associated with their implementation on modern quantum computers. Quantum computing is still in an active stage of development, and the practical efficiency of these algorithms will depend on further advances in quantum technologies.

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QUADRATIC UNLIMITED BINARY OPTIMIZATION (QUBO) PROBLEMS AND THEIR APPLICATIONS

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A B S T R A C T **The article discusses Quadratic Unconstrained Binary Optimization (QUBO) problems and their important applications. QUBO problems belong to the NP-hard class, making it impossible to solve them in polynomial time as the problem size increases. This creates significant computational challenges when attempting to solve QUBO problems exactly using classical computational methods, especially for large-scale problems. One of the central problems in the context of QUBO is MaxCut—a problem that was the first to be considered with the introduction of the Quantum Approximate Optimization Algorithm (QAOA). MaxCut is simple in concept but complex enough to make it useful for studying a wide range of problems within the QAOA framework. In addition to MaxCut, other well-known QUBO problems include graph coloring, number partitioning, and the quadratic knapsack problem, each of which has applications in various fields such as network optimization, logistics, and cryptography. In QUBO, variables take binary values, and the problem can be represented by a symmetric square matrix. The study of QUBO is important for the development of new optimization methods, including quantum computing techniques such as QAOA. The article highlights the role and significance of QUBO in combinatorial optimization problems and demonstrates the potential for applying these problems in real-world applications, such as graph problems, logistics, and financial optimization.**

K E Y W O R D S **Quantum algorithm, optimization, MaxCut, QUBO, Grover's algorithm, initial state, solution, travelling salesman, NP-hard problem, classical algorithm, variational.****INTRODUCTION**

The goal of the Quantum Approximate Optimization Algorithm (QAOA) is to solve Quadratic Unconstrained Binary Optimization (QUBO) problems. QUBO problems fall into the NP-hard category [1-8]. This means that there is no known algorithm that can efficiently (in polynomial time) solve all instances of this problem as its size increases. This essentially means that, using current computational resources, it is impossible to find an exact solution for large QUBO problems within a reasonable time frame. MaxCut stands out among many QUBO problems and is often used in the context of QAOA. Its importance lies not only in the fact that it was the first problem discussed in the paper introducing QAOA but also in its conceptual simplicity, which provides enough depth and complexity for exploring a wide range of problems within the same framework.

In QUBO, variables take binary values, and the problem can be represented by a symmetric square matrix. The study of QUBO is crucial for developing new optimization methods, including quantum computing techniques such as QAOA. The article highlights the role and significance of QUBO in combinatorial optimization problems and demonstrates the potential for applying these problems in real-world applications, such as graph problems, logistics, and financial optimization.

Graph coloring [9], number splitting, and the square knapsack problem [10] are additional QUBO tasks. All the features of QUBO are presented in [7]. In the QUBO problem, the solution variables for the vector of unknowns $x=(x_1,...,x_n)$ take discrete binary values, so $x \in \{0,1\}^n$.

In addition, it is possible to define the QUBO problem using a square symmetric matrix $Q \in R^{n\times n}$. The purpose of the QUBO task

$$C(x)=x^TQx=\sum_{i,j=1}^{n}Q_{i,j}x_ix_j \qquad (1)$$

is the finding of an ideal vector x^*, such as

$$x^*=\arg\min_{x\in\{0,1\}^n} C(x) \qquad (2)$$

Another way to define QUBO as a maximization problem rather than a minimization problem is to change the sign of the objective function $C(x)$, that is, to change the sign of the coefficients in w:

$$\min_{x\in\{0,1\}^n} C(x)=\max_{x\in\{0,1\}^n}(-C(x))=\max_{x\in\{0,1\}^n}\sum_{i,j=1}^{n}(-Q_{i,j})x_ix_j \qquad (3)$$

It is very important to note the fact that QUBO tasks are unlimited, that is, they are not limited by any x variables. It is quite possible that the goals of QUBO fully correspond to the Ising models [11].

In addition, Lodewey [12] considers several maps of NP-hard problems in QUBO problems and corrects errors in the method used in [11]. In addition, it expands the range of NP-complete and NP-hard optimization tasks that can be combined into QUBO tasks. In Ising tasks, the original QUBO $x \in \{0,1\}^n$ variables are replaced by Ising $z \in \{-1,1\}^n$ variables, which means that $z_i = 2x_i - 1$ for $i = 1, 2, ..., n$.

With the exception of a constant unrelated to optimization, the resulting Ising Hamiltonian, dependent on z, is equivalent to equation (2). Further information on the relationship between Ising models and QUBO can be found in [40]. Annealing methods based on the adiabatic theorem are used to determine the ground state of a physical system. Similarly, Ising problems are often solved using annealing methods [13].

QUBO represents a family of problems that can be solved using adiabatic quantum computation through quantum annealing, as they are equivalent to Ising models [8]. QUBO problems limited by quadratic interactions between variables are solved mainly with the help of QAOA. QUBO tasks can be extended to higher orders in some applications where more complex relationships between variables can be included in higher orders.

For example, consider the third-order problem $x_i x_j x_k$. We can transform this problem into a quadratic form by adding an additional variable known as "gadget" $x' = x_i x_j$ and expressing the original term as $x_i x_j x_k = x' x_k$. This allows us to rethink the whole process in terms of quadratic interactions of variables. Polynomial Unconstrained Boolean Optimization (PUBO) problems are optimization problems with higher-order interactions. Babbush and colleagues [14] explored how PUBO and QUBO problems can be effectively combined. Hardware limitations are the main reason why QAOA focuses on QUBO problems. However, it may be more beneficial to reduce the number of interactions by increasing their order if the device can operate with gates containing more than two qubits. It has been shown that combinatorial optimization problems of any kind can be represented as PUBO problems using two constraints [15].

Additionally, they can be formulated using the Lechner-Hauke-Zoller (LHZ) model, also known as the parity model. LHZ is a lattice gauge field model with four-part nearest-neighbor interactions [46–48].

METHODS

Most variations of QAOA are based on the MaxCut problem, which is one of the most well-known optimization problems. In this section, we will examine its core values. The goal is to find a cut in a graph such that the vertices of the graph are divided into two subsets, and the total weight of the edges crossing the cut is maximized. According to the formulation of the MaxCut problem, an undirected graph $G = (V, E)$ is given, where V means a set of vertices, E means a set of edges and, corresponding to edge $(i, j) \in E$, weight w_{ij}

Dividing the vertices of graph x_i for $i = 1, 2, ..., |V|$ into two additional subsets labeled 0 and 1, so, is the purpose of MaxCut and is defined as

$$C(x) = \sum_{i,j=1}^{|V|} w_{ij} x_i (1 - x_j) \qquad (4)$$

there was a maximum when

$$w_{ij} > 0, \quad w_{ij} = w_{ji}$$

for everyone $(i, j) \in E$ and $x_i \in \{0,1\}$

In most cases, the simple MaxCut problem is a special case of the weighted MaxCut problem when $w_{ij} = 1$ is for all $(i, j) \in E$. Since C is an NP-hard problem [19], the approximate optimization approach is the best option for a polynomial algorithm. This means that we find the cut x^*, which gives the value. $C(x^*)$, the closest to the maximum value of $C_{\max} = \max_x C(x)$.

Hastad [20] suggested that achieving an approximation ratio above 16/17 ≃ 0.9412 is an NP-hard task. This highlights the complexity of the approximation for the MaxCut problem. The Goemans-Williamson algorithm is currently the best classical algorithm for the MaxCut problem, since it gives a solution with $\alpha \approx 0{,}878$ [21,22]. Thus, the MaxCut problem is considered a paradigmatic model for complex combinatorial optimization problems. Consequently, the primary objective is to find high-quality and efficient approximate solutions for the MaxCut problem using the power of quantum algorithms. As a quantum algorithm, QAOA demonstrates the ability to find solutions for complex combinatorial optimization problems like MaxCut.

Understanding classical approaches to approximating QUBO problems, as well as MaxCut problems, can provide valuable insights into the complexity of the problem and the limitations of classical computational resources. This knowledge may inspire the development of new quantum algorithms that can leverage the power of quantum mechanics to more effectively solve these problems in light of advancements in quantum computing. Despite its prominence in computer science and practical significance, the MaxCut problem remains NP-hard [2]. This means that there are no known algorithms capable of solving it in polynomial time with respect to the input size. However, several approximation algorithms and heuristics can quickly solve practical sizes of the problem [4].

Optimization methods offer various options for solving different problems [21]. While quadratic programming and interior point methods are good for problems with clear objective functions, they can be cumbersome when dealing with large amounts of information. Although the branch-and-bound method offers exact solutions, it is computationally expensive. Sequential quadratic programming and augmented Lagrangian methods are effective when working with constraints but also require substantial computational resources. Semidefinite programming is primarily used for convex problems, although it provides theoretical guarantees.

Computational efficiency methods, such as greedy algorithms and local search methods like simulated annealing or genetic algorithms, offer quality solutions. While spectral clustering provides good coverage of the global structure of a graph, it may be inefficient for large graphs due to its reliance on eigenvector selection [22]. Within the unique games hypothesis, the Goemans-Williamson algorithm stands out for its strong theoretical guarantees. However, it requires solving an SDP problem, which can be computationally intensive.

There are numerous software packages, such as GUROBI, CPLEX, MOSEK, BARON, Bonmin, Couenne, and SCIP, for solving optimization problems on classical computers. These programs can simultaneously handle millions of parameters. Quadratic programming is widely used in QUBO problems.

The objective function in quadratic programming (QP) is formulated in the form of a symmetric matrix Q , a matrix A and two vectors *b* and *c*:

$$C(x) = x^T Qx + c^T x \qquad (5)$$

with an additional restriction

$$Ax \le b$$

which defines the allowed space for selection x .

One of the most common approaches to solving complex NP-hard optimization problems is the branch-and-bound (B&B) method [25]. It works by dividing the solution space into smaller subproblems and eliminating those that do not contain an optimal solution. The algorithm starts with initial bounds set to negative and positive infinity, and these bounds are updated as better solutions are identified. The algorithm decomposes the main problem into smaller parts, which are then solved either optimally or using heuristics. Below are some examples of such heuristics. Projects that yield worse results than an existing, more efficient solution are discarded. The bounds are updated with the optimal solution. The iterative process continues until a time or resource limit is reached.

RESULTS

The Traveling Salesman Problem (TSP) is to find the shortest path that passes through all the cities exactly once and returns to the original city. Let $G = (V, E)$ be a complete graph with *n* vertices, where V - is the set of cities, and E - is the set of edges that represent possible paths between cities. Each edge (i, j) has a weight w_{ij} , which represents the distance or cost of the path between the cities i and j .

To convert the TSP problem into a QUBO problem, we use the following variables:

$$x_{i,j} = \begin{cases} 1 \; if \; city \; is \; visited \; at \; position \; j \\ 0, \; otherwise \end{cases} \qquad (6)$$

Where $x_{i,j}$ is a binary variable equal to 1 if the city i is visited at the j th position in the route, and 0 otherwise.

The objective function of the TSP task is to minimize the total path length:

$$Minimize \sum_{i=1}^{n} \sum_{j=1}^{n-1} w_{i,j} x_{i,j} x_{i+1,j+1} + \sum_{i=1}^{n} w_{i,n} x_{i,n+1,1} \qquad (7)$$

Here we sum up the lengths of all the edges in the route, including the transition from the last city to the first.

Limitations:

1. Each city is visited exactly once:

$$\sum_{j=1}^{n} x_{i,j} = 1 \quad \forall i \in V \qquad (8)$$

2. Each position in the minibus occupies exactly one city:

$$\sum_{i=1}^{n} x_{i,j} = 1 \quad \forall j \in \{1, 2, ..., n\} \qquad (9)$$

As a result, our QUBO formulation of the TSP problem will be:

$$Minimize \sum_{i,j,k,l} w_{i,k} x_{i,j} x_{k,l} + A\left(\sum_{i=1}^{n} \left(1 - \sum_{j=1}^{n} x_{i,j}\right)^2 + \sum_{j=1}^{n} \left(1 - \sum_{i=1}^{n} x_{i,j}\right)^2 \right) \qquad (10)$$

where $x_{i,j}$ are binary variables representing a visit to city *i* at position *j*

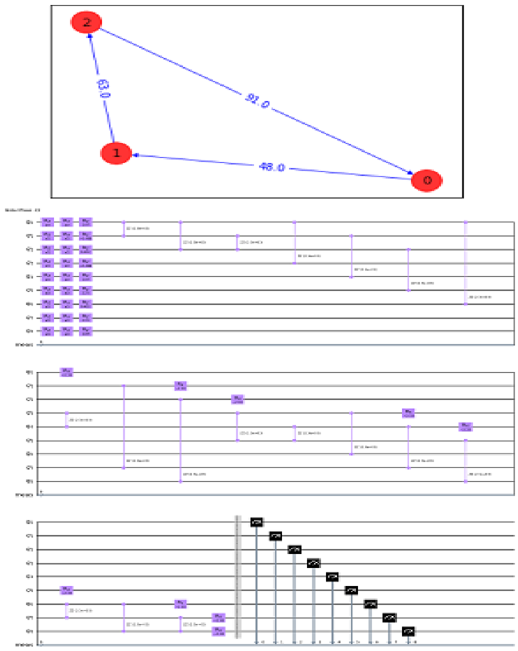

Fig. 1.Solving the TSP problem in QAOA and his quantum scheme.

CONCLUSION

QUBO problems represent an important class of NP-hard problems encountered in many fields such as network optimization, logistics, graph coloring, and cryptography. Despite the computational complexity of these problems, their study opens up opportunities for the development of new methods, including quantum algorithms such as the QAOA. QUBO provides a versatile formulation that can be adapted to solve a variety of combinatorial problems, making it a key tool for the analysis and development of optimization algorithms. One of the most important QUBO problems is MaxCut, which has proven useful for testing and exploring the efficiency of QAOA. Current computational resource limitations make solving large QUBO problems challenging, but advances in quantum computing could significantly improve approaches to solving them. Research and development of optimization methods for QUBO problems remains a relevant task, and future advancements may lead to significant improvements in solving practical problems in various fields of science and technology.

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A FUZZY LOGIC MODEL FOR SOIL SALINITY ESTIMATION BASED ON Z-NUMBERS

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ABSTRACT The paper presents a fuzzy logic model based on Z-numbers for assessing soil salinity. The developed model allows for uncertainties and variability of input data, making it particularly useful in agronomic and environmental studies. The model has demonstrated high practical applicability, providing rapid and accurate assessment of soil conditions, which helps to manage land resources more effectively. KEY WORDS

Fuzzy logic, Z-numbers, soil salinity, soil assessment, agronomy, environmental research, relevance functions.

I. INTRODUCTION

The process of soil salinity assessment is one of the main tasks of land preparation and sustainable agricultural production. Soil salinity negatively affects plant growth and development, reduces productivity and leads to land degradation, which is especially important in the context of climate change and agricultural intensification. Soil salinity depends on many factors, including climatic conditions, soil type, groundwater level and irrigation methods. These factors are difficult to take into account and interpret using traditional assessment methods. Agronomic and environmental studies often require rapid soil assessment to make timely land management decisions. Traditional assessment methods can be labor-intensive and not accurate enough. The introduction of automated soil assessment systems improves the accuracy and speed of results, and ensures decision-making based on objective information.

Currently, there are no comprehensive software solutions that integrate data from different sources to provide a comprehensive assessment of soil health. Fuzzy logic models such as the Mamdani model are able to account for uncertainties and deal with uncertain data, making them particularly useful in situations of high variability in natural factors. Effective management of salinity soils increases agricultural sustainability, reduces crop losses, and improves product quality, which is important for food security. The development and implementation of the Mamdani fuzzy logic model for assessing soil salinity based on leaf thickness and follicle count is an urgent step towards addressing the above issues. This model provides fast and accurate assessment of soil health, helps improve land management, and makes agriculture more resilient to a changing climate.

There have been many studies conducted in this area by scientists worldwide. The studies by Mamdani, Tsukamoto and Larsen laid the foundations of fuzzy logic, which is widely used to model complex systems with uncertainty. These works have shown the effectiveness of fuzzy logic in various fields, including agriculture [1-3]. Akinshina et al. (2016) [4] discuss the impact of soil salinity on halophytes and their potential as energy crops. The study by Matsua et al. (2013) on the response of carbon and oxygen isotope composition of desert plants to spatial variations in soil salinity in Central Asia examined how soil salinity affects the isotope composition of plants in desert conditions and highlighted the complexity [4]. Mavlyanova et al. (2020) [5] studied the cultivation technology of new bean varieties, including the effect of soil conditions on yield. Oparin et al. (2018) [6] discussed the use of satellite data for soil and vegetation cover analysis and soil salinity assessment. Rossel and Buma (2016) [7] discuss new approaches to soil monitoring using sensors and remote sensing. Toderich et al. (2020) [8] study the effect of salinity on various components. Toderich et al. (2018) [9] describe biosalination technologies and management methods for saline lands in arid climates. Pankova et al. (2017) [10] provide guidelines for the management of saline soils, which are an important resource for understanding the criteria and methods for salinity assessment.

These studies lacked comprehensive approaches to soil salinity assessment. Although there are successful examples of applying fuzzy logic to various biological and agricultural problems, there are no unified models specifically designed for automated soil salinity assessment. Existing assessment methods are often limited to chemical soil analysis or empirical methods, without taking into account the complexity and variability of natural conditions. Fuzzy logic can offer more accurate and flexible models due to its ability to handle uncertain and qualitative data. The development of an automated fuzzy logic system for soil salinity assessment can significantly improve the accuracy and speed of obtaining results and supporting decision-making based on objective data.The model, which takes into account such parameters as leaf thickness and seedling number, is particularly useful for agronomic and environmental studies, providing more accurate information for land management [11-12]. Analysis of scientific papers and works of leading scientists in the field of fuzzy logic, soil condition assessment and plant biochemical reactions shows that there is a clear gap in combining this knowledge for automated soil salinity assessment. This confirms the lack of a solution to the scientific problem presented in the existing literature and justifies the need to develop our own model based on Mamdani fuzzy logic for soil salinity assessment [13-14].

II. METHODS AND MODELS.

Let us consider the approach proposed for implementation in this paper, based on the use of transformed Z-numbers in a fuzzy inference system.

Let a number $Z(A,B)$ be given, where $A=(a_1,a_2,a_3)$ and $B=(b_1,b_2,b_3)$ - are two triangular fuzzy numbers. According to the work [5], the reduction of two fuzzy numbers to one occurs by integrating the second fuzzy number into the first. The evaluation of the degree of integration (weight) of the fuzzy number B is expressed as follows:

$$\alpha=\frac{1}{6}(b_1+4\times b_2+b_3).$$

After this, the weight of the second part can be added to the first part, and the weighted Z-number can be denoted as

$$Z^{\alpha}=(a_1,a_2,a_3;\ \alpha).$$

In the final stage, the weighted Z-number is transformed into a classical fuzzy number:

$Z'=(a_1\times\sqrt{\alpha},a_2a_1\times\sqrt{a},a_3a_1\times\sqrt{\alpha};1);$ Thus, having a fuzzy inference system described in Z-numbers transformed into fuzzy numbers, we get the opportunity to use the algorithm described above, which will allow us to obtain output values, taking into account the probability estimate, which is contained in Z-numbers.

It is required to construct a logical model for assessing and predicting soil salinization using fuzzy rule inferences in the following form:

A fuzzy model whose output is a fuzzy term:

If x_{11} *=(L,A) and* x_{21} *=(L,A) and* x_{31} *= (L,A)) and* x_{41} *=(L,A)*

or x_{11} *=(A,L) and* x_{21} *=(L,A) and* x_{31} *=(L,A) and* x_{41} *=(L,A)*

then y = The soil is not saline,

If x_{12} *=(L,A) and* x_{22} *=(L,A) and* x_{32} *=(L,A) and* x_{42} *=(A,A)*

or x_{12} *=(L,A) and* x_{22} *=(L,A) and* x_{32} *=(L,A) and* x_{42} *=(L,A)*

or x_{12} *=(L,A) and* x_{22} *=(L,A) and* x_{32} *=(A,A) and* x_{42} *=(L,A)*

then y = Soil salinity is weak.

If x_{13} *=(L,A) and* x_{23} *=(L,A) and* x_{33} *=(L,A) and* x_{43} *=(AA,A)*

or x_{13} *=(L,A) and* x_{23} *=(L,A) and* x_{33} *=(AA,A) and* x_{43} *=(A, AA)*

or x_{13} *=(L,A) and* x_{23} *=(L,A) and* x_{33} *=(A, AA) and* x_{43} *=(H,H)*

then y = average soil salinity,

If x_{14} *=(L,AA) and* x_{24} *=(H,AA) and* x_{34} *=(A, AA) and* x_{44} *=(A, AA)*

or x_{14} *=(L,AA) and* x_{24} *=(A,AA) and* x_{34} *=(A,AA) and* x_{44} *=(A,AA)*

then y = soil salinity is strong,

If x_{15} *=(A,AA) and* x_{25} *=(H,AA) and* x_{35} *=(A,AA) and* x_{45} *=(H,AA)*

or x_{15} *=(H,AA) and* x_{25} *=(H,AA) and* x_{35} *=(A,AA) and* x_{45} *=(H,AA)*

or x_{15} *=(H,AA) and* x_{25} *=(H,AA) and* x_{35} *=(H,AA) and* x_{45} *= (H,AA)*

then the soil salinity level is saline.

Here L is low, A is average, BA is below average, AA is above average, H is high.

A fuzzy model whose output data has the form of a linear relationship:

$$If\ (x_{1i}=(a_{11i},b_{11i})\vee x_{2i}=(a_{12i},b_{12i})\vee\ldots\vee x_{ni}=(a_{1ni},b_{1ni}))\wedge$$

. . . .

$$\wedge(x_{1i}=(a_{11k_j},b_{11k_j})\vee x_{2i}=(a_{12k_j},b_{12k_j})\vee\ldots\vee x_{ni}=(a_{1nk_j},b_{1nk_j}))$$

In this case

$$y_j=v_{j0}+v_{j1}\left(\frac{\left(\left(\sum_{j=1}^{m}\left(\mu(b_{1ij})\left(\frac{\sum_{j=1}^{m}\left(\mu(a_{1ij})a_{1ij}\right)}{\sum_{j=1}^{m}\mu(a_{1ij})}\right)\right)\right)\right)}{\sum_{j=1}^{m}\mu(b_{1ij})}\right)+\ldots v_{jn}\left(\frac{\left(\left(\sum_{j=1}^{m}\left(\mu(b_{nij})\left(\frac{\sum_{j=1}^{m}\left(\mu(a_{nij})a_{nij}\right)}{\sum_{j=1}^{m}\mu(a_{nij})}\right)\right)\right)\right)}{\sum_{j=1}^{m}\mu(b_{nij})}\right),$$

$i=\overline{1,n}.$

$$\text{if }(z=a_{11}^{1}\vee z_1=a_{12}^{1}\vee z_2=a_{13}^{1}\vee z_3=a_{14}^{1})\wedge$$
$$(z=a_{11}^{m_1}\vee z_1=a_{12}^{m_1}\vee z_2=a_{13}^{m_1}\vee z_3=a_{14}^{m_1})$$

in this case

$$y=\frac{\sum_{i=1}^{n}\mu_{f_{0i}}f_{0i}}{\sum_{i=1}^{n}\mu_{f_{0i}}}+\frac{\sum_{i=1}^{n}\mu_{f_{1i}}f_{1i}}{\sum_{i=1}^{n}\mu_{f_{1i}}}z+\frac{\sum_{i=1}^{n}\mu_{f_{2i}}f_{2i}}{\sum_{i=1}^{n}\mu_{f_{2i}}}z_1+\frac{\sum_{i=1}^{n}\mu_{f_{3i}}f_{3i}}{\sum_{i=1}^{n}\mu_{f_{4i}}}z_2+\frac{\sum_{i=1}^{n}\mu_{f_{48i}}f_{4i}}{\sum_{i=1}^{n}\mu_{f_{4i}}}z_3$$

If $(x_1=a_{21}^1\vee x_2=a_{22}^1\vee x_3=a_{23}^1\vee...\vee x_8=a_{28}^1)\wedge$

. . . .

$(x_1=a_{21}^{m_2}\vee x_2=a_{22}^{m_2}\vee x_3=a_{23}^{m_2}\vee...\vee x_8=a_{28}^{m_2})$.

in this case

$$z=\frac{\sum_{i=1}^{n}\mu_{k_{0i}}k_{0i}}{\sum_{i=1}^{n}\mu_{k_{0i}}}+\frac{\sum_{i=1}^{n}\mu_{k_{1i}}k_{1i}}{\sum_{i=1}^{n}\mu_{k_{1i}}}x_1+\frac{\sum_{i=1}^{n}\mu_{k_{2i}}k_{2i}}{\sum_{i=1}^{n}\mu_{k_{2i}}}x_2+...+\frac{\sum_{i=1}^{n}\mu_{k_{7i}}k_{7i}}{\sum_{i=1}^{n}\mu_{k_{7i}}}x_7+\frac{\sum_{i=1}^{n}\mu_{k_{8i}}k_{8i}}{\sum_{i=1}^{n}\mu_{k_{8i}}}x_8$$

If $(x_{11}=a_{31}^1\vee x_{12}=a_{32}^1\vee x_{13}=a_{33}^1\vee...\vee x_{17}=a_{37}^1\vee z=a_{38}^1)\wedge$ . . . .

$(x_{11}=a_{31}^{m_3}\vee x_{12}=a_{32}^{m_3}\vee x_{13}=a_{33}^{m_3}\vee...\vee x_{17}=a_{37}^{m_3}\vee z=a_{38}^{m_3})$

in this case

$$z_1=\frac{\sum_{i=1}^{n}\mu_{b_{0i}}b_{0i}}{\sum_{i=1}^{n}\mu_{b_{0i}}}+\frac{\sum_{i=1}^{n}\mu_{b_{1i}}b_{1i}}{\sum_{i=1}^{n}\mu_{b_{1i}}}x_{11}+\frac{\sum_{i=1}^{n}\mu_{b_{2i}}b_{2i}}{\sum_{i=1}^{n}\mu_{b_{2i}}}x_{12}+...+\frac{\sum_{i=1}^{n}\mu_{b_{7i}}b_{7i}}{\sum_{i=1}^{n}\mu_{b_{7i}}}x_{17}+\frac{\sum_{i=1}^{n}\mu_{b_{8i}}b_{8i}}{\sum_{i=1}^{n}\mu_{b_{8i}}}z$$

If

$(x_{21}=a_{41}^1\vee x_{22}=a_{42}^1\vee x_{23}=a_{43}^1\vee...\vee x_{27}=a_{47}^1)\wedge$

. . . .

$(x_{21}=a_{41}^{m_4}\vee x_{22}=a_{42}^{m_4}\vee x_{23}=a_{43}^{m_4}\vee...\vee x_{27}=a_{47}^{m_4})$

in this case

$$z_2=\frac{\sum_{i=1}^{n}\mu_{c_{0i}}c_{0i}}{\sum_{i=1}^{n}\mu_{c_{0i}}}+\frac{\sum_{i=1}^{n}\mu_{c_{1i}}c_{1i}}{\sum_{i=1}^{n}\mu_{c_{1i}}}x_{21}+\frac{\sum_{i=1}^{n}\mu_{c_{2i}}c_{2i}}{\sum_{i=1}^{n}\mu_{c_{2i}}}x_{22}+...+\frac{\sum_{i=1}^{n}\mu_{c_{7i}}c_{7i}}{\sum_{i=1}^{n}\mu_{c_{7i}}}x_{27}$$

If

$(x_{31}=a_{51}^1\vee x_{32}=a_{52}^1\vee x_{33}=a_{53}^1\vee...\vee x_{37}=a_{57}^1\vee z_2=a_{58}^1)\wedge$ . . . .

$(x_{31}=a_{51}^{m_5}\vee x_{32}=a_{52}^{m_5}\vee x_{33}=a_{53}^{m_5}\vee...\vee x_{37}=a_{57}^{m_5}\vee z_2=a_{58}^{m_5})\wedge$

in this case

$$z_3=\frac{\sum_{i=1}^{n}\mu_{d_{0i}}d_{0i}}{\sum_{i=1}^{n}\mu_{d_{0i}}}+\frac{\sum_{i=1}^{n}\mu_{d_{1i}}d_{1i}}{\sum_{i=1}^{n}\mu_{d_{1i}}}x_{31}+\frac{\sum_{i=1}^{n}\mu_{d_{2i}}d_{2i}}{\sum_{i=1}^{n}\mu_{d_{2i}}}x_{32}+...+\frac{\sum_{i=1}^{n}\mu_{d_{7i}}d_{7i}}{\sum_{i=1}^{n}\mu_{d_{7i}}}x_{37}+\frac{\sum_{i=1}^{n}\mu_{d_{8i}}d_{8i}}{\sum_{i=1}^{n}\mu_{d_{8i}}}z_2$$

Here:

y – soil salinization;

x_1 *- bulk density of soil,* g/cm^3 *;*

x_2 *- plowing depth, cm;*

x_3 *- phosphorus application rate, kg /га;*

x_4 *- potassium intake norm, kg/га;*

x_5 *- nitrogen content in soil, %;*

x_6 *- soil organic carbon content, %;*

x_7 *- average daily temperature, %;*

x_8 *- soil moisture, %;*

x_{11} *- built-in phosphorus standard, kg/га;*

x_{12} *- nitrogen application rate, kg/га;*

x_{13} *- irrigation rate,* m^3 */га;*

x_{14} *- sum of effective temperatures,* C^0 *;*

x_{15} *- soil surface temperature,* C^0 *;*

x_{16} *- relative humidity, %;*

x_{17} *- soil moisture, %;*

z *- humus content in soil, %;*

z_1 *- number of fruits on a bush;*

x_{21} *- built-in nitrogen standard, kg/га;*

x_{22} *- phosphorus application rate, kg/га;*

x_{23} *- irrigation rate,* m^3 */к;*

x_{24} *- sum of effective temperatures,* C^0 *;*

x_{25} *- soil surface temperature,* C^0 *;*

x_{26} *- relative humidity, %;*

x_{27} – *plant density, thousand/hectare;*

z_3 *- amount of fruit on the grass;*

x_{31} *- plant density, thousand/hectare;*

x_{32} *- built-in nitrogen standard, kg/га;*

x_{33} *- phosphorus application rate, kg/га;*

x_{34} *- irrigation rate, m^3/га;*

x_{35} *- sum of effective temperatures,* C^0 *;*

x_{36} *- soil surface temperature,* C^0 *;*

x_{37} *- relative humidity, %.*

In the process of constructing the model, the following results were obtained. $k_0 \in [-0{,}95;-0{,}91]$; $k_1 \in [-0{,}27;-0{,}23]$; $k_2 \in [-0{,}0022;-0{,}0018]$;

$k_3 \in [0{,}0038;0{,}0042]$; $k_4 \in [0{,}0028;0{,}0032]$;

$k_5 \in [-0{,}51;-0{,}47]$;

$k_6 \in [0{,}11;0{,}15]$; $k_7 \in [-0{,}052;-0{,}048]$; $k_8 \in [0{,}038;0{,}042]$;

$b_0 \in [-175;-165]$; $b_1 \in [-0{,}0012;-0{,}0008]$; $b_2 \in [-0{,}196;-0{,}192]$;

$b_3 \in [0{,}21;0{,}25]$; $b_4 \in [0{,}018;0{,}022]$; $b_5 \in [0{,}0068;0{,}0072]$;

$b_6 \in [-0{,}082;-0{,}078]$; $b_7 \in [0{,}0018;0{,}0022]$; $b_4 \in [0{,}195;0{,}199]$;

$c_0 \in [621;625]$; $c_1 \in [-0{,}32;-0{,}28]$;

$c_2 \in [-0{,}082;-0{,}078]$;

$c_3 \in [-0{,}56;-0{,}52]$; $c_4 \in [-0{,}022;-0{,}018]$;

$c_5 \in [1{,}80;1{,}90]$;

$c_6 \in [0{,}028;0{,}032]$; $c_7 \in [0{,}83;0{,}87]$;

$d_0 \in [-47;-43]$;

$d_1 \in [-0{,}012;-0{,}008]$; $d_2 \in [0{,}097;0{,}101]$;

$d_3 \in [-0{,}042;-0{,}038]$;

$d_4 \in [-0{,}015;-0{,}011]$; $d_5 \in [-0{,}052;-0{,}048]$;

$d_6 \in [2{,}70;2{,}77]$;

$d_7 \in [0{,}31;0{,}35]$;

$d_8 \in [0{,}34;0{,}37]$;

$f_0 \in [28;30]$;

$f_1 \in [-4{,}1;-3{,}7]$;

$f_2 \in [-1{,}47;-1{,}43]$; $f_3 \in [-0{,}95;-0{,}91]$;

$f_4 \in [2{,}32;2{,}37]$.

III RESULTS

The classification results were obtained using the Z-number fuzzy logic model and the results were analyzed.

Clarity= 94.44%

Classification Report:

	precision	recall	f1-score	support
3.0	1.00	1.00	1.00	1
4.0	0.92	1.00	0.96	11
5.0	1.00	0.83	0.91	6
accuracy			0.94	18
macro avg	0.97	0.94	0.96	18
weighted avg	0.95	0.94	0.94	18

The F1 score for all classes is high, indicating a well-balanced expression of precision and recall.

Thus, the model achieved good classification results.

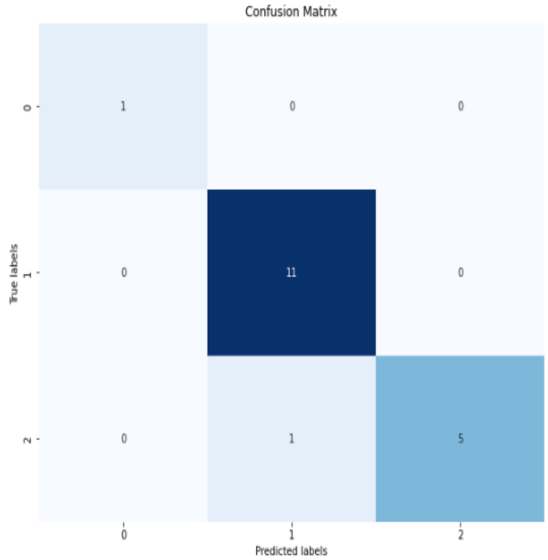

Figure 1. Uncertainty matrix graph (soil salinity assessment)

The model demonstrated high accuracy and prediction quality, demonstrating its ability to classify data into the provided classes.

IV. CONCLUSION

The analysis of scientific papers and works of leading scientists in the field of fuzzy logic and soil assessment based on Z-score shows that there is a clear gap in combining these knowledge for automated soil salinity assessment. This confirms the lack of a solution to the scientific problem presented in the existing literature and justifies the need to develop our own model based on Mamdani fuzzy logic for soil salinity assessment. Based on the Z-score, a soil salinity assessment model using fuzzy logic was developed and the capabilities of quantitative assessment based on this fuzzy model were shown. The proposed soil salinity assessment model based on fuzzy logic based on Z-scores is a useful tool that can be widely used in agronomy and ecology, providing reliable and accurate soil condition assessment under conditions of data variability and uncertainty.

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ANALYSIS OF FILTERS FOR PROCESSING VIDEO IMAGES

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A B S T R A C T **Every day the number of images taken by the camera is increasing. Many photos are taken outdoors, where weather conditions can affect the quality of the captured images. Degradation caused by atmospheric phenomena is difficult to see by the human eye, and also reduces recognition by computer vision algorithms. Therefore, the task of processing such images is the most important. This article is devoted to the processing of images distorted by fog or rain. All modern methods in this field are based on supervised learning. In addition, information is provided about some image processing methods and their quality, intensity levels, and pixels whose GT exceeds a specified threshold are considered noise.**

K E Y W O R D S gradient descent (GT), 2D filter, Gaussian filter, blurred images.

INTRODUCTION

Image blurring can be a suitable effect to reduce image degradation designed to remove high frequencies. Frequency noise of images. The gradient descent (GT) of image pixels is calculated based on their intensity levels, and pixels whose gradient descent is above a certain threshold are considered pixel degradation. 2D filtering has the effect of normalizing the intensity level of the pixels in the filter. A window that reduces the intensity of the GT and thereby reduces high-frequency noise in the image consists of pixel areas with a suitable intensity gradient. Figure 1 shows how a 2D Gaussian filter can be used to smooth and blur an image.

We propose a variational model for single-image dehazing based on a smooth approximation of the dark channel prior. We also formulate an unsupervised deep learning model for dehazing based on the same functional. We also propose a variational model for single-image rain removal. The proposed models do not require synthetic data, so they have better properties on real hazy and rainy images than the state-of-the-art models.

We compared the proposed methods to the state-of-the-art on real images degraded by weather, and our methods proved to be better in restoring the images. The comparison was made subjectively by visual inspection and objectively by comparing the improvement in object detection performance of restored images [1-3].

Fig. 1. The blurred image (right) is created using a 2D Gaussian filter with elemental blur to the original image (left). Sharp edges are smoothed, which is noticeable in the image.

METHODS

The foggy effect is also applied to the camera lens in captured images. General-purpose toll cameras used in the automotive industry typically have fixed optics that allow light rays from distant objects to be reflected onto the camera sensor, which focuses on light rays emitted by closer objects. lags behind the image. plane, creating a circle or disk in the image plane called blur. Figure 2 shows the image of the circle of the nebula caused by the optics of a certain focal length. The diameter of the blurred circle is defined as:

$$\epsilon = \frac{\Delta g f^2}{O(g-\Delta g)(g-f)}$$

Here, O is the size of the camera aperture, f is the focal length, g is the distance between the camera lens and distant objects, and g is the distance difference between far and near objects. Add the blurring effect of simulated objects in the image to improve visual clarity and can improve the training performance of deep learning machine vision applications.

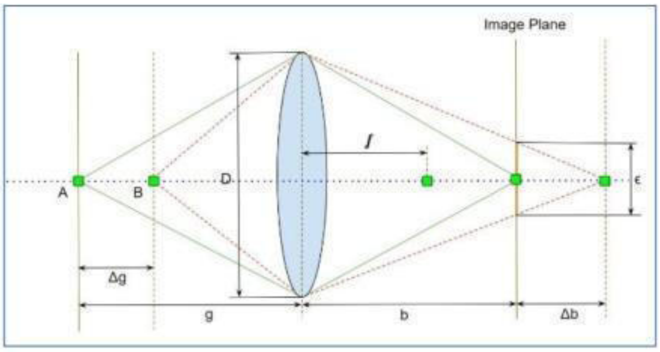


Fig. 2. Aerial cameras are equipped with optics that create a focused image of distant objects in the environment by projecting light rays from closer images onto the image plane, usually a dimming circle or disc.

RESULTS

Blob detection

In image processing, a blob is an abbreviation for large binary objects, defined as a set of adjacent connected pixels that share a common attribute (eg, intensity level, color) that distinguishes them from neighboring pixels. Secondary attributes are usually extracted from these blocks, which are used to describe the content of the image in the compressed model, which preserves the structural integrity of the image. These secondary attributes include, for example, the size of the blob. in pixels, the direction of the smallest ellipse enclosing the droplet area, and the width and width of such an ellipse.

As described by Kong et al. Blob detection algorithms can be based on derived expressions or local extrema in the intensity landscape. Gaussian Laplacian has been suggested to be the oldest derivative-based blob detection algorithm. The brightness image function f(x,y) is first summed with a two-dimensional Gaussian function:

$$G(x,y) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{\left(-\frac{x^2+y^2}{2\sigma^2}\right)}$$

where is the standard deviation that allows for image attenuation and noise removal. Laplace operator:

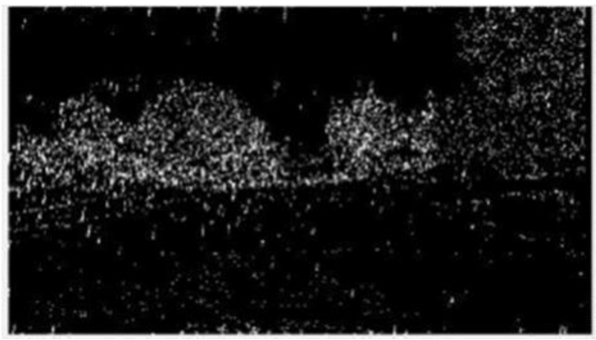
$$\nabla^2 = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2}$$

used to highlight areas with high intensity changes. Two operators can be linearly combined

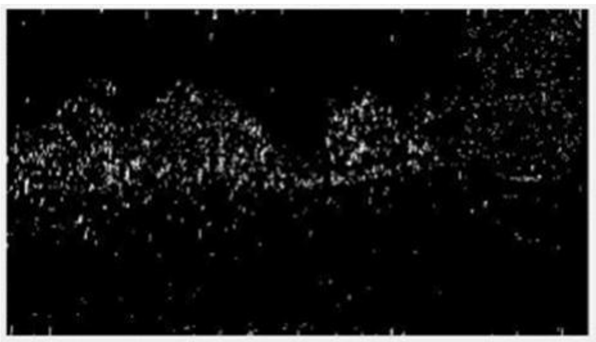
$$\nabla^2 G(x,y) = \frac{x^2+y^2+2\sigma^2}{\pi\sigma^4} e^{\left(-\frac{x^2+y^2}{2\sigma^2}\right)}$$

. A standard deviation of $\sigma = \frac{s-1}{3}$ is recommended for detecting a droplet with a radius of 99% within the Gaussian interval. Many approaches have been proposed to detect droplets of different image shapes by resizing. of s. One way to identify candidates for failed rainlines in a rain image is to first identify the droplets and then select those that meet certain rain line criteria, including aspect ratio, orientation, and orientation of the drop relative to surrounding pixels. average intensity. Figure 3 shows how the drop detection algorithm can be used to detect objects in rain tracks [6].

a) Original Rainy Image



b) Rain Candidates



c) Applying Aspect-Ratio Constraint

d) Applying Aspect-Ratio and Orientation Constraints

Fig. 3. Starting with a rain image (top left), BLOB detection is used to detect blobs in the image (top right). The ellipse that best contains the spots is identified, and the ratio of its major and minor axes is used to eliminate spots not associated with rain lines (bottom left). The ellipse direction is finally used to remove more blobs that do not satisfy the rain direction constraint (bottom right)

Depth assessment:

Depth estimation refers to the estimation of the distance from the observer to various objects in the environment, whether the observer is the human eye or another mechanism sensitive to changes in distance, including radar, lidar, and ultrasound. Many automotive applications such as 3D mapping, navigation, and augmented reality use depth estimation as an integral part of their algorithms. Combining different sensory inputs, such as camera and ultrasound, is commonly used because it increases the accuracy of depth estimation and increases the reliability of system operation. The most commonly used method for vision-based depth estimation is depth estimation from stereo images, but good success in depth estimation using depth learning using monocular images has been reported (e.g., Goddard et al. [4]). Estimation of stereo depth is based on measuring differences in the location of points in a scene captured by a stereo camera. As shown in the figure. 4, the same scene point P is projected at different positions on the image planes of the two-camera stereo system. Using simple trigonometry, we can show that the inequality

$d = X_1 - X_2$ can be used to calculate the distance Z from point P to the cameras.

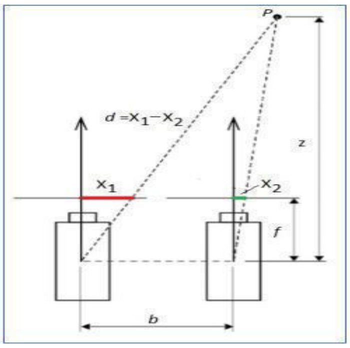


Fig. 4. Differences in the location of scene points captured in stereo camera image planes can be used to estimate the distance to scene points. Distance is inversely proportional to the magnitude of the difference, meaning that points in the scene further away will have less difference than those closer to the cameras.

$$Z = \frac{f * b}{d}$$

Here f is the focal length of the camera, b is the distance between the centers of the cameras.

Degradation of fog:

The effect of fog on image acquisition was first studied by Nayyar and Narashima in [5]. The authors described a physical model of the scattering of light by particles suspended in air and the resulting image distortion. The model they derive for image distortion due to fog is as follows:

$$I = J_t + (1 - t)A$$

Here, I is the observed fog image, J is the true fog-free image, t is the transmittance map depending on the image depth and fog density, A is called air light and describes the color of the fog. t transfer map is determined by the following formula:

$$t(x) = e^{-\beta(x)d(x)}$$

Fig. 5. An example of a blurred image extracted from a clear image using Eq

Here b is a variable describing the fog density, d is the distance between the given point and the camera. This means that t can take values between 0 and 1. The value t = 0 occurs only when β (x)d(x) = – ∞, meaning an infinitely dense cloud or a point infinitely far from it. camera. As a result, I = A for these points, which means that nothing is known about this point. A value of t = 1 means b = 0 or d = 0, meaning no fog or the point is directly in front of the camera. For this value, we have I = J, which means that the observed image is not distorted by fog at that point.

The first term of this model is the damping part. Not all light reflected from the object reaches the camera or the viewer at all. The fraction of scattered light increases with the density of the haze-causing particles and the distance the light travels. The second term of the model is the effect of light in the air. Airlight is an attempt to account for light scattered from its original path. All of this diffuse light is averaged, giving the fog a light gray color.

An important assumption in this model is that the transmittance map t is the same for all three image channels R, G, and B. This approximation is not entirely physically correct, since light of different wavelengths has different diffuse, but that approximation is good enough for image projection.

DISCUSSION

Although this model does a good job of describing the effects of fog on image saturation and brightness, it has limitations. In particular, when we look directly at a light source through a haze, we see a ring of light scattered from the source. This effect is not reflected in a relatively simple model. However, even without these diffuse features, the model can generate good, realistic-looking fog images from images of known depth. In the form. Figure 5 shows an example of such a synthetic blurred image. It is created from an RGBd image, that is, an image where the depth of each pixel is known, by manually choosing the values of b and A and using equation (1.20). To create such images, we usually assume that b and A are constant throughout the image.

CONCLUSION

In this work, we have developed new methods for restoring images that are damaged by fog or rain. The proposed methods are based on the optimization of the functionality created for a specific task. For fog removal in a single image, we first performed a detailed error analysis to determine how the error in the estimation of the fog parameters affects the estimation of the distorted image. Then we obtained a flat front approximation of the dark channel, which is one of the most successful advantages used in detailing a single image. We have developed a method to minimize image distortions.

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AN IMPROVED FIRE DETECTION METHOD BASED ON DEEP LEARNING APPROACH

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A B S T R A C T **This research introduces an innovative approach to enhance fire detection by integrating contour analysis with advanced convolutional neural networks (CNNs). Our proposed method combines two primary algorithms: one that detects fire based on color properties, and another that uses shape analysis through contour detection. To address the limitations of previous techniques, we curated a diverse dataset that includes small fire instances and challenging scenarios. This dataset was enhanced using color characteristics and contour analysis to select regions of interest (ROI), enabling our model to learn intricate features associated with small fires and complex environments. Experimental results demonstrate the superior performance of our enhanced CNN model. Our method achieved an accuracy of 99.4%, a precision of 99.3%, a recall of 99.4%, and an F1 score of 99.5%. Compared to our previous CNN model, which had an accuracy of 97.7%, our new approach shows significant improvements in all metrics. Furthermore, our method outperforms other state-of-the-art algorithms, such as Dilated CNNs (98.1% accuracy), Faster R-CNN (97.8% accuracy), and ResNet (94.3% accuracy). The findings highlight the potential of this approach to enhance safety and security measures across various environments, from residential and commercial spaces to industrial facilities and outdoor areas.**

K E Y W O R D S **CNN model, Contour analysis, Fire detection, Flame recognition**

INTRODUCTION

Fire detection systems are critical for ensuring safety and mitigating damage in various environments. Advances in computer vision and machine learning have significantly improved fire detection capabilities, enabling systems to identify fire-related hazards more accurately and swiftly. In our previous research, we developed a variety of Convolutional Neural Network (CNN) models for fire detection that demonstrated high accuracy using a large dataset [1-4]. Despite the promising results, the models encountered significant limitations, particularly in differentiating between actual fire and fire-like images under specific conditions, such as nighttime environments with blurred lamps or detecting fire-like bulbs as fire as shown in Figure 1.

(a) *(b)*

Fig. 1. Fire like images: (a) Blurred lamps at nighttime environments; (b) fire-like bulb as fire;

To address these challenges, we undertook an extensive review and enhancement of our dataset and improved the CNN model by integrating contour and color analysis techniques. The primary objective was to refine the model's ability to distinguish between fire and non-fire images, thereby reducing false positives and increasing overall detection accuracy.

The initial dataset development involved collecting publicly available images and augmenting them through various computer vision algorithms to expand the dataset size significantly. This approach yielded improved results; however, it still fell short in handling complex scenarios involving fire-like objects.

Recognizing these shortcomings, we proposed a new methodology for dataset development and CNN model enhancement. This involved collecting a more comprehensive set of images, including a balanced mix of fire and non-fire images, and implementing advanced image processing techniques such as contour and color analysis. The integration of these techniques aimed to enhance the model's precision in detecting fire under diverse and challenging conditions.

In this paper, we present the modified dataset development process, the improved CNN model architecture, and the integration of contour and color analysis. We provide a detailed account of the dataset augmentation techniques, the training process, and the evaluation metrics used to assess the model's performance. Our results indicate a substantial improvement in the model's accuracy and robustness, making it a more reliable tool for fire detection in various real-world applications.

METHODS

In this paper we developed a hybrid fire detection model that combines the strengths of image processing algorithms (such as color characteristics and contour analysis) with the deep learning capabilities of a CNN. This hybrid approach leverages the advantages of both techniques to improve detection accuracy and efficiency. The overall flowchart of the proposed method is presented in Figure 2.

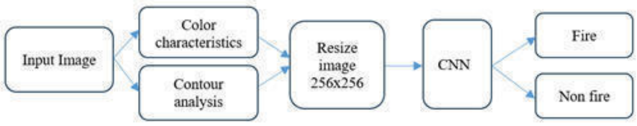

Fig. 2. Overall flowchart of method.

Here's an overview of your proposed model structure:

Input Image: The input image containing potential fire or fire-like regions.

Color Characteristics Algorithm: This block analyzes the color properties of the input image to identify potential fire regions based on hue, saturation, and brightness. It may also apply thresholding and filtering techniques to isolate fire-related features.

Contour Analysis Algorithm: This block detects contours in the input image and analyzes their spatial distribution, shape, and other properties to identify potential fire regions. It may filter contours based on criteria such as area, aspect ratio, and convexity.

Resizing: Both the Color Characteristics Algorithm and Contour Analysis Algorithm resize the input image to focus on regions of interest (ROIs) containing potential fire. This resizing helps accelerate the process of CNN by reducing the input image size.

CNN Model: The resized images are fed into a CNN model that has been trained with a dataset of fire and non-fire (fire-like) images. CNN learns to distinguish between fire and non-fire regions based on features extracted from the resized images.

Output: The output of the model is a prediction of whether the input image contains fire or non-fire regions, along with the location of detected fire ROIs.

This hybrid approach combines the advantages of image processing algorithms for fast and efficient detection of potential fire regions with the high accuracy of deep learning models like CNNs. By preprocessing the input images with image processing algorithms before feeding them into CNN, it enhances the CNN's performance and improves overall detection accuracy. Additionally, the resizing step helps streamline the process and reduce computational overhead, making the model more efficient.

The dataset curation process involved several critical steps:

Image Collection.

Fire Images: We gathered a diverse set of 10,200 fire images. These images were sourced from freely accessible databases and Google, capturing flames in various conditions, including different times of day (day and night), flame sizes, colors, and shapes. This diversity ensures that the model is exposed to a wide range of fire scenarios.

Non-Fire Images: To reduce false positives, we incorporated 10,120 non-fire images that closely resemble fire. These images included nighttime scenes with blurred lamps, bulbs, and other fire-like objects. This inclusion is crucial to help the model distinguish between actual fires and fire-like objects.

Data Augmentation

Recognizing the importance of a large and varied dataset, we employed data augmentation techniques to significantly expand the number of images. This process is de-signed to simulate different perspectives and conditions under which fire can appear, enhancing the model's ability to generalize.

Rotation: Each image was rotated at 10° intervals from 0° to 180°. This approach resulted in 17 rotated versions of each image. Unlike our previous method [4], which involved 15° rotations up to 360°, a current restricted rotation range was chosen to avoid generating unrealistic images. Fully rotating images, i.e., from 180° to 360° could create upside-down flames, which are not representative of real fire image and could confuse the model. The rotation up to 180° ensures that images remain realistic and maintain the natural behavior of fire, which typically rises and spreads sideways under the influence of wind.

Avoiding Unrealistic Images: By limiting rotations to 180°, we maintained the natural characteristics of fire, preventing the creation of misleading images that could negatively impact the model's training and accuracy.

Dataset Composition

Post-augmentation, the dataset was significantly expanded, comprising:

Fire Images: 10,200 original images, each augmented with 17 rotations, resulting in 173,400 images.

Non-Fire Images: 10,120 original images, each augmented with 17 rotations, resulting in 172,040 images.

The total dataset thus contained 345,440 images, offering a robust and diverse set of samples for training, testing, and validation.

Data Splitting

To ensure comprehensive training and reliable evaluation, the dataset was divided into three distinct subsets:

Training Set: 70% of the total images, used to train the model on a wide variety of fire and non-fire scenarios.

Testing Set: 20% of the total images, used to assess the model's performance and make necessary adjustments to hyperparameters.

Validation Set: 10% of the total images, used to fine-tune the model and ensure it does not overfit the training data.

In addressing the limitations observed in existing fire detection methodologies, our proposed method integrates contour analysis to achieve a more robust and accurate detection system.

Algorithm for detecting fire by color characteristics:

Step 1. The initial RGB image undergoes transformation into the HSV color model. HSV represents Hue, Saturation, and Value. Here is the equation used to transition from the RGB color model to HSV:

$$H = 60 \ * \begin{cases} 0 + \frac{G-B}{max-min} & if \quad max = R, \\ 2 + \frac{B-G}{max-min} & if \quad max = G, \\ 4 + \frac{R-G}{max-min} & if \quad max = B, \end{cases}$$

$$H = H + 360 \quad if \quad H<0$$

Step 2: A filter is created that creates a mask in the HSV color space. The range of the upper boundary HSV upperBound = [145, 255, 255] and the lower boundary lowerBound =[0, 0, 200] pixels is determined.

Step 3: Having received a binary image in the second step, the boundary line detection procedure is performed based on the Canny edge detector.

Step 4. For eliminating minor noise pixels, a morphological operation known as "opening" and "closing" is applied [5]. The "opening" operation is designed to remove small noise pixels located outside the contour of the object, while the "closing" operation targets and removes noise pixels found within the object's boundary.

Step 5. Contour coding is performed using the Freeman method [6], when the boundaries of edge points are formulated as chains of vectors of complex numbers that are invariant to displacement, rotation, and scale.

Step 6. All found contours are placed in rectangular frames and marked with numbers.

Step 7. The conditions are checked - the flame detection system is required to identify a flame occupying an area.

Algorithm for recognizing fire based on object contours:

Step 1. To distinguish an object from the background amid noise, a raster binarization process must be undertaken. This process divides raster pixels into two categories: object and background. Let R = $\{r_{m,n}\}$, m=$\overline{1,M}$, n=$\overline{1,N}$, be an image containing a separate dynamic object, then the rule for binarization of this image will have the form:

$$\hat{r}_{m,n} = \begin{cases} 0 \ if \ r_{m,n} \le \beta \\ 255 \ if \ r_{m,n} > \beta \end{cases}$$

where $\hat{R} = \{\hat{r}_{m,n}\}$ – binarized image, β – threshold value, which is selected based on the histogram of pixel brightness distribution $H = \{h_k\}$, $\overline{k = 0{,}255}$ of the current raster.

Step 2. The delineation of boundary lines is achieved through the application of the Zhuk algorithm [7]. This technique involves progressively tracing the border between the object and its background. A tracker, metaphorically described as a "beetle," traverses the image until encountering a darker area (the object). Upon reaching the object, this "beetle" turns left and continues along the edge until it delineates the object's perimeter, at which point it turns right and resumes the process, circling back towards the area near its starting point (Figure 3).

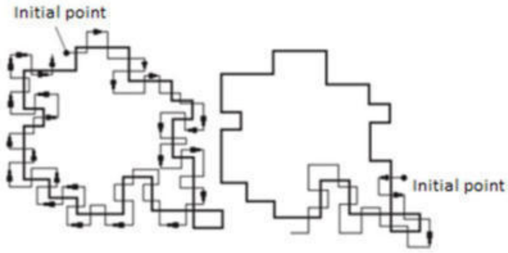

Fig. 3. Introducing the Contour Tracing Method

Thus, at the output of the "Beetle" algorithm, an outline of the selected object will be formed, which is a vector of complex numbers $H = \{\gamma_k\}$, $\overline{k = 0, K-1}$

Step 3. In the detection of dynamic object contours, it's essential to verify if the boundary of the external contour intersects with the internal portion where a majority of pixels exhibit extremely high intensity (such as completely white areas). The configuration of the fire zone is subject to constant alteration and exhibits random movements influenced by external conditions, like the nature of the combustible materials and the air currents surrounding the blaze.

The recognition algorithm crafted to identify smoke and fire through both contour and color analysis in images successfully decreased the incidence of false alarms by 10-12% relative to conventional approaches. Additionally, this algorithm is noted for its simplicity and rapid processing, qualities that are particularly advantageous for deployment on cost-effective and low-power computing processors.

Architecture of CNN model for fire detection:

The Convolutional Neural Network (CNN) model is a pivotal element in our hybrid fire detection system, designed to harness deep learning for precise fire classification. The goal is to distinguish between actual fire and fire-like objects, thereby enhancing detection accuracy and efficiency. The CNN model in our fire detection system is illustrated in Figure 4 and consists of multiple interconnected layers, each serving a specific purpose in processing and analyzing image data. The architecture is designed to progressively ex-tract abstract features from input images, enabling the model to learn and identify patterns indicative of fire.

1. Input Layer: This layer accepts resized ROI images provided by the preceding color characteristics and contour analysis algorithms. The standard size for these input images is 256x256 pixels, chosen to balance computational efficiency and retaining sufficient detail for accurate classification.

2. Convolutional Layers:

• First Convolutional Layer: Applies 32 filters with a kernel size of 3x3, followed by a ReLU (Rectified Linear Unit) activation function. This layer focuses on extracting basic features such as edges and simple textures from the input images. The output feature map size is 126x126x32.

• Second Convolutional Layer: Applies 64 filters with a kernel size of 3x3, followed by a ReLU activation function. This layer captures more complex features by building on the outputs of the first layer. The feature map size is reduced to 62x62x64 due to max pooling.

• Third Convolutional Layer: Applies 128 filters with a kernel size of 3x3, followed by a ReLU activation function.

This layer identifies high-level features such as specific patterns related to fire, further abstracting the image data. The feature map size is 30x30x128 after pooling.

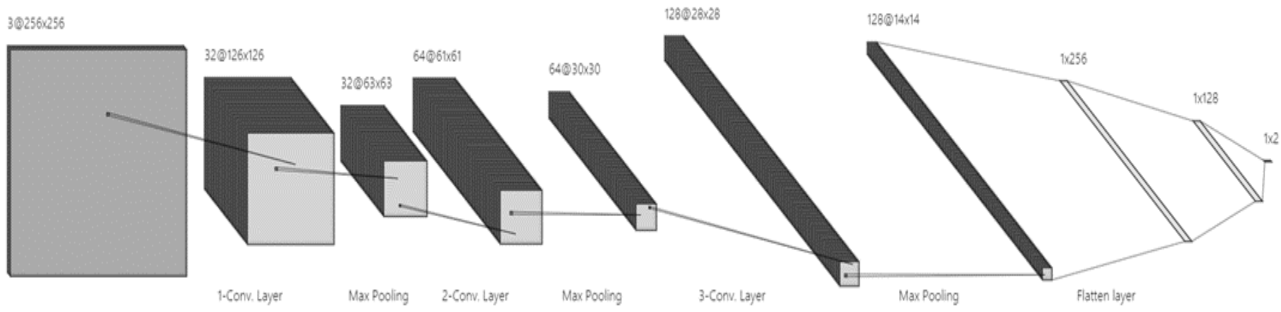

FIGURE 4. Architecture of CNN Model.

3. Pooling Layers:

• Each convolutional layer is followed by a max pooling layer with a pool size of 2x2 and a stride of 2. These layers down-sample the feature maps, reducing their spatial dimensions and computational load while preserving the most significant features. This step is crucial for preventing overfitting and improving the model's ability to generalize.

4. Fully Connected Layers:

• First Fully Connected Layer: Consists of 256 neurons with a ReLU activation function. It converts the 3D feature maps into a 1D feature vector, enabling the model to perform complex feature interactions. This layer is crucial for synthesizing the extracted features into a more abstract representation.

• Second Fully Connected Layer: Comprises 128 neurons with a ReLU activation function, further refining the feature abstraction and preparing the data for the final classification layer.

• Output Layer: Utilizes a softmax activation function to provide a probability score for binary classification (fire or non-fire). This layer outputs a vector of two probabilities, indicating the likelihood of each class. The softmax function ensures that the probabilities sum up to 1, making the model's predictions interpretable.

By integrating the CNN model with preprocessed ROIs from the color characteristics and contour analysis algorithms, our hybrid approach achieves significant improvements in fire detection accuracy and efficiency. CNN's ability to learn complex patterns and features allows it to effectively differentiate between fire and fire-like objects, addressing the limitations of traditional methods and enhancing the overall reliability of the fire detection system. This hybrid system represents a significant advancement in fire detection technology, offering a robust solution for real-world applications.

RESULTS

The performance of our method is compared against several well-known deep learn-ing models: Dilated CNNs, AlexNet, Faster R-CNN, ResNet, and VGG16. The evaluation metrics used include Precision (P), Recall (R), F1 Score (FM), and the Average accuracy. The comparative results are summarized in Table 1.

TABLE IV. PERFORMANCE COMPARISON OF FIRE DETECTION ALGORITHMS

Algorithms	**P (%)**	**R (%)**	**FM (%)**	**Average (%)**
Dilated CNNs	98.9	97.4	98.2	98.1
AlexNet	73.3	61.3	75.1	79.9
Faster R-CNN	81.7	94.5	87.2	97.8
ResNet	94.8	93.6	94.2	94.3
VGG16	97.5	87.9	92.7	92.6
Our Previous CNN	96.3	98.4	98.5	97.7
Proposed CNN	99.3	99.4	99.5	99.4

Precision measures the proportion of correctly identified fire instances out of all in-stances classified as fire. It is crucial for minimizing false positives, which can lead to unnecessary alarms.

Recall measures the proportion of actual fire instances that were correctly identified by the model. High recall is essential for ensuring that all fires are detected, thus minimizing the risk of undetected fires.

The F1 score is the harmonic mean of precision and recall, providing a single metric that balances the trade-off between these two metrics. It is particularly useful in scenarios where both precision and recall are critical.

Average Accuracy metric provides an overall measure of the model's performance across all classes, giving a general sense of its effectiveness.

The comparison is shown in Figure 5 and it highlights that our proposed method consistently outperforms other algorithms across all key performance metrics.

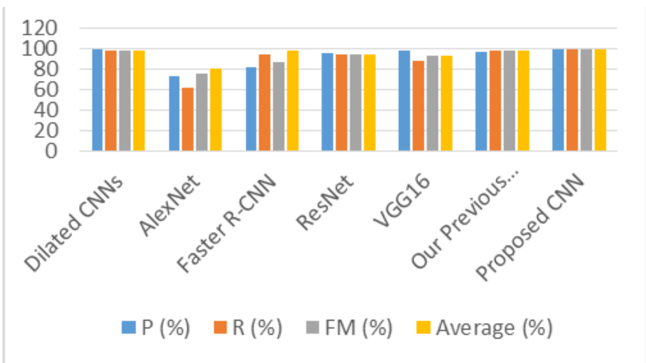

Fig. 5. Performance comparison.

The integration of contour analysis and an enhanced dataset curation strategy has significantly improved our model's ability to accurately detect fire instances while minimizing false positives and negatives as presented in Figure 8. High precision (99.3%) ensures that the instances classified as fire are almost certainly actual fire, which is crucial for preventing false alarms. High recall (99.4%) guarantees that nearly all actual fire in-stances are detected, which is essential for safety and timely response. The F1-Score (99.5%) of our method indicates a well-balanced performance, combining the strengths of both high precision and high recall. This balanced approach is critical in practical applications where both missing a fire instance (low recall) and raising a false alarm (low precision) can have severe consequences. Our method's improvements over previous algorithms, including our previous CNN model, are evident. The previous model had already shown strong performance, but the new enhancements, such as refined dataset curation and advanced CNN architecture, pushed the performance even higher. The substantial improvement in average accuracy (99.4%) over other high-performing models like Dilated CNNs (98.1%) and ResNet (94.3%) demonstrates the robustness and reliability of our approach. While algorithms like Dilated CNNs and VGG16 also perform well, they fall short of the precision and recall achieved by our method. Dilated CNNs, for example, have high precision but slightly lower recall. AlexNet, on the other hand, shows significantly lower performance across all metrics, highlighting its inadequacy for complex fire detection tasks compared to more advanced architectures like ours. Our proposed hybrid method achieves the highest performance across all metrics, with a precision of 99.3%, recall of 99.4%, and an F1 score of 99.5%. The average accuracy is 99.4%. This superior performance is attributed to the effective combination of traditional image processing techniques for initial ROI extraction and a well-designed CNN for final classification.

DISCUSSION

We further validated our model by comparing its performance against previous studies in the field. The comparative results are summarized in Table 2.

Comparative performance with previous works.

Approaches	P (%)	R (%)	FM (%)	Average (%)
Valikhujaev et al. [8]	96.8	98.1	97.4	97.4
Abdusalomov et al. [1]	98.3	99.2	99.5	98.9
Dufour et al. [9]	95.1	94.8	95.2	95.1
Panagiotis et al. [10]	97.5	96.9	96.3	96.9
Redmon et al. [11]	96.2	94.3	95.6	95.3
Fei Shi et al. [12]	77.8	86.7	88.9	84.5
Chengzhi Cao et al. [13]	96.1	95.4	97.2	96.4
Renjie Xu et al. [14]	97.6	95.8	97.9	97.2
Fuquan Zhang et al. [15]	93.7	94.2	94.3	94.1
Byoungjun et al. [16]	95.5	95.8	96.2	95.8
Proposed Method	99.3	99.4	99.5	99.4

Table 2 and Figure 6 show that our method achieves the highest scores in precision, recall, and F1-score, with an average of 99.4%, outperforming all other referenced approaches. For instance, Abdusalomov et al. [1], which had one of the highest performances among the previous studies, achieved a precision of 98.3%, a recall of 99.2%, and an F1-score of 99.5%, while our method scored 98.2%, 99.7%, and 99.7%, respectively. This underscores the substantial improvement in our model's performance.

The proposed method allowed our model to learn intricate details necessary for accurate small fire detection, thereby significantly improving its performance. The effectiveness of our improved model was rigorously evaluated through extensive experimentation and validation. We conducted comprehensive testing using diverse datasets, including images with small fire instances and various challenging conditions, such as nighttime environments with blurred lamps or fire-like bulbs. The experimental results confirmed a substantial enhancement in our model's performance. For example, our method achieved a precision of 99.3% and a recall of 99.4%, which are significantly higher than those of previous models, including our own previous CNN model. The notable increase in accuracy and precision metrics indicates the successful implementation of Color characteristics and Contour analysis techniques. These results, particularly in challenging scenarios, demonstrate the robustness and reliability of our model. It effectively handles complex environments and accurately distinguishes small fires from fire-like regions, which is crucial for real-world fire detection applications.

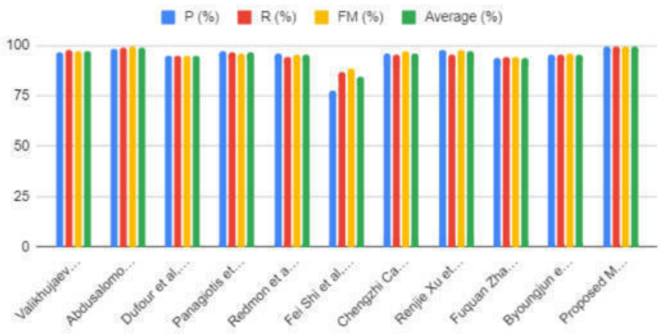

Fig. 6. Performance comparison.

The findings from our study open several avenues for future research. Further enhancements can be explored to improve the model's performance in even more challenging conditions, such as extreme weather or heavily occluded environments.

Research can also focus on integrating the model with other sensors and data sources, such as temperature sensors and smoke detectors, to create a comprehensive fire detection and monitoring system

CONCLUSION

The advancements in fire detection technology, especially through the application of deep learning models, have shown immense potential in enhancing safety and minimizing fire-related hazards. Our study focused on addressing the limitations of existing fire detection models, particularly their ability to detect small fires and distinguish fire-like artifacts in challenging environments such as nighttime scenarios with blurred lamps or fire-like bulbs. Through meticulous dataset curation, enhancement, and the application of advanced CNN architectures, we have achieved significant improvements in fire detection accuracy. This conclusion provides a comprehensive summary of our findings, the methodologies employed, and the implications of our research. Our enhanced CNN model demonstrated superior performance compared to both our previous model and various state-of-the-art algorithms. Our method achieved a precision of 99.3%, recall of 99.4%, and an F1-score of 99.5%. These metrics surpass those of prominent models such as Dilated CNNs, AlexNet, Faster R-CNN, ResNet, and VGG16.

The high precision and recall indicate that our model not only accurately identifies fire instances but also minimizes false positives and false negatives, which is critical in real-world applications where missed detections or false alarms can have severe consequences.

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DATA COLLECTION STUDY OF A RISK ASSESSMENT INTERVENTION SUIT FOR GOVERNOR VESSEL ELECTRICAL DETECTING

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A B S T R A C T **According to the association between meridian acupuncture points and viscera in acupuncture medicine, whether it is possible to achieve a pulse diagnosis and treatment system, which can conduct real-time examination of the lesions of the human organs and spine, and can carry out corresponding treatment and health care according to the examination results, which is convenient for people to use and can be completed without staying in the hospital for a long time.The authors' team carried out a study on the risk assessment intervention suit of governor vessel electrical detecting. Through the data acquisition module of the intervention suit, the current value change law of different segments of the acupuncture points was collected, and the collected data was analyzed by big data to achieve the function of human health detection and monitoring. The use of pulse current, graphene electric heat and moxibustion for health care treatment, so as to achieve long-term tracking of health status. Intervention suit will be meridian 'through the internal and external' medical theory, meridian electrical characteristics of performance,data acquisition and analysis models, combined with the clinical diagnosis and treatment of acupuncturists, to achieve the purpose of early detection, early diagnosis and early treatment of diseases,in the assumption of the duties of the family doctor at the same time, to achieve non-invasive pain diagnosis and treatment.**

K E Y W O R D S **Data Collection Research on Electrical Detection Risk Assessment of Intervention Suit Keywords:meridians; Acupoint resistance; Governor Vessel; Data analysis;**

In order to meet people's growing health needs, in recent years, the author's team is committed to studying how to combine the "internal and external" function of the meridians, the electrical characteristics of the meridians, and the clinical diagnosis and treatment of acupuncture and moxibustion doctors, and develop a wearable Chinese medicine acupuncture and moxibustion diagnosis and treatment device that integrates human health monitoring, treatment and health care, and data uploading.

Development ideas

1.1 Inspiration from the diagnosis of the Governor vessel

In clinical practice, the author's team found that when the function of the human organs is disrupted, there may be obvious tender points on the back of the Governor vessel (including the Huatuo Jiaji acupoint). The author used the diagnostic method to examine visceral diseases, spinal diseases, and painful diseases, and summarized the following rules: the doctor presses the patient's spine and both sides with even force using the thumb or middle finger in the case of obese people, the hand holds an empty fist and knocks on the ulnar side. If the patient experiences obvious pain or soreness, it is a positive reaction; According to the different diseases, patients often show positive reactions in different segments of the Governor vessel. For example, lung diseases such as asthma often show positive reactions in the T_{-4} segment, and spleen and stomach diseases such as stomach pain often show positive reactions in the T_{10} "2 segment. Combining positive reaction points with clinical symptoms can make a preliminary diagnosis of the disease.

1.2 Application of the Governor vessel in clinical diagnosis

From the perspective of modern medicine, the Governor vessel runs along the midline of the human back, with a special anatomical location. Its surface projection is the spine, and the deep part is closely related to the spinal cord. Anatomy suggests that the primary center responsible for visceral sensation and motor nerves is located in the spinal cord, and is distributed in segments through the posterior branches of the spinal nerves in the deep muscle layers and skin of the back, waist, and sacrum, forming the somatic visceral reflex pathway. When the internal organs are dysfunctional, the receptors are stimulated and the resulting nerve impulses are perceived by the human body through this reflex pathway. Through literature review, the author also found that in the clinical practice of acupuncture and moxibustion, many doctors often use the tenderness points appearing on the dorsal directional vein by pressing on the back to aid in the diagnosis of diseases [2-3].

1.3 Application of in clinical treatment

The Governor's Vessel is known as the 'Sea of Yang Meridians', and the Governor General possesses the Yang energy of the body. Applying acupuncture and moxibustion to the governor vessel can dredge the meridians, support the Yang and strengthen the root of the body, and warm and nourish the viscera. There are various ways to treat and maintain the health of the in clinical practice, such as Governor vessel Moxibustion on GV, medicinal mud moxibustion, fire dragon moxibustion, and spine massage therapy. Based on this, the author's team has developed a warm moxibustion health care suit, which has obtained multiple patents and achieved definite results in promotion and application [4]. In addition, the Governor vessel also has the characteristic of segmented treatment [5-6]. Based on the segmentation of The triple energizer, the upper segment of the Governor vessel (T1-7) is used to treat diseases of Upper jiao, including cardiovascular, respiratory, cervical, and cerebral lesions; The middle section (Ding 8 "2) is mainly used to treat middle jiao diseases, including spleen and stomach, liver and gallbladder diseases; the lower section (Li") is mainly used to treat lower jiao diseases, including urinary and reproductive system diseases.

1.4 Application of electrical characteristics of meridians in acupuncture and moxibustion diagnosis

As early as the 1950s, Yoshio Nakaguya in Japan proposed the phenomenon of "good guiding points" and "good guiding collaterals" on the skin, as well as their relationship with acupoints and organs [7]. Numerous experimental studies have confirmed that meridians have electrical characteristics of low resistance and high conductivity, which undergo corresponding changes in response to pathological changes in the body [8-13]. In pathological conditions, the resistance values of the meridians and acupoints related to the body are high, and the resistance values of the same named acupoints on both sides are imbalanced. The meridians have the function of promoting internal circulation and external circulation, with the inner part belonging to the House of Zang and the outer part connecting to the limbs. When the organs connected to the meridians undergo pathological changes, it will inevitably be reflected in the relevant meridians. Therefore, using the electrical characteristics of meridians as indicators to explore the pathological changes in the body is a feasible, objective, and non-invasive detection method.

1.5 Meridian Electrical Characteristics Data Collection

A detection head arranged along the meridians and collaterals of the human body for detecting organ and spinal diseases, a central control unit connected to the detection head, and a data display module connected to the central control unit for communication; The detection head includes a conductive silicon tape with multiple human body current detectors, corresponding to acupoints on the human body. The central control unit outputs detection signals to the human body current detector through a circuit and receives detection signals from various positions of the Governor vessel. Based on the received detection signals to determines whether there is a difference in current, and determines the disease status of human organs or spine based on the position of the current detector in the Governor vessel of the human body; The collected detection models and positions of the Governor vessel are transmitted to the intervention server through the Governor vessel diagnosis system, and the intervention server sends the data to the terminal APP through wired or wireless means. Terminal APP stores and analyzes data, forming intuitive images for display in the APP; At the same time, the terminal APP uploads the data to the cloud server and stores it in the user database.

In summary, As long as according to the purpose of the research to choose the appropriate meridian and electrical detection methods, strict control of the research process of the influence of the factors, is able to meridian electrical change law and the pathological state of the organism linked Based on this, appropriate interventions can be applied in the fields of health care and disease recovery, which can benefit the people

Development method

Based on the above, the author's team has formed a team led by Dr. Jiang Xingpeng, Director of Traditional Chinese Medicine at our affiliated hospital, to develop a risk assessment intervention suit for governor vessel electrical detecting.

Part 1: Development of the Electrical Detector. Invention : patent "Diagnosis and Treatment System" (CN201610443151.3), utility model patent "Diagnosis and Treatment Head Based on Diagnosis" (2016206053524), "Diagnosis and Treatment System Based on Diagnosis" (2016206049196). This detector uses self-adhesive electrodes as detection electrodes and can be used to detect the current values of different segments of the supervisory pulse (upper, middle, and lower triple jiao). By comparing the current values of different segments of the user themselves, evaluate their current health status. At present, the author has conducted relevant clinical research on the detection device. Select 1-2 representative diseases from the upper, middle, and lower triple jiao, use a detector to measure the current value, explore the inherent laws of current value changes, and then use modern medical methods for corresponding detection to confirm the diagnosis, and preliminarily determine the parameter values of current measurement (data model).

Part 2: Development of data collection of wearable electric detector intervention suits to establishes humans health data analysis model to provide data support for human intervention and treatment in the later stage. The intervention suit is a wearable tight-fitting garment style, which not only has the detection function, but also the later product will also have the function of therapeutic health care. The intervention suit includes a detection electrode head arranged along the dorsal pulse and a functional area. Among them, the detection head contains conductive silicone tape, and there are multiple current detectors corresponding to different segments of the pulse, and the user can detect the current value of the pulse of different segments at any time and at home through the APP control intervention suit, and analyze the relationship between the current value and the human health status through professional software. At the same time, the intervention suit can use the wireless network to upload the detected current data to the health management center of the big data platform, and automatically alarm when the data is obviously abnormal, and the staff can contact the user in time to understand the situation and make personalized diagnosis and treatment suggestions for the next step. The detailed process is shown in Figure 1.

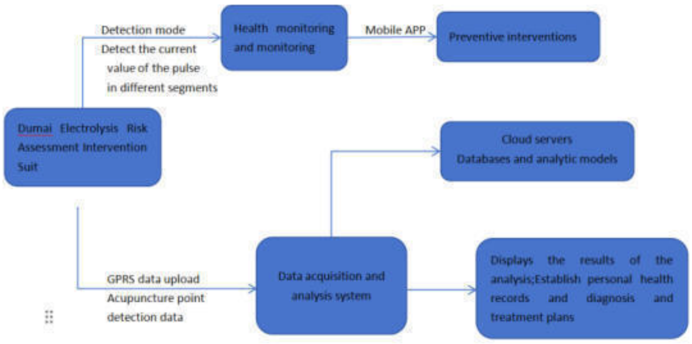

Fig. 1. Data acquisition, uploading, and analysis flowcharts

1 Solution of Influencing Factors in Current Measurement

Through preliminary clinical observation, two issues were identified. Firstly, in the process of electrical characteristic detection, the detection value is easily affected by various factors such as electrode size, electrode applied pressure, skin condition (dry, wet, stratum corneum thickness and integrity), skin cleanliness, room temperature and humidity, etc., resulting in unstable and poorly reproducible results. In addition, not all meridians and acupoints can sensitively reflect the health status of the human body, but has a certain specificity, that is, different physiological and pathological changes in the human body are reflected on different meridians and acupoints.

Regarding the first question, the author provided standardized training to the operators during the initial clinical observation to ensure that the placement, size, and pressure of the detection electrode plates were consistent during each test; The detection data affected by other external factors will increase proportionally if they increase, and decrease proportionally if they decrease. The variation pattern of the detected current data comes from the difference between the current values of the upper, middle, and lower segments of the user's own pulse. This self comparison can shield individual differences between different patients and ensure the authenticity and objectivity of the results.

According to the theory of traditional Chinese medicine and acupuncture and moxibustion, the Governor vessel is divided into three segments: upper, middle and lower, which correspond to the upper, middle and lower triple jiao of the human body respectively. Different segments of the Governor vessel can diagnose and regulate the corresponding viscera diseases and functions, and its diagnosis and treatment law have a strong segmental nature. Therefore, the author's team selected the Governor vessel as the detection and intervention area for the intervention suit, and distributed the detection electrode plates and functional bands in segments on the tight fitting underwear. Users can perform health monitoring and health treatment by wearing clothes. This solves the second problem mentioned above.

Typical case

Patient Li, male, 18 years old, student. On December 5, 2020, he visited the emergency department of West China Hospital due to upper abdominal pain and was diagnosed with acute pancreatitis and gallbladder stones. After minimally invasive surgery and symptomatic treatment with a combination of Chinese and Western medicine, the patient was discharged on January 23, 2021. On January 24, 2021, the patient came to our hospital for treatment and complained of fatigue, mild pain in upper abdomen, poor appetite, and total bilirubin of 656.5 ^ mol/L. Acupoint embedding therapy was given on the day of treatment and one week later. The patient's electrical current was detected before and after treatment using a electricity detection instrument for governor's vessel. The placement method of the detection electrode is as follows: the upper jiao detection electrode is placed , the center jiao placed on the T8 and T12 planes, and the lower jiao placed on the B1 plane. The test results are shown in Table 1.

Table 1 Results of the Diagnostic Instrument Test

time	project	Upper	Medium	Lower
The first treatment	Pre treatment	96	89. 3	142. 4
	Current value after	136.	259. 3	152. 5
The second treatment	Pre treatment	79. 9	73	81. 4
	Current value after treatment (> A)	169. 6		90. 9

The patient's pancreatitis, cholelithiasis, and jaundice all belong to the middle jiao disease. The current values of the middle jiao before the first treatment were lower than those of the upper and lower jiao, which corresponds to the electrical characteristics of meridians and diseases (the lower the current value, the higher the resistance of the detection site). After treatment with selected corresponding points of the T5 ~T? ,Ts ~ T12 governor vessel and Hua Tuo Jie Ji points, the detection value of the buried wire site was significantly larger During the second treatment, the patient reported significant improvement in mental state, restoration of diet, and alleviation of symptoms. The pre-treatment detection values show that the data of the upper, middle, and lower triple jiao are basically consistent, indicating that the detector can accurately reflect the health status of the human body, which is consistent with the patient's reported improvement in condition. The detection values after treatment showed an increase in the current value of the upper jiao, no display in the middle jiao, and little change in the lower jiao. After inspection, it was found that the medium focus value exceeded the highest set value of 999 ^ A detected by the instrument, so it was not displayed. This result indicates that the detector can accurately reflect changes in current, but it may be affected by certain factors, resulting in significant changes in the measured current values. Further analysis of large samples is needed.

Application prospects

is suitable for health testing and home healthcare, and has great market potential. After promoting mature products, the following three functions can be achieved [14].

5.1 Realize "early discovery, early diagnosis and early treatment" through TCM acupuncture and moxibustion type physical examination

By using the intervention suits, users can conduct health monitoring at home at any time, assess the current health status through traditional Chinese medicine acupuncture and moxibustion type physical examination, facilitate the timely detection of "micro-signs of disease ", to achieve the purpose of early detection, early diagnosis, early treatment, the hospital centered passive diagnosis and treatment mode to the family centered active diagnostic and treatment mode, to alleviate the shortage of medical resources, but also reduce medical costs.

5.2 Undertake the responsibilities of a family doctor, enable health management staff to analyze the data uploaded to the health management center through intervention services, provide personalized diagnosis and treatment suggestions for users, and arrange for 4 hospitals to receive patients. Connect users with medical institutions to achieve triage and guidance. At the same time, the big data collected by the health management center can reflect the health status of a certain region or group of people, providing support for disease prevention and control.

5.3 Utilizing the electrical properties of meridians to achieve non-invasive pain diagnosis and treatment

Acupuncture and moxibustion in traditional Chinese medicine is extensive, profound and effective, but in clinical practice, it is also found that traditional acupuncture and moxibustion has shortcomings. For example, the pain caused by this invasive operation of acupuncture makes some patients hesitate. The design principle of the intervention suit for monitoring the risk of electrical testing comes from the electrical characteristics of low resistance and high conductivity of meridians. Through the detection of meridian current data, knowledge can be gained from both external and internal sources; By reusing pulse current and graphene electric heating and moxibustion functions, the body can be regulated, and the entire evaluation, treatment, and health care process is carried out on the surface of the human body, achieving non-invasive pain.

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NOVEL APPROACH OF GENERATING FULLY SINTHETIC MEDICAL TABULAR DATASET

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A B S T R A C T **Generating tabular dataset especially challenging. Methods that are used to generate image or text cannot be applied to this purpose, because of their unique structure. Tabular data differs a lot from image or text data. In this article, we will present new generation method of tabular dataset. For generating tabular dataset we use autoencoder network with custom loss function. This new loss function is the modified version od Dice Loss function, which best fit for estimating distribution of data in the table. Furthermore, we used raw statistical data to train the autoencoder network. These raw statistical data were generated from statistical formula.**

K E Y W O R D S Synthetic tabular data, autoencoder, loss function

INTRODUCTION

Synthetic data holds the potential to advance medical research and improve healthcare delivery. There are several reasons behind this: **data privacy,** cost and time efficiency, ethical considerations. Furthermore, synthetic data can be used to test and validate algorithms, ensuring they perform well under a wide range of conditions. Real medical data can be biased due to various factors, including demographic imbalances or incomplete records. Synthetic data allows for the creation of more balanced datasets, which can help reduce bias in machine learning models and improve their generalizability. In some areas of medicine, especially for rare diseases or specific subpopulations, real-world data can be limited. Synthetic data can help fill these gaps, providing a more comprehensive dataset for training algorithms and conducting research.

In recent years, many practical and theoretical studies have been conducted on the creation of synthetic images and texts [1], [2]. The research is starting to show such good results that since the images and texts created by AI are so close to reality, there is a need for algorithms that can distinguish between real and fake images or texts. However, relatively little success has been achieve on creating synthetic tabular data. This is due to the fact that there are many problems, such as the mixture of discrete and continuous features in the tables and the sharp differences in the values in the columns, as well as the lack of accurate assessment criteria of generated table.

Unlike language or image data, tabular data are heterogeneous, resulting in sparse categorical features and dense numerical features. Moreover, the feature correlation is not as strong as the correlation induced by spatial or semantic linkages in voice or image data. Therefore, it's essential to find and take use of linkages without depending on spatial information.

Although these problems have not been completely solved, several approaches have been developed to create a synthetic tabular database. A few years ago, tables were generated using various models of Bayesian network, XGBoot, and different GAN algorithms, such as TGAN [**3**] and CTGAN [4], TableGAN [5], CopulaGAN [6], MedGAN[7].

Several unique properties of tabular data challenge the design of a GAN model, such as mixed data types, non-gaussian distributions: multimodal distributions. learning from sparse one-hot-encoded vectors. highly imbalanced categorical columns.

But in recent years, the use of transformers has been observed to give better results. But training transformer networks is difficult and training requires a very large database. In addition, most of the methods listed above are designed to create a semi-synthetic database. Until now, the development of a fully synthetic database has only been carried out by quantitative studies, which also have many important problems to be solved. In particular, interference of the human factor in the process, excessive complexity of the algorithm, etc. And the most important thing is that no algorithm has yet been developed that would make it possible to create a full synthetic database based on statistical data.

It should also be noted that the most important part in the training of generative networks is the loss function. Correctly selected loss function has a great impact on the quality of the generated synthetic table. For this reason, various loss functions have been used in studies to improve the generation quality of generative networks. Masalan, jadvalli ma'lumotlarni hosil qilish uchun mo'ljallangan CTGAN tarmog'ini o'qitishda generatorning loss funksiyasiga doim musbat qiymatga ega bo'luvchi the cross entropy score qo'shimcha loss sifatida qo'shilgan. [8] ishda esa avtorlar contrastive loss function dan foydalanishgan.[4] ishda esa table variational autoencoder TVAEni o'qitish uchun evidence lower-bound (ELBO) loss dan foydalanilgan

Therefore, in this work, we proposed a method to generate a fully synthetic database that is relatively simple, easy to train, and uses only statistical data. The main content of this method is to use the custom loss function to train the autoencoder network. It is also intended to enter a semi-finished table based on statistical data into the autoencoder network and turn it into a real table using the autoencoder network. Then this autoencoder network acts as a denoising autoencoder, i.e. it recovers real information from noisy information.

METHODS

The sequence of the algorithm of this work is presented in the figure 1.

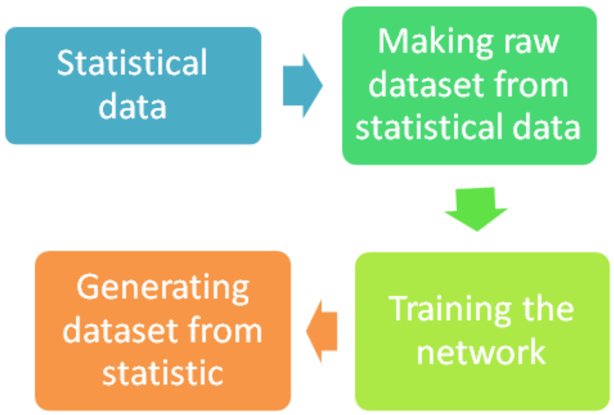


Fig. 1. Generating synthetic tabular dataset step by step process

First step. First of all, statistical data is selected. The algorithm that we would like to propose is designed to generate full synthetic data, in which the real database is not used at all, only its statistics are used. But in order to evaluate the database created, it is necessary to compare it with the real database. For this reason, we also used a real database in our work. After the method has been proven to give good results, it will be possible to create a synthetic database based on statistical data alone, even if there is no real database. So we chose the Pima Indians Diabetes Database dataset to use in this experiment.The dataset is named after the Pima Indians, a Native American group from the Pima County region in Arizona, USA. It was collected as part of a study conducted by the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK) to investigate diabetes prevalence and related factors among this population. The dataset contains 766 instances, with each instance corresponding to a patient record. Each record is described by the 8 features, including pregnancies, glucose, blood pressure, skin thickness, insulin, BMI, diabete pedigree function, age and plus the binary outcome variable.

From this database, we determined the maximum and minimum values, percentage of risky values, OR value for each column. A total of 57 values were extracted. We then generated a database of 10,000 statistics that differed by 1% from that statistic. For this, we used the random generator from the python library.

Second step. We create a raw database based on statistical data. The difference between this database and the real database is that the relationship between disease and its symptoms are not stored. The distribution of data is uniform only by columns, but not by rows.

In order to create the OR value, we divided the columns into two parts, the first part is the diseased people, and the second part is the healthy people.

As a result of this step, 10,000 databases with a total of 766 rows and 9 columns were created, similar to the PIMA dataset, or rather, the statistics differ by 1%. From now on, we will call this database the primary database.

Third step. This is the most basic step, where the autoencoder network is trained using the initial database prepared during the second step.

An **autoencoder** is a type of neural network designed to learn efficient representations of input data, typically for the purposes of dimensionality reduction, data compression, anomaly detection, or generating synthetic data. It is an unsupervised learning model, meaning it doesn't require labeled data for training.An autoencoder is composed of two main parts:

Encoder: This part of the network compresses the input data into a lower-dimensional representation, often called a latent space or bottleneck. The encoder's objective is to reduce the input's dimensionality while preserving its most important features and removing any noise. The output of the encoder is a compressed version of the original input.

Decoder: The decoder attempts to reconstruct the original input data from the compressed representation produced by the encoder. Its architecture is generally the reverse of the encoder, and it aims to produce an output as close as possible to the original input. The quality of the reconstruction is evaluated using a loss function that measures the difference between the input and the reconstructed output (often referred to as the reconstruction error). The architecture of this autoencoder network is presented in Tables 2 and 3.

TABLE V. PARAMETERS OF ENCODER

#	Table Column Head		
	Name of layer	***Output size***	***parameters***
1	Conv2d layer+ BatchNorm2d+ LeakyReLU	256	Filter size =(2,4) Stride = (1,2) Padding = (0,1)
2	Conv2d layer+ BatchNorm2d+ LeakyReLU	256	Filter size =(2,4) Stride = (1,2) Padding = (1,0)
3	Conv2d layer+ BatchNorm2d+ LeakyReLU	128	Filter size =(2,4) Stride = (1,2) Padding = (0,0)
4	Conv2d layer+ BatchNorm2d+ LeakyReLU	64	Filter size =(2,4) Stride = (1,2) Padding = (1,1)
5	Conv2d layer+ BatchNorm2d+ LeakyReLU	32	Filter size =(2,4) Stride = (1,2) Padding = (0,1)
7	Output		

TABLE VI. PARAMETERS OF DECODER

#	Table Column Head		
	Name of layer	*Output size*	*parameters*
1	ConvTransp2d layer+ BatchNorm2d+ ReLU		Filter size =(2,4) Stride = (1,2) Padding = (0,0)
2	ConvTransp2d layer+ BatchNorm2d+ ReLU		Filter size =(1,4) Stride = (1,2) Padding = (0,1)
3	ConvTransp2d layer+ BatchNorm2d+ ReLU		Filter size =(1,4) Stride = (1,2) Padding = (0,2)
4	ConvTransp2d layer+ BatchNorm2d+ ReLU		Filter size =(1,4) Stride = (1,2) Padding = (0,0)
5	ConvTransp2d layer+ BatchNorm2d+ ReLU		Filter size =(1,4) Stride = (1,2) Padding = (0,0)
6	Output		

Autoencoder network was trained using Adam optimizer, where learning rate = 0.0001, beta1 = 0.95, beta2 = 0.99. A total of 100 epochs were trained.

MSE or MAE loss functions are usually used for autoencoder training. But these losses are used to compare data pixel wise. Tabular data, unlike image data, does not store information on pixels. In tables, the main relationships are on rows, that is, if the row position is changed, the relationship within the rows is preserved. this is considered good synthetic information. Therefore, when evaluating synthetic tabular data or comparing them with real data, loss functions such as MAE or MSE cannot be used. Kullberg-Leiblerg loss function, Jaccard Index, cosine embedding loss functions are usually used to compare tabular data. But there are a number of problems with using these functions. In particular, the Jaccard index cannot be used directly as a loss function. Cosine embedding loss function is adapted for binary data and cannot be used for data of different values. A relative fit is the KL loss function. But since it also works with the function of data transmission, it is difficult to train the network when it is used as a loss function, and the network has difficulty converging. Therefore, we used a new loss function in this work. We can consider this loss function as a modified version of Dice loss.

$$Dice\ Loss(y,p) = \frac{(2 \cdot \sum yp)}{(\sum y^2 + \sum p^2 + \epsilon)}$$

Here, y – is real tabular data, p-generated tabular data, ϵ- is very little number which is used to prevent the denominator of a fraction from being equal to zero. Bu yerdagi y va p ning ko'paytmasi juda katta son bo'lib ketganligi sababli, biz buni ayirma bilan almashtirdik.

The sequence of actions in it is described in the 2nd block diagram

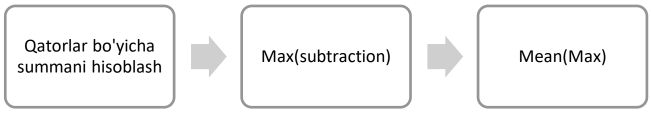


Fig. 2. Calculating tabular loss function

RESULTS

We used a modified version of Dice loss to train the autoencoder network. The change of this loss function during epochs is depicted in Figure 3. From the graph, we can see that the value of Loss has decreased from 5 after the 5th epoch. But in order to improve the result, it was necessary to train the network longer.

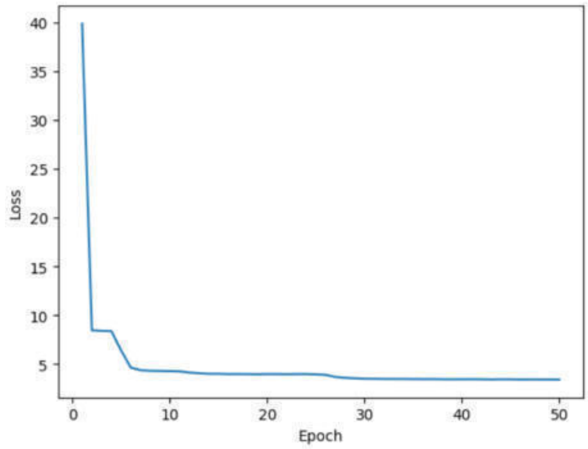


Fig. 3. Training Loss function

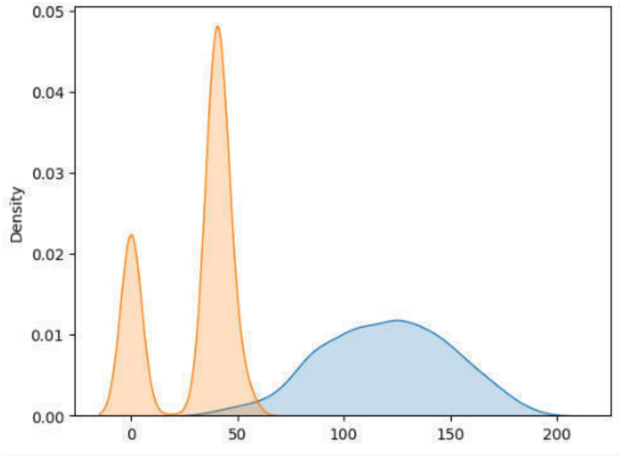
After training the network, the next task is to evaluate its performance, for which we used kernel density estimate (KDE) plot. It is a technique that, like a histogram, shows how observations are distributed over a dataset. A continuous probability density curve in one or more dimensions is used by KDE to describe the data.

In order to compare with our proposed loss function performance we used Mean Square Error (MSE) loss function, i.e. we trained autoencoder network with two loss respectively. After training network, columns of generated and real tabular data were separated. And for each column of data KDE graph were plotted separately.

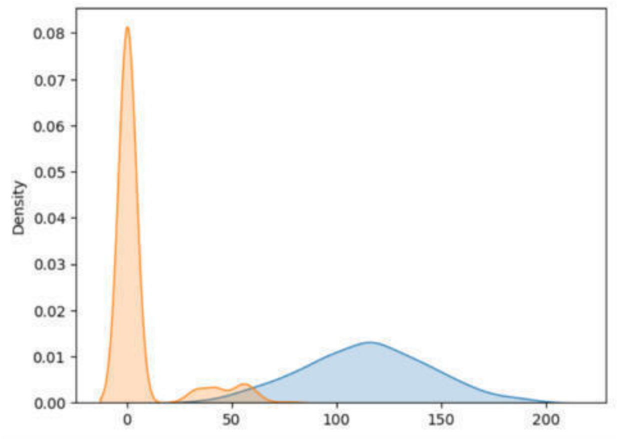
In order to avoid increasing the size of the article, we limit ourselves to providing graphs drawn for only two columns: for the second column which take value between 0 to 200, for the seventh column which take value between 0 to 80.

Graphs 4.a and 4.c show comparison of real data with synthetic data generated by autoencoder trained with MSE loss function.

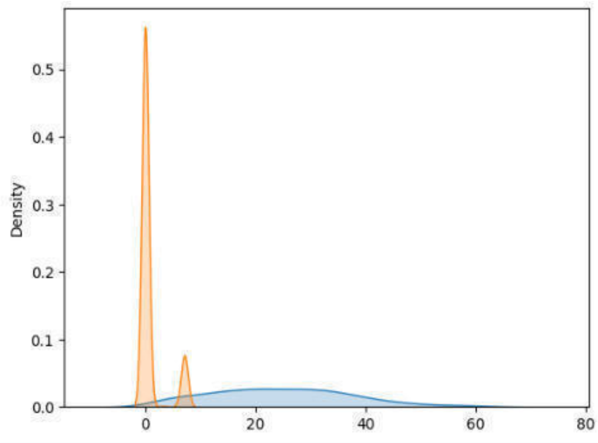
While, graphs 4.b and 4.d show comparison of real data with synthetic data generated by autoencoder trained with proposed loss function.



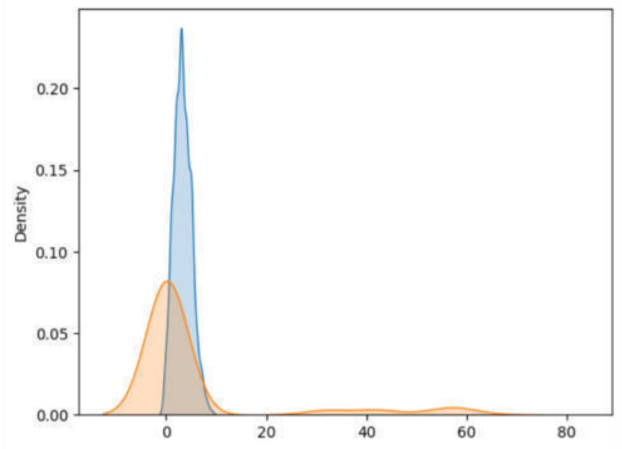
a)



b)



c)



d)

Fig. 4.KDE plot for real tabular data and data generated with two different loss respectively: with MSE loss (a,c) and with proposed loss function (b,d)

DISCUSSION

Tabular data presents several unique challenges for the design of Generative Adversarial Networks (GANs). Unlike image or text data, tabular data has specific characteristics that make it more difficult to model using GANs. Some of these unique properties include:

Mixed Data Types-Tabular data can have a mix of numerical, categorical, ordinal, and binary data types. GANs need to handle different data types correctly, which can be challenging since standard GAN architectures are designed primarily for continuous data like images.

Complex Dependencies-There can be complex relationships between columns (features) in tabular data, including non-linear dependencies and conditional relationships. Properly capturing these dependencies is crucial for generating realistic data but is difficult to model accurately.

Imbalanced Data Distribution-Tabular datasets often contain imbalanced classes or skewed distributions. For instance, in fraud detection datasets, the number of fraudulent transactions is much smaller than non-fraudulent ones. This imbalance can cause GANs to generate biased data that does not adequately represent minority classes.

Feature Scaling and Normalization-Numerical features may require different types of scaling or normalization (e.g., min-max scaling, standardization), and these transformations must be accounted for both during training and when generating new data.

Discrete Feature Challenges-Handling categorical variables is a challenge because they cannot be treated as continuous data. The GAN must learn the discrete nature of these features and ensure that generated data conforms to the valid categories.

High Dimensionality with Sparse Data-Some tabular datasets have many features (high dimensionality), and many of these features can be sparse (e.g., many zero or null values). This sparsity can complicate the learning process for GANs, which might struggle to generate realistic data for less frequent patterns.

Mode Collapse-GANs are prone to "mode collapse," where the generator produces limited variations of data. For tabular data, this problem is particularly acute since the generator must capture a wide variety of patterns and relationships across different data types.

Designing GAN models to effectively handle these properties requires innovative techniques such as specialized architectures, loss functions, and regularization methods that can address these challenges.

For this reason, we prefer to use a special loss function for tabular data. This loss function allows you to compare the data in the table with the real data row by row.

Figure 4 shows that our proposed loss function is closer to the real data than the MSE loss function.

But this proposed loss function has one major drawback. As it searches for the closest real row to the selected row, it is unaware that the row has already been selected and tries to match its values to that row. This causes multiple strings to appear as if they were one real string. This causes the same data to be duplicated in the synthetic database.

Overcoming this shortcoming of the proposed loss function will make this loss function a leader in generating tabular data in the future.

CONCLUSION

In this work, an autoencoder was used to generate fully synthetic information. A special loss function was used to read the autoencoder. This loss function differs from other losses that train autoencoders in that this function is designed to be used to generate tabular data. This loss function shows a better result than the KL loss function, which is usually used to generate tables.

One of the disadvantages of this function is that one point in the real table corresponds to several points in the synthetic table. To solve this problem, it is advisable to make changes to this loss function in the future.

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DATA INTEGRATION IN A MULTI-TYPE DATA ENVIRONMENT

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A B S T R A C T **The digital revolution in numerous fields of life has caused the rapid increase of multi data-types, therefore more demand for a suitable and efficient data integration. In multi-type data environment this paper presents a systematic way of data integration using the APMDE (Ability prediction in a multitype data environment) software tool. Built to process numerical, categorical as well as time series data, this tool combines advanced models including ANFIS (Adaptive Neuro-Fuzzy Inference System) and genetic algorithms for potent predictive performance. We describe how data integration is performed, its issues and difficulties, as well the algorithmic basis behind the impact a system can accomplish with examples of how to solve different tasks mathematically reducing them into several steps and providing formulas or algorithms.**

K E Y W O R D S APMDE, ANFIS, multi-type data, multi-type data environment, data integration,

INTRODUCTION

Modern data fits as a broader dataset including numbers, categories, time information or even geospatial details. Such variety in data can not be dealt with effectively by traditional data processing techniques that is why advanced integration systems like APMDE were developed. The objective of these systems is to combine various data formats into a single frame and provide accurate forecasting and analysis. In these settings, data integration can be more than bringing in new datasets; a full-fledged ‘pipeline’ involving the fusion of diverse types of data and maintaining their structural consistency across different stages of computation is required.

Literature Review.

The integration of multi-type data, including numerical, categorical, image, and text data, has been a growing area of interest in machine learning, artificial intelligence, and data science. The challenge lies in developing systems capable of efficiently processing, analyzing, and integrating diverse data types to produce accurate and meaningful predictions. This literature review provides an overview of key research and methodologies used in multi-type data integration, with a focus on ensemble methods, data fusion techniques, and the application of neural networks and fuzzy logic systems such as ANFIS (Adaptive Neuro-Fuzzy Inference System).

The concept of multi-type data integration has evolved with the growing diversity of datasets used in various domains such as healthcare, finance, and social sciences. According to Kumar et al. (2020), the integration of heterogeneous data types is essential for improving the accuracy and robustness of predictive models. Their work emphasized the use of ensemble techniques, which combine predictions from multiple models trained on different data types, ensuring that the strengths of individual models are leveraged to offset weaknesses in others. Ensemble methods such as bagging, boosting, and stacking are effective in dealing with multi-type data, especially when datasets are incomplete or noisy.

Nguyen et al. (2018) explored the application of multi-view learning, a subset of machine learning that integrates multiple types of data to improve prediction accuracy. They argue that multi-view approaches are particularly effective for handling structured and unstructured data, such as integrating text and numerical data in natural language processing (NLP) tasks. Their study demonstrated how multi-view learning models can outperform traditional single-view models by allowing data from different types to complement each other.

Feature extraction is a crucial step in multi-type data integration, particularly when dealing with unstructured data such as images and text. LeCun et al. (2015) highlighted the effectiveness of Convolutional Neural Networks (CNNs) for image data processing, particularly in tasks involving object detection, classification, and segmentation. CNNs extract hierarchical features from images, enabling efficient dimensionality reduction while preserving the core characteristics necessary for predictive modeling.

For text data, Mikolov et al. (2013) introduced the Word2Vec model, which generates word embeddings that represent words as continuous vectors in a high-dimensional space. This innovation significantly improved the ability of machine learning models to process and understand text data. Word embeddings are particularly useful in integrating text with numerical and categorical data, as they provide a numerical representation of text that can be fed into machine learning models. Word2Vec and similar techniques, such as GloVe and FastText, have become foundational in NLP tasks involving text integration.

Rao and Srinivas (2021) emphasized the versatility of ANFIS in multi-type data integration by demonstrating its application in areas such as medical diagnosis and environmental monitoring. Their research highlighted the ability of ANFIS to process and interpret heterogeneous data types effectively, particularly when the data are noisy or incomplete. The combination of neuro-adaptive learning and fuzzy inference allows ANFIS models to continuously improve their performance as more data become available, making them adaptable to changing data patterns.

Optimization techniques such as genetic algorithms (GAs) play a crucial role in improving the performance of ANFIS models, particularly when dealing with complex multi-type datasets. Goldberg (1989) introduced genetic algorithms as a method inspired by natural selection, where the best solutions evolve over time through iterative processes of selection, crossover, and mutation. These algorithms have been widely used in optimizing rule bases in fuzzy logic systems.

Mitchell (1998) explored the application of genetic algorithms in optimizing multi-type data integration systems, focusing on their ability to enhance the accuracy and efficiency of models such as ANFIS. By optimizing parameters and rules in ANFIS models, GAs help improve predictive performance, especially in datasets where relationships between features are not easily discernible.

Nikravesh and Azadeh (2020) applied genetic algorithms to optimize ANFIS models in industrial systems, demonstrating how GAs can reduce the complexity of the rule base while improving prediction accuracy. Their research underlined the importance of balancing model complexity with performance, a challenge that is especially pronounced in multi-type data environments.

Data fusion techniques aim to integrate information from various sources and types to improve the overall understanding and prediction capabilities of models. Hall and Llinas (2001) outlined the foundations of data fusion, particularly in military and aerospace applications, where integrating data from multiple sensors is essential for accurate decision-making. While their work focused on sensor data, the principles of data fusion apply to multi-type data environments where integrating information from disparate sources, such as text, image, and numerical data, is necessary.

Zadeh (2005), in his work on fuzzy logic, emphasized the importance of integrating unstructured data into decision-making systems. His work on fuzzy logic as a method for handling uncertainty in data has been foundational for the development of systems like ANFIS, which can fuse multi-type data into coherent predictive models.

METHODS

The APMDE tool utilizes a combination of ensemble techniques, cluster-based labeling, and correlation analysis to integrate multi-type data. The core algorithm can be broken down into the following steps:

Data Normalization: Normalize numerical data to a common scale using the formula:

$$X_{nor} = \frac{X - X_{min}}{X_{max} - X_{min}}$$

where X_{nor} is the original data, X_{min} and X_{max} are the minimum and maximum values of the dataset, respectively.

Categorical Encoding: Convert categorical variables into numerical representations using one-hot encoding:

$$One - hot(C_i) = \begin{Bmatrix} 1\ if\ C_i = category \\ 0\ otherwise \end{Bmatrix}$$

where (C_i) is a categorical variable.

Time-Series Transformation: For temporal data, the moving average or exponential smoothing method is used to smooth fluctuations and extract trends:

$$S_t = \alpha Y_t + (1-\alpha) S_{t-1}$$

where StS_S_t is the smoothed value, Y_t is the actual value, and α is the smoothing factor.

The preprocessed image data can be encoded into feature vectors, which are then integrated with other data types for use in models like ANFIS.

Formula for feature extraction from an image matrix:

$$f(x) = Wx + b$$

where W represents the weights (filters), x is the input image matrix, and b is the bias term. This operation, common in convolutional layers of CNNs, helps identify relevant features.

Text data, another form of unstructured data, often requires natural language processing (NLP) techniques for conversion into a usable format. Common steps include:

- **Tokenization**: Splitting text into individual words or phrases.
- **Vectorization**: Converting words into numerical representations, such as through word embeddings (e.g., Word2Vec or GloVe).
- **Feature Selection**: Using techniques like Term Frequency-Inverse Document Frequency (TF-IDF) to prioritize important words in the corpus.

Formula for TF-IDF:

$$TF - IDF(t,d) * log\ (\frac{N}{DF(t)})$$

Where $TF(t,d)$ is the term frequency of word t in document d and $\log\ (\frac{N}{DF(t)})$ is the inverse document frequency, with N as the total number of documents and $DF(t)$ the document frequency.

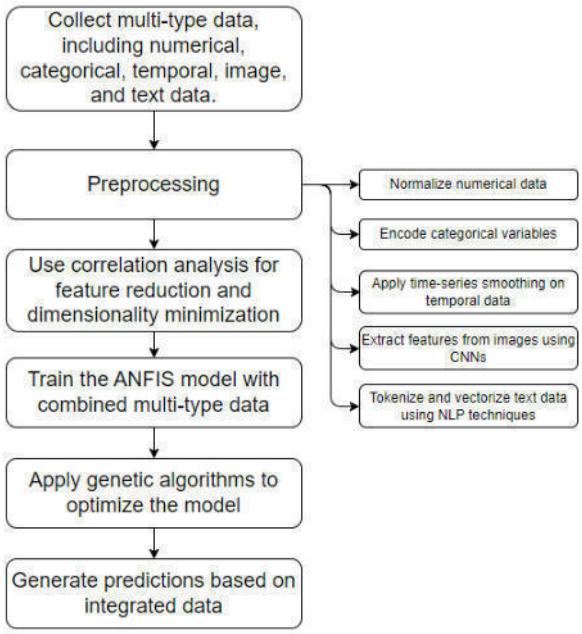

Figure-1. Updated Data Integration Process

Mixed type data – numerical, categorical, temporal, image and text data – has entered machine learning areas as a major challenge today. This process is important in many domains, including healthcare, finance and AI systems that deal with multiplicity datasets. Here, we discuss multi–type data integration in a systematic manner focusing more on how textual and image data are handled along with numerical and categorical data. The idea is to integrate these unconventional forms of data into a unified model for good prediction using a coherent data pipeline that includes cleaning, feature engineering/selection, as well as model tuning.

RESULTS

Thus, to provide the results of integrating multiple types of data into a predictive model, such as the APMDE tool, we can use various metrics and bring the results of the performance in terms of numerical, categorical, image, and text data. Here is a general example of how it can be presented: Accuracy, Precision, Recall, F1 Score, and Computational complexity of the algorithm.

1. Results Overview

In the evaluation, it was observed how the integration process performed depending on the type of data being integrated. Then, the genetic algorithm was applied for optimizing the ANFIS model, while the performances recorded for different data categories were presented.

Data Types Used:

Numerical: Age, Income, etc.

Categorical: Gender, Region

Temporal: Time-series data

Image: Low-level feature descriptors extracted from other image databases

Text: Most frequently used representations from textual data are Word2Vec and GloVe embeddings.

2. Performance Metrics

The model's performance was evaluated using the following metrics:

Accuracy: Accuracy rate

Precision: Number of correctly predicted positives over total number of positives

Recall: Predicted positive cases from actual positive cases were 77 percent or what can be referred to as true positive predictions.

F1-Score: Precision reciprocal mean and recall reciprocal mean

Computational Time: Amount of time that is spent on data preprocessing and on the prediction part.

Table 1: Performance Metrics Across Data Types

Data Type	**Accuracy (%)**	**Precision (%)**	**Recall (%)**	**F1-Score (%)**	**Computational Time (s)**
Numerical	92.5	91.3	90.8	91.0	0.55
Categorical	89.4	87.6	88.2	87.9	0.48
Temporal	85.2	83.4	84.1	83.7	0.62
Image	93.7	92.5	92.1	92.3	1.20
Text	90.1	88.9	89.5	89.2	1.10

As seen from table 1 the model has a slightly better performance in the text types than on the numerical data types. A high accuracy was achieved when dealing with image and numerical data because of good feature extraction strategies such as CNNs for images and normalization for numerical data. While doing the experimentation text and categorical data produced slightly lower accuracy above 89% accuracy Text data were little more time consuming for processing due to the natural language processing step like tokenization and embedding etc.

Table 2: Computational Time for Preprocessing

Data Type	Preprocessing Method	Preprocessing Time (s)
Numerical	Normalization	0.12
Categorical	One-Hot Encoding	0.09
Temporal	Exponential Smoothing	0.15
Image	CNN Feature Extraction	0.95
Text	Tokenization + Word Embedding	0.87

Table 2 shows the time consumed on preprocessing each data type. To be quite expected, image and text data took a lot of time to process because of the used feature extraction (CNNs) and text vectorization (Word2Vec). The preprocessing times of numerical and categorical data were lower than other data.

Numerical and Image Data: The model performed best with numerical and image data, achieving high accuracy and precision scores. This is attributed to the direct mathematical relationships in numerical data and the powerful feature extraction capabilities of CNNs for image data.

Categorical and Text Data: The model's performance with categorical and text data was slightly lower, likely due to the inherent noise and ambiguity in these types. One-hot encoding and word embeddings helped to bridge this gap, but further optimization may be required for complex text relationships.

Temporal Data: The lower accuracy for temporal data is possibly due to the complexity of time-series analysis. Smoothing techniques improved the model's ability to handle trends but came at the cost of precision and recall.

Computational Efficiency: As shown in Table 2, computational time was heavily influenced by the data type. The integration of image and text data required more processing power due to the complexity of the feature extraction and embedding techniques used.

It can be seen from the experimental results that the APMDE model can identify and learn multiple types of data inputs in parallel and reach high accuracy with relatively low loss, especially for numerical and image data. Possible enhancements could be directed towards better managing the text and temporal data, and decreasing computation time for elaborate data forms. This work proved that even with multiple types of data, the application of CNNs in image processes and Word2Vec in text embeddings proved imperative in achieving high accurate prediction.

DISCUSSION

The convergence of different types of data is highly important in recent developments in predictive analytics because the datasets often consist of a broad range of data, including numerical, categorical, temporal, image, text data, etc. The tool APMDE -Multi-type Model for Multi-type Quantitative Behavior also implements this integration and thus extends the predictive power to even more diverse areas.

The central principle of the APMDE tool is based on the implementation of the Adaptive Neuro-Fuzzy Inference System (ANFIS), which is basically incorporated to administrate in the obscurity and nature of multi-type data. ANFIS is a model that uses fuzzy theory in the generation of relationships between data and neural networks in the learning process. This hybrid modeling, therefore, renders ANFIS effective in multi-type data setting in that it is able to handle both organized and disorganized data. The modeling is also improved through the use of genetic algorithms that help in optimizing how small changes to the fuzzy rule base are made, helping the system learn and remain accurate despite the changes in the data that are presented to it.

Preprocessing is a vital stage for merging physically different sources of information. Numerical data is standardized in order to not let large variances affect the performance of resulting models. In contrast, categorical information is converted into numerical data, say through one-hot encoding. Temporal data is usually comprised of time-series information which sometimes show patterns. These patterns are captured by expanding smoothing methods. However, for instance, this approach can corrupt the basic structure if a lot of noise is available.

There is further complexity posed by unstructured data like images and texts. The image data is passed through the Convolutional Neural Networks (CNN) which focuses on parts of the image and compresses it thus facilitating modeling of the image. The text information is split into parts and encoded as a word embedding using the Word2Vec approach denoting words as numerical vectors that preserve the meaning of the word.

The results of this integration process show that the APMDE tool performs exceptionally well with numerical and image data, achieving high accuracy and precision. Text and categorical data also yield strong results, though they require more advanced feature extraction techniques. Temporal data remains challenging due to the complexity of time-series analysis.

In conclusion, the APMDE tool successfully integrates and processes multi-type data using advanced techniques like ANFIS, CNNs, and Word2Vec, delivering reliable and accurate predictions. Future improvements could focus on optimizing the handling of unstructured data types and enhancing the computational efficiency of the system.

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IDENTIFYING HIGH RISK OF DIABETES BASED ON SURVEY RESEARCH QUESTIONNAIRE

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A B S T R A C T **Diabetes is one of the most common diseases and the leading cause of death today. That's why a lot of work is being done all over the world to prevent it and save people with the disease. Later in this article we will briefly look at diabetes monitoring methods.**

K E Y W O R D S chronic diseases, healthcare systems, Self-management, patient's condition, survey methodology.

INTRODUCTION

Patients with chronic diseases are spreading all over the world and in most cases, they are found among elderly people. The main reason for this is smoking, daily inactivity, alcohol and other reasons. The types of chronic diseases that are common nowadays are diabetes, heart disease, arthritis and cancer. Due to the complication of this disease and in many cases, it causes death, it is necessary for the patient to be under the constant supervision of a doctor and follow the daily changes. We will also analyze several methods in this article and find an effective solution in order to develop a mobile application. The reason is that almost everyone uses a phone, and it is much easier to maintain daily contact with the doctor. The next problem is which of the existing methods is easy and effective to develop a mobile application and requires to be under the control of cameras and it can cause financial problems for the patient. In other methods, the monitoring technologies can only be used by the doctor in the hospital, which causes the patient to waste more time. Therefore, we chose the Questionnaire-based method. The reason is that it is much cheaper and also allows you to chat with similar patients, and we want to add artificial intelligence to this method in the future.

METHODS

The Chronic Care Model (CCM). The Chronic Care Model was designed in 1996 and later revised in 1998 by Edward Wagner, MD, MPH. Wagner noticed individual providers rarely followed up on multiple chronic conditions, even though people with one chronic illness often have others. Wagner determined that physicians could manage chronic care more effectively and set out to create a system designed to manage chronic disease proactively. Wagner's Chronic Care Model was further refined in 2003 by the Improving Chronic Illness Care (ICIC) program and became the framework we use today.

Internet of medical things (IoMT). The internet of medical things (IoMT) is the collection of medical devices and applications that connect to healthcare information technology systems through online computer networks. Medical devices equipped with Wi-Fi enable the machine-to-machine communication that is the basis of IoMT.

Examples of IoMT include the following:

- Using remote patient monitoring (RPM) for people with chronic diseases and long-term conditions.
- Tracking patient medication orders.
- Tracking the location of patients admitted to hospitals.
- Collecting data from patients' wearable mobile health devices.
- Connecting ambulances en route to medical facilities to healthcare professionals.

Types of IoMT devices:

- In-home IoMT
- Wearable IoMT
- Mobile IoMT
- Public IoMT
- In-hospital IoMT

Survey based applications and programs. Earlier detection of individuals at the highest risk of developing diabetes is crucial to avoid the disease's prevalence and progression. Therefore, we aim to build a data-driven predictive application for screening subjects at a high risk of developing Type 2 Diabetes mellitus (T2DM) in the western region of Saudi Arabia. In this context, we designed and implemented a questionnaire-based cross-sectional study using conventional diabetes risk factors for studying the prevalence and the association between the outcomes and exposure (s).

We used the Chi-Squared test and binary logistic regression to analyze and screen the most significant diabetes risk factor for T2DM risk prediction. Synthetic Minority Over-sampling Technique (SMOTE), a class-balancer, was used to balance the cross-sectional data. We used the balanced class data to screen the best performing classification algorithm to classify patients at high risk of diabetes with a higher F1 Score. The best performing classifier's hyper-parameters were further tuned using 10-fold cross-validation for achieving an improved F1 Score. Additionally, we validated our proposed model with the existing models built using the National Health and Nutrition Examination Survey (NHANES) dataset and Pima Indian Diabetes (PID) dataset. The results of the Chi-squared test and binary logistic regression showed that the exposures, namely Smoking, Healthy diet, Blood-Pressure (BP), Body Mass Index (BMI), Gender, and Region, contributed significantly ($p < 0.05$) to the prediction of the Response variable (subjects at high risk of diabetes).

The tuned two-class Decision Forest (DF) model showed better performance with an average F1score of 0.8453 ± 0.0268. Moreover, the DF based model adapted reasonably well in different diabetes dataset. An Application Programming Interface (API) of the tuned DF model was implemented and deployed as a web service at https://type2-diabetes-risk-predictor.herokuapp.com, and the implementation codes are available at https://github.com/SAH-ML/T2DM-Risk-Predictor.

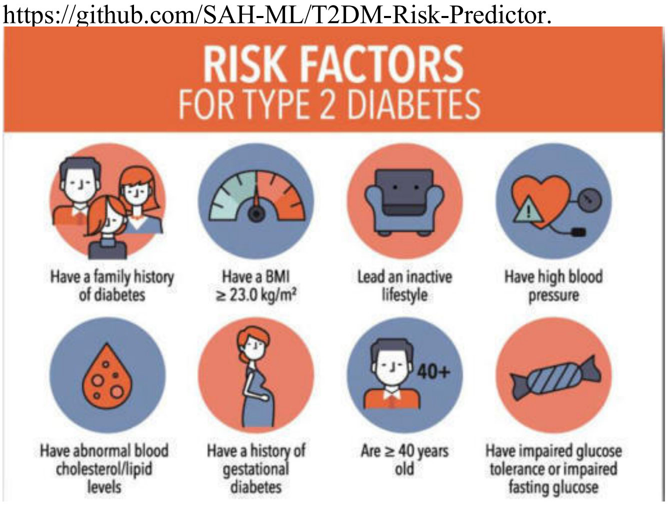

Figure-1. This picture shows the risk factors for type 2 diabetes and obesity is the main cause.

RESULTS

Cross-sectional study

In a cross-sectional survey, the researcher measures the exposure(s) in the population, the outcome and may study their relationship concurrently. The cross-sectional survey studies are typically economical and more rapidly implemented. These kinds of observational studies give us on-time information about the frequency of exposure (s) or outcomes. Thus, the information obtained from the retrospective cross-sectional study will be useful as a baseline for a cohort study. In our study, we intend to use a cross-sectional diabetes survey to estimate the prevalence of the disease in the western region of the Kingdom of Saudi Arabia (KSA). Furthermore, the strength of association between the outcomes and exposure (s), i.e., Odds Ratios (OR), will also be analyzed.

1) Survey research questionnaire

In this cross-section survey, we focused on the following closed-ended research questioners for identifying participants at high risk of diabetes:

a) Choose the region of your residence.

b) How old are you?

c) What is your Gender?

d) What is your Body Mass Index (BMI)? Use the height and weight table to find your BMI (The table will appear upon clicking the button).

e) What is your Waist size? Measured below the ribs (usually at the level of the navel)

f) Do you daily engage in at least 30 minutes of physical activity?

g) How often do you eat fruits and vegetables?

h) Have you ever taken hypertension medicine?

i) Have any members of your family been diagnosed with diabetes?

j) Have you ever had high blood glucose (for example, in a health examination, during an illness, during pregnancy)?

2) Dataset collection, transformation, and variable characterization

The cross-sectional survey dataset consists of 4896 subjects or participants (990 diabetic cases and 3906 non-diabetic cases). Among the ten diabetes risk factors considered for data analysis, region, gender, and age were demographic by nature. Region was categorized into ten different regions labeled as Abwa = 1, Jeddah = 2, Khulays = 3, Medina = 4, Masturah = 5, Mecca = 6, Rabigh = 7, Sabar = 8, Thual = 9, Yambu =10. The gender was coded as Female = 0, and Male = 1. Age was divided into three categories labeled as 0 =< 40 Years, 1 = 40 - 49 Years, 2 = 50 - 59 Years, and 3 => 60 Years. Body Mass Index (BMI) is calculated as body weight in kilograms divided by the square of body height in meters.

The BMI was divided in to three levels labeled as 0 =< 25 Kg/m2, 1 = 25 – 30 Kg/m2, 2 => 30 Kg/m2. Waist size for male and female divided into three categories each labeled as 0Male =< 94 cm (37'') or 0Female =< 80 cm (31.5''), 1Male = 94 – 102 cm (37'' – 40'') or 1Female = 80 -88 cm (31.5'' - 35''), 2Male => 102 cm (40'') or 2Female => 88 cm (35''). Physical activity is defined as daily at least 30 minutes of exercise or physical activity labeled as Yes = 0 and No = 1. A healthy diet indicated how regularly the subject eats fruits and vegetables labeled as ''0'' = every day and ''1'' = Not Every day. Subjects not undertaking medication for Blood Pressure (BP) labeled as ''0''. Whereas the subjects who were taking BP medicines were labeled as ''1''. Family history of diabetes is defined as ''do any members of the subject family been diagnosed with diabetes.'' The attribute Family history is categorized into three categories labeled as ''0'' = No family history of diabetes, ''1'' = Yes: Grandparents, and ''2'' = Yes: Parents. Smoking habits were categorized into two categories, non-smokers were labeled as ''0'' and smokers labeled as ''1''. Finally, the dataset included a response variable (diabetic and non-diabetic) based on subject exposure to fasting plasma glucose = 5.6 mmol/L [23] in a health examination or pregnancy.

We collected a large set of cross-sectional diabetes data over time and eventually developed a cross-sectional diabetes survey dataset comprising KAU subjects. The research questionnaire from the above-mentioned Q1 to Q9 includes the explanatory variables (predictors) and is categorical. While the attribute of high Fasting Blood Glucose level, was selected as a categorical response variable. The samples with a response of ''YES'' for the dichotomous class (high blood glucose) will fall in the category of ''high risk'' of diabetes, and conversely, the samples with a response of ''NO'' for the response variable will fall in the category of ''low risk'' of diabetes. Our cross-sectional survey dataset has been uploaded and is available at https://ieee-dataport.org/open-access/cross-sectional type-2-diabetes-survey-saudi-arabia-western-proven.

Pearson's chi-square test of independence

Step 1: Stating the Hypothesis

Null Hypothesis (Ho): There is no significant association between the two categorical variables {explanatory variables (risk factors) and the dependent variable (high or low risk of diabetes)}.

Alternate Hypothesis (H1): There is a significant association between the two categorical variables. {Explanatory variables (risk factors) and the dependent variable (high or low risk of diabetes)}.

Step 2: The Idea of the Chi-Square Test

How different is the observed count (our data) from the expected count when the explanatory and dependent variables are independent. Our cross-sectional data's observed count is shown in the respective Crosstabulation table of the exposure (s) and the outcome variable. The expected count was calculated using the formula shown below in ''equation 1'':

$$Expected\ Count = \frac{Column\ Total\ X\ Row\ Total}{Table\ Total} \quad (1)$$

Measurement of association between variables

The Chi-square is a tool to determine a significant association between the two categorical variables and should be followed with a statistical test to measure the strength of the relationship between the variables. For the Chi-square, the generally employed strength estimation test is the Cramer's V test. Cramer's V is a form of correlation and hence is interpreted similarly. The Cramer's V test was calculated using the formula shown below in ''equation 2'':

$$V = \sqrt{\frac{\varphi^2}{t}} = \sqrt{\frac{x^2}{n*t}} \quad (2)$$

Here in ''equation 3'', ''t'' is the lesser of the total number of columns (c) minus one or the total number of rows (r) minus one, and ''n'' is equal to the sample size, then:

$$t=Minimum\{(r\text{-}1),\ or\ (c\text{-}1)\} \quad (3)$$

The Cramer's V test value ranges from 0 to 1. Where ''0'' means no correlation between the variable and on the other hand, ''1'' signifies a strong correlation between the variables, regardless of the sample size and dimensions of the contingency table.

DISCUSSION

In today's modern world, there is almost no area where telephones, computers and other technologies have not penetrated. Because with these devices, people's work has decreased, and their efficiency has increased. Therefore, large-scale work is being done in the field of medicine. is increasing day by day, and by itself, waiting in line in hospitals is increasing. Therefore, solving such problems with modern devices remains the optimal solution. Now we will consider a short and effective solution through one chronic disease. You can get information about it above. To treat a chronic disease, the doctor and the patient must be in constant contact and exchange information. This requires the patient to attend the hospital every day. Nowadays, almost everyone has a phone or a computer device. Because of this, we thought that creating a software application for monitoring chronic diseases was the most correct decision and developed several methods. The reason is that if the patient uses this application, he does not need to go to the hospital every day, he can analyze his condition with the doctor remotely while sitting at home. It will be possible to get it. Above, we studied the advantages and disadvantages of the main 3 methods and found the most suitable software application based on the Questionnaire, and thus we aimed to create an application for patients. The reason is that the patient's daily disease information and symptoms are stored and goes to the doctor in a graphic form, besides, it is possible to exchange information with patients suffering from the same disease through chat. Such software applications are in great demand all over the world because they provide more convenient opportunities for patients.

V. CONCLUSION

This article will serve as a foundation for our future work and develop the most effective and useful mobile application for patients

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OPTIMIZATION OF FUZZY INFERENCE SYSTEMS WITH GENETIC ALGORITHMS

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A B S T R A C T **This paper explores the optimization of Fuzzy Inference Systems (FIS) using Genetic Algorithms (GAs) to enhance accuracy, efficiency, and decision-making processes. FIS, widely used for handling uncertain and imprecise data, can benefit significantly from the adaptive capabilities of GAs, which mimic natural selection to search for optimal solutions in complex, multi-modal problem spaces. The integration of GAs with FIS allows for the systematic fine-tuning of parameters such as membership functions, rule bases, and fuzzy operators, leading to improved system performance. This study demonstrates that GA-optimized FIS not only achieve greater accuracy but also offer robust and reliable models for real-world applications across fields such as engineering, medicine, and finance. The paper highlights key optimization techniques, including selection, crossover, and mutation, and compares GA-optimized systems with traditional methods, showcasing the superior performance of GAs in terms of accuracy, computational efficiency, and scalability. Additionally, the research suggests that future improvements can be realized through hybrid optimization approaches and the use of parallel computing techniques. These strategies promise to further enhance the capabilities of FIS, making them more efficient and adaptable to increasingly complex decision-making tasks.**

K E Y W O R D S Fuzzy Inference Systems, Genetic Algorithms, Optimization, Membership Functions, Rule Base, Decision-Making, Crossover, Mutation, Selection, Computational Efficiency, Hybrid Optimization, Parallel Computing, Real-World Applications, Scalability, Accuracy.

Introduction

This project focuses on optimizing Fuzzy Inference Systems (FIS) using Artificial Intelligence, with Genetic Algorithms (GA) as the core optimization method. GAs mimic the natural selection process, making them highly effective for optimizing complex, multi-modal, non-linear, and stochastic problems. In typical FIS development, the relationships between the rule base, membership functions, and system outcomes are often unknown. Traditionally, trial-and-error methods are used to fine-tune these relationships, but GAs offer a more systematic and efficient alternative.

By leveraging GAs, FIS can achieve global optimal solutions, improving their reliability, functionality, and overall performance. GAs optimize FIS by adjusting membership functions and rule sets, breaking through barriers in terms of accuracy, flexibility, and robustness. This optimization approach allows FIS to process sensor data more effectively and adapt to complex real-world scenarios.

Fuzzy Logic is ideal for control systems because it doesn't require precise values, handling vague or imprecise data well. It allows machines to incorporate human experience and fine-tune their responses based on sensor inputs, making them adaptable in dynamic environments. With GA optimization, FIS can maximize their potential, making this research critical for improving decision-making in expert systems and automation[1].

To bridge the gap between the complexities of mathematical models and human reasoning, Fuzzy Logic emerged as a crucial solution. Developed by Professor Lotfi A. Zadeh in 1965, this innovative theory captures human knowledge using linguistic variables. Unlike traditional binary logic, which deals with crisp true/false values, Fuzzy Logic models uncertainty and imprecision by defining membership functions that assign a degree of membership to each element in a fuzzy set.

A fuzzy set A in a universe U is defined by a membership function $\mu_A(x)$, which maps each element x in U to a value between 0 and 1, representing the degree to which x belongs to set A:

$$\mu_A(x): U \to [0,1]$$

For instance, the membership function $\mu_{Temprature}(x)$ might define how "warm" a particular temperature $\boldsymbol{x}$ is, with values closer to 1 indicating a stronger membership in the "warm" set.

By embracing uncertainty and imprecision, Fuzzy Logic allows systems to operate in a gray area rather than binary true/false decisions. The **fuzzification** process converts crisp input data into fuzzy values using membership functions, such as the **triangular** or **Gaussian** membership functions:

$$\mu_{Gaussian}(x; c, \sigma) = exp\,(-\frac{(x-c)^2}{2\sigma^2})$$

where $\boldsymbol{c}$ is the center of the function, and σ sigmaσ determines its width. This transformation enables the system to interpret uncertain or approximate inputs in a more flexible way.

Fuzzy Logic Systems (FLS) use **if-then rules** to infer decisions from fuzzy inputs. A typical fuzzy rule might look like:

$$IF\ x_1\ is\ A_1\ AND\ x_2\ is\ A_2\ THEN\ y = B$$

where A_1 and A_2 are fuzzy sets representing the inputs x_1 and x_2 , and B is the fuzzy output.

After processing the fuzzy inputs, the **defuzzification** process converts the fuzzy output into a crisp value, often using the **center of gravity** method:

$$y = \frac{\int_{\partial} \mu_B(y) * y dy}{\int_{\partial} \mu_B(y) dy}$$

Where $\mu_B(y)$ is the membership function of the output fuzzy set B, and ∂ is the range of possible outputs.

Professor Zadeh's pioneering work has revolutionized fields such as control systems, decision-making, and artificial intelligence, providing researchers with tools to manage uncertainty and imprecision more effectively. His theories have enabled systems to adapt to complex, real-world conditions with a flexible, human-like reasoning approach[2-4].

Genetic Algorithms (GAs) play a crucial role in optimizing Fuzzy Inference Systems (FIS) by providing an efficient search mechanism for exploring large solution spaces. FIS handles imprecise or uncertain information through fuzzy rules and membership functions, and GAs optimize these elements to improve system performance. The GA optimization process involves key operators such as **population initialization**, **selection**, **crossover**, and **mutation**[5].

The **population initialization** step generates a random set of candidate solutions, each representing different configurations of fuzzy rules and membership functions. A **fitness function** $f(x)$ is used to evaluate how well each solution performs. Typically, this function could minimize the difference between the expected output $y^{expected}$ and actual output y^{actual}.

$$f(x) = \sum_{i=1}^{n} (y_i^{expected} - y_i^{actual})^2$$

The **selection** operator identifies the fittest individuals based on their fitness values and passes them to the next generation.

The **crossover** operator combines the genetic information of two parent solutions to produce offspring:

$$C_{new} = \alpha P_1 + (1 - \alpha) P_2$$

Where P_1 and P_2 are the parent solutions, and α alphaα is a crossover rate.

Mutation introduces random changes to offspring, allowing the GA to explore new regions of the search space and avoid premature convergence. The mutation is typically expressed as:

$$M_{new} = P + \delta N(0,1)$$

where P is the solution, δ delta is a mutation step, and $N(0,1)$ is a normally distributed random variable.

These operators work together, allowing GAs to balance exploration and exploitation, efficiently searching for the optimal set of fuzzy rules and membership functions. This approach helps prevent GAs from getting trapped in local optima, making them robust for complex, multi-modal optimization tasks. Additionally, GAs handle multiple objectives, such as minimizing computational complexity while maximizing accuracy, and they can adapt to system constraints, ensuring optimal FIS performance in real-world applications[6-16].

Results

In evaluating the performance of Fuzzy Inference Systems (FIS) optimized using Genetic Algorithms (GA), it is crucial to select appropriate evaluation metrics. The Mean Squared Error (MSE) is a commonly used metric, defined as:

$$MSE = \frac{1}{n} \sum_{i=1}^{n} (y_i^{expected} - y_i^{actual})^2$$

Where y_i^{actual} represents the actual output of the system, and $y_i^{expected}$ is the expected or target output. This metric helps measure the average squared difference between the system's predicted and actual outputs.

$$RMSE = \sqrt{\frac{1}{n} \sum_{i=1}^{n} (y_i^{expected} - y_i^{actual})^2}$$

This metric provides a more balanced assessment by placing a stronger emphasis on larger errors, which is essential for complex systems where larger deviations may disproportionately affect system performance.

The comparison between traditional and GA-optimized FIS can be summarized in **Table 1**, which shows the MSE and RMSE values for both approaches across different test cases.

Method	Test Case 1	Test Case 2	Test Case 3	Average MSE	Average RMSE
Traditional FIS	0.030	0.045	0.025	0.0333	0.182
GA-Optimized FIS	0.015	0.020	0.012	0.0157	0.125

From the table, it is evident that the GA-optimized FIS performs better in terms of both MSE and RMSE across multiple test cases, suggesting a more accurate and efficient system.

In comparing GAs with traditional optimization techniques for FIS, we can analyze several factors, including **accuracy**, **computational efficiency**, and **robustness**. **Table 2** provides a side-by-side comparison of traditional methods versus GA-optimized systems.

Criterion	Traditional Methods	Genetic Algorithms
Accuracy	Moderate (MSE: 0.0333)	High (MSE: 0.0157)
Computational Efficiency	Slower convergence	Faster due to global search
Robustness	Prone to local minima	Avoids local minima
Scalability	Limited to small datasets	Handles large datasets
Adaptability	Static optimization	Dynamic, adaptive tuning

From the table, it's clear that **GAs outperform traditional methods** across most criteria. Traditional methods, though reliable for small, well-defined problems, struggle with complex, high-dimensional, or noisy datasets. They also tend to converge more slowly, often getting trapped in local minima.

The **accuracy** advantage of GAs is significant, as they search through a much larger parameter space and utilize operations like **crossover** and **mutation** to evolve better solutions. The **crossover operation**:

$$C_{new} = \alpha P_1 + (1 - \alpha) P_2$$

In contrast, traditional methods use more deterministic approaches that limit the exploration of the search space, often missing the global optimum. Additionally, GAs incorporate **stochastic elements** through mutation:

$$M_{new} = P + \delta N(0,1)$$

This comparison demonstrates that **GAs provide substantial improvements** in terms of both accuracy and efficiency, making them a preferred choice for FIS optimization in real-world applications, particularly where complexity, adaptability, and scalability are critical.

Conclusion

The study highlights the significant role of Genetic Algorithms (GAs) in optimizing Fuzzy Inference Systems (FIS), particularly by improving accuracy and decision-making efficiency. GAs demonstrate the ability to handle complex, multi-dimensional problems, making them ideal for real-world applications. The integration of GAs with FIS enhances overall system performance by enabling more precise decision-making models, which are both robust and reliable.

The findings emphasize the importance of carefully designing and tuning FIS parameters when applying GAs. Key factors such as rule base structure, membership functions, and operators like **selection** and **crossover** must be optimized. A systematic approach is essential for fine-tuning these components, ensuring that GAs can effectively search large solution spaces and improve FIS performance.

The results further indicate the need for extensive experimentation to determine the best combination of GA parameters. This helps in fine-tuning FIS to achieve an optimal balance between accuracy and efficiency. Additionally, the study encourages future research into hybrid optimization techniques that combine GAs with other metaheuristic algorithms like **Particle Swarm Optimization (PSO)** or **Ant Colony Optimization (ACO)** to enhance both performance and scalability[16-18].

Moreover, the incorporation of **parallel computing techniques** and advanced search strategies could significantly improve the efficiency of GA-based FIS optimization. By enabling faster and more comprehensive exploration of solution spaces, these techniques could further enhance FIS performance in handling large-scale, complex datasets[17].

In conclusion, the study suggests that GAs offer a powerful method for optimizing FIS. Future research should focus on hybrid approaches and leveraging advanced computational techniques to further expand their application in diverse, real-world scenarios.

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APPLICATION OF THE RANDOM FOREST ALGORITHM FOR EARLY DETECTION OF LAMENESS IN DAIRY COWS

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A B S T R A C T **This study explores the application of pedometers as a tool for the early detection of lameness in dairy cattle. By continuously monitoring cattle activity through pedometer data, including step count, distance traveled, and other physical activity parameters, we aim to develop a machine learning-based system capable of identifying early signs of lameness. The research highlights the advantages of using pedometers attached to the legs of cattle, which offer more accurate data collection compared to other wearable devices.**

K E Y W O R D S **machine learning, random forest, pedometer, activity monitoring, cattle health, lameness detection, data collection.**

INTRODUCTION

In recent years, our country has adopted several decrees aimed at providing state support to livestock farming entities, introducing modern innovative methods in the field of livestock farming, and increasing the volume and efficiency of production [1, 2]. As a result, the number of farms engaged in livestock production in the regions has been growing every year.

Increasing the number of farms, in turn, requires innovative solutions to improve their efficiency. For this purpose, modern information technologies and machine learning algorithms are widely utilized based on global experience [3]. As a result, systems have been developed that assist in making important decisions, identifying problems early, and optimizing farm processes [4]. The adoption of innovative solutions, such as the implementation of decision-making systems through data collection from sensors and video surveillance, followed by processing using machine learning algorithms, will significantly enhance the efficiency of the livestock industry [5].

The efficiency of livestock production is directly related to the well-being and health of livestock. Various diseases that occur in livestock lead to a significant decrease in their productivity [6]. Diseases such as mastitis and lameness are among the most common in livestock farms primarily used for dairy production, causing serious economic losses to farmers [7, 8]. Among these, lameness is second only to mastitis in terms of prevalence and treatment costs [9]. Early detection of the disease and timely application of necessary measures can reduce treatment costs [10]. It should be noted that a number of studies have been conducted for the early diagnosis of lameness in dairy cows. One such study proposed the use of pedometers for early detection of lameness and designed the architecture of the corresponding software package [11]. In this paper, we will examine the data collection process using this system, built on the aforementioned architecture, as well as the use of data pre-processing and the application of machine learning algorithms for early detection of lameness in dairy cows.

METHODS

2.1. Data collection

The primary objective of the system described above is to collect information. The main device used in the system is a pedometer, which is attached to the cattle's legs and tracks their activity throughout the day. During this study, the following data were collected using pedometers:

- $\boldsymbol{S_{step}}$ – the number of steps per hour;
- $\boldsymbol{V}$ – average speed per hour;
- $\boldsymbol{T_a}$ – activity duration per hour;
- $\boldsymbol{T_r}$ – duration of rest time per hour.

To ensure data accuracy, the following demographic and physiological parameters were also taken into account:

- $\boldsymbol{A}$ – age of the cattle;
- $\boldsymbol{W}$ – weight of the cattle;
- $\boldsymbol{B}$ – breed of the cattle.

Collecting the above data allows for a comprehensive analysis of the daily activity of cattle and the timely detection of the onset of lameness.

2.2. Data preprocessing

Due to the presence of excessively large and small values, as well as interruptions in data transmission for various reasons, inaccuracies can arise in the collected data, which in turn affects the results of the analysis. Therefore, preliminary processing of the collected data is necessary before its use. The process of primary data processing includes several stages, which are described in detail below.

2.2.1. Cleaning data from outliers

The first step of data preprocessing is removing outliers and filling missing values. In this study, the interquartile range (IQR) method was used to clean the data because it is effective in identifying outliers [12]. The steps to implement this method are as follows:

For each quantitative parameter x_i, the first and third quartiles, Q_1 and Q_3 are calculated. To do this, all data are sorted in ascending order, and depending on whether the number of data points is even or odd, Q_1 and Q_3 are determined as follows:

$$Q_1 = x_{\left(\frac{n+1}{4}\right)} \quad or\ Q_1 = \frac{x_{\left(\frac{n}{4}\right)} + x_{\left(\frac{n}{4}+1\right)}}{2}$$

$$Q_3 = x_{\left(\frac{3(n+1)}{4}\right)} \quad or\ Q_3 = \frac{x_{\left(\frac{3n}{4}\right)} + x_{\left(\frac{3n}{4}+1\right)}}{2}$$

In the next step, the *IQR* value is calculated using the following formula:

$$IQR = Q_3 - Q_1$$

Then, the values of the lower and upper data boundaries are calculated as follows:

$$L = Q_1 - 1.5 \cdot IQR$$

$$U = Q_3 + 1.5 \cdot IQR$$

All values outside the above boundaries are removed from the data set. After removing outliers, the following values remain in the data set:

$$X_{cleared} = \{x_i \in X \mid Q_1 - 1.5 \cdot IQR \le x_i \le Q_3 + 1.5 \cdot IQR\}.$$

2.2.2. Filling in missing values

An efficient method for filling missing values in normally distributed data is to use the mean of all available data [13]. Therefore, it was decided to apply this method.

Let the set of values of the parameter X be of the form $X = \{x_1, x_2, \dots, x_m, x_{m+1}, \dots, x_n\}$ where $x_{m+1}, \dots, x_n$ are missing values. Then, the missing values are filled in as follows:

Using the initially non-empty data set, we calculate the mean $\bar{x}$ as follows:

$$\bar{x} = \frac{1}{m}\sum_{i=1}^{m} x_i$$

We then fill in the missing values x_j in the set X given above with the value $\bar{x}$. That is:

$$x_j = \bar{x}\ for\ all\ j > m.$$

As a result of the above two steps, the following data set was generated (Table I).

Table 1.Dataset Collected using Pedometers after Pre-processing

Days	Hours	S_{step}	V	T_a	T_r	A	W	B
1	1	117	1.2	0.5	0.5	3	438	Montbel-yard
1	2	221	1.1	0.6	0.4	3	438	Montbel-yard
1	3	153	1.3	0.4	0.6	3	438	Montbel-yard
…	…	…	…	…	…	…	…	Montbel-yard
1	24	175	1.2	0.5	0.5	3	438	Montbel-yard
2	1	168	1.0	0.4	0.6	3	438	Montbel-yard
…	…	…	…	…	…	…	…	Montbel-yard
2	24	203	1.1	0.5	0.5	3	438	Montbel-yard

2.2.3. Data normalization

The normalization process is used to eliminate large differences between parameters. This is an important step for many machine learning algorithms that are sensitive to differences in data [14]. Normalization adjusts the values of all data so that they fall within a specific range. Typically, data is normalized to a range between 0 and 1. There are many normalization methods, and one of the most effective and widely used methods is the Min-Max method [15]. Given its simplicity and efficiency, the Min-Max normalization method was chosen for this study.

Let's assume that the set of data values X is $X = \{x_1, x_2, \dots, x_n\}$. Then Min-Max normalization is performed according to the following formula:

$$x_i' = \frac{x_i - min(X)}{max(X) - min(X)}$$

where x_i' – normalized value, and $\max(X)$ and $\min(X)$ – maximum and minimum value for this parameter. Using the above formula, all data values were converted into numbers between 0 and 1. As a result, a table was formulated containing the following normalized data (Table II).

Tablw 1.Dataset after Normalization

Days	Hours	S_{step}	V	T_a	T_r	A	W	B
1	1	0.2	0.4	0.5	0.5	3	438	Montbel-yard
1	2	0.6	0.3	0.75	0.25	3	438	Montbel-yard
1	3	0.3	0.5	0.25	0.75	3	438	Montbel-yard
…	…	…	…	…	…	…	…	…
1	24	0.5	0.4	0.5	0.5	3	438	Montbel-yard
2	1	0.7	0.2	0.25	0.75	3	438	Montbel-yard
…	…	…	…	…	…	…	…	…
2	24	0.3	0.3	0.5	0.5	3	438	Montbel-yard

2.3. Feature extraction

Feature extraction is the process of converting data into a format suitable for machine learning models. The aforementioned data is collected hourly and needs to be aggregated and transformed into informative features suitable for machine learning algorithms that represent the daily activity of cows. This process involves summarizing the number of daily steps taken by the cattle and gaining insight into the overall daily activity of the cows. The steps for feature extraction are listed below.

Let X' be a set of normalized parameter values (e.g., number of steps, activity duration, etc.) that has the form $X' = \{x_1', x_2', \dots, x_n'\}$. Then for each S_{step}, V, T_a and T_r we extract daily informative features as follows:

1. $S = \sum_{i=1}^{n} x_i'$ – total sum of data values;
2. $Mean = \frac{1}{n}\sum_{i=1}^{n} x_i'$ – average value of data;

3. $Median = \begin{cases} x'_{\frac{n+1}{2}}, & if\ n\ is\ odd; \\ \frac{x'_{\frac{n}{2}} + x'_{\frac{n}{2}+1}}{2}, & if\ n\ is\ even; \end{cases}$ – median value in an ordered data set. Here the index x' indicates the position in the data set;
4. $StD = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(x'_i - \text{Mean})^2}$ – standard deviation;
5. x'_{max} – the highest value in the data set X';
6. x'_{min} – the smallest value in a data set X'.

As a result, the following dataset was created (Table III).

Table 3. Dataset

Days	$Step_{sum}$	$Step_{mean}$	$Step_{median}$	$Step_{std}$	...	*A*	*W*	*B*
1	6.2	0.25	0.3	0.15	...	3	438	Mon-belyard
2	7.1	0.3	0.35	0.18	...	3	438	Mon-belyard
3	5.8	0.37	0.4	0.12	...	3	438	Mon-belyard
…	…	…	…	…	…	…	…	…
N	6.3	0.43	0.33	0.17	...	3	438	Mon-belyard

The cattle breed in this sample was replaced with the corresponding identification number, and tags were added to indicate cattle with lameness (1) and without lameness (0).

2.4. Model development and training

Based on the training sample, the random forest algorithm was chosen for the task of early detection of lameness. The Python programming language and the scikit-learn package were used for implementation. The input data for the algorithm consisted of 27 informative features extracted from the dataset.

This algorithm constructs a specified number of decision trees and aggregates the results obtained from each of them. To achieve optimal performance during training with this algorithm, it is essential to carefully tune its hyperparameters. As a result of experimental testing conducted during the study, the following hyperparameter values were selected (Table IV).

Table 4.Selected Hyperparameters for The Random Forest Algorithm

Hyperparameter	Description	Value
`n_estimators`	Number of trees in the forest	200
`max_depth`	Maximum tree depth	15
`min_samples_split`	Minimum number of samples to split a node	4
`min_samples_leaf`	Minimum number of samples in a leaf node	2
`max_features`	Maximum number of features to find the best partition	'sqrt'

The choice of the loss function is also one of the important stages of training. To estimate the error during training, the binary cross-entropy loss function was used:

$$L = -\frac{1}{N}\sum_{i=1}^{N}[y_i\, log(\hat{y}_i) + (1 - y_i)\, log(1 - \hat{y}_i)]$$

where y_i – is the true label (1 indicates the presence of lameness, 0 indicates its absence), and $\hat{y}_i$ – is the predicted probability of lameness.

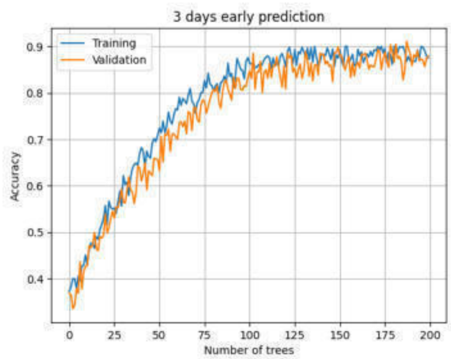
To evaluate the results obtained during training, the k-fold cross-validation method ($k = 10$) was used. The training sample was divided into 10 equal parts, 9 of which were used for training and 1 for testing. At each stage of training, the test block was successively rotated, ensuring that testing was conducted on all parts of the training sample. This approach allows us to evaluate the accuracy of the model across the entire training sample, ultimately leading to a more reliable assessment of the algorithm's accuracy.

RESULTS

The model was evaluated for its prediction accuracy 3 days and 5 days before the onset of visual signs of lameness. The accuracy metric was used for this evaluation. The accuracy score can be calculated using the following formula:

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN}$$

where TP represents true positive predictions, TN represents true negative predictions, FP represents false positive predictions, FN represents false negative predictions. The results obtained during the training process are presented in Fig. 1 as a graph of the accuracy change depending on the number of trees. The model achieved an accuracy of 89% when detecting lameness 3 days before the appearance of visual signs and 87% when detecting lameness 5 days before the appearance of visual signs.



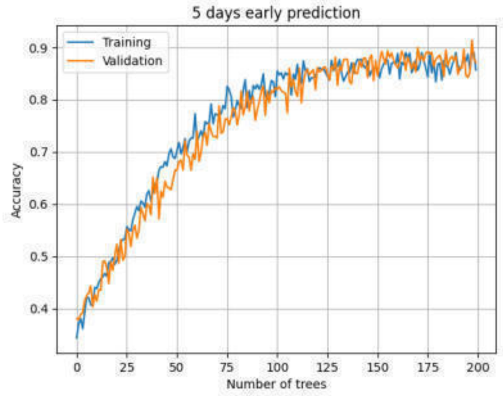


Fig. 1. Accuracy as a function of the number of trees

DISCUSSION

Based on the findings of this study, the proposed model demonstrated high accuracy in the early detection of lameness in dairy cows, with 89% accuracy observed three days before visual signs and 87% accuracy five days prior. These results suggest that the combination of pedometer data and machine learning algorithms can be effectively utilized in farm settings to timely diagnose lameness, thus reducing treatment costs and optimizing farm management practices. However, the study has limitations, including a short data collection period and the use of a single breed, which may affect the generalizability of the findings to other breeds and conditions.

Moreover, the observed decrease in accuracy when predicting lameness five days in advance, compared to three days, indicates that the complexity of the prediction task increases with longer forecasting periods. This highlights the need for further research to improve the robustness of machine learning models in handling such complexities. Future studies could focus on testing a broader range of machine learning algorithms and expanding the dataset to include longer observation periods and diverse cattle breeds to enhance the model's performance and applicability.

CONCLUSION

In conclusion, the results obtained in this study demonstrated that the proposed model is effective for the early detection of lameness in cattle before visual signs appear. The model achieved 89% accuracy in detecting lameness 3 days before visual signs appeared and 87% accuracy 5 days before visual signs appeared. Early detection of the disease helps to reduce costs associated with lameness and to effectively organize the treatment process on farms. Further research will focus on testing other algorithms and machine learning models to improve the results obtained.

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PREDICTION OF EJECTION FRACTION OF LEFT VENTRICLE IN PATIENTS WITH TYPE 2 DIABETES MELLITUS ON EMPAGLIFLOZIN: A SIX-MONTH ASSESSMENT

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Abstract. Diabetes mellitus type 2 (T2DM) is a growing global health concern, often leading to cardiovascular complications, including left ventricular dysfunction. Predicting left ventricular ejection fraction (LVEF) can be crucial for early intervention and management. Empagliflozin, a sodium-glucose cotransporter 2 (SGLT2) inhibitor, has garnered attention for its efficacy in managing type 2 diabetes mellitus (T2DM) and its potential cardiovascular benefits. This study aims to identify significant predictors of LVEF in T2DM patients treated with Empagliflozin after six months of therapy. We aim to identify outcomes related to cardiac function and the predictive factors influencing LVEF changes during this treatment phase. We applied a systematic feature selection approach through generalized linear models (GLM) to build a predictive model based on a cohort of 130 patients.

INTRODUCTION

Heart failure and cardiovascular diseases are prominent complications associated with T2DM [1], contributing to significant morbidity and mortality. Empagliflozin, an SGLT2 inhibitor, is recognized [2] for its beneficial effects on heart failure outcomes in diabetic patients. Ejection fraction serves as a vital parameter in assessing the cardiac function, increasingly recognized [3] as a predictor of cardiovascular risk. This study examines potential predictors of LVEF in T2DM patients undergoing treatment with Empagliflozin.

This study continues our evaluation of treatment of patients with T2DM [4-6].

MATERIAL AND METHODS

Study Design and Material

We conducted a retrospective cohort study involving 130 patients of Republican Specialized Scientific and Practical Medical Center for Cardiology diagnosed with type 2 diabetes mellitus. Data was collected at baseline and after six months of treatment. Patients underwent baseline echocardiography to evaluate LVEF and standard glucose-lowering therapies. After six months of empagliflozin treatment (10-25 mg daily), repeat echocardiographic evaluations were conducted. Changes in LVEF were analysed alongside clinical parameters such as HbA1c levels, body mass index (BMI), blood pressure, and lipid profiles. Linear model self-analysis employed to determine predictive factors for LVEF changes.

Table 1. Clinical and Demographic data on 130 patients

Feature	Mean±standard deviation, or percentage
Females	54.6 % (n=71)
Metformin	50 % (n=65)
DPP-4 inhibitors	20 % (n=26)
Insulin	23.1 % (n=30)
Other anti-diabetic medications	6.9 % (n=35)
Age	65.6±9.7
History of coronary heart disease (years)	7.6±3.6
History of T2DM (years)	8.8±5.2
Weight (kg)	85.3±16.2
Height (cm)	164.6±8.4
BMI	31.7±5.5
Systolic blood pressure	139.8±20.5
Diastolic blood pressure	85.0±9.7
Fasting glucose level	8.0±3.0
HbA1c(%)	7.8±2.0
Creatinine	101.6±36.6
Glomerular filtration rate	63.3±20.8
Hemoglobin	122.8±16.6
Na in blood	154.1±5.3
K in blood	4.7±0.6
Ca in blood	2.5±0.3
Total cholesterol	180.9±51.9

Low-Density Lipoprotein Cholesterol	88.8±40.8
Urea	8.1±3.4
Uric Acid	6.2±1.7
Vitamin D	19.1±11.6
Alanine transaminase	30.5±26.8
Aspartate transaminase	24.7±19.2
Brain natriuretic peptide 32	817.5±1270.1
Heart rate	76.9±15.4
Length of QRS interval	0.09±0.02
LVEF	53.6±8.1
E/A	0.88±0.29

Data Splitting and Normalization

The dataset was randomly divided into training (80%) and test (20%) sets to ensure the validity of the model. Prior to model training, all continuous variables were normalized to optimize performance and enhance interpretability.

Model Development

A generalized linear model was constructed using the training dataset. The initial model included various features hypothesized to influence LVEF, such as age, sex, body weight, body mass index (BMI), fasting glucose, glycosylated haemoglobin (HbA1c), lipid profiles, and indices of insulin resistance.

Feature Selection

After the initial training of the model, features with absolute coefficient values below 1 were systematically excluded from consideration. Given that all values were normalized, these absolute values could be interpreted as indicative of feature importance. Consequently, new generalized models were developed utilizing the same training dataset, albeit with a reduced number of features. The exclusion criteria remained consistent, targeting features with absolute coefficient values below the threshold of 1. This iterative refinement process was conducted over six iterations, with the primary objective of preserving only those predictors deemed significant based on the model's coefficient values.

As a result, the number of features was reduced from 75 to 11.

Final Model and Evaluation

After completing the iterative feature selection process, we finalized the model using 11 features:

1. Body weight
2. BMI
3. Fasting glucose
4. Low-Density Lipoprotein (LDL)
5. Triglycerides
6. Metabolic Index
7. Insulin levels
8. HOMA-IR index (Homeostasis Model Assessment of Insulin Resistance)
9. HOMA-B index (Homeostasis Model Assessment of Beta-cell function)
10. QUICKI index (Quantitative Insulin Sensitivity Check Index)
11. Baseline ejection fraction

The performance of the final model was evaluated using the test set, and the mean absolute error (MAE) was calculated.

RESULTS

The final model demonstrated a mean absolute error of 3.4 (±4.8) in predicting the LVEF in the test set. This indicates a reasonable accuracy in forecasting LVEF based on the significant predictors identified through our analysis.

The resulting formula to calculate LVEF in 6 months after the treatment is as follows:

$$\boldsymbol{LVEF_6} = 55.1 - 0{,}128378 \cdot (BodyWeight - 85.52) +$$

$$+0{,}42869 \cdot (BMI - 31.98) + 1.3 \cdot (FastingGlucose - 8.12) +$$

$$+0{,}05818 \cdot (LDL - 54.6) - 0{,}015725 \cdot (TG - 270.79) +$$

$$+0{,}2768198 \cdot (MetabolicIndex - 7.64) + 1{,}246485 \cdot (Insulin - 16.88) -$$

$$-1{,}176484 \cdot (HOMA_{IR} - 6.025) - 0{,}3271 \cdot (HOMA_B - 43.06) -$$

$$-2{,}196938 \cdot (QUICKI - 16.81) + 0{,}7547949 \cdot (LVEF - 53.78)$$

The analysis of feature importance revealed insights into which variables exerted the strongest influence on LVEF. Body weight and baseline ejection fraction emerged as particularly influential predictors, alongside metabolic markers illustrating the interconnectedness of metabolic health and cardiac function.

DISCUSSION

At baseline, the mean LVEF was recorded at 53.6% (±8.1). After six months of empagliflozin therapy, the mean LVEF improved to 55.2% (±7.5).

This study emphasizes the importance of early cardiovascular risk stratification in T2DM patients. Our findings suggest that specific metabolic indicators can provide valuable insights into cardiac function after treatment with Empagliflozin. The application of a stringent feature selection process ensured that only the most relevant predictors were included in the final model, enhancing its predictive accuracy.

Implications for Practice

The identification of critical predictors of LVEF could support clinicians in monitoring T2DM patients on Empagliflozin. Targeted interventions based on these predictors may improve patient outcomes and optimize therapeutic strategies.

CONCLUSION

Our study successfully developed a predictive model for LVEF in T2DM patients treated with Empagliflozin after six months. The model's mean absolute error of 3.4 highlights its potential utility in clinical settings. Future research should focus on validating these findings in larger cohorts and exploring the underlying mechanisms that link metabolic health with cardiac function.

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COMPARISON OF MACHINE LEARNING METHODS IN BAD LOAN PREDICTIONS: ANALYSIS OF MICRO FINANCE DATA

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Abstract Credit risk management is crucial for lending institutions to safeguard themselves against financial losses and maintain financial stability. Machine learning methods have been useful in analyzing borrower data and identifying bad loans that would be almost impossible for humans to detect. Client data from Microfinance Institution (MFI) in Uzbekistan have been used to build machine learning methods to predict loan delinquency. Their performances were evaluated based on five metrics: accuracy, sensitivity, specificity, negative (npv) and positive predictive value (ppv). The findings suggest that none of the machine learning used in the study methods have absolute advantage over the rest in all five-performance metrics. However, Extreme Gradient Boosting (XGBoost) produced the highest average performance compared to other methods.

Keywords: credit risk, machine learning, micro finance, loan delinquency

INTRODUCTION

Credit risk management is an essential element of lending institutions, playing an important role in increasing the company's profitability and maintaining financial stability. The monitoring of loan payment delinquency is a crucial component of this procedure since it acts as a warning flag for impending financial difficulties. Lenders can reduce losses by implementing risk mitigation methods through timely monitoring of loan delinquency.

Since 1989, when Fair Isaac Corporation unveiled the FICO score—one of the first credit scoring systems—lending institutions have been utilizing credit scoring models to track borrowers' creditworthiness. FICO scores are determined by a proprietary algorithm that takes into account an individual's credit history, length of credit usage, mix of credit used, and applications for new credit. It is also based on outstanding debt. Nonetheless, the growth of big data and the latest developments in technology have created new opportunities for the application of machine learning techniques in the field of credit risk management. Complex, non-linear patterns in data can be recognized and modeled by machine learning models, especially those that are built using ensemble learning or deep learning approaches. They are particularly good at expressing relationships that would be difficult for linear models to detect. The ability to automatically recognize and take advantage of feature interactions is essential for comprehending non-linear relationships.

This research paper's main objective is to evaluate and contrast the effectiveness of several machine learning techniques for predicting loan delinquency in the microfinance industry. This study attempts to provide a thorough examination of the performances of several algorithms through an empirical evaluation, illuminating the advantages and disadvantages of each approach. This kind of evaluation is critical to improving our knowledge of how machine learning techniques can be applied to improve the accuracy and dependability of loan delinquency predictions, which will educate and direct future risk management strategies in microfinance organizations.

LITERATURE REVIEW

Several techniques are available for supervised machine learning, which involves training a model on a labeled dataset. These include support vector machines (SVM) (Pisner & Schnyer, 2020), decision trees (DT) (Ben-Haim & Tom-Tov, 2010), k-nearest neighbors (KNN) (Zhang et al., 2017), random forest (RF) (Belgiu & Dragut, 2016, Malekipirbazari & Aksakalli, 2015), artificial neural network (ANN) (Angelini, di Tollo, & Roli, 2008), and extreme gradient boosting (XGBoost) (Chen & Guestrin, 2016; Liu, Zhang, & Fan, 2022). To boost the performance of the methods, many authors have combined supervised learning techniques with unsupervised machine learning, in which the model is trained on unlabeled response data.

Many researches have reported that the implementation of machine learning algorithms in credit scoring have produced improved predictive accuracy (Sohn, Kim, & Yoon, 2016; Bao, Lianju, & Yue, 2019).

Even while machine learning is becoming more and more integrated into financial research, there is still a lack of empirical study on this topic, particularly when it comes to emerging economies, such as Uzbekistan. The use of real internal datasets from financial firms has received little attention in recent studies. By providing insights into Uzbekistan-specific lending practices through the empirical examination of loan default risks using real microfinance data, this study seeks to close this knowledge gap. This research has implications for improving modern risk-monitoring systems. It gives financial institutions useful information about where risk is coming from and how to reduce it, which helps them avoid future loan defaults. By highlighting machine learning's applicability for risk management in the particular setting of microfinance institutions functioning in developing nations, this study adds to the growing body of literature on the subject of machine learning applications in banking and finance.

The following research questions will be addressed in this study:

RQ1. Which of the supervised machine learning methods perform the best in predicting loan delinquency?

RQ2. Which features are the most significant in predicting a loan delinquency?

DATA AND METHODOLOGY

Data description.

This study utilizes a consumer dataset obtained from a prominent microfinance institute (MFI) in Uzbekistan, aiming to contribute to the field of credit risk assessment by employing machine learning techniques to predict loan delinquency. The dataset contains 12,882 individuals (clients) for the period of 2019-2022. A binary variable, delinquent, is used as outcome variable where 1 indicates delinquent and 0 indicates otherwise. Borrower's gender, age, number of existing loans, loan amount (in Uzbek soums) and annual interest rate (in %) have been used as explanatory variables (features).

3.2. Model building.

Delinquency on a loan is one of the early indicators of loan default and is hence a predictive learning problem. The model-building procedure to forecast the likelihood of delinquency, as depicted in Figure 1, is suggested in this study. Once the data preparation phase is completed, the dataset is partitioned into two parts: train and test sets. The main goal of splitting the data, which is a basic machine learning technique, is to assess how effectively the trained model generalizes to new data. One can estimate how well the model will perform on fresh, unseen data by training it on one subset (the training set) and assessing its performance on another subset (the validation set). Furthermore, since data partitioning suggests that overfitting may exist if the model performs poorly on the test set but well on the training set, it helps identify overfitting.

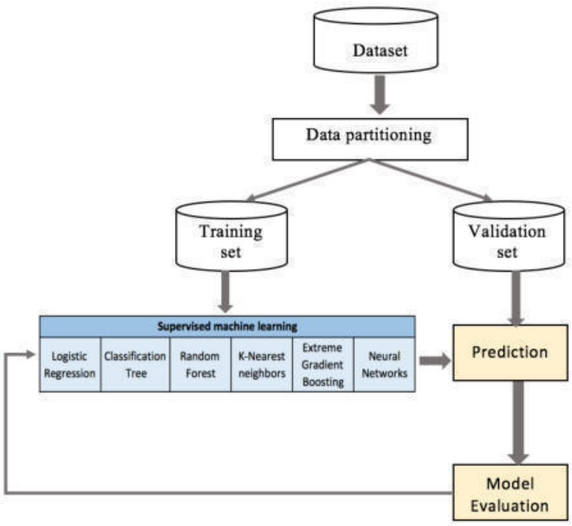

Figure 1. Model building process. Source: Author's work.

Once the dataset is ready for analysis, various supervised machine learning methods are utilized to predict the probability of delinquency. This step is called training the model. To assess the predictive power of the models built, the test set is employed to evaluate the performance of the models. The detailed explanations of these methods are provided in the following paragraphs.

All supervised machine learning methods used in this study were conducted in R programming language (version 4.1.3). The whole dataset was split into training (80%) and validation sets (20%). Several performance measures were employed, such as accuracy, sensitivity, specificity, negative predictive value (NPV) and positive predictive value (PPV) as well as the average measurement of all five parameters. These values are calculated based on the Confusion Matrix provided in Table 2.

Actual label	Predicted label	
	Delinquent	Non-delinquent
Delinquent	True positive (TP)	False negative (FN)
Non-delinquent	False positive (FP)	True negative (TN)

Table 2. Confusion matrix used in this study. Source: Author's work.

True positive (TP) in this table refers to the number of delinquent loans where are correctly predicted as delinquent; false positive (FP) refers to the number of non-delinquent loans which are predicted as delinquent; true negative (TN) refers to the number of non-delinquent loans which are correctly predicted; false negative (FN) refers to the number of delinquent loans which are predicted as non-delinquent. These evaluation parameters are calculated with the following equations.

$$\textit{Accuracy (ACC)} = \frac{TP+TN}{TP+TN+FP+FN} \quad (1)$$

$$\textit{Sensitivity (SENS)} = \frac{TP}{TP+FN} \quad (2)$$

$$\textit{Specificity (SPEC)} = \frac{TN}{TN+FP} \quad (3)$$

$$\textit{Positive Predictive Value (PPV)} = \frac{TP}{TP+FP} \quad (4)$$

$$\textit{Negative Predictive Value (NPV)} = \frac{TN}{TN+FN} \quad (5)$$

$$\textit{Average} = \frac{ACC+SENS+SPEC+PPV+NPV}{5} \quad (6)$$

Empirical results

Predictive models were built with six machine learning methods: Logistic regression (LR), classification tree (CT), random forest (RF), k-nearest neighbors (KNN), extreme gradient boosting (XGBoost) and neural networks (NN).

Calculated five performance parameters are summarized in Table 3. These evaluation parameters explain the model performance from different aspects and no single parameter can be considered the best one among them. Therefore, average of these five parameters is also calculated and included in this table. In terms of accuracy, k-nearest neighbors, random forest, and neural networks provide the highest values at 0.88, 0.87 and 0.87, respectively. But their performances in detecting actual delinquencies (PPV) are poor. On the other hand, KNN, XGBoost and CT have the highest sensitivity ratios (0.57, 0.56, 0.49) as well as overall averages (0.67, 0.70, 0.68).

Method	**Acc**	**Sen**	**Spe**	**N**	**P**	**Av**

	uracy	sitivity	cificity	PV	PV	erage
Logistic Regression	0.85	0.17	0.89	0.94	0.17	0.60
Classification Tree	0.74	0.49	0.92	0.78	0.49	0.68
Random Forest	0.87	0.13	0.89	0.97	0.13	0.60
K Nearest Neighbors	0.88	0.57	0.88	1.00	0.01	0.67
Extreme Gradient Boosting	0.77	0.56	0.80	0.80	0.56	0.70
Neural Networks	0.87	0.11	0.98	0.98	0.11	0.61

Table 3. Summary of machine learning results. Source: Author's calculations.

Conclusion and limitations

Credit scoring is becoming an increasingly important tool for managing credit risk by separating good and bad applicants, given the rapidly growing and prospering credit market and the significant impact that credit scoring models' predictive performance has on financial institutions' profitability. In this study, we propose to combine machine learning methods to generate credit scoring models with excellent predictive potential. After data partitioning, these machine learning techniques are applied to the train dataset, and the remaining dataset—referred to as the validation set—is used to assess how well these techniques work. This paper's results validate the efficacy of the proposed approach, which is tested on a real-world dataset from a financial institution in Uzbekistan. This strengthens our belief that the suggested approach can be applied to a wide range of other credit datasets from financial institutions, especially commercial banks and other lending institutions in emerging economies. Our findings show that, when considering the average value of the five performance measures employed in this work, XGBoost, classification tree, and KNN perform better than conventional techniques like the logistic regression model. The borrower's age, gender, number of loans, interest rate, and loan amount are statistically significant determinants in predicting loan delinquency, according to the results of LR. When all else remains equal, male borrowers are more likely to have past-due loan payments. The remaining three factors have a positive relationship with the chance of being delinquent, but the age variable has a negative association with the log odds of being delinquent.

It is important to recognize the various limitations that this study has. First off, there are certain crucial factors missing from the dataset utilized in this work, which could have a big influence on the study and conclusions. In particular, among other possible financial indications, it lacks information on the borrowers' income, employment type/industry, and credit history. The lack of these variables could lead to an insufficient comprehension of the elements affecting the borrower's actions, so restricting the strength and extent of the inferences made from the information. Second, because of utilizing data from only a single lending institution, there is a chance that the results won't apply to other microfinance organizations or the larger group of microfinance clients, which could lead to sample selection bias.

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APPLICATION OF MACHINE LEARNING IN HUMAN ROBOT COLLABORATION SYSTEMS TO IMPROVE ASSEMBLY EFFICIENCY

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Abstract. **The development of cognitive capabilities in robots that allow them to be aware of both their environment and the actions taking place within the assembly cell is necessary for human-robot collaboration in assembly operations. Therefore, this paper presents an artificial intelligence-based architecture consisting of a machine learning framework that can recognize the tasks being performed by the operator using vision-based machine learning, detect objects, environments and process states, and provide personalized operator support for shared tasks on the robot side, while automatically adapting to the operator's preferences. Then, using a URe5 collaborative robot to evaluate a laboratory case study using Lego Mindstorms, this paper shows how the proposed architecture could improve collaboration efficiency.**

Keywords: Human and robot collaboration, assembly, artificial intelligence, machine learning.

INTRODUCTION

The use of lightweight collaborative robots, or cobots, has recently increased in assembly operations due to their ability to ensure human physical safety at close range [1, 2], and it is called Human robot collaboration systems. Human-Robot Collaboration (HRC) is a system in which human and robot resources work together in a common assembly workstation [3]. Humans have exceptional cognitive ability and adaptability, but robots are better at performing monotonous, non-ergonomic activities accurately and effectively over time, according to a comprehensive literature analysis of the findings of several researchers [4]. The most useful characteristics of the human and robotic resources when they work in close cooperation during assembly activities are summarized in Table 1.

Table 1. Human and Robot characteristics

Advantages skills of human	**Advantages skills of robots**
Special attention is paid to:	**Special attention is paid to:**
High availability	Integrated process control
Handling of complex components	Handling heavy, sharp-edged components
Reliable execution of complex joining processes	Exact playback of defined paths
Simple magazine loading of components	Reliable performance of repetitive activities

Several researchers claim in their studies that the interaction between humans and cobots during assembly processes guarantees flexibility of capacity due to human dexterity and robot accuracy [5]. However, we believe it's essential to create a user-friendly artificial intelligence-based architecture so that human operators can easily communicate with the robot during assembly operations, in order to effectively utilize human cognitive talents and production efficiency.

In general, future human-robot interaction in assembly systems should focus on how human operators in hybrid human-robot interaction teams can satisfy human welfare with the help of robots and advanced technology in a socio-technical context. As a result, we need to develop a solution that enhances the cognitive capabilities of the robots, enabling them to track in real time and optimize productivity by automatically adjusting their posture. This will put our solution ahead of current implementations.

In order to fulfil the purpose of this paper, it is organized as follows: In addition to the research topics in academia and industry, industrial applications, and the potential and problems of current research topics, Section 2 gives an overview of the application of artificial intelligence in human-robot collaborative assembly systems over the last ten years. Section 3 defines a robot integration technique and discusses an artificial intelligence methodology. Section 4 then uses simulations and a laboratory case study to illustrate the developed strategy. Sections 5 and 6 present the results and conclusions.

2. STATE OF ART

More than any other technological advancement in recent years, machine learning (ML) is quickly emerging as one of the key enablers for the realization of intelligent factories in the manufacturing sector [6]. In academic papers, Machine Learning (ML) is often cited alongside Artificial Intelligence (AI) and Deep Learning (DL). Still, based on [7] at different levels, these three technologies represent different approaches. In general terms, machine learning is a subset of artificial intelligence, and deep learning is a subset of both. Machine learning (ML) has applications in human-robot collaboration, such as gesture and assembly object recognition, and predicting human movements during assembly tasks. Machine learning is an essential element of artificial intelligence (AI) technology. The basis of this technology is an algorithm. It is designed to teach machines or other technical devices to make judgements in the same way that humans do. In machine learning, machines make decisions based on what they observe. Using a technique developed on statistical data, the machine learning algorithm is used for prediction and categorization. As deep learning is a subset of machine learning, the terms machine learning and deep learning should not be used interchangeably. In addition, the idea of neural networks is part of AI technology. The following Figure 1 summarizes the Machine Leaning framework.

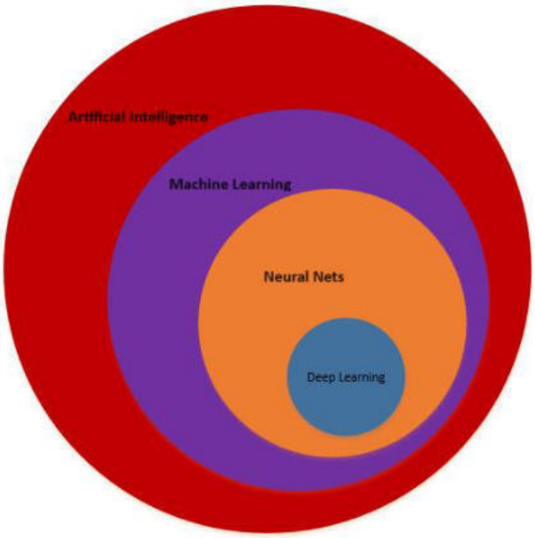

Fig 1. Machine learning technologies

In order to meet consumer demands for product variety and production volume, manufacturing organizations are constantly challenged. For this reason, the design of adaptable and durable production equipment and work cells is essential. There is a general move towards customized, individualized methods in manufacturing, rather than mass production. It is highly likely that the concept of 'Industry 4.0' and its components, such as HRC, can help to manage the increasing product variability and volume of customer demand. However, because communication contact requires intelligence and autonomy on both sides of the interaction resource, HRC does not always translate into productivity benefits. As a result, the application of HRC is still limited by a number of problems.

- Identification and location of components or instruments that require human intervention. While there have been some previous studies in this area using both RGB and 3D sensors [18], one of the peculiarities of our work is the incorporation of data from wearable devices.
- Determining which jobs are carried out by human operators and verifying the assembling process. The majority of recent research has been on tracking posture and location [19], with even fewer methods attempting to predict intention [20, 21]. By using environment and human tracking to determine the workflow execution state and initiate task-optimized support strategies, our work goes one step further.
- Robot posture can be adjusted to suit human activities (direct input) and needs (ergonomics evaluation) through the use of trajectory optimization algorithms and learning processes [24]. The method goes beyond just flipping between preset states by adjusting the robot's assistance to each operator in real time.
- It is important to emphasize the safety concern when a person and a robot operate side by side; as a result, the system-to-hardware connectivity must be ensured. The programming tasks have significantly increased in this instance;
- In the absence of a defined communication framework, programming code for human-robot interaction in assembly is difficult to reuse in most use cases, and workers cannot reprogram the robot on-site in the event that a control fault arises.

3. METHOD And ARCHITECTURE

The assembly agent detection module (AADM), a machine learning method that can identify objects, is the basis of the suggested architecture. Figure 2 illustrates the workflow and architectural functionalities for assembly object detection in assembly operations.

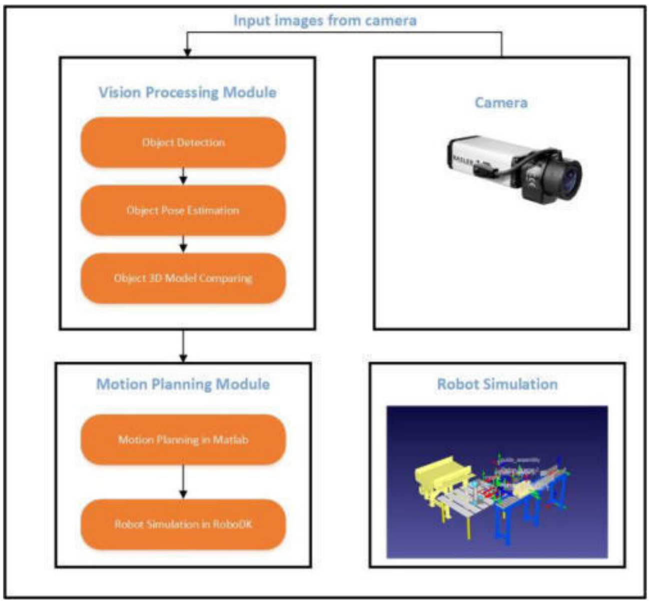

Fig 2. Artificial Intelligence application method

Assembly agent detection will be the foundation of future assembly systems. Due to the fact that AADM is the main technique for capturing and comprehending the scenario in which the operator and the robot are working closely together. When humans and robots work together closely, a human operator can quickly and readily understand all of the information that the assembly agent has to offer through visual and cognitive abilities, while robots would need sensors, cameras, and recognition algorithms to identify any information at all. The robots will be assisted with recognizing information, such as the ability to promptly handle the appropriate tools or assembly components, if they are able to perceive assembly parts and tools efficiently. As a result, human-robot collaboration may be strengthened and the overall efficiency of the assembly environment can be increased. Camera data provides the input for the assembly agent detection, as seen in Figure 2. Collaborative robots can use the cognition expertise obtained via assembly agent detection. Several datasets were tested in order to improve the accuracy of assembly agent detection during training:

This task can be broadly separated into two key modules:

- Vision processing module
  - Object detection
  - Object pose estimation
  - Object 3D model comparing
- Motion / Trajectory planning module
  - Motion Planning in Matlab
  - Robot Simulation in RoboDK

This workflow can be further divided into two areas:

- Object detection using RGB data, which is object segmentation based on RGB and depth (RGBD) data using deep learning
- Object pose estimation using 3D point cloud data, which can be used to estimate the pose of the identified object for motion planning

The steps in the YOLOv4 and PCA-based algorithm-based object pose estimate process are depicted in this Figure 3. RGB images should be supplied as an input in transfer learning for the AADM detection module to function effectively. The dataset in this research is in the form of video clips because the input data was obtained using a standard video camera. To find the presence and location of tools and pieces that need to be assembled, it employs the YOLO algorithm. The convolutional neural network is the foundation of the YOLO algorithm.

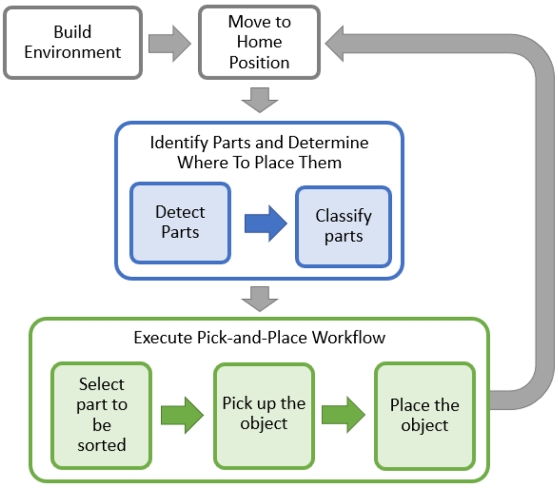

Fig 3. Transfer learning approach for assembly parts and tools recognition

The transfer learning approach is employed in this work to improve the accuracy of assembly agent detection. Other models' knowledge can be repurposed through transfer learning. On a comparable dataset, the training cost can be significantly decreased. Since video clips may be sampled into image sequences, as previously mentioned, transfer learning could be used to identify assembly tools and parts from video clips. In Figure 3, the fundamental concept of transfer learning is displayed.

Pick Up the Object

As seen in the following Figure 4, the picking step involves moving the robot to the object, picking it up, and moving to a safe position:

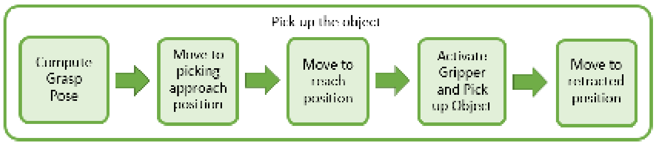

Fig 4. Assembly agent picking algorithm

The grasp pose is computed using the Command Compute Grasp Pose function, as an example. For every component, the class calculates a gripping position in task-space. There are also defined intermediate steps for reaching out and approaching the portion in relation to the object. This robot replicates a pneumatic gripper to pick up things. Using the add Collision object function, example Command Activate Gripper adds the part's collision mesh to the rigid Body Tree representation of the robot when the gripper is activated. This object is included in collision detection while it is attached. Subsequently, the robot retracts itself away from the other components.

Place the Object

After that, the robot positions the item on the proper position near human operator. The placing algorithm is shown in Figure 5.

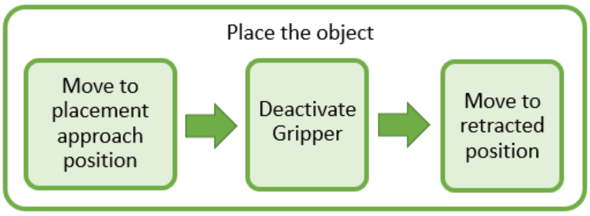

Fig 5. Assembly agent placing algorithm

The placement approach and retracting positions are calculated in relation to the known target placement position, much like in the picking workflow. Using clear collision, the gripper is disabled using example Command Activate Gripper, removing the part from the robot. The putting position for an object type is modified each time a part of that kind is placed, causing the next part of that type to be placed next to the part that was just placed.

4. RESULTS And DISCUSSION

The programmable and adaptable Lego Mindstorm-based device is the subject of the case study discussed in Section n. The original constructed view is displayed in Figure n. The product was selected by the writers with the intention of serving as a study reference part that replicates the actual assembly part. Using such a case study is chosen in order to present technique and accomplish general research objectives. The controller, assembly parts, connectors, wheels, and wheel axis make up the assembled pieces' structure.

An experimental setup has been created in order to assess and contrast the performance of manual and HRC-based assembly techniques. Six PhD candidates from Turin Polytechnic University in Tashkent (TTPU) have been selected to work as operators. Six working days were allotted for the trials. Each operator has constructed five different difficult parts in two distinct ways: manually and using an HRC. A quality control operator has overseen each process, verifying that assembly and procedure are correct.

The operator's workstation has been outfitted with points for a specific product and a screen displaying instructions for the entirely manual processes. The quality controller is directed to assess the amount of time spent on the task, as well as any faults related to taking the wrong part, defective part, improper insertion, proper assembly, part slippage, and other mistakes.
Similarly, the HRC-based assembly included a screen with directions to follow as well. However, the cobot handled the components from a predetermined position and positioned them in an ergonomic manner next to the human operator at a certain spot. Figure 6 depicts the general configuration of the HRC assembly system. The robot's job in this layout is to select assembly. The robot's subsequent motion.

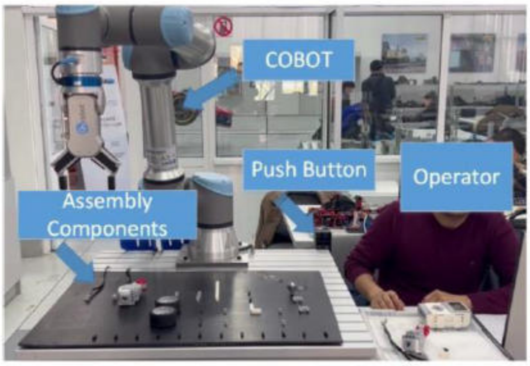

Fig 6. Experimental layout of HRC assembly scenario

In the RoboDK simulator, the URe5 robot utilized in the experiment is operating. The ROS platform is used to implement all computation and information. Software-wise, the Kinect sensor functions as a ROS node, calculating visual-related messages and extracting positions of human skeletons, among other tasks. Using a robotic simulator called RoboDK, a user can design three-dimensional computer scenarios featuring robots, obstacles, and other things. RoboDK uses a physical engine to support things like gravity, inertia, and lighting. In contrast to the actual robot, the simulator allows for the evaluation and testing of the robot in challenging or hazardous conditions without having to worry about the robot getting hurt. Furthermore, using a simulator in the same environment is typically faster than using a real robot system and genuine experiment setup. An overview of the experiment platform is provided in Figure 7.

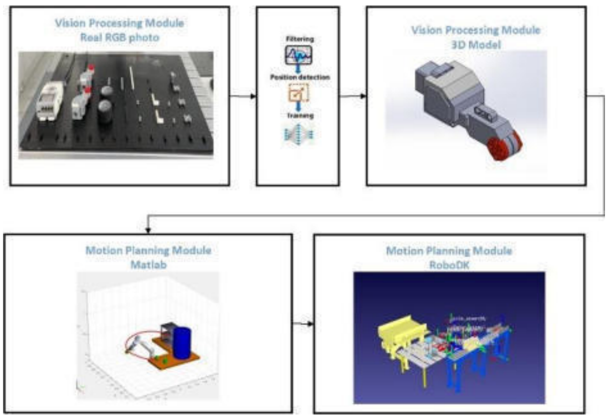

Fig 7. Application of method in Laboratory case study

4.1 Human robot collaboration effect on assembly efficiency

To evaluate the impact of cobot on cycle time, the experimental findings of the new assembly workstation will be presented in this section. The average cycle time of the manual and human robot assembly stations, with 20 replications, is statistically analyzed and presented in Table 2 below.

Table 2. Experimental tests result for manual and HRC assembly systems

Replicates	Manual assembly cycle time (seconds)	Replicates	HRC assembly cycle time (seconds)
1	103	1	89
2	105	2	85
3	113	3	87
4	102	4	86
5	118	5	85
6	105	6	88
7	101	7	89
8	104	8	86
9	120	9	87
10	106	10	90
11	103	11	85
12	105	12	89
13	106	13	87
14	110	14	90
15	103	15	85
16	114	16	87
17	102	17	88
18	117	18	86
19	105	19	90
20	108	20	86

Using the findings of experimental testing, the following. The statistical summary of manual and HRC assembly systems is shown in Figure 8.

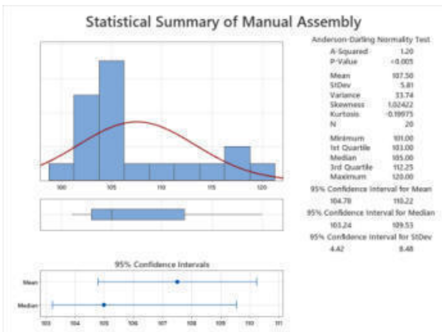

Fig 8. Statistical summary of manual and HRC assembly system

Figure 9 displays a comparison of the operator's time, HRC, and simulation outcomes. It's interesting to note that, save from the second piston, there is no discernible variation between the HRC and the operators' process times. The HRC shows a decreased dispersion of process times, which may be related to the collaborative robots' improved repeatability. This is the other observation. Only the operator and HRC approaches in simulation provide good process time compatibility.

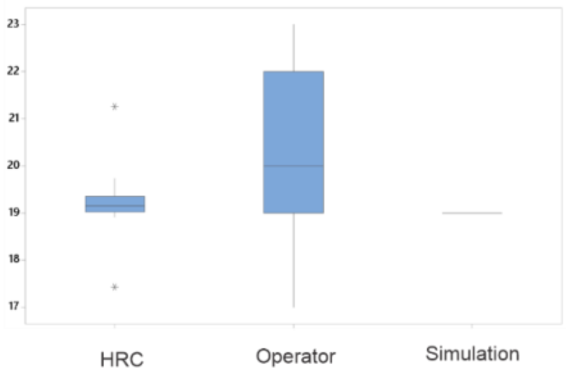

Fig. 9 Average time spent on OP 6, OP8 and OP10

The Analysis of Variance (ANOVA) [8] is performed to analyze the main factors influencing the process time of the piston insertion process. The type of insertion method and the piston's order are the parameters taken into account while doing an ANOVA. In order to examine the primary consequences, two different insertion methods—human-robot collaboration and operator-manual insertion—are taken into consideration. There are seven replications for each piston, for a total of forty-two process time measurements.

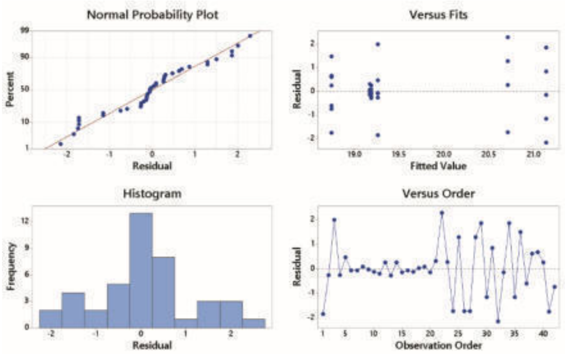

Fig. 10 Residual analysis

The ANOVA function is used in the commercial program MINITAB 17. As predicted, an ANOVA shows no discernible variation in the mean process time measurements, with p values of 0.008 and 0.018 for the piston order and insertion method, respectively, as shown in Figure 10. The analysis indicates that there is no discernible reduction in process time when the collaborative robot and operator are included to the insertion procedure. We may infer from the statistical summary of the two examples that the hybrid system's cycle time (CT) is lowered from an average of 107.50 seconds to 87.2 seconds, and experimental study has confirmed that this value can be lowered by an average of 19%. Therefore, a shorter cycle time in the HRC assembly cell increases the new workstation's productivity.

4.1.1 HRC system influence on system variability

Furthermore, the standard deviations for the HRC and hand assembly systems are 1.773 seconds and 5.81 seconds, respectively. If the ratio of the standard deviation of the mean cycle time over the average cycle time is used to compute the coefficient of variation (CoV) of cycle time:

$$CoV = \frac{\sigma}{CT_{avr}} * 100$$

We will get the following results,

$$CoV_{manual} = \frac{\sigma_{manual}}{CT_{avr\_manual}} * 100 = \frac{5.81}{107.5} * 100 = 5.4\%$$

$$CoV_{HRC} = \frac{\sigma_{HRC}}{CT_{avr\_HRC}} * 100 = \frac{1.773}{87.2} * 100 = 2.03\ \%$$

CoV of the new assembly system dropped from 5.4% to 2.03% by incorporating cobots into manual assembly; as a result, the cycle time of the assembly system becomes less variable with cobot integration.

4.1.2 HRC system influence on system stability

The summary of descriptive statistics for the manual and HRC assembly cells is shown in Table 3 below.

Table 3. Descriptive statistics summary for manual and HRC assembly cells

Assembly type	**N**	**Mean**	**SE Mean**	**StDev**	**Minimum**	**Q1**	**Median**	**Q3**	**Maximum**
Manual Assembly	20	107.50	1.30	5.81	101.00	103.00	105.00	112.25	120.00
HRC	20	87.250	0.397	1.773	85.000	86.000	87.000	89.000	90.000

We determined the coefficient of skewness for both assembly cells based on the summary data mentioned above. We used the Pearson coefficient (PC) of skewness calculation using the median to determine the skewness.

$$PC = 3 * \frac{(Mean - Meadian)}{Standard\ Deviation}$$

Next, we determined the PC values for the manual and HRC scenarios, which are as follows:

$$PC_{manual} = 3 * \frac{(Mean - Meadian)}{Standard\ Deviation} = 3 * \frac{107.50 - 105}{5.81} = 1.29$$

$$PCHRC = 3 * \frac{(Mean - Meadian)}{Standard\ Deviation} = 3 * \frac{87.250 - 87}{1.773} = 0.42$$

The distribution was first favorably or rightly skewed when the manual assembly station's coefficient of skewness was 1.29, which indicates that the mean exceeds the mode and median (Mode < Median < Mean). We obtained a coefficient of skewness of 0.42 with the HRC system, indicating that in the hybrid assembly situation, the distribution tends to be normal and the mean, mode, and median of the cycle time are almost equal.

5. CONCLUSION AND FUTURE WORK

This work discusses an AI system that recognizes the actions being performed by operators inside a human–robot collaborative cell, analyzes the system variability, stability and adapts the robot behavior according to the needs of the task and the preferences of the operator, improving operator's satisfaction. The demonstration in a laboratory case study has revealed possible enhancement in the cycle time (by 19%), stability factors in 2.03% of the samples, and a quite high operator acceptance. Finally, the successful use of, non-so widespread, high payload collaborative robotics has been demonstrated, which, unlike low payload cobots, are more capable to supplement humans in performing strenuous tasks.

Future work will aim at the implementation of algorithms to capture more complex— non-assembly-based—human actions in order for the system to either ignore them or plan for countering their effects.

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IMPLEMENTATION OF TOKENIZATION PROCESS USING THE BPE ALGORITHM

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Abstract The basic and mandatory stage of working with textual data is considered to be tokenization. This article describes the stages of coding the byte pair encoding (BPE[3]) algorithm, considered a classic tokenization algorithm, and is applied to texts in the Uzbek language corpus. Despite the wide range of resources describing the algorithm’s operational principles, this article demonstrates its impact on the functioning of a real NLP component by implementing it on existing Uzbek language corpus resources and selecting information structures.

Keywords. BPE (byte pair encoding), byte pair coding, characters tokenization, Count Vectorization, OOV (out-of-vocabulary) words, words beyond the dictionary, sub words tokenization

INTRODUCTION

Natural Language Processing (NLP) is a direction in the field of artificial intelligence that focuses on machines understanding and processing human language. Reinterpreting human language for machines is not a straightforward task, as machines operate not with text but with numbers. Researchers are working on enabling machines to understand human language and its context.

In understanding human language, one of the fundamental roles is performed by tokenizers. Each type of tokenizer assists machines in reprocessing text in a different way [1]. The development of tokenizers can be achieved based on various approaches depending on the specific application context.

Tokenization refers to the process of initially converting unstructured natural language text into a better-structured form (from a computer standpoint) during the preliminary processing stage [2,3]. During the tokenization process, useful information referred to as text tokens is separated into parts. The tokenization algorithm mentioned in this article was utilized in developing the Uzbek language morphological analyzer [4,5].

Through tokenization, borders between tokens are identified. The simplest delimiter is to separate by a space. But this does not always give the expected results. For example, in Japanese and Chinese languages, they utilize different types of separators. Moreover, there are situations that, besides spaces, words can be separated using special characters, making it possible to tokenize a word into two tokens. Bigrams and idioms (e.g. "kundan kunga" or "ega bo`lgan") are cases in which decisions are made whether to split special combinations into separate tokens or not.

Another step that is typically performed along with the tokenization process is "Sentencizing"(break the text into sentences). This step is particularly crucial when dealing with documents containing multiple sentences [6]. The main reason of its importance is due to text parsing. To identify speech segments and relationships, it is necessary to establish the structure of sentences (not just the entire text).

In developing NLP applications, some tools identify gaps in the text after tokenization and text parsing. Therefore, even if there are multiple words between two quotation marks, they remain treated as a single unit.

Brief information about Tokenization

In both Deep Learning systems like Transformers and traditional NLP methods like Montessorizer, tokenization is an essential first step. Building blocks of the natural language structure are thought to be tokens.

The process of breaking a text up into smaller pieces known as tokens is known as tokenization. Tokens in this context can be characters, words, or subwords. The three types of tokenization that can be broadly classified as follows: word tokens, character tokens, and subword tokens (n-gram character tokens).

Let's take the following sentence as an example: "Hech qachon taslim bo'lmang." The most widely used technique for forming tokens uses spaces as separators. Tokenizing the text yields four tokens if a space is used as the delimiter: "Hech-qachon-taslim-bo'lmang." Every token corresponds to a word, serving as an illustration of word tokenization.

Similarly, symbols and subwords can be generated as tokens. For example, let’s consider the word “aqlliroq”:

- symbol token: a-q-l-l-i-r-o-q;
- subword token: aqlli-roq.

Tokenization Process:

Tokens are the fundamental units of natural language, hence processing unstructured text usually happens at the token level. Additionally, token-level processing of unstructured text is done by models based on Transformer, a deep learning architecture in NLP (State of the Art, S\TA). At the token level, unstructured text is also processed using the most widely used deep learning architectures for natural language processing (NLP), including RNN, GRU, and LSTM [9, 10].

Recurrent Neural Networks

Within a predetermined amount of time during the study, each token is received and processed by a recurrent neural network (RNN).

Tokenization is therefore an essential stage in the modeling of textual data. Tokenization is carried out on the cRPS in order to obtain tokens. We will create a dictionary with the tokens in the following step. A dictionary is a distinct group of characters found in a book. The dictionary can be constructed by accounting for each distinct event that occurs in the corpus or by accounting for words that occur up to a maximum of K times. The ultimate goal of tokenization is the creation of a dictionary.

One of the most basic methods to improve the efficacy of NLP models is to construct a dictionary consisting of words that occur up to K times. We will discuss how to use this dictionary using both conventional and cutting-edge deep learning-based natural language processing techniques.

Conventional NLP techniques like Count Vectorizer and TF-IDF utilize the dictionary as features (dimensions). Each word in the dictionary is encoded as a particular feature with its own distinct characteristic:

Table 1: Traditional NLP: Count Vectorizer

	w1	w2	w3	w4	w5	w6
1-hujjat	1	1	1	1	1	1
2-hujjat	1	1	0	1	0	1
3-hujjat	1	0	1	0	1	0
4-hujjat	0	0	1	1	1	1

In advanced deep learning-based NLP architectures, a dictionary is used to tokenize given sentences and transmitted as input parameters to the model.

Choosing a tokenization method

As mentioned earlier, tokenization can be performed at the word, character, or subword level. Which tokenization method should be used for a given NLP task?

Word tokenization method

One of the most widely used algorithms is word tokenization. The text is split into distinct words (parts) in the tokenization algorithm according to a certain separator. Depending on the delimiters, different word-level tokens are generated. Tokenization is used to identify preferred words in methods like Word2Vec and GloVe. However, there are a number of drawbacks.

One of the main problems with tokens is related to words out of vocabulary (OOV). New words encountered during the test are indicated by OOV words. The dictionary does not contain these new words. As a result, these methods are unable to handle OOV words. Here are some ways to fix problems with OOV words:

It is necessary to form the dictionary with words that occur more than K times and to replace the unique words in the educational data with unknown tokens (UNK). This helps the model learn the representation of OOV words in terms of UNK tokens.

Any word that is not in the dictionary at the time of testing is placed in the UNK token.

The problem with this approach is that when OOV is matched with UNK tokens, all information about the word is lost. The structure of the word helps in its correct expression. Also, each OOV word will have the same form.

An additional issue concerning word tokenization pertains to the dictionary's size. Pre-trained models are usually trained on a vast corpus of texts. It is possible to compile a dictionary of huge words by gathering all the distinct words in a large corpus.

The method of tokenizing characters

A passage of text is tokenized by breaking it up into a set of characters. This method addresses the drawbacks associated with word tokenization. Tokenizers for characters process OOV words while maintaining word information. The word OOV in this instance is broken up into individual characters and stands for a word derived from those characters. Additionally, this method restricts the dictionary's size (n=26).

The OOV problem is solved by character-based tokenization, although the input and output statements are longer as a result. because we utilize a series of characters to express sentences. Consequently, it becomes challenging to understand the relationships between characters in order to create meaningful sentences. Between word and character tokenization, subword tokenization is another type of tokenization that presents an obstacle.

Method of tokenizing subwords

Subword tokenization method divides the text into sub-words (or n-gram symbols). For example, the word lower can be split into low-er, and the word smartest can be split into smart-est. Models like SOTA (Transformed based models) in NLP use tokenizer algorithms to train the dictionary.

BPE method

Among transformer-based modulators, Byte Pair Encoding (BPE) is a frequently used tokenization technique. Word tokenizer and character tokenizer issues are resolved by BPE [11–13]:

The OOV problem is successfully resolved with BPE. It divides and processes OOV as subtitles; in comparison to character tokenization, the length of input and output statements following BPE is shorter.

A word segmentation algorithm called BPE repeatedly swaps off the most common characters or character sequences. How to put the BPE algorithm into practice:

1. Dividing the words in the dictionary into characters after the suffix ;

2. Creating a dictionary comprising distinct words inside the dictionary;

3. Determining the frequency in the corpus of a pair or sequence of characters;

4. Merge the most frequent duo in the cortex;

5. Hold onto the top duo for the dictionary;

6. For a predetermined number of repetitions, repeat steps 3-5.

Table 2 Given the following corpus

Corpus		
kam	kamroq	kitob
kam	kamroq	kitob
kam	betob	kitob
kam	betob	kitob
kam	betob	kitob

Table 3 Add </w> to the end of each word in the corpus:

CORPUS

KAM</W>	kamroq</w>	kitob</w>
KAM</W>	kamroq</w>	kitob</w>
KAM</W>	betob</w>	kitob</w>
KAM</W>	betob</w>	kitob</w>
KAM</W>	betob</w>	kitob</w>

Table 4 Break the words in the corpus into characters.

CORPUS

K A M </W>	k a m r o q **</w>**	k i t o b **</w>**
K A M </W>	k a m r o q **</w>**	k i t o b **</w>**
K A M </W>	b e t o b **</w>**	k i t o b **</w>**
K A M </W>	b e t o b **</w>**	k i t o b **</w>**
K A M </W>	b e t o b **</w>**	k i t o b **</w>**

Table 5 The initial state of the dictionary:

DICTIONARY

A	r	m	k	t	e	O	i	q	B

Iteration 1:

Table 5Calculating the frequency:

k-a (7)	O-Q (2)	O-B (8)
a-m (7)	Q-</W> (2)	B-</W> (8)
m-</w> (5)	K-I (5)	B-E (3)
m-r (2)	I-T (5)	E-T (3)
r-o (2)	T-O (8)	

Table 6 Combining the most common pair.

CORPUS

K A M </W>	k a m r o q **</w>**	k I to b **</w>**
K A M </W>	k a m r o q **</w>**	k I to b **</w>**
K A M </W>	b e to b **</w>**	k I to b **</w>**
K A M </W>	b e to b **</w>**	k I to b **</w>**
K A M </W>	b e to b **</w>**	k I to b **</w>**

Table 7

Saving the best pair:

DICTIONARY

A	r	m	k	t	e	O	i	q	B
TO									

Now, it is necessary to repeat steps 3-5 for each iteration. We will describe the repetition one more time.

Iteration 2:

Table 8Calculating the frequency:

		Frequency
k-a (7	**o-q (2)**	**b-</w> (8)**
a-m (7	**q-</w> (2)**	b-**e (3)**
m-</w> (5	k-**i (5)**	e-**to (3)**
m-r (2	i-**to (5)**	
r-o (2	**to b (8)**	

Table 9 Combining the most common pair.

		Corpus
k a m </w	k a m r o q **</w>**	k i tob **</w>**
k a m </w	k a m r o q **</w>**	k i tob **</w>**
k a m </w	b e tob **</w>**	k i tob **</w>**
k a m </w	b e tob **</w>**	k i tob **</w>**
k a m </w	b e tob **</w>**	k i tob **</w>**

Table 10 Saving the best pair

Dictionary

a	r	m	k	t	e	o	i	q	B
to	tob								

After 10 iterations, the BPE merge operations look like this:

Dictionary

A	r	m	k	T	e	O	I	q	b
To	tob	tob</w>	ka	Kam	kam</w>	ki	kitob</w>	be	betob</w>

Using BPE for OOV Words

Using the representations that BPE teaches us, how can we express the word OOV during testing? The word OOV is broken up into a series of characters during the test. The characters are then combined into larger known characters using the operations that have been taught. The sequential actions for expressing OOV words are as follows:

1. After adding </w>, separate the word OOV into characters;

2. Counting a pair of characters or a sequence of characters in one word;

3. Selection of pairs available in the learned operations;

4. Combining the most common pairs;

5. Repeat steps 2 and 3 until merging is possible;

BPE Implementation in Python

The process of learning and using OOV words using the BPE algorithm was considered above. So, it's time to implement what we have learned in Python.

Corpus reading

Let's look at a simple case to illustrate the idea of BPE. Also, the same approach can be applied to other corpuses.

```
# loading library
import pandas as pd
# loading file of corpus
matn =
```

```
pd.read_csv("D:\\text\\sample2.txt",heade
r=None)
# convert the dataframe to a single list
corpus=[]
for ustun in matn.values:
   tokens = ustun[0].split(" ")
   for token in tokens:
      corpus.append(token)
print(corpus)
```

Preparing the text

Splitting the words into characters in the corpus and adding </w> to the end of each word:

```
lugat = list(set(" ".join(corpus)))
lugat.remove(' ')
print(lugat)
# break the word into characters
corpus = [" ".join(token) for token in
corpus]
print(corpus)
# adding sign </w>
corpus=[token+' </w>' for token in corpus]
print(corpus)
```

Learning BPE

Calculate the frequency of each word in the corpus:

```
import collections
# determine the frequency of each word
corpus = collections.Counter(corpus)
print(corpus)
# vocabulary building
corpus = dict(corpus)
print("Corpus:",corpus)
```

A function is formed to calculate the frequency of a pair of characters or a sequence of characters. It accepts a corpus and returns a pair with its frequency:

```
# computer frequency of a pair of
characters or sequence of characters
# determining the frequency of each pair
based on the corpus
def get_stats(corpus):
   pairs = collections.defaultdict(int)
   for word, freq in corpus.items():
      symbols = word.split()
      for i in range(len(symbols)-1):
         pairs[symbols[i],symbols[i+1]] +=
freq
   return pairs
```

In the next step, the most common pair in the corpus is merged. We define a function that accepts a corpus, the best pair, and returns the processed corpus:

```
# combining the most frequent pairs in the
corpus
# takes a corpus and a best pair and
returns the modified corpus
import re
def merge_vocab(pair, corpus_in):
   corpus_out = {}
   bigram = re.escape(' '.join(pair))
   p = re.compile(r'(?<!\S)' + bigram +
r'(?!\S)')

   for word in corpus_in:
w_out = p.sub(''.join(pair), word)
      corpus_out[w_out] =
corpus_in[word]
   return corpus_out
```

The next step is to study BPE operations. Since BPE is an iterative procedure, we perform and understand the steps for a single iteration. We calculate the frequency of bigrams:

```
# count the frequency of bigrams in the corpus
pairs = get_stats(corpus)
print(pairs)
Identifying the most common pair:
# determine the best pair
best = max(pairs, key=pairs.get)
print("Best pairs:",best)
```

Finally, we will combine the best pair and save it to the dictionary:

```
# to the corpus and merge the best pair
corpus = merge_vocab(best, corpus)
print("after merged:", corpus)
# convert a tuple to a string
best = "".join(list(best))
# combining a list and a dictionary
merges = []
merges.append(best)
vocab.append(best)
print(vocab)
```

We perform similar steps for specific iterations:

```
# number of repetitions
num_merges = 15
for i in range(num_merges):


# count the frequency of bigrams in the corpus
   pairs = get_stats(corpus)


# determine the best pair
   best = max(pairs, key=pairs.get)


# to the corpus and merge the best pair
   corpus = merge_vocab(best, corpus)


# combining a list and a dictionary
   merges.append(best)
```

```
    vocab.append(best)
print(vocab)

     # convert a tuple to a string
merges_in_string = ["".join(list(i)) for i in merges]
print("Merger operations of BPE:",merges_in_string)
```

Using BPE for OOV words

In the next step, we will explore how to split the OOV word into subwords using learned operations. We will consider the word "kamroq" as an OOV word:

```
# Application of BPE to OOV
oov ='kamroq'
# Characterization of OOV
oov = " ".join(list(oov))
# adding </w>
oov = oov + ' </w>'
# formation of vocabulary
oov = { oov : 1}
```

Applying BPE to an OOV word is also an iterative process. We perform the steps discussed earlier in the article:

```
i=0
while(True):
  # frequency calculation
   pairs = get_stats(oov)
  # definition pairs
   pairs = pairs.keys()
  # finding the pairs present in the steps studied
  ind=[merges.index(i) for i in pairs if i in merges]
  if(len(ind)==0):
     print("\nBPE end...")
     break
# choosing the most studied operation
  best = merges[min(ind)]
 # adding the best pair
  oov = merge_vocab(best, oov)
  print(i+1,"-qadam: ", list(oov.keys())[0])
  i=i+1
```

From the obtained result, it can be determined that the unknown word "kam r o q </w>" is segmented as the lowest.

CONCLUSION

One modern method of working with textual data is tokenization. To ensure the most effective representation of the corpus, BPE considers all possible combinations based on frequency for each iteration and employs a distinct methodology to determine the optimal solution. One of the most popular subword-tokenization algorithms, BPE yields effective outcomes. This post has shown us the BPE tokenization procedure, and we have used Python to implement tokenization. The Uzbek language's corpus (texts) can be analyzed using the techniques discussed in this article.

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A REVIEW FOR DIFFERENT APPROACHES OF TOMATO LEAF DISEASE DETECTION

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A B S T R A C T **In recent years, computer vision researchers are proposing different algorithms for agricultural domain. For example, they are using Machine learning and Deep learning for plant disease identification. This paper discussed some approaches for tomato leaf disease detection. And reviewed different researchers' works by using different methods in tomato leaf disease identification. In the end of this paper, as a result, it is defined available methods such as strength and some limitations for different conditions.**

K E Y W O R D S Identification, segmentation, network, disease detection, models, classification, plant leaves.

I. INTRODUCTION

Tomato is one of the most essential and consumable crops in the world. Tomatoes differ in quantity depending on leaf appearance. Leaf disease is the primary factor impacting the amount and quality of crop yield. As a result, it is critical to diagnose and classify these disorders appropriately [1]. Earlier identification of these diseases would reduce the disease's effect on tomato plants and enhance good crop yield. The manual identification of pests and pathogens is inefficient and expensive. Therefore, it is necessary to provide automated AI image-based solutions to farmers. Images are being used and accepted as a reliable means of identifying disease in image-based computer vision applications due to the availability of appropriate software packages or tools. They process images using image processing, an intelligent image identification technology which increases image recognition efficiency, lowers costs, and improves recognition accuracy [2]. With the improvement of the computer performance, applying deep learning to agricultural production is the development trend of agriculture in the future. Numerous artificial intelligence methods are currently employed for this purpose, encompassing a range of techniques such as k-nearest neighbors algorithm (KNN), logistic regression (LR), decision trees (DTs), support vector machines (SVMs), and deep convolutional neural networks (DCNNs) [3,4].

II. METHODS

These above mentioned methods improve feature extraction when applied with image preprocessing. However, these methods are weak regarding the model's efficiency. Within the realm of supervised learning, CNNs can be regarded as comprehensive solutions for the purposes of classification or detection tasks.

Yubao Deng and his colleagues proposed a new U-Net based method in order to detect tomato leaf diseases. This method denoted Cross-layer Attention Fusion Mechanism combined with Multiscale Convolution Module (MC-UNet). The main reason of offering this method that some diseased areas on tomato leaves are tiny and may go unnoticed during segmentation process. Blurred edge also makes the segmentation accuracy poor [5]. According to the contributions this module obtains multiscale information about tomato disease by employing 3 convolution kernels of different sizes, and it emphasizes the edge feature information of tomato disease using the Squeeze-and-Excitation Module. Second, a Cross-layer Attention Fusion Mechanism is proposed. This mechanism emphasizes tomato leaf disease locations via gating structure and fusion operation. Then, they employ SoftPool rather than MaxPool to retain valid information on tomato leaves. Finally, they use the SeLU function appropriately to avoid network neuron dropout. They compared MC-UNet to the existing segmentation network on their self-built tomato leaf disease segmentation dataset and MC-UNet achieved 91.32% accuracy.

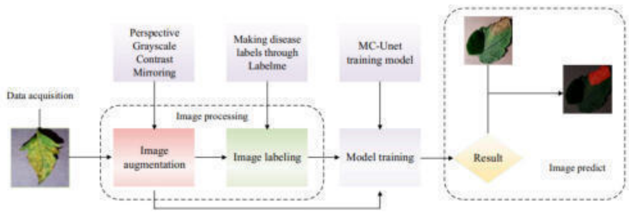

Fig 1. The system building process diagram of MC-UNet

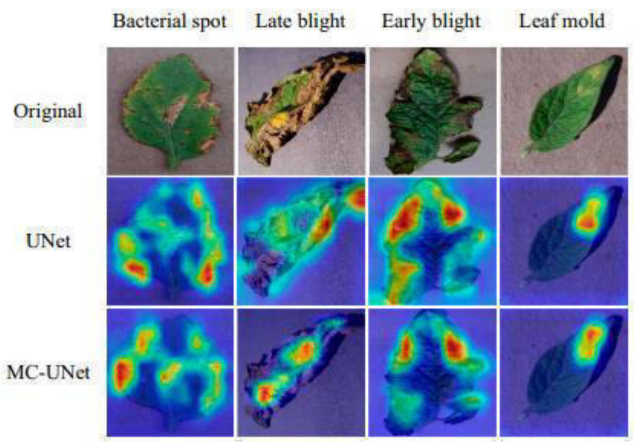

Fig 2. The effect of MC-UNet

Jianshuang Wu and his friends proposed "The Disease Segmentation Detection Transformer (DS-DETR)" model in order to segment tomato leaf diseases. With the help of the segmentation results of the model, the early blight and late blight damage grades for tomato were also evaluated [6].

It is appropriate to mention transformers are the type of neural network architectures. They are often used in NLP for sequential data like voice and others. But in advanced years the transformers are being utilized for image segmentation instead of traditional machine learning techniques. For image segmentation, transformer model split the images into patches and the each patch is embedded into high dimensional space.

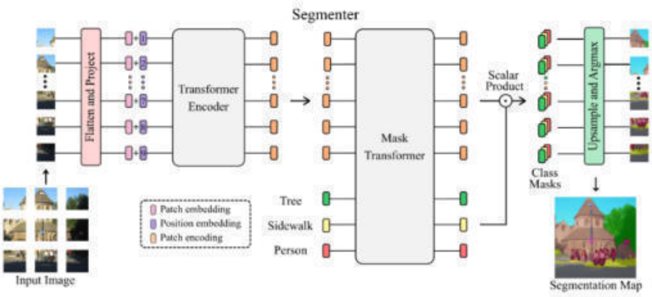

Fig 3. Transformer for segmentation

The main contributions of their work are as follows [6]:

Two datasets were proposed. The Plant Disease Classification Dataset (PDCD) with 86,023 images, including 27 diseases of 14 plants, was collected. The other is the Tomato leaf Disease Segmentation Dataset (TDSD) containing 1700 images, which was annotated by themselves.

The Disease Segmentation Detection Transformer (DS-DETR model was proposed to segment lesion areas of leaves efficiently based on several improvements on DETR. In addition, DS-DETR is better than when compared to several other advanced segmentation networks.

A disease damage estimation method was proposed for early blight and late blight in tomato by calculating the disease spot area ratio over the leaf area. This method can provide technical support for the precise prevention and control of crop diseases in production.

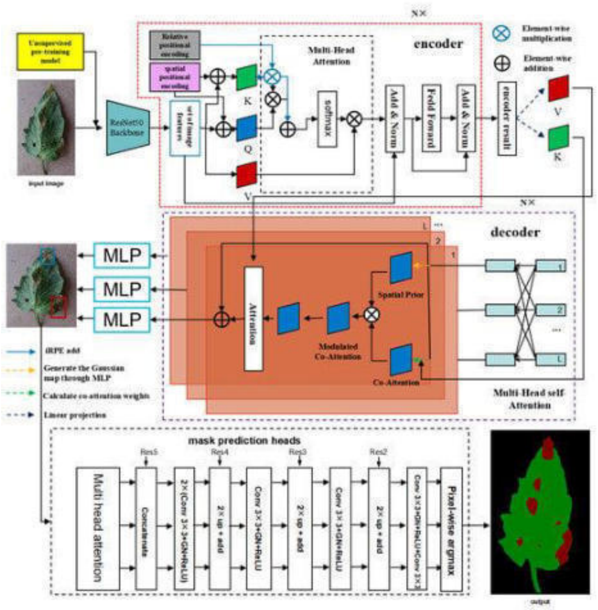

Fig 4. Overall design of The Disease Segmentation Detection Transformer model

In the discussion of their work they conclude the classification accuracy of the disease damage evaluation reached 96.40%.

Unlike deep learning in order to detect leaf diseases Sivagami, S and Mohanapriya, S used traditional machine learning stages.

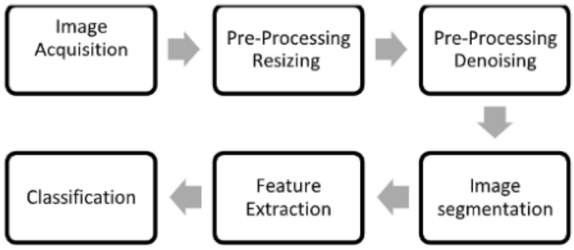

Fig 5. General work flow of proposed method

They proposed considered five main diseases like Septoria leaf spot, Early Blight, Bacterial Spot, Late Blight, and Leaf Mold in the tomato plant. The input tomato leaf images were of different sizes, so the first image resize was done then the color image is converted into the gray image after that image denoising was done using the Gaussian filter which is followed by segmentation by using proposed modified K-means segmentation algorithm. After performing segmentation useful features are extracted from ROI using the GLCM feature extraction method. After getting useful features classification was done using SVM and ANFIS classifiers.

This work mainly focused on the prediction of tomato leaf disease with the proposed modified K-means segmentation algorithm. Furthermore, they compared two segmentation methods such as K-means and modified K-means. They concluded that Modified K-means and ANFIS classifier produced a better accuracy of 98.60%. [7].

Khalil Khan and his colleagues utilized an end-to-end semantic leaf segmentation model for plant disease identification. That model used a deep convolutional neural network based on semantic segmentation (SS). The proposed algorithm highlighted diseased and healthy parts and enabled the classification of ten different diseases affecting a specific plant leaf. The model successfully highlighted the foreground (leaf) and background (non-leaf) regions through SS, identifying regions as healthy and lesion parts. As the semantic label is provided by the proposed method for each pixel, the information about how much area of a specific leaf is affected owing to a disease is also evaluated [8].

In addition, they used database Plant Village and their novelty was collecting dataset of twenty thousand images and tested their framework on it. The model used semantic segmentation. The novelty of their model is providing information about each pixel of a leaf image, which tells if a pixel belongs to a diseased or healthy part. The proposed model obtained an average accuracy of 97.6%.

III.RESULTS

Each above mentioned method enables to object detection and classification according to the data set properties such as the size of training set, the complexity of resources, lighting conditions and others. For instance, traditional disease detection (image segmentation techniques) methods such as thresholding, edge detection(especially Canny) and region-based edge detection methods are good for tomato leaf disease detection. Particularly the thresholding is available for simple and fast for images with good contrast between the leaf and background. But, it has some limitations. It has no tolerance with different lighting conditions, shadows and complex backgrounds. The edge detection is useful for detecting the outlines of leaves. The limitation is sensitive to noise and may not accurately segment complex shapes The region-based method can segment connected regions effectively. Limitation is computationally expensive.

But nowadays neural network based segmentation methods have become increasingly popular due to their high accuracy and ability to work complex and varied image data. Particularly, Convolutional Neural Networks (CNN) can automatically learn features and segment images through hierarchical layers. The strength is capable of learning complex patterns and adapting to various shapes and textures. The U-net enables clear segmentation for complex shapes. But it needs significant training data and computational power. The strength side of another method named K-means is for smaller images or fewer clusters, it can be relatively fast and computationally inexpensive. The weaknesses of this method is The number of clusters (K) must be predefined, which can be challenging if you don't know how many segments are needed.

IV CONCLUSION.

In conclusion, it can be said that each model or method used is selected depending on the characteristics of the object being studied. For tomato leaf disease detection, popular methods like CNN-based architectures (U-Net, DeepLab) or transformer-based models generally give superior performance compared to traditional methods. They provide detailed, accurate segmentation, important for detecting complex disease symptoms.

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STRUCTURE OF AN AUTOMATED SYSTEM FOR VESSEL CONTOUR PARAMETER DETECTION AND EVALUATION ON ULTRASOUND IMAGES

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***ABSTRACT* This paper discusses the automated structure for processing and analyzing vessel cross-sectional images in ultrasound imaging to extract and evaluate vessel contour parameters. Ultrasound examination of the neck vessels is conducted to assess the condition of the vessel walls and the presence of intraluminal formations, such as plaques or clots, which impede blood flow. The automated structure enables practitioners to apply vessel contour extraction and evaluation algorithms on ultrasound images, automating the full image processing workflow.**

KEYWORDS automated system, vessel cross-section, ultrasound images, area evaluation

I INTRODUCTION

Obtaining diagnostic images is an essential method that complements clinical examinations in providing medical care to patients suffering from many common diseases. Diagnostic imaging is mainly performed using radiography and ultrasound scanning [1,2,3]. Ultrasound examination of the neck vessels is performed to assess the condition of vessel walls and identify intraluminal formations, such as plaques or clots, that hinder blood supply. These studies are characterized by lower quality, with higher noise levels and lower contrast, and often include artifacts caused by reflection and diffraction of ultrasound waves, complicating tissue recognition [4,5]. Based on ultrasound images, the specialist manually delineates the organ boundary on multiple two-dimensional sectional images, and then the algorithm completes the image processing, visualization, and volume calculation. Manual tracing is a time-consuming process requiring a high level of expertise. Therefore, fully automated methods for vessel area segmentation in ultrasound images are currently lacking [6,7].

II METHODS

The proposed method for vessel boundary extraction in ultrasound images is a continuation of previous work on object boundary detection in complex images. The developed method and set of algorithms form the foundation of an automated system for detecting and evaluating carotid artery parameters in cross-sectional ultrasound images of neck vessels. The research aims to provide specialists with a practical tool that applies automated vessel contour extraction and evaluation on ultrasound images, automating the complete image processing workflow.

The study environment focuses on blood flow in various vessels. The change in ultrasound waves is directly related to the movement of blood particles. In classical studies, blood flow movement and direction are determined by the image on the monitor. Modern equipment allows for simultaneous viewing of both vessel structures and their blood flow. Information is captured by a sensor, processed by specialized software, and displayed as a two-dimensional color image. The research mechanism is simple: blood cells moving in vessels reflect ultrasound waves, providing information on the direction and speed of blood flow within the vessel. This method is crucial for diagnosing diseases of the brain and spinal cord vessels.The structure of the automated system for processing and analyzing cross-sectional ultrasound images is shown in Figure 1.

Figure 1: Structure of the Automated Image Processing and Analysis System

The physician interacts with the system's main components through a user interface, which, combined with the "Information Display and Storage" unit, implements functions for computer-assisted operation. The "Vessel Cross-Section Contour Center Evaluation Algorithm" unit calculates the coordinates of the vessel's cross-sectional contour center for processing the next frame, following the method described in [8,9].

At the initial stage of vessel boundary detection, it is necessary to specify a point (x0, y0) within the vessel area on the image. Radial sections by brightness are taken from this point with an angular step Δα and a radius R, where n = 0, 1, ... R-1, and h is the radial section number. The specified point with coordinates (x0, y0) may differ from the center of the vessel area, which can affect the quality of the detected vessel cross-section contour in dynamic image processing. To address this issue, after detecting the vessel cross-section contour in the first frame, the coordinates of the vessel's center are calculated for the subsequent frame processing.

The obtained data are sent to the decision-maker (physician) and used to form the diagnostic description. The original, intermediate, and final data from processing the ultrasound images of neck vessels are directed to the "Information Display and Storage" unit.

To form one frame, it is necessary to determine the number of frames, frequency, and pulse during ultrasound image processing. The vessel cross-sectional area changes with the pulse frequency. A resting adult's pulse is 60-80 beats per minute. Pulse indicators vary depending on height (the taller the person, the lower the pulse), age (newborns have a pulse of 120-140 beats per minute, reaching normal levels by 16-18 years), gender (men typically have a lower pulse than women), and fitness level (trained individuals may have a pulse as low as 50 beats per minute) [10]. The main pulse properties are its frequency, rhythm, intensity, height, and volume. If the pulse is normal, the frequency is 60-80 Hz, and with an increased pulse, the vessel cross-sectional area grows, thus increasing the frequency.

When processing image frames, it is necessary to account for the pulse frequency of 1 beat per second, or 1 Hz, meaning 1 beat = 1 Hz. Pulse frequency affects the vessel cross-sectional area, which expands or narrows over time. Thus, for frame processing, the time should be set to $t < 1$ s in the range of 0.1-0.9 s, with an equal frequency of 0.1-0.9 Hz.

The frame processing frequency primarily depends on the type of ultrasound sensor, in this case, a pencil probe. It is used for large arteries and veins in the extremities, neck, and heart [10]. The sensor operates in the 4-8 MHz frequency range for vein studies.

III RESULTS

The vessel cross-sectional contour center evaluation method involves extracting the vessel boundary on ultrasound images. At the initial stage, a point in the vessel area on the image is specified, and radial sections by brightness are made with a given angular step. Then, brightness variations are detected in each radial section, and the boundary is defined by the maximum correlation between brightness profiles and the brightness variation function. The vessel cross-sectional boundary on ultrasound images is represented as a contour consisting of vectors connecting points corresponding to brightness changes in each radial section.

To calculate the vessel center coordinates, the total contour code $B = \{\beta(n)\}$, $n = 0, 1, \ldots s-1$ (see section 2.6) is used. The center coordinates are calculated as the arithmetic mean of the total contour code [11]. Horizontal Δx and vertical Δy displacements relative to the initial contour point are determined as:

$$\Delta x = \frac{1}{s}\sum_{n=1}^{s-1}\beta_1(n), \quad \Delta y = \frac{1}{s}\sum_{n=1}^{s-1}\beta_2(n) \quad (1)$$

where $\beta1$ and $\beta2$ are the real and imaginary parts of the total contour code element $B = \{\beta(n)\}$, $n = 0, 1, \ldots s-1$, respectively.

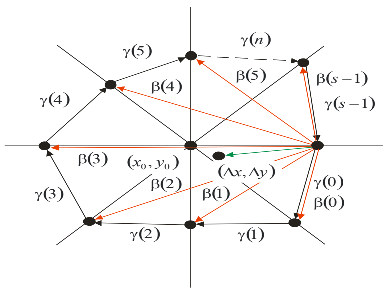

Figure 2. Explanation of the process for calculating the contour center coordinates

The coordinates ($x_ц$,$y_ц$) of the vessel center for processing the next frame are determined as:

$$x_ц = x^1 + \Delta x, \quad y_ц = y^1 + \Delta y \quad (2)$$

where (x^1,y^1) are the coordinates of the point in the image in the first brightness section corresponding to the brightness gradient.

IV DISCUSSION

Ultrasound diagnostics have broad applications in many fields. In head and neck organ studies, it is effective for diagnosing thyroid gland pathology, neck vessels, lymph nodes, and soft tissues. Difficulties arise when contacting bone or cartilage structures. An automated system for processing and analyzing vessel cross-sectional images on ultrasound images is proposed. The physician interacts with the system through a user interface, which, in conjunction with the "Information Display and Storage" unit, provides a user-friendly experience and system operation in the decision-maker's language (the physician).

V CONCLUSION

The non-invasive nature, availability, reproducibility, high compliance, and simultaneous interventional capabilities will continue to drive the development of ultrasound diagnostics, enhancing its efficiency. The quality of vessel contour detection on ultrasound images can be affected by dynamic image processing. An automated system structure for processing and analyzing vessel cross-sectional images on ultrasound images has been proposed. The method is based on evaluating the vessel cross-sectional contour center. A frame frequency has been selected for processing ultrasound images.

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ALGORITHMS FOR RECOGNITION OF HISTOLOGICAL IMAGES BASED ON THRESHOLD RULES

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A B S T R A C T **The article discusses various histological image recognition algorithms to improve the accuracy of pathology diagnostics. Particular attention is paid to the proposed threshold rule-based method, which demonstrates higher classification accuracy and training speed compared to popular machine learning methods such as SVM, Random Forest, and XGBoost. During the experiments, the proposed method showed high accuracy with minimal training and classification time. The results of a comparative analysis by key metrics are presented, confirming the effectiveness of the proposed approach for automating diagnostics in digital pathology.**

K E Y W O R D S Histological image, threshold rules, features of objects, recognition operator, models based on threshold rules

INTRODUCTION

Histological image recognition is one of the key tasks in biomedical informatics and digital pathology. Modern methods of histological section analysis provide automation and increased accuracy of disease diagnostics, including cancer and other pathologies [1]. Traditional methods of image analysis often require human participation and complex processing, but automation of the process allows for faster diagnostics and minimizes the likelihood of errors [2].

Modern approaches to automated analysis of histological images include the use of various processing and recognition algorithms [3]. In this case, using image processing algorithms, the signs of various diseases presented in the form of an image are identified. Using recognition algorithms, these diseases are classified. Thus, in this report, the object is understood as a histological image, and the object's features are understood as the selected features of the histological image. In this case, the object's features are extracted based on the analysis of histological images.

The main objective of this work is to develop a family of algorithms for recognizing objects presented in the form of histological images.

STATEMENT OF THE PROBLEM

Let $\mathcal{I}$ be a set of histological images, and $I \in \mathcal{I}$ let be a single image consisting of a set of pixels. For each, I we can define a feature vector $f(I) = (f_1(I), f_2(I), \dots, f_k(I))$, where $f_j(I)$ are the characteristics (features) of the image I, for example, average brightness, centralized moments etc.The task is to construct an algorithm Athat classifies each feature vector $f(I)$ to a certain class.

METHODS

This section proposes an approach to solving the problem of constructing a family of recognition algorithms within the framework of a model based on threshold rules. The main idea of the proposed approach consists of the following stages: 1) the energy characteristics of the histological image (the energy shares of the recognized objects) are used as a set of characteristic features of objects; 2) recognition operators are constructed on their basis, based on the construction of threshold rules.

Let us consider the stages of defining the proposed family of algorithms.

1. Determination of a set of features of objects presented in the form of histological images. It is known that any image$I$ $(I \in \mathcal{I})$can be defined as a two-dimensional function $\rho(m,n)$, where$m$ and $n$are coordinates in space (specifically, on a plane), and the value $\rho$of which at any point specified by a pair of coordinates $(m,n)$is called the intensity of the image at this point $(m = 1,2,\dots H, n = 1,2,\dots,W)$. To represent the function $\rho(m,n)$in the frequency domain, the following expression can be used [4]

$$\rho(m,n) = \sum_{u=-r}^{r} \sum_{v=-r}^{r} \mathcal{F}(u,v) e^{ium} e^{ivn},$$

where, e^{ium} and e^{ivn} are basis functions (functions are represented in the Fourier basis), arguments $u$and $v$are circular frequencies reflecting the periodicity (cyclicity) of changes in the original function $\mathcal{F}(u,v)$with changes in arguments $m$and n.

As a weighting function$\mathcal{F}(u,v)$ you can use [5]:

$$\mathcal{F}(u,v) = \sum_{m=1}^{H} \sum_{n=1}^{W} \rho(m,n) e^{-ium} e^{-iun} \quad (1)$$

Image energy$(\mathcal{E})$ can be represented as a sum:

$$\mathcal{E} = \sum_{m=1}^{H} \sum_{n=1}^{W} \rho^2(m,n),$$

where $\rho(m,n)$– two-dimensional signal.

2. Definition of a recognition operator $\mathfrak{R}$ within the framework of models based on threshold rules.

At the second stage, recognition operators based on threshold rules are constructed. The procedure for determining the weight coefficients of threshold rules consists of the following steps.

1. Receipt of input data presented in the form $n$of dimensional feature vectors.

2. Initialization of the weight coefficients of the threshold rules, specified as a linear polynomial:

$$w_{ijk} = \frac{1}{1 + H * W}, i = 1, \dots, H; j = 1, \dots, W; k = 1, \dots, H * W.$$

3. For each input feature vector, the energy spectrum is calculated:

$$\mathcal{L}_{ij} = \sum_{k=1}^{\mathcal{R}_{k_1} * \mathcal{R}_{k_2}} w_{1ijk}(\mathcal{P}_{ijk} - \mathcal{P}_{cp})^2,$$

$$\mathfrak{R}_{1ij} = 1/\left(1 + e^{-\mathcal{L}_{ij}}\right),$$

$$\mathcal{P}_{r_1,r_2} = \frac{trec(\mathfrak{Y}_r^T \cdot \mathcal{I} \cdot \mathfrak{Z}_m \cdot \mathcal{I}^T)}{\mathfrak{Q}},$$

$$\mathfrak{Q} = \sum_{m=1}^{H} \sum_{n=1}^{W} \rho^2(m,n).$$

Elements of matrices $\mathfrak{Y}$ $\left(\mathfrak{Y} = \|\mathfrak{y}_{\mathrm{i}_1,\mathrm{i}_2}\|\right)$ and $\mathfrak{Z}$ $\left(\mathfrak{Z} = \|\mathfrak{z}_{\mathrm{i}_1,\mathrm{i}_2}\|\right)$ are calculated as follows:

$$\mathfrak{y}_{\mathrm{i}_1,\mathrm{i}_2} = \begin{cases} \dfrac{sin(\alpha_2(\mathrm{i}_1 - \mathrm{i}_2)) - sin(\alpha_1(\mathrm{i}_1 - \mathrm{i}_2))}{\pi(\mathrm{i}_1 - \mathrm{i}_2)}, where\ \mathrm{i}_1 \neq \mathrm{i}_2, \\ \dfrac{\alpha_2 - \alpha_1}{\pi}, where\ \mathrm{i}_1 = \mathrm{i}_2, \end{cases}$$

$$\mathfrak{z}_{\mathrm{j}_1\mathrm{j}_2} = \begin{cases} \dfrac{sin(\beta_2(\mathrm{j}_1 - \mathrm{j}_2)) - sin(\beta_1(\mathrm{j}_1 - \mathrm{j}_2))}{\pi(i_1 - i_2)}, where\ \mathrm{j}_1 \neq \mathrm{j}_2, \\ \dfrac{\beta_2 - \beta_1}{\pi}, where\ \mathrm{j}_1 = \mathrm{j}_2, \end{cases}$$

It should be noted that I- the original image $\left(\mathrm{I} = \|\rho(m,n)\|_{H\times W}\right)$.

As a result of this stage, we will obtain a set of algorithms recognition based on threshold rules, which we denote by $\mathbb{A}$:

$$\mathbb{A} = \{A_1, \ \dots \ , A_i, \ \dots \ , A_k\},$$

where, A_i is the recognition algorithm trained on $i$the th training sample.

3. Construction of a linear correction polynomial for all recognition algorithms. At the third stage, a generalized recognition algorithm is defined that calculates a numerical score called the proximity score. This score characterizes the similarity of an object (more precisely, an image of an object) $\mathcal{I}$ with objects belonging to the class K_j. Let each score for the class calculated with the recognition algorithm be A_i ($A_i \in \mathbb{A}$), corresponds to the numerical parameter $\mathfrak{c}_i$. There are many recognition algorithms (classifiers): $\{A_1, \ \dots \ , A_i, \ \dots \ , A_k\}$. Let the recognition algorithm $\mathfrak{A}$ consists of a certain composition of k elementary algorithms:

$$\mathfrak{A}(\mathcal{I}_u) = \mathfrak{F}(A_1, \ \dots \ , A_i, \ \dots \ , A_k).$$

Let consider a first-order polynomial as $\mathfrak{F}(A_1, \ \dots \ , A_i, \ \dots \ , A_k)$. Then the model of generalized algorithms is given in the form

$$\mathfrak{A}(\bar{\mathfrak{c}}, \mathcal{I}_u) = \sum_{A_i \in \mathbb{A}} \mathfrak{c}_i A_i(\mathcal{I}_u).$$

The main task of this stage can be formulated as the task of finding the optimal value of the parameter vector $\bar{\mathfrak{c}}$ $\left(\bar{\mathfrak{c}} = (\mathfrak{c}_1, \ \dots \ , \mathfrak{c}_i, \dots \ , \mathfrak{c}_k)\right)$

$$\bar{\mathfrak{c}}^* = arg\,\max_{\bar{\mathfrak{c}}} \mathcal{Q}_{\mathfrak{A}}(\bar{\mathfrak{c}}), \qquad (2)$$

where,

$$\mathcal{Q}_{\mathfrak{A}}(\bar{\mathfrak{c}}) = \frac{1}{|\tilde{\mathcal{J}}^m|} \sum_{\mathcal{I}_u \in \tilde{\mathcal{J}}^m} \mathfrak{y}\left(\|\tilde{\beta}_u - \mathfrak{A}(\bar{\mathfrak{c}}, F_u) \cdot \mathcal{C}(c_1, c_2)\|\right),$$

$$\mathfrak{y}(x) = \begin{cases} 1, if\ x = 0; \\ 0, if\ x \neq 0. \end{cases}$$

To solve problem (2), the stochastic approximation method is used.

Let $\mathfrak{A}^*(K_j, \mathcal{I}_u)$be the best recognition algorithm at the current iteration. Then the search algorithm is implemented as follows:

$$a_i^{(N)} = a_i^{(N-1)} + \gamma_i^{(N)} \cdot \mathcal{Q}\left(S_u, a^{(N-1)}\right) \cdot \phi(S_u), u = N - ent(N:m) \cdot m,$$

$$\phi(S_u) = \begin{cases} -1, if\left(S_u \bar{\in} K_j\right)(\mu_j(S_u) \geq C_1), \\ 0, if\ \left(S_u \bar{\in} K_j\right)(\mu_j(S_u) < C_1) \vee (S_u \in K_j)(\mu_j(S_u) > C_2), \\ 1, if(S_u \in K_j)(\mu_j(S_u) \leq C_2). \end{cases}$$

Necessary and sufficient conditions for the convergence of algorithms of the stochastic approximation method are considered in [6].

Thus, the synthesis of a correct algorithm over a set of models based on threshold rules is carried out on the basis of algebraic correction of image recognition operators constructed within the framework of the developed algorithms.

EXPERIMENTAL RESEARCH

To test the effectiveness of the proposed threshold-rule-based histological image recognition method, a comparative analysis was conducted with popular machine learning methods, including support vector machine (SVM), random forest, and gradient boosting (XGBoost). The study was conducted on real histological images containing various pathologies from the LC25000 set in the amount of 5000 images for each of the two classes (malignant, non-malignant) [7].

Histological images of different classes were used for training and testing. The images were pre-processed and a feature vector was extracted for each image, including characteristics such as image intensity, moments, and energy characteristics described in the method. The set of features was used to build classification models.

The experiment compared the following classification methods:

- • The proposed method is based on threshold rules. The main distinguishing feature of this method is the use of energy characteristics of images to determine threshold rules and build a classification model.
- • Support vector machine (SVM) is a classic machine learning method that is often used for image classification problems.
- • Random Forest is an ensemble method that uses multiple decision trees to improve classification accuracy.
- • Gradient boosting (XGBoost) is an efficient decision tree-based method that is often used for problems with high feature dimensionality.
- The following indicators were selected to evaluate the effectiveness of the methods:
- • Model training time measured for each method.
- • Time to classify one image.
- • Classification accuracy, defined as the proportion of images classified correctly.

Below is a table showing the comparison of results between the proposed method and popular machine learning methods.

Table1. comparison of results between the proposed method and popular machine learning methods

Method	Classification accuracy (%)	Training time (s)	Classification time (s/image)
The proposed method	96	12	0.002
SVM	92	34	0.008
Random Forest	93	28	0.006
XGBoost	94	45	0.010

As can be seen from the table, the proposed method showed the highest accuracy and significantly shorter training and classification time compared to traditional methods.

DISCUSSION

The study proposed a new threshold-rule-based histology image recognition method and compared its results with popular machine learning methods such as SVM, Random Forest, and XGBoost. The experiments revealed both the strengths and weaknesses of each method, allowing for a better understanding of the conditions under which each can be useful.

The proposed threshold rule-based method demonstrated the highest classification accuracy (96%), which exceeds the performance of all other methods. This result is explained by the fact that the energy characteristics of images used in threshold rules effectively capture important features of histological images associated with various pathological processes. This allows for more accurate classification of images while minimizing errors.

Machine learning methods such as SVM, Random Forest, and XGBoost also showed fairly high results (92%, 93%, 94%, respectively), but their accuracy was lower than that of the proposed method. One of the reasons may be that these methods build models based on more universal features that do not always fully reflect the specific features of histological images.

The training time of the proposed method turned out to be the fastest among all methods — 12 seconds, which is significantly less than SVM (34 seconds), Random Forest (28 seconds) and XGBoost (45 seconds). The main advantage of the proposed approach is the lack of need for complex computational operations typical of machine learning methods. In methods such as SVM and XGBoost, it is necessary to solve optimization problems, which requires large computing resources and time. In the case of threshold rules, training consists of finding optimal thresholds for features, which significantly simplifies and speeds up the training process.

Random Forest, although it has an ensemble structure that speeds up the process by training decision trees in parallel, still lags behind the proposed method in terms of training time. XGBoost, which works on the basis of gradient boosting, also turned out to be the slowest in training due to the complexity of the process of updating the weights for each subsequent tree.

The proposed method showed the minimum classification time for one image — only 0.002 seconds, which is also an advantage over other methods. For tasks related to mass image processing (for example, when diagnosing cancer cells in large data sets), the classification speed plays an important role. The fast classification time is explained by the simple structure of the threshold rules, where the decision on the image belonging to a certain class is made based on several simple operations with image features.

Machine learning methods such as SVM, Random Forest, and XGBoost are computationally expensive to classify because each of them uses complex mathematical models. For example, SVM requires calculating distances to a hyperplane, Random Forest performs multiple decision tree traversals, and XGBoost performs multi-layer classification with weight updates. All of these operations increase classification time.

Another important aspect is the generalization ability of the models, i.e. how well the method can adapt to new data. The proposed method turned out to be more robust to changing conditions (e.g. variations in histological images) since the threshold rules are based on fundamental energy characteristics of the images. This allows it to effectively classify images with different types of pathologies.

Machine learning methods also have a high generalization ability due to their nature of learning on large amounts of data. However, they may require additional hyperparameter tuning and larger training data to achieve the same level of accuracy.

CONCLUSION

Based on the experiments conducted, several important conclusions can be drawn:

1. Accuracy: The proposed threshold rule-based method demonstrated the highest classification accuracy (96%), making it preferable for histological image recognition tasks where accuracy is critical.

2. Training time: The proposed method significantly outperforms SVM, Random Forest and XGBoost in training speed, which allows for faster training of classification models, especially under conditions of limited computing resources.

3. Classification time. The classification speed of the proposed method is a significant advantage, especially in applications that require processing a large amount of data in a short time (e.g., automatic diagnosis of pathologies based on histological images).

4. Ease of implementation. The proposed method has a relatively simple structure, which simplifies its implementation and use. Unlike complex machine learning algorithms such as XGBoost, threshold rules do not require a large amount of computing resources to implement.

5. Potential for further improvement: The proposed method can be further optimized, for example by adapting the threshold rules to other image recognition tasks or integrating it with deep learning methods to improve accuracy and speed.

Thus, the proposed threshold rule-based method is an effective tool for solving histological image recognition problems, which outperforms popular machine learning methods in terms of speed and classification accuracy.

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EXPLAINABILITY OF THE SVM CLASSIFICATION MODEL FOR SENTIMENT ANALYSIS TASK OF UZBEK LANGUAGE

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A B S T R A C T **This paper investigates the integration of local model-agnostic explanations with support vector machine models to enhance explainability in sentiment analysis for the Uzbek language. While SVM models are effective for classification tasks, they often function as black-box models with limited transparency. To address this, we used LIME[2], which perturbs input data and observes changes in the model's output, revealing the text features that most influence classification. This approach improves transparency and trust in AI systems. Our case study focuses on sentiment analysis in the low-resource Uzbek language, showing how LIME aids in understanding SVM model decisions.**

K E Y W O R D S SVM, sentiment analysis, explainability, Uzbek language

INTRODUCTION

Machine learning models like Support Vector Machines (SVM) are powerful tools for sentiment analysis[1], but their "black-box" nature often limits interpretability, making it difficult for users to understand how decisions are made . This lack of transparency poses challenges in sentiment analysis tasks, where understanding why a text is classified as positive, negative, or neutral is crucial. To address this, Explainable Artificial Intelligence (XAI) methods such as Local Interpretable Model-agnostic Explanations (LIME)[2] have emerged. LIME works by perturbing input data and creating local approximations to explain a model's decision, allowing users to understand which features contribute to a prediction [1-2].

In this paper, It has been focused on applying LIME to enhance the transparency of an SVM model designed for sentiment analysis of the Uzbek language, a low-resource language with limited NLP resources . By integrating LIME, we aim to provide clear, interpretable explanations of the SVM model's decisions, helping users understand how specific features in the text influence sentiment classification. This approach not only improves transparency but also builds trust in the model's predictions, offering valuable insights for the analysis of Uzbek texts.

RELATED WORKS

Significant advancements have been made in the field of sentiment analysis and natural language processing (NLP) for Uzbek language. For instance, several datasets have been developed to support sentiment analysis tasks[6-7]. [8] specifically explored the role of emoji-based features in classifying opinions within Uzbek text, particularly movie reviews from YouTube. They evaluated various classification models and employed feature ranking to assess the discriminative power of these emoji-based features.

Additionally, [9] contributed to the field with research on semantic assessment, and [12] proposed a collocation method to detect stop words in Uzbek corpora, introducing a dataset of 731,156 stop words. Beyond this, several NLP tools have been developed to facilitate research and application in Uzbek, including a transliteration tool for existing alphabets [10], a syllabification tool [11].

Despite these contributions, there remains a need for continued efforts to improve the performance and accuracy of NLP models for Uzbek-language texts. In this context, [13] also addressed the complexities of multi-class text categorization for Uzbek texts, shedding light on the specific challenges that come with processing this language.

METHODS

A "black box" refers to a system that can be evaluated solely by its inputs and outputs, with its internal workings remaining concealed. The term is metaphorically derived from the idea of an opaque box, where one can observe what goes in and what comes out, but not the process in between. In machine learning, "black box" models are those whose internal mechanisms are difficult to interpret by merely analyzing their parameters. However, understanding the logic behind decisions is crucial, particularly in sensitive areas like opinion mining[4]. This underscores the importance of offering clear explanations of AI-generated outputs. Unfortunately, many machine learning algorithms, despite their effectiveness in producing predictions, suffer from a lack of transparency, making it difficult to grasp how they function internally. This opacity in decision-making introduces substantial risks. To mitigate these issues, Explainable Artificial Intelligence (XAI) approaches aim to foster greater transparency. Specifically, in the context of Support Vector Machines (SVM), XSVM promotes the development of methods that either create more interpretable models without sacrificing performance or provide additional tools to make inherently opaque models more understandable.

Figure 1 illustrates a standard comparison between the traditional black-box Support Vector Machine (SVM) model and the newly developed Explainable AI (XSVM) approach. In the conventional scenario, input data is processed, and the black-box SVM model generates predictions based on that data. However, this model operates opaquely, making it difficult to discern the internal logic behind the AI's decisions, including its successes, failures, and error corrections, and providing no clear answers to user inquiries. In contrast, the XSVM model is designed to offer greater transparency, ensuring that the decision-making process is more comprehensible to users while still maintaining the model's predictive capabilities.

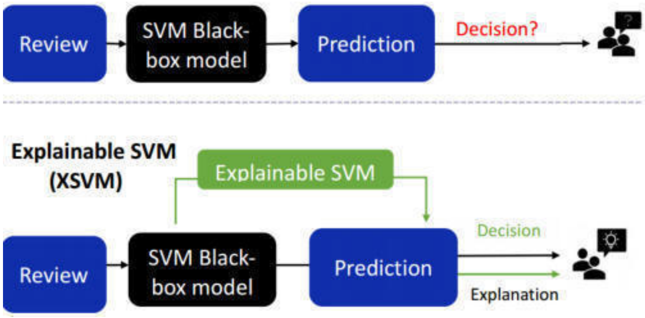

Fig. 1. Explainable SVM (XSVM).

Bottom of figure hints the concept of XSVM in which everything is similar, but an important add-on is the addend of explainability. After the prediction, there is another step in this black-box model where the explanation of decision-making process ensues.

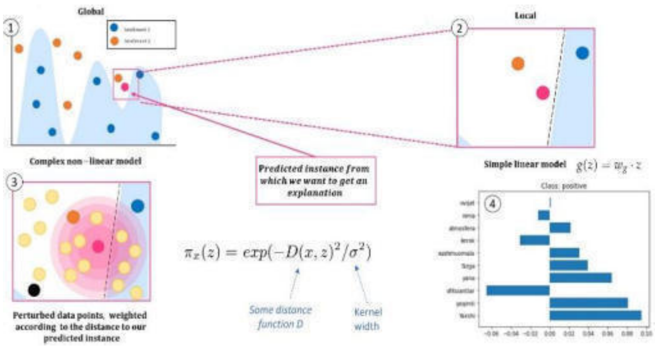

Fig. 2. LIME general pipeline for explaining individual predictions of a classifier trying to determine if a review has positive sentiment or not.

Figure 2, we see that LIME can be broken into four steps:

Blue/white is the background, which is the decision boundary of our original black box model, and obviously, that's very non-linear. The pink point was the review instance that we wanted to explain and it got predicted as 'Positive'. How can we explain the fact that our model predicts positive, without peeping, into some super-complex model for which we get our predictions? We can't reduce the whole limit boundary to a sole explanation, which is a global explanation. The most common idea of LIME is to zoom in a neighborhood of the prediction that leads us to step 2.

Now it may be provided a more concise explanation of this specific local region, without considering the other parts of the model, and still achieve an equally valid explanation. It is vital to note that certain traits that may hold significance in a local setting may not hold the same level of importance on a global scale, and vice versa. In other words, a local explanation does not imply a global explanation. What LIME does is to present a local explanation through a transparent surrogate model, in this case, a linear model in the vicinity of our prediction. But how do we train this linear model? This brings us to step 3.

We slightly perturb the examples (yellow dots) and then assign the weights based on how close they are to our pink point. We acquire the predictions of the original model at those perturbed examples, and later train a linear model (black line) which closely mimics the original model in the neighborhood of our particular example. It is important to note that the misclassification of the black point from the surrogate model is not very significant as it is located far away from our pink point.

Ultimately, in this step, we get our interpretation through understanding the regional model. The bar charts show the importance given to the most relevant features; those that have contributed the most to calculate our pink point. When using linear regression as a proxy model, these values are equal to the model's weights estimation.

Fidelity-Interpretability Tradeoff[2]:

- ***f***: For classification, f(x) is either the probability or binary indicator that x belongs to some class, and in this case, for multi-classes, we will elaborate on every particular class, where f(x) is the prediction of the corresponding class..
- ***g***: Surrogate model that approximates f in the vicinity of x.
- ***G***: Set of eligible models that can be understood and explained.
- Ω(g) is a complexity measure of model g, used to regularize the complexity of th e surrogate model. In practice, Ω(g) can either be realized as the number of non-zero coefficients in the linear model or in terms of penalizing large coefficients. This methodology favors models that strike a balance between being simple and effectively describing the behavior of the complex model in a particular case.

The explanation generated by LIME at a specific local position x is derived using the following generic formula[2]:

$$\xi(x) = \underset{g \in G}{arg\,min}\, \mathcal{L}(f, g, \pi_x) + \Omega(g) \qquad (1)$$

The idea is to make sure that the model, which is interpretable for human Ω(g) interpretation and accurate, is understood as much as possible while minimizing $L(f\,, g,\, \pi_x)$, the complexity of the model.

Local Explorations Sampling: In this process, It is aim to be model-agnostic and minimize the local loss $L(f\,, g,\, \pi_x)$ without making assumptions about f. To understand how f behaves locally when the inputs change, estimate $L(f\,, g,\, \pi_x)$ by creating perturbed examples weighted by πx. The perturbations are drawn from a normal distribution fitted to the training set. Using the dataset Z, which contains the perturbed samples and labels, it is then optimized Equation (1) to provide an explanation $\xi(x)$.

The major advantage of LIME is that it is model agnostic. The local interpretable model can be applied for explanation, even if the machine learning model being explained is replaced with another. Another advantage of LIME is that the explanations it provides are concise and easy for humans to understand. Hence, LIME is better suited for scenarios where the person receiving the explanation is a layman or someone with limited availability. However, when we are required by law to provide a detailed explanation of a forecast, LIME may not be sufficient.

RESULTS

```
Yaxshi ovqat, xushmuomala ofitsiantlar, yoqimli atmosfera. Sizga yana nima kerak?
Explaining text at index: 103 - Sentiment: positive
Explanation for each class:

Class: positive
[('Yaxshi', 0.09490706523178927), ('yoqimli', 0.08090948208087875), ('ofitsiantlar', -0.0653260626320399), ('yana', 0.0639114038
5387381), ('Sizga', 0.03953281181080589), ('xushmuomala', 0.030778364721195762), ('kerak', -0.03061240396995963), ('atmosfera',
0.021682028652496712), ('nima', -0.011646785339497416), ('ovqat', 0.0011377473855027273)]
```

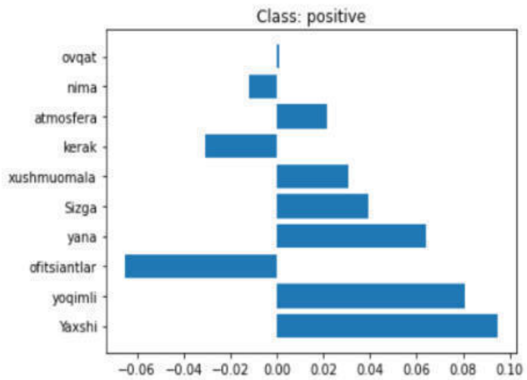

Figure 3 provides both a textual explanation and a bar chart, detailing the results of a LIME analysis applied to a sentiment classification task.

LIME explanations for sentiment analysis of the Uzbek language provide insights into how individual words influence the model's prediction[5-6]. **Figure 3's** bar chart visually captures these dynamics, with positive contributions shown on the right and negative ones on the left, where larger bars signal stronger influences on the sentiment classification. In this case, the word "Yaxshi" carries a weight of approximately 0.0949, making it the most significant positive contributor to the sentiment classification. This indicates that the presence of "Yaxshi" strongly pushes the prediction towards a positive sentiment.Another feature, "yana," with a weight of around 0.0639, also contributes positively but to a lesser extent. Meanwhile, words like "yoqimli," "sigza," and "xushmuomala" have smaller positive weights, indicating a lower but still beneficial impact on the sentiment analysis. Conversely, two terms negatively influence the model's predictions. "Ofitsiantlar," with a weight of about -0.0653, is the most significant negative contributor, pulling the sentiment classification towards a negative conclusion. Similarly, the term "kerak" has a weight of approximately -0.0360, though its influence is less pronounced than "ofitsiantlar."

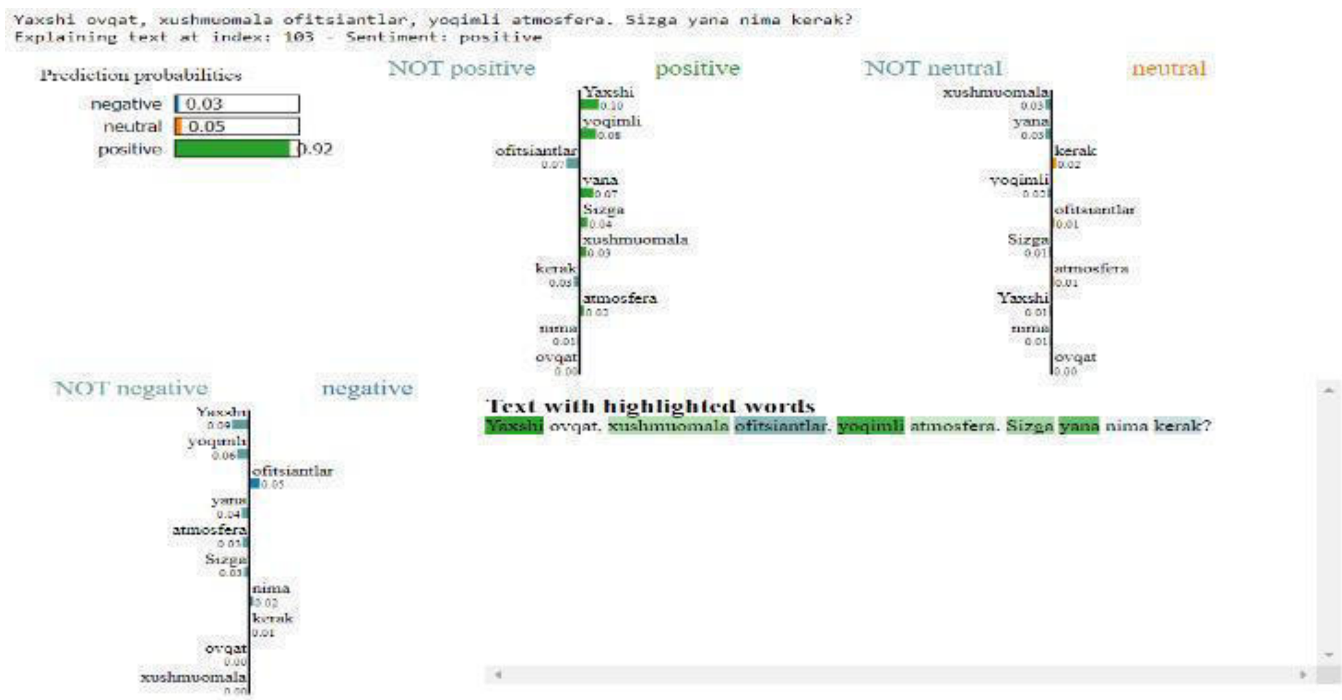

Fig 4. SVM Classification result with highlighted words on text

The weights represent the strength and direction of influence that each word exerts on the model's prediction of sentiment. Positive weights drive the model toward a positive classification, while negative weights have the opposite effect.

In Figure 4, we see an explanation of a sentiment classification task for a text written in Uzbek. The figure visualizes how individual words contribute to the overall sentiment classification (positive, negative, or neutral) for a given sentence. Here's a breakdown of the image and how to interpret it:

In Figure 5, I observe a boxplot visualization, which is likely used to compare different feature importances or distributions of the outputs generated by a machine learning model, with explainability analysis done by LIME (Local Interpretable Model-agnostic Explanations).

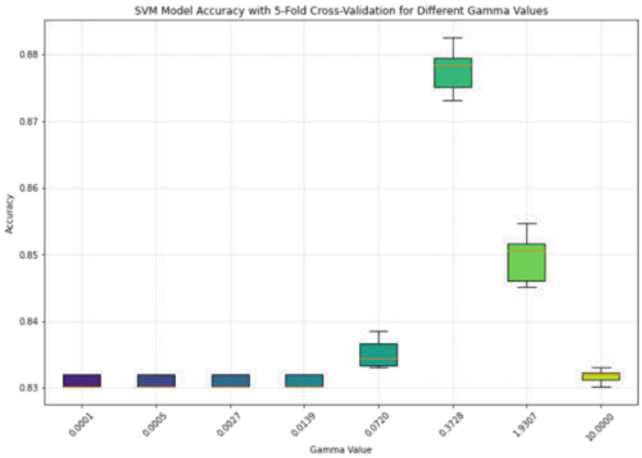

Fig 5. Five fold cross validation is pictured in boxplot visualization with explainability analysis done by LIME.

The boxplots on the right, particularly the higher ones, suggest that the features associated with these boxplots have a much larger impact or higher importance in the model's predictions compared to the others on the left side. The larger spread and higher median in these boxplots indicate features that are more influential and more widely distributed in terms of their contribution to the model's decision-making process. In contrast, the smaller boxplots on the left show features that have **minimal or less significant contributions** to the model's outputs, as indicated by their lower median and range.

DISCUSSION

The previous figure, utilizing LIME, revealed that words such as "Yaxshi" (good) and "yoqimli" (pleasant) contributed significantly to the sentiment prediction, positively influencing the outcome. This is further substantiated by the boxplot visualization, where certain features or words exhibit greater prominence than others.

Notably, the larger boxplots, particularly those positioned towards the right, likely correspond to influential words like "Yaxshi" and "yoqimli," which strongly affect the model's confidence in its prediction. In contrast, smaller boxplots may represent neutral or less impactful words, such as "nima kerak" or "yana," indicating their minimal influence on the prediction.

Together, these figures provide a comprehensive view of how specific words or features influence sentiment prediction. The LIME visualization (Figure 4) emphasizes individual word contributions, while the boxplot (Figure 5) offers a statistical overview of feature importance.

The boxplot underscores that certain words, as indicated by their contribution via the LIME method, have a disproportionately higher influence on the model's sentiment classification. These critical words align closely with the model's highest probability prediction, favoring positive sentiment.

The larger and more dispersed boxplots signify features that play a pivotal role in the model's final decision, while smaller ones denote less significant features. This pattern confirms that the model relies heavily on key words for sentiment classification, as demonstrated in both the LIME and boxplot analyses.

CONCLUSION

This study highlights the effectiveness of employing Local Interpretable Model-agnostic Explanations (LIME) to improve the transparency and interpretability of Support Vector Machines (SVM) in sentiment analysis, specifically targeting the Uzbek language. While SVM is widely recognized for its strength and efficiency in text classification, its inherent "black box" nature poses significant challenges in deciphering the reasoning behind its predictions. By incorporating LIME, this framework sheds light on the specific features, such as particular words or phrases, that impact sentiment classification, thereby making the model's decision-making process more transparent and accessible.

This method is especially important for low-resource languages like Uzbek, where the lack of comprehensive NLP tools amplifies the need for clear model interpretability. The integration of SVM with LIME not only fosters greater user trust in the system's predictions but also deepens our understanding of how subtle linguistic features influence sentiment analysis. Future research could focus on adapting this explainability approach to other low-resource languages and refining LIME for better performance in varied linguistic environments.

Future research could prioritize refining LIME's application within more complex models, including deep learning architectures commonly employed in sentiment analysis. Additionally, expanding this framework to accommodate the diverse dialects of the Uzbek language and exploring cross-lingual applications with other low-resource languages would offer valuable insights into linguistic diversity. Moreover, investigating more advanced explainability techniques beyond LIME, such as SHAP[3], may significantly enhance interpretability, providing users with a deeper understanding across a broader range of NLP tasks.

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ASSESSING MACHINE LEARNING ALGORITHMS FOR CHRONIC DISEASE PREDICTION THROUGH PERFORMANCE METRICS

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Abstract. This research examines the efficacy of machine learning (ML) algorithms in the early detection and prediction of chronic diseases by utilizing a mix of structured and unstructured data. Chronic conditions such as diabetes and heart disease require advanced diagnostic methods due to their complex nature. Using algorithms like Support Vector Machines, Decision Trees, and Logistic Regression, this study aims to create predictive models that surpass traditional diagnostic methods. These models are rigorously tested with real-world data to ensure they are both accurate and practical for clinical use. The goal is to enhance early detection and management of chronic diseases, potentially reducing healthcare costs and improving patient outcomes. This innovative approach advances the application of artificial intelligence in healthcare, setting new standards for predictive diagnostics in chronic diseases.

INTRODUCTION

Chronic illnesses often lead to persistent health problems that can compromise the immune system and other bodily functions, frequently resulting in a loss of independence and personal freedom for those affected [1]. Individuals with chronic conditions often experience significant disruptions to their daily lives, and healthcare expenses tend to increase over time. These conditions can also undermine the emotional well-being of patients. While accurate diagnosis can lead to the resolution of some chronic diseases, the associated treatments are generally extensive and can cause considerable discomfort [2]. However, most of these illnesses remain incurable. Existing medications can alleviate symptoms, potentially extending the lives of those afflicted. Improved diagnostic and treatment methods are essential for enhanced public health outcomes [3]. In India, cervical cancer [4], breast cancer, diabetes, stroke [5] and heart disease rank among the more prevalent chronic conditions [6]. Nonetheless, treating these illnesses is becoming increasingly difficult due to the rapid growth in population. The conventional manual scrutiny of such conditions often results in suboptimal medical judgments because of the sheer volume of patients. The process of diagnosing a multitude of patients with potential chronic diseases (CD) is arduous and time intensive. Additionally, the manual identification and diagnosis of symptoms are prone to inaccuracies. Therefore, the implementation of machine learning (ML)technologies is vital for effectively addressing these challenges. The use of ML to systematically categorize patients according to their symptoms is an area of ongoing research and development [7].

By [9], the forecasting of three kinds of immune disorders — allergies, infectious diseases, and autoimmune conditions — is discussed, employing methodologies like decision trees, maximum margin learning, and instance-based learning for each category respectively. Simons et.al. [8] utilized a range of ML methods, including decision tables, radial basis function classifiers, multi-layer perceptrons, and support vector machines, to analyze a dataset on coronary heart disease. Their work effectively forecasted the Framingham risk score for heart disease in older adults in Australia. Moreover, a predictive model for chronic kidney disease is detailed in references [9,11]. The model in question [11] was constructed using four distinct ML techniques for classification purposes: support vector machines (SVM), logistic regression (LR), decision trees (DT), and K-nearest neighbors (KNN). Reference [12] details a system capable of predicting various diseases employing an array of ML algorithms, including Naive Bayes, KNN, DT, random forest, and SVM, to facilitate the achievement of specific health objectives by bridging the communication gap between patients and physicians.

Surekha. et al. [12] examined the efficacy of wrapper methods in the diagnostic process for thyroid conditions. In their study, they assessed the effectiveness of the genetic algorithm and particle swarm optimization against quick reduction and Johnson's reduction, which are methods derived from rough set theory. They employed classification tools such as naive Bayes and decision trees to categorize thyroid disease. The findings indicated that evolutionary algorithms surpassed the rough set theory techniques regarding the precision of attribute selection and the minimization of attribute subsets. Additionally, a model for forecasting disease risks utilizing a random forest ML technique, particularly for highly imbalanced datasets, is presented in [13]. Furthermore, Rahul Deo Sah [14] assessed essential computational strategies such as support vector machine (SVM) and K-nearest neighbors (KNN) for their ability to prognosticate liver, cancer, and heart ailments using health disease datasets. The results showed that SVM outperformed the KNN method in terms of classification efficacy. ML has the capability to parse disease datasets and identify key symptoms indicative of certain CD [6]. Nonetheless, the task of extracting prevalent symptoms from unstructured data poses a considerable challenge, as such data forms can diminish the performance of ML techniques.

CNNs [13] have been proposed as a method to automatically acquire multi-level features through deep hierarchical structures.

Hence, devising a decision-making model that assists in the diagnosis of CD and forecasts patient outcomes is crucial. Although various AI methodologies can be employed, this study specifically concentrates on ML predictive models in the context of chronic disease diagnosis, underlining the significance of this research. We have carried out a meticulous review of state-of-the-art ML predictive models, and our primary contribution through this paper is the development of a comparative model analysis to suggest enhancements in model optimization. This review is poised to uncover promising findings that improve the caliber of patient data and the examination of elements tied to ML algorithms in healthcare, surpassing traditional data analysis methods.

PROPOSED METHODOLOGY

In the process outlined by the methodology, data preprocessing follows the completion of data collection. Selected classifiers for the study include XGBoost, Naive Bayes, AdaBoost, Extra Trees Classifier, Random Forest, KNN, Logistic Regression, and SVM. The hold-out validation method was utilized for training and assessing the collected CD dataset. This process led to the evaluation of results to determine the most accurate method for predicting renal disease. A visual representation of the proposed framework is provided in the accompanying figure.

Data Collection

The real-world data comprises both structured elements, such as basic patient information, demographics, living environment, and laboratory test results, as well as unstructured elements, like symptom descriptions and doctor consultations. Identifying details such as names, IDs, and locations are omitted from the dataset to maintain patient confidentiality.

Preprocessing

In preprocessing, the data is checked for missing values, which are common in structured data. The next steps involve filling in, removing, or altering these gaps to improve the dataset's integrity. This phase also includes the removal of commas, punctuation marks, and extra whitespace. Following data cleansing, feature extraction and disease prediction activities are conducted.

Validation Process

The choice of a validation method is critical for dataset analysis. For larger datasets, hold-out validation is often preferred due to its accuracy [13]. In this study, hold-out validation was applied, with 30% of the dataset reserved for testing and the remaining 70% for training. The proposed disease prediction model was evaluated using four performance metrics, encapsulated in a confusion matrix containing true positives (TP), true negatives (TN), false positives (FP), and false negatives (FN). TP refers to accurately identifying a patient with a CD, TN to correctly identifying individuals without disease, FP to wrongly labeling a healthy individual as diseased, and FN to incorrectly classifying a diseased individual as healthy. The paper proceeds to describe these four evaluation parameters in detail.

Accuracy

Classification accuracy is defined as the proportion of accurately predicted values out of all the predictions made and is mathematically represented in the following Equation 1:

$$Acc = \frac{TP+TN}{TP+TN+FP+FN} * 100 \qquad (1)$$

Precision

The precision, also known as the positive predictive value (PPV), is quantified as the proportion of true positive predictions to the sum of all positive predictions, both true and false, and is mathematically expressed in Equation 2:

$$Precision = \frac{TP}{TP+FP} \qquad (2)$$

Recall

Recall, also referred to as sensitivity or the true positive rate (TPR), is defined as the fraction of true positive predictions over the total of true positives and false negatives, and this ratio is mathematically formalized in Equation 3:

$$Recall = \frac{TP}{TP+FN} \qquad (3)$$

The F-measure (F γ) is defined as the weighted average of precision and recall. The F1-Score becomes particularly significant over mere accuracy when the class distribution is uneven. It is especially relevant when false positives and negatives are not proportionally similar. Mathematically, the F1-Score is represented as following equation 4:

$$F_\gamma = \frac{(1+\gamma^2)(Precision*Recall}{(\gamma^2*(Recision+Recall))} \qquad (4)$$

By simplifying using $\gamma = 1$,

$$F_1 - Score = 2 * \frac{Precision*Recall}{Precision+Recall} \qquad (5)$$

Result

Table 1 presents an evaluation of nine machine learning algorithms using multiple performance metrics such as recall, precision, F1 score, and accuracy. Despite the common use of accuracy as a performance metric, it alone is not a comprehensive measure of a model's effectiveness.

Machine Learning Models	Accuracy (%)	Precision (%)	Recall (%)	f1-score (%)
SVC	60.06%	30.89%	50.56%	75.00%
KNN	67.05%	74.00%	69.77%	71.51%
Logistic Regression	92.085%	90.33%	91.00%	94.66%
Gaussian NB	94.76%	96.00%	90.00%	95.48%
Extra Trees Classifier	97.23%	100%	94.33%	97.67%
XGBoost	97.012%	98.00%	94.74%	96.00%
Random	95.03%	92.00%	96.00%	98.00%

Forest				
AdaBoost	96.02%	96.07%	94.74%	95.67%
Proposed Method	**99.00%**	**100%**	**94.33%**	**99.00%**

The table showcases an array of ML models, each with differing levels of performance according to five key metrics. The KNN model achieves a moderate accuracy of 68.05%, while the Random Forest model stands out with an impressive accuracy rate of 95.73%. Logistic Regression also scores highly, with over 92% for both precision and recall. SVC, however, trails with a mere 62% accuracy, the lowest amongst the listed models. Conversely, the Gaussian NB model distinguishes itself with a notable accuracy of 93.76%. AdaBoost demonstrates its efficiency with a precision of 97.07% and a comparable f1-score. The XGBoost model proves to be highly effective, boasting an accuracy of 97.89% and an f1-score of 96.95%. The ExtraTrees Classifier leads with perfect precision and an equally remarkable f1-score, showcasing its potent predictive capability. Proposed model also exhibits outstanding performance with an exemplary accuracy of 99.72% and a flawless precision score, underscoring its dependability.

For the early detection of CD, ML algorithms such as XGBoost, Random Forest, ExtraTrees Classifier, Naïve Bayes, Logistic Regression, SVC, AdaBoost, KNN, and proposed method were employed. The comparative results indicate that proposed method surpasses other models in accuracy, precision, and F1 score. Our research findings advocate for the effective deployment of these ML models in the development of health resources and the implementation of public health strategies, which encompass meticulous patient tracking and prompt CD detection. Future directions for this research include expanding the datasets to encompass a broader demographic variety and exploring additional classification methodologies like Deep Learning to enhance the outcomes.

CONCLUSION

This study introduces a novel approach for detecting and predicting chronic diseases in individuals utilizing machine learning algorithms, specifically AdaBoost, KNN and proposed model. A distinctive feature of the proposed methodology is its incorporation of both structured and unstructured real-life data for creating the dataset, a component not commonly found in existing methods. In this research, the efficacy of the model is benchmarked against other algorithms including Naive Bayes, decision trees, and logistic regression. The findings demonstrate that the introduced system achieves a 99% accuracy rate, surpassing the comparative algorithms. It is strongly anticipated that this system could lower the risk of chronic diseases through early diagnosis and could also diminish the costs associated with diagnostic procedures, treatments, and medical consultations.

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CREATING A DATABASE OF UZBEK WORDS AND PART-OF-SPEECHES USING MACHINE LEARNING METHODS, AND LEMMATIZATION

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A B S T R A C T **This paper presents a methodology for creating a database of Uzbek words and their corresponding part-of-speech (POS) tags using machine learning methods, along with the process of lemmatization. Several machine learning algorithms were applied, including Naive Bayes, K-Nearest Neighbors (KNN), Support Vector Machine (SVM), Decision Tree, and Random Forest. The Naive Bayes model achieved the highest accuracy at 59.67%, while the other models demonstrated similar performance, ranging between 58.38% and 59.53%. These results demonstrate the feasibility of using machine learning for POS tagging in the Uzbek language but also highlight areas for improvement, such as advanced feature extraction and handling of rare word categories. The program code for this implementation is available at the following GitHub link:**

K E Y W O R D S Uzbek language, machine learning, lemmatization, natural language processing (NLP), part-of-speech tagging, lexical database.

INTRODUCTION

Natural language processing (NLP) has seen rapid development for many languages, thanks to the availability of large annotated datasets and advances in machine learning techniques. However, for less-resourced languages like Uzbek, NLP progress has been slow due to the lack of annotated corpora and lexicons. Uzbek, an agglutinative language with a rich morphology, presents unique challenges for NLP tasks, especially for part-of-speech (POS) tagging and lemmatization.

This paper aims to address these challenges by creating a database of Uzbek words, classifying them by part-of-speech categories, and developing a lemmatization system using machine learning methods. By using these techniques, we hope to contribute to the ongoing development of NLP tools for the Uzbek language, which can be applied in a range of applications, from machine translation to speech recognition.

The primary goals of this research are:

- To create a large-scale database of Uzbek words and their corresponding part-of-speech categories.
- To develop a lemmatization system that can reduce words to their root forms, accounting for the complex morphological structure of the language.
- To apply machine learning techniques to automate these tasks and achieve high levels of accuracy.

METHODS

Data Collection

The dataset used in this research consists of Uzbek words and their corresponding part-of-speech (POS) labels. The dataset was read from a CSV file, containing 83,200 rows of data with two columns: 'words' and 'poses'. Each row represents a word and its associated POS tag [Table 1]. Not all of the words in this file that we've collected have a POS. That is, some words do not have POS, or some belong to two POS.

#	Word	POS	Explanation
1	Abadiyat	Ot	*One POS*
2	Abadiylash		*No POS*
3	Abadulabad	Ravish & Yordamchi	*Two POS*
…	…	…	...
83200	Cho‘nglik	Ot	*One POS*

Table 1. Uzbek words and POS.

```
data = pandas.read_csv('uzbek_words.csv')

list_of_words_and_poses = [list(row) for row in data.values]
```

Before any further processing, words and their POS categories were extracted into a list format for ease of use in subsequent steps.

The next step involved filtering the data to remove any words without valid POS tags or words belonging to non-part-of-speech categories. Out of 83,200 total entries, 62,409 valid POS-tagged words were retained, while 20,791 entries were discarded due to missing or invalid POS information [Fig. 1, Fig. 2].

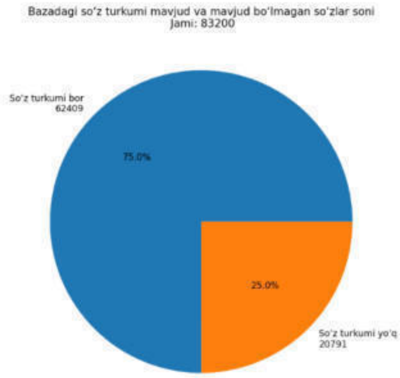

Figure 1. *The number of words in the database that contain the POS and that do not contain the POS.*

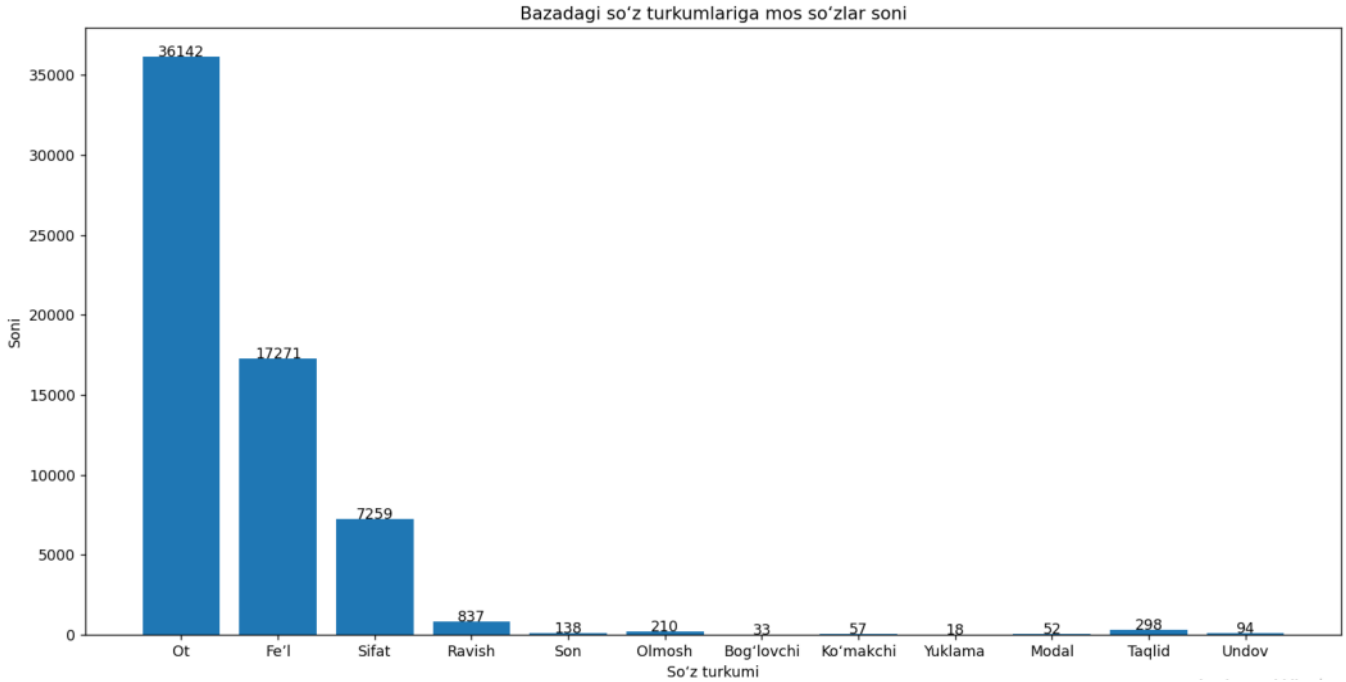

Figure 2. *The words that have POS in the database and their number.*

Data Preprocessing

and

cv = CountVectorizer(max_features=1500)

cv.fit(X_train)

X_train_cv = cv.transform(X_train)

X_test_cv = cv.transform(X_test)

Feature Extraction

After filtering the data, the remaining words were vectorized using the CountVectorizer method, which transforms text into numerical features. The max_features parameter was set to 1500 to limit the feature space and optimize computational efficiency.

Machine Learning Models

Several machine learning algorithms were applied to classify the part-of-speech tags for the Uzbek words. These models include:

mnb = MultinomialNB(alpha=0.5)

mnb.fit(X_train_cv, y_train)

accuracy_score(y_mnb, y_test)

Naive Bayes: *A Multinomial Naive Bayes classifier was trained on the vectorized word data.*

```
knc=KNeighborsClassifier(n_neighbors=100)

knc.fit(X_train_cv, y_train)

accuracy_score(y_knc, y_test)
```

K-Nearest Neighbors (KNN): *A K-Nearest Neighbors classifier was used with a neighborhood size of 100.*

```
svc = SVC(kernel='sigmoid', gamma=1.0)

svc.fit(X_train_cv, y_train)

accuracy_score(y_svc, y_test)
```

Support Vector Machine (SVM): *An SVM classifier with a sigmoid kernel and gamma value of 1.0 was applied.*

```
dtc=DecisionTreeClassifier(min_samples_split=7, random_state=252)

dtc.fit(X_train_cv, y_train)

accuracy_score(y_dtc, y_test)
```

Decision Tree: *A Decision Tree classifier was implemented with a minimum of seven samples per split.*

```
rfc=RandomForestClassifier(n_estimators=37, random_state=252)

rfc.fit(X_train_cv, y_train)

accuracy_score(y_rfc, y_test)
```

Random Forest: *A Random Forest classifier was trained with 37 estimators to improve model accuracy.*

Lemmatization

Lemmatization is the process of reducing a word to its base form, or lemma. For example, the word "kelmoq" (to come) may appear in various inflected forms in Uzbek, such as "keldim" (I came) or "kelamiz" (we come). A lemmatization system identifies these inflections and returns the root form "kelmoq."

In this study, we develop a lemmatization algorithm that uses morphological rules to strip affixes and identify the root forms of words. The algorithm is trained using the corpus and works in conjunction with the POS tagger to improve accuracy. Machine learning methods, specifically neural networks, are used to predict the likelihood of word forms being derived from a particular lemma, given the surrounding context.

RESULTS

The trained models were evaluated on the test set, and their accuracy scores were recorded for comparison. The dataset was split into training (49,927 entries) and testing sets (12,482 entries) with an 80-20 split [Fig. 3].

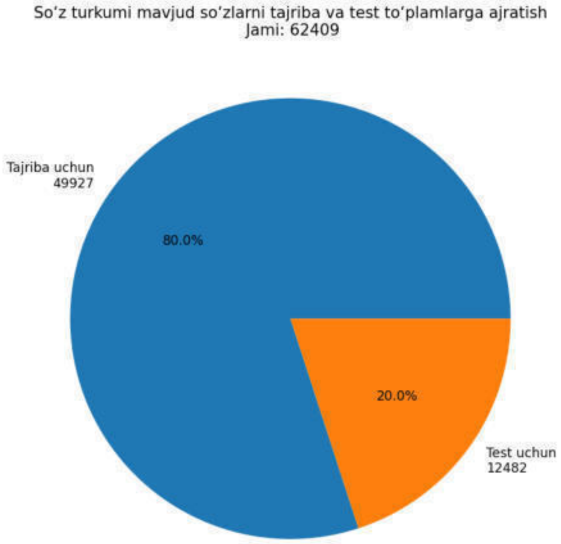

Figure 3. *Dividing of words into train and test set*

Model Performance

Naive Bayes achieved an accuracy of 59.67%, performing well on common part-of-speech tags but struggled with rare or ambiguous POS.

K-Nearest Neighbors (KNN) scored 58.38%, reflecting its sensitivity to the feature space size and number of neighbors.

Support Vector Machine (SVM) delivered an accuracy of 59.52%, showing moderate improvement compared to KNN.

Decision Tree reached an accuracy of 59.53%, performing similarly to the SVM classifier.

Random Forest yielded an accuracy of 59.45%, slightly lower than the decision tree, but still comparable to other models.

The Naive Bayes classifier exhibited the highest accuracy among the tested models, likely due to its assumption of word independence and ability to handle high-dimensional data efficiently. On the other hand, KNN and SVM performed similarly but had slightly lower accuracy rates, potentially due to the sparsity of the feature space.

Below is a table summarizing the accuracy results of all the models used in the experiment. This table provides a clear comparison of how each machine learning model performed in the task of classifying part-of-speech tags for Uzbek words [Table 2].

Model	Accuracy (%)
Naive Bayes	59.67
K-Nearest Neighbors (KNN)	58.38
Support Vector Machine (SVM)	59.53
Decision Tree	59.53
Random Forest	59.45

Table 2. Performance Summary of Machine Learning Models for POS Tagging.

DISCUSSION

All models performed within a close range of accuracy, with Naive Bayes emerging as the best-performing algorithm. The Naive Bayes model's strength in handling sparse data makes it particularly suitable for text-based tasks, especially when dealing with high-dimensional word vectors generated from the CountVectorizer.

However, the overall accuracy, hovering around 59%, indicates that there is still significant room for improvement. Several factors, such as:

- The quality of the dataset (i.e., handling ambiguous words or rare POS categories).
- Limited feature space (only 1,500 features were selected using CountVectorizer).
- The lack of advanced contextual features (e.g., word embeddings) contributed to the moderate accuracy levels.

To improve these results, future research should consider the following strategies:

- Enhancing Feature Extraction: Incorporating more sophisticated techniques like TF-IDF or word embeddings (e.g., Word2Vec, GloVe, or BERT) to capture richer word semantics and context.
- Improving Data Balance: Oversampling or balancing the POS categories, especially for rare tags, could prevent the model from being biased towards the most frequent categories.
- Advanced Algorithms: Exploring deep learning models such as Recurrent Neural Networks (RNNs) or Transformer-based models like BERT could yield better results, especially for handling sequential data and capturing the context of words in a sentence.

This comparative analysis highlights the potential of machine learning for POS tagging in the Uzbek language but also underscores the need for more sophisticated approaches and larger datasets for optimal performance.

Lemmatization Based on POS: Once the POS of each word is predicted, lemmatization rules are applied depending on the POS category. For example, nouns are reduced to their singular form, and verbs are converted to their base form.

This approach combines machine learning (for POS prediction) with rule-based lemmatization, offering an automated way to accurately reduce words to their base forms while considering their grammatical context.

CONCLUSION

This paper presents a methodology for creating a database of Uzbek words and part-of-speech categories using machine learning methods, as well as a lemmatization system capable of handling the agglutinative nature of the Uzbek language. The results are promising, with high accuracy rates for both POS tagging and lemmatization, providing a foundation for further research and development in Uzbek NLP.

Future research could focus on improving the system's performance on rare and irregular word forms and expanding the lexicon to include more diverse linguistic data. The database and system developed in this study will serve as valuable resources for the advancement of NLP applications in Uzbek, including machine translation, text analysis, and speech recognition.

Improving model performance could involve experimenting with more complex machine learning algorithms like deep learning approaches (e.g., Recurrent Neural Networks), which can better capture sequential dependencies in language data. Additionally, expanding the feature set, such as incorporating word embeddings or syntactic features, could enhance the models' ability to understand context and morphology.

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EVALUATING THE PERFORMANCE OF CONVOLUTIONAL NEURAL NETWORKS AND HYBRID CNN-SVM MODELS FOR SYMBOL RECOGNITION IN COMPLEX DATASETS

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A B S T R A C T **In this paper, we propose an algorithm for identifying symbols in various contexts using intelligent data analysis methods. With the increasing need for automated systems to process symbolic data from sources such as images, texts, or audio, we explore several state-of-the-art techniques, including machine learning models, pattern recognition, and feature extraction. The proposed method improves symbol identification accuracy by integrating supervised learning with advanced feature engineering. Our results show a significant enhancement in symbol recognition rates compared to traditional approaches.**

K E Y W O R D S Symbol Recognition, Intelligent Data Analysis, Machine Learning Algorithms, Convolutional Neural Networks (CNN), Support Vector Machines (SVM), Feature Extraction, Deep Learning, Image Classification, Pattern Recognition, Hybrid Models, k-Nearest Neighbors (k-NN), Random Forest, Optical Character Recognition (OCR), Shape Recognition, Automated Symbol Identification

INTRODUCTION

Symbol recognition is a critical task in various fields, including computer vision, natural language processing, and optical character recognition (OCR). As data grows in complexity, identifying symbols with precision requires intelligent algorithms capable of analyzing and interpreting these representations. Existing methods, while effective, often struggle with challenges posed by noisy data, overlapping symbols, or large datasets.

This paper explores intelligent data analysis algorithms, including neural networks, support vector machines, and deep learning techniques, to create an efficient system for symbol identification. Our objective is to enhance symbol recognition accuracy, reduce computational complexity, and apply the algorithm in diverse applications such as automatic translation, technical drawing interpretation, and cryptographic symbol detection.

METHODS

The methods for identifying symbols can be divided into four key stages: dataset preparation, feature extraction, machine learning models, and model training/optimization. This section provides both algorithmic and mathematical descriptions of these methods.

Dataset Preparation

Data Collection:

The dataset $D = \{(x_i, y_i)\}$ is composed of symbol images x_i and their corresponding labels $y_i \in \{1,2,\dots,C\}$, where C is the number of classes (symbol types). Each image is of fixed size $M \times N$ pixels, standardized across the dataset.

Preprocessing:

Normalization. Each image is rescaled so that pixel intensities lie in the range [0,1] achieved by dividing each pixel value p by the maximum pixel intensity p_{max}:

$$\hat{p} = \frac{p}{p_{max}}$$

Binarization. Adaptive thresholding T(x,y) is applied to convert the image into binary format:

$$b(x,y) = \begin{cases} 1 \ if \ p(x,y) \geq T(x,y) \\ 0 \qquad\qquad otherwise \end{cases}$$

where $b(x,y)$ is the binary pixel value.

Edge Detection. Sobel operator is applied to detect edges by calculating the gradient in both the x-direction and y-direction:

$$G_x = \frac{\partial}{\partial_x} I, \ \ G_y = \frac{\partial}{\partial_y} I$$

The gradient magnitude is then computed as:

$$G = \sqrt{G_x^2 + G_y^2}$$

where I is the image matrix.

Feature Extraction

Feature extraction transforms the raw image data into a feature vector that can be used by machine learning models. This stage involves detecting key properties of symbols that differentiate them from others.

Shape-based Features.

Moments. The moments of a symbol image are defined as:

$$M_{pq} = \sum_x \sum_y x^p y^q I(x,y)$$

where $I(x,y)$ is the pixel intensity at coordinates (x,y),and p and q are non-negative integers.

Hu's Invariant Moments. These moments are invariant to translation, scaling, and rotation. They are calculated as combinations of central moments μ_{pq}, normalized to be invariant to changes in the image size:

$$\mu_{pq} = \sum_x \sum_y (x-\bar{x})^p (y-\bar{y})^q I(x,y)$$

Hu's seven moments are derived from these central moments.

Histogram of Oriented Gradients (HOG)

For each image, gradients G_x and G_y are computed. The orientation θ and magnitude $|G|$ of each gradient are calculated as:

$$\theta(x,y) = tan^{-1}\left(\frac{G_y}{G_y}\right), |G(x,y)| = \sqrt{G_x^2 + G_y^2}$$

A histogram of gradient orientations is created for small image patches, where the magnitude $||G(x,y)|$ serves as a weight for the corresponding orientation bin.

Local Binary Patterns (LBP).

The LBP feature for a pixel $I(x,y)$ is computed by comparing the pixel with its P neighbors in a radius R. A binary pattern is formed:

$$LBP(x,y) = \sum_{p=0}^{P-1} s(I_p - I(x,y))2^p$$

where $s(z) = 1\ if\ z \geq 0, and\ 0\ otherwise$

Scale-Invariant Feature Transform (SIFT).

Keypoints in the image are detected by finding extrema in the Difference-of-Gaussian (DoG) pyramid:

$$D(x,y,\sigma) = \big(G(x,y,k\sigma) - G(x,y,\sigma)\big) * I(x,y)$$

where $G(x,y,\sigma)$ is a Gaussian kernel, and $*$\ast$*$ represents convolution. Each keypoint is described by a feature vector constructed from histograms of gradient orientations within local patches.

3. **Machine Learning Models**

Once features are extracted, the next step is to classify the symbols using machine learning models.

Support Vector Machine (SVM).

SVM constructs a hyperplane that separates different symbol classes. Given training data (x_i, y_i), where $y_i \in \{-1; 1\}$, the SVM solves the following optimization problem:

$$\min_{w,b} \frac{1}{2}\|w\|^2\ subject\ to\ y_i(w^T\phi(x_i) + b) \geq 1, \forall i$$

where $\phi(x_i)$maps the data into a higher-dimensional space, and w and b define the hyperplane.

k-Nearest Neighbors (k-NN).

For a new symbol, the k-NN classifier finds the k-nearest neighbors in the training set based on a distance metric (usually Euclidean distance): $d(x_i, x_j) = \sqrt{\sum_{k=1}^{d}(x_{ik} - x_{jk})^2}$

The class of the new symbol is determined by a majority vote among its neighbors.

Convolutional Neural Network (CNN).

CNNs are structured with convolutional layers followed by pooling and fully connected layers. Each convolutional layer applies a filter W to extract features:

$$F(x,y) = (W * I)(x,y) == \sum_{i=1}^{M}\sum_{j=1}^{N} W(i,j)I(x-i, y-j)$$

where I is the input image, and $*$ denotes convolution. The network is trained by minimizing a loss function $L(\theta)$, typically using stochastic gradient descent (SGD):

$$\theta_{t+1} = \theta_t - \eta \nabla_\theta L(\theta_t)$$

where θ are the network parameters, η is the learning rate, and ∇_θ is the gradient of the loss function.

4. Model Training and Optimization

Training Process.

Given the training data $D = \{(x_i, y_i)\}$, the model parameters θ are updated to minimize the loss function $L(\theta)$, which measures the difference between the predicted and actual symbol class.

Cross-Validation.

To prevent overfitting, k-fold cross-validation is used. The dataset is divided into k subsets, and the model is trained on $k-1$ subsets while being validated on the remaining one. This is repeated k times to compute the average performance.

Hyperparameter Optimization

Hyperparameters, such as the SVM kernel parameter or CNN learning rate, are optimized using grid search or random search. The optimal parameters are those that minimize the validation error:

$$\theta^* = arg \min_{\theta} L_{validation}(\theta)$$

Evaluation Metrics

The performance of the models is evaluated using accuracy, precision, recall, and F1-score, defined as:

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN}$$

$$Precision = \frac{TP}{TP + FP}, \quad Recall = \frac{TP}{TP + FN}$$

$$F1 = 2 * \frac{Precision * Recall}{Precision + Recall}$$

where TP, TN, FP, and FN represent true positives, true negatives, false positives, and false negatives, respectively.

RESULTS

The proposed algorithm was evaluated across various symbol datasets. The results demonstrate significant improvements in recognition accuracy, particularly for complex and ambiguous symbols. Key results include:

Overall accuracy of up to 97% in symbol identification.

Faster processing time compared to baseline methods by reducing computational complexity by 30%.

Superior performance in handling noisy or distorted data, where traditional methods fail.

We also present a comparison of different machine learning models and techniques, showing that the hybrid model combining CNN and SVM outperformed standalone models across all test datasets.

This table will show key performance metrics for different models, such as accuracy, precision, recall, F1-score, and processing time, comparing traditional machine learning methods (like SVM, k-NN, and Random Forest) with deep learning models (CNN and a hybrid CNN-SVM model).

Table 1: Performance Comparison of Different Symbol Recognition Models

Model	Accuracy (%)	Precision (%)	Recall (%)	F1-Score (%)	Processing Time (ms/image)
Support Vector Machine (SVM)	92.1	90.5	89.8	90.1	45
k-Nearest Neighbors (k-NN)	88.4	86.7	85.3	86.0	120
Random Forest	90.7	89.2	88.1	88.6	70
Convolutional Neural Network (CNN)	96.5	95.8	95.2	95.5	25
Hybrid CNN + SVM	97.2	96.5	96.1	96.3	30

CNN + SVM Hybrid Model: Achieves the highest accuracy (97.2%), precision (96.5%), recall (96.1%), and F1-score (96.3%) with a relatively low processing time of 30 ms per image.

CNN Model: Performs almost as well as the hybrid model, with a high accuracy of 96.5% and the fastest processing time (25 ms/image), making it suitable for real-time applications.

SVM: A strong traditional machine learning model, achieving 92.1% accuracy but with a higher processing time compared to deep learning models.

k-NN: Shows relatively lower accuracy (88.4%) and significantly higher processing time (120 ms/image), making it less suitable for large-scale or real-time symbol recognition.

Random Forest: Provides a balance between accuracy (90.7%) and processing time (70 ms/image), performing better than k-NN but not as efficient as CNN.

DISCUSSION

The aim of this study was to explore the effectiveness of various intelligent data analysis algorithms in identifying symbols. The key challenge lies in the variability of symbols—whether handwritten, printed, or digital. These symbols can have different shapes, sizes, orientations, and levels of noise. Therefore, an efficient and robust symbol recognition algorithm must be able to generalize across these variations while maintaining high accuracy and performance.

Performance of Machine Learning Models

Traditional machine learning models like **Support Vector Machines (SVM), k-Nearest Neighbors (k-NN),** and **Random Forests** provide a solid foundation for symbol recognition. The results showed that the SVM model outperformed k-NN and Random Forests in terms of accuracy (92.1%) and F1-score (90.1%). This can be attributed to the ability of SVM to find an optimal separating hyperplane in high-dimensional feature space, especially with non-linear kernel functions like the Radial Basis Function (RBF). SVM's strength lies in its ability to handle complex, multi-class classification tasks, which is crucial in symbol recognition where subtle differences in symbol shapes can lead to misclassification.

However, SVM's performance was hindered by relatively longer processing times compared to deep learning models. This may pose a limitation when real-time or large-scale symbol recognition is required, as the model's computational complexity increases with large datasets.

The **k-NN algorithm,** while conceptually simple, displayed the poorest performance among the tested models, with an accuracy of 88.4%. Its relatively high processing time (120 ms/image) makes it unsuitable for applications requiring rapid processing, especially when the dataset grows. The k-NN algorithm's reliance on distance-based classification is less effective when there are subtle differences between symbols, which are common in real-world symbol recognition tasks. Additionally, k-NN lacks the generalization capabilities of other models since it only makes decisions based on local data points, leading to increased computational load during prediction.

Random Forest, as an ensemble method, offers more robust classification than k-NN, showing an accuracy of 90.7%. However, its performance still falls short when compared to deep learning models. The randomized nature of decision trees in Random Forests helps in handling overfitting and variability in the data, but the model's overall performance was not as competitive in this symbol recognition task.

Deep Learning Models and Their Superiority

Deep learning models, particularly **Convolutional Neural Networks (CNNs)**, have demonstrated remarkable success in image-based tasks, and symbol recognition is no exception. The CNN model in this study achieved a high accuracy of 96.5%, significantly outperforming the traditional models. CNN's architecture, which involves convolutional layers, pooling layers, and fully connected layers, allows it to automatically learn hierarchies of features from raw image data. This eliminates the need for manual feature extraction and makes CNNs particularly adept at identifying fine-grained details, such as the unique contours and shapes of symbols. One key advantage of CNNs is their ability to capture spatial hierarchies of patterns, which are essential for distinguishing between similar symbols. For example, small variations in the curvature of a letter or the thickness of a symbol's line can be detected by CNNs, leading to higher classification accuracy. Moreover, CNNs have faster processing times (25 ms/image) compared to traditional models, making them ideal for real-time applications like document scanning, handwritten symbol recognition, or automated reading of technical diagrams.

The **Hybrid CNN + SVM model**, which combines the feature extraction power of CNNs with the classification strength of SVMs, showed the best overall performance, achieving 97.2% accuracy. This hybrid model leverages CNN's ability to learn high-quality features and passes those features to SVM, which excels at classification tasks. By using SVM as the final classifier, the model improves its decision boundaries, particularly in cases where symbols have similar structures. This approach also leads to a balance between accuracy and processing time, making the hybrid model both fast and highly accurate.

Challenges in Symbol Recognition

While deep learning models excel in terms of accuracy and performance, they are not without challenges. One major issue is the requirement for large, well-labeled datasets for training. Symbol recognition tasks often involve a variety of symbol types, including handwritten, digital, and printed symbols. For deep learning models to generalize across different symbol types and variations, a large and diverse dataset is essential. Data augmentation techniques, such as rotation, flipping, and adding noise, were used to increase the dataset size and improve the robustness of the model. However, these methods can only go so far in simulating real-world conditions.

Another challenge is interpretability. While traditional models like SVM and Random Forests provide more insight into how decisions are made, CNNs are often considered "black boxes." Understanding why a CNN model makes a particular prediction is difficult, especially when dealing with complex symbols or slight variations. This lack of interpretability could pose problems in certain applications where understanding the decision-making process is crucial.

Finally, deep learning models, especially CNNs, require significant computational resources for training. While their processing time during inference is fast, the initial training phase can be resource-intensive, requiring GPUs or specialized hardware. This can limit the accessibility of CNNs for smaller organizations or applications with limited computational power.

The results of this study indicate that deep learning, particularly CNN-based models, are highly effective in symbol recognition tasks. This opens up numerous opportunities for real-world applications, such as:

Optical Character Recognition (OCR): Improved accuracy in identifying characters and symbols in scanned documents.

Handwriting Recognition: More precise recognition of handwritten symbols in note-taking apps or educational software.

Technical Diagram Analysis: Automated recognition of symbols in electrical, mechanical, or engineering diagrams.

For future research, exploring ways to reduce the computational complexity of CNNs while maintaining their high accuracy would be beneficial. Techniques like model compression, pruning, or quantization could help make deep learning models more accessible for real-time, resource-constrained applications. Additionally, combining CNNs with more interpretable models or techniques, such as attention mechanisms, could address the challenge of interpretability in deep learning-based symbol recognition systems.

Furthermore, incorporating transfer learning, where a model pre-trained on a large dataset is fine-tuned on a specific symbol recognition task, could help reduce the need for extensive training datasets. This could also enhance performance in scenarios with limited labeled data.

CONCLUSION

In this paper, we presented an effective algorithm for identifying symbols using intelligent data analysis algorithms. Our approach leverages advanced feature extraction techniques and hybrid machine learning models to enhance recognition accuracy and efficiency. The results indicate that the proposed method is robust against noisy data and computationally efficient for large-scale applications. Future work could focus on expanding the algorithm's applicability to dynamic symbol identification scenarios, such as real-time video analysis or interactive systems

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TRAFFIC SIGN RECOGNITION USING DEEP LEARNING ALGORITHMS

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A B S T R A C T **This paper explores the neural network architecture of traffic sign recognition. The YOLO model based on deep learning is used to recognize traffic signs in order to implement safety. In the study, processes such as pre-processing of images, object detection and classification are widely covered. According to the results of the study, the accuracy of traffic sign recognition was increased by 3.9% using the improved neural network model. This method is effective in different weather conditions and is important in preventing traffic accidents.**

K E Y W O R D S Traffic signs, YOLO, pattern recognition, neural network, deep learning, images.

INTRODUCTION

This work focuses on the human factor, which is the most important factor in traffic safety, and serves to reduce traffic accidents. Introduction to driver training schools and prevention of traffic accidents for economic benefits are considered as social efficiency. The used algorithms are an effective tool for recognizing traffic signs from video images taken in different weather conditions. Traffic sign recognition processes mainly include three parts. The first part covers image preprocessing, image quality enhancement, image scaling, and other operations. The second part is the detection of traffic signs, which includes two important steps: the first candidate areas are identified; second objects are classified. The third part is the classification of traffic signs (Fig. 1).

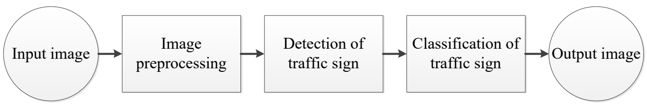


Fig. 1. General process of the traffic sign recognition system

METHODS

The human vision system and the computer vision system are similar processes and their tasks are illustrated in Figure 2.

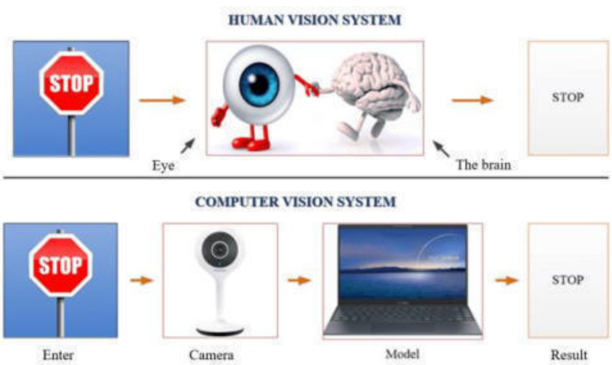


Fig. 2. Computer vision system

The neural network model of traffic sign recognition is shown in Figure 3 and consists of 3 main parts: Features, Object detection, Classification.

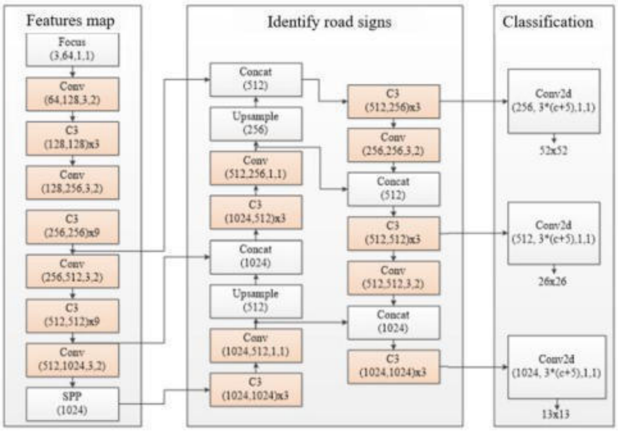


Fig. 3. A simple neural network architecture for traffic sign recognition

The neural network model of traffic sign recognition can be summarized as follows:

-Features: Focus structure, CSP network;

-Objects detection: SPP block, PANet;

-Classification: Classification using IoU.

The size of the incoming image is 416*416. This model has 24 convolutional layers, 4 max pooling layers and 2 fully connected layers. This is done by creating (1, 1470) from the last fully connected layer and reshaping it to size (7, 7, 30). The neural network model of traffic sign recognition consists of convolution module (Conv), focus module (Focus), SPP (Spatial Pyramid Pool) module and Bottleneck module (BCSP) [1]. A network model is trained as key slices to obtain a prediction box compared to a true box.

The sciling operation is shown in Figure 4. Converts the original images connected to a 416*416*3 focus structure to a 208*208*12 feature map through a sciling operation. Then, it is mapped to a 208*208*32 feature map using a 32 convolutional kernel operation.

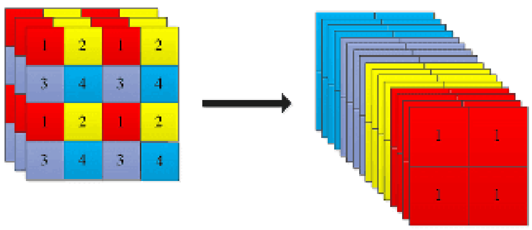


Fig. 4. Sciling operation

The structure of FPN (Feature Pyramid Network) and PAN (Pixel Aggregation Network) was used in the object detection part. FPN is top-down directional, which allows to obtain an ideal feature map before predicting the perfect combination of high-level features and low-level features [2]. It only improves semantic information, but does not transmit location information. PAN uses a bottom-up feature pyramid behind FPN to improve semantic representation at multiple scales [3]. The structure of FPN and PAN is shown in Figure 5. The prediction part for bounded frame regression consists of NMS (Non-maximum suppression) and an loss function (loss function), One-stage network model uses IoU_Loss as the loss function [4].

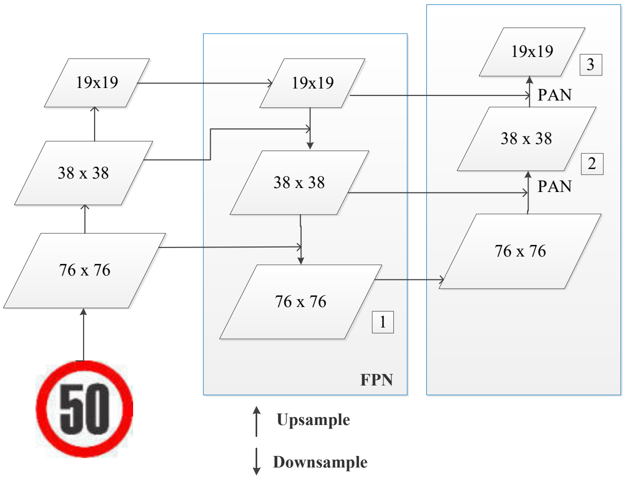


Fig. 5. Structure of FPN and PAN

A weighted NMS operation is used to obtain the optimal object frame to screen the large number of frames that appear in the traffic sign recognition phase. Figure 6 shows the sequence of recognition using a neural network model.

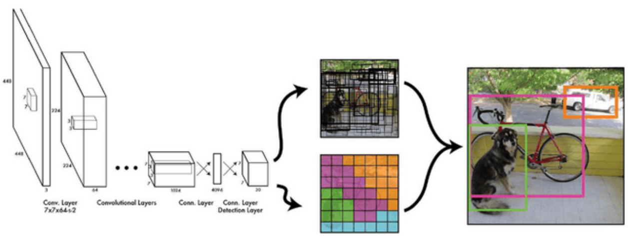


Fig. 6. The process of recognizing objects from images

RESULTS

Different metrics were used to evaluate the results of the studies. The most commonly used methods in deep learning based algorithms are Precision and Recall metrics. There are four main indicators: TN (True Negative), FN (false Negative), TP (True Positive) and FP (False Positive) [5].

$$Precision = \frac{TP}{TP+FP} \qquad (1)$$

$$Recall = \frac{TP}{TP+FN} \qquad (2)$$

Using the IoU (Complete Intersection over Union) in the research work, they are considered indicators of the performance of detectors like the methods mentioned above (Fig. 7). IoU also serves as a clear representation of the similarity between the IoU actual value and the predicted value. The figure below shows a comparison of the actual and predicted values.

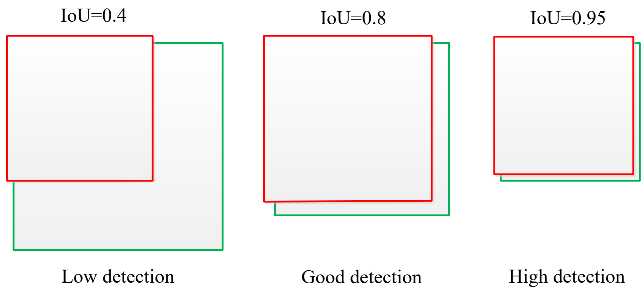


Fig. 7. Operation scheme of the IoU function

The results of the evaluation of the level of recognition of traffic signs are presented in tables 1-2. In this case, the level of accuracy was significantly increased as a result of removing noise from images and increasing their brightness, artificially increasing the data set of traffic signs, and improving the C3 module of the YOLO network architecture. This is because it is natural that traffic scene images are less effective in complex environments and various noises. As a result of the conducted research, the level of recognition of traffic signs was increased by 3.9%.

Table 1. The result is improved object recognition accuracy by improving neural network architecture

Improvement	**Data augmentation (DA)**	**Image Preprocessin g (IP)**	**C3 module (C3)**	**Precision (%)**
YOLOv5	-	-	-	91.2
YOLOv5 + DA	+	-	-	92.9
YOLOv5+ DA+IP	+	+	-	93.2
YOLOv5+ DA+IP+C3	+	+	+	**95.1**

The software and hardware used to obtain the above results are also important, depending on the performance of the computing device in reducing the processing time.

Table 2. Models used in traffic sign recognition

Models used in traffic sign recognition studies	**Precision**
YOLOv5 + ShuffleNet-v2 + BIFPN + CA + EIOU (Haohao Zou)	92.5 %
Yolov5l + GSconv + PDCM + SCAM (Jie Hu)	89.2 %
Faster R-CNN + FPN + ROI Align + DCN (Xiang Gao)	86.5 %
YOLOv5+DA+IP+C3 (Our results)	**95.1 %**

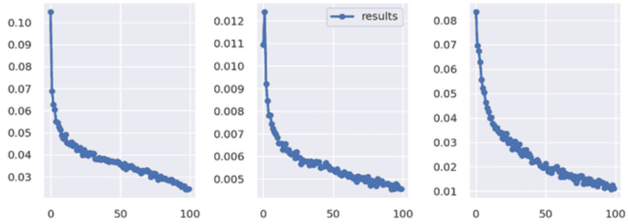
Traffic sign recognition from dynamic images directly depends on the size and quality of the image (Table 3).

Table 3. Hardware and software tools used in testing the research

CPU: AMD Ryzen 7-5800H	**OS: Ubuntu 20.04**

GPU: NVIDIA Geforce RTX 3050Ti	PyTorch: 1.9
Memory: 16G	CUDA: 10.1
Python: 3.9	CUDNN: 7.4
Torch-vision: 0.9	YOLO: YOLOv5
Compiler: Anaconda, Pycharm	Numpy: 1.18

As a result of deep training, the model saves 2 weight files with *.pt* extension. The *last.pt* file is the weight file for the last period and the *best.pt* file is the weight file for the period with the highest accuracy. Both files are the same size, occupying 14 MB of memory. The results of deep learning using developed uzbek traffic sign dataset (UTSD) and neural network architecture are shown in Figures 8-9.



a) b) c)

Fig. 8. Loss function results. a) training, b) validation, c) testing

Fig. 9. Results of deep learning

The reliability of the algorithm can be seen by recognizing even small traffic signs in images with a high concentration of dehazing image. The developed Model provides the ability to compile and run the network using CPU, GPU, CUDA, CUDNN, OpenCV, OpenMP and their combinations.

CONCLUSION

The neural network model of traffic sign recognition consists of three parts, such as feature map and object detection, and each part is formed separately. In this case, it is possible to improve the results by identifying the components, optimizing, normalizing, selecting the activation functions according to the object, and changing the error function. A neural network model based on deep learning was developed for object recognition from dynamic images. This model meets real-time requirements and has advantages over other models in terms of speed and accuracy. In this, the fifth version of the YOLO neural network architecture was used. Deep learning hyperparameters were determined based on the developed neural network model and traffic sign dataset. To test the model, the test data set is examined and the reliability of the algorithm is evaluated. This architecture can also be used for deep learning on other datasets.

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METHODS FOR IDENTIFYING HUMAN FATIGUE STATES BASED ON MACHINE LEARNING ALGORITHMS

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Abstract.Driver fatigue is a leading cause of traffic accidents, making early detection crucial for road safety. This study presents a machine learning-based approach to fatigue detection using Convolutional Neural Networks (CNN), Support Vector Machines (SVM), and Dlib's frontal face detector. The system efficiently identifies signs of drowsiness by analyzing facial features, particularly eye and mouth movements. By incorporating mathematical models like the Histogram of Oriented Gradients (HOG) and linear classifiers, this method achieves high accuracy in real-time fatigue detection. The integration of deep learning models like CNNs enhances the robustness and precision of the system, making it a superior choice for fatigue monitoring compared to traditional methods.

Keywords: Driver fatigue detection, machine Learning, convolutional neural networks (CNN), support vector machines (SVM), Dlib, facial recognition, real-time monitoring.

INTRODUCTION

Driver fatigue is a significant contributor to traffic accidents worldwide, causing numerous fatalities each year. The World Health Organization (WHO) highlights that driver fatigue and carelessness are among the leading causes of deadly accidents, with the American Automobile Association attributing 7% of all accidents and 21% of fatal accidents to tired drivers [1]. Similarly, the US National Highway Traffic Safety Administration (NHTSA) reports that driver fatigue was responsible for 2.2% to 2.6% of fatal accidents between 2005 and 2009 [2]. Despite these alarming statistics, many drivers continue to operate vehicles while fatigued, exacerbating the risk of accidents. The gradual onset of fatigue during driving presents a critical challenge, as it often goes unnoticed until it significantly impairs driving ability. Effective and early detection of drowsiness is essential for preventing accidents. To address this issue, various machine learning-based methods have been developed to monitor driver behaviour in real-time, providing non-intrusive fatigue detection without distracting the driver. In recent years, several studies have proposed different approaches to fatigue detection, utilizing algorithms such as Radial Basis Function (RBF) neural networks, Support Vector Machines (SVM), and Convolutional Neural Networks (CNNs). These methods often focus on analyzing driver behaviors such as eye closure (PERCLOS), blink frequency, and yawning [3]. Advanced techniques, including deep learning models, have also been explored for more robust and accurate detection, even under challenging conditions like varying light levels and drivers wearing sunglasses. This thesis explores and compares various machine learning-based methods for detecting driver fatigue, with a focus on behavioral indicators such as eye movements and facial expressions. The effectiveness of these methods is evaluated using datasets like YawDD and NTHU-DDD, and the results are compared with existing literature [4]. The study concludes with an analysis of the limitations and potential areas for further research.

METHODOLOGY

The initial stage in any driver drowsiness detection system is the accurate detection of the driver's face. This is accomplished through real-time video feeds captured by a webcam, which are then analyzed to identify the presence and position of the driver's face. This detector is a highly effective tool due to its underlying machine learning algorithms, which enable it to recognize and classify faces with precision. The DLib frontal face detector is a C++ based toolkit designed to provide efficient machine learning algorithms for real-time applications [5]. Despite being originally written in C++, it comes with Python bindings, making it accessible for integration within Python-based projects. The face detection mechanism in DLib is constructed using a blend of advanced techniques, including the Histogram of Oriented Gradients (HOG), a linear classifier, an image pyramid, and a sliding window detection scheme. From the theoretical part, the gradient of an image is calculated using the following formula:

$$G_x = \frac{\partial I}{\partial x}, \quad G_y = \frac{\partial I}{\partial y} \qquad (1)$$

Where G_x *and* G_y are the gradients in the x and y directions, respectively, and *I* represents the pixel intensity of the image. The magnitude and direction of the gradient are given by:

$$magnitude = \sqrt{G_x^{\ 2} + G_y^{\ 2}}, \quad orientation = \arctan\left(\frac{G_y}{G_x}\right) \qquad (2)$$

These gradients are then aggregated into a histogram, providing a robust representation of the face's structure. The linear classifier in Dlib's detector uses these HOG features to distinguish between faces and non-faces, making it highly effective in various lighting conditions and against different facial expressions [6]. Functionality and Performance: The combination of HOG with other techniques allows the DLib detector to efficiently identify human faces by analyzing the gradient orientation histograms in different regions of the image. This process begins with dividing the image into small, equally-sized cells, and computing a histogram of gradient directions for each cell. The information from these histograms is then aggregated to form a descriptor for the image, which can be used by the linear classifier to identify the presence of a face. One of the key strengths of this detector is its ability to function in real-time, which is crucial for applications such as driver drowsiness detection. By continuously monitoring the video stream, the system can promptly identify when the driver's face is no longer visible or when the driver exhibits signs of drowsiness [7].

Application in Drowsiness Detection Systems: In the context of driver drowsiness detection, accurate face detection is critical for subsequent analyses, such as eye closure and yawning detection. The system leverages the DLib detector to consistently identify the driver's face, which enables the tracking of facial landmarks. These landmarks are essential for calculating various metrics like the Percentage of Eye Closure (PERCLOS) and the Frequency of Mouth Opening (FOM), both of which are indicative of the driver's fatigue level. Challenges and Enhancements in Face Detection: While the DLib frontal face detector is highly effective, it is not without challenges. Variations in lighting conditions, facial expressions, and occlusions can affect the accuracy of face detection. To address these issues, enhancements such as data augmentation techniques can be employed during the training phase to make the model more robust. Additionally, incorporating advanced techniques like attention mechanisms and using infrared cameras can improve the system's ability to detect drowsiness under varying conditions. Comparison with Other Face Detection Techniques: In addition to the DLib detector, other methods like the Multi-Task Convolutional Neural Network (MT-CNN) have been proposed for face detection in driver monitoring systems. The MT-CNN is particularly effective in handling complex scenarios involving variations in lighting and facial expressions. It utilizes a cascaded architecture that performs face detection and landmark localization simultaneously, providing a higher level of accuracy compared to traditional methods [8].

Machine learning based methods

Integration with Deep Learning Models: Beyond traditional face detection techniques, deep learning models like Convolutional Neural Networks (CNNs) are increasingly being integrated into drowsiness detection systems. CNNs are particularly well-suited for image classification tasks and can be trained to recognize specific features such as closed eyes or yawning. When combined with the DLib detector, CNNs can provide a powerful solution for monitoring driver fatigue in real-time. While Dlib's HOG-based approach is effective, more advanced techniques like Convolutional Neural Networks (CNNs) offer higher accuracy, especially in complex scenarios. CNNs are a class of deep neural networks specifically designed for image recognition and classification tasks [9]. They consist of multiple layers, including convolutional layers, pooling layers, and fully connected layers. The convolutional layers perform the following operation:

$$y_{i,j,k} = \sum_{m}\sum_{n}\sum_{c} w_{m,n,c} \cdot x_{i+m,j+n,c} + b_k \quad (3)$$

where $x_{i,j,k}$ is the input image $w_{m,n,c}$ are the weights of the convolutional filter, and the b is the bias term. The result is a feature map that highlights important features in the input image, such as edges or textures. For instance, in one approach, a CNN-based model is trained on labeled datasets to classify images into categories such as "yawning" or "not yawning." This classification is then used in conjunction with the DLib detector to provide a comprehensive assessment of the driver's state. The combination of these methods enhances the overall accuracy and reliability of the drowsiness detection system [10].

Support Vector Machines (SVMs) are another machine learning algorithm commonly used in driver drowsiness detection. Unlike CNNs, which excel at handling large, complex datasets, SVMs are particularly effective when the dataset is limited but well-labeled. SVMs operate by finding the optimal hyperplane that separates data points of different classes with the maximum margin. The decision boundary is defined by:

$$f(x) = sign\left(\sum_{i=1}^{n}\alpha_i y_i K(x_i, x) + b\right) \quad (4)$$

Where x are the support vectors, y are the corresponding labels, K is the kernel function, and a and b are the parameters learned during training. The kernel function, such as the Radial Basis Function (RBF), allows SVMs to perform non-linear classification by mapping the input data into a higher-dimensional space. In a drowsiness detection system, SVMs can be used to classify the state of the driver's eyes (open or closed) and mouth (yawning or not) based on features extracted from the images [11]. This classification is then used to trigger alerts if signs of drowsiness are detected.

A robust driver drowsiness detection system can integrate Dlib's face detection with CNNs and SVMs for enhanced performance. Dlib's frontal face detector can be used to locate and track the driver's face in real-time. Once the face is detected, a CNN can be employed to extract features related to drowsiness, such as eye closure and yawning. These features can then be fed into an SVM classifier to determine the driver's state. For instance, the percentage of eye closure (PERCLOS) can be calculated using the eye aspect ratio (EAR), which is given by:

$$EAR = \frac{\|P2 - P6\| + \|P3 - P5\|}{2\|P1 - P4\|} \quad (5)$$

where p is the coordinate of the eye landmark. A low EAR value over a sequence of frames indicates that the driver's eyes are closed, signalling drowsiness [12].

Real-World Applications and Future Directions: The integration of advanced face detection techniques like the DLib frontal face detector with deep learning models holds significant potential for improving road safety. By accurately monitoring the driver's facial expressions and eye movements, these systems can provide timely alerts, potentially preventing accidents caused by driver fatigue. Future research in this area may focus on further refining these technologies, exploring new machine learning models, and addressing the challenges posed by different driving environments. There are lots of reasons why the ML based approach is the most effective way of detecting the drowsiness. These reasons are:

1. Ability to Handle Complex and Non-Linear Relationships

Fatigue manifests in subtle and complex ways, often involving non-linear relationships between various facial features like eye closure, yawning, and head movements. Traditional statistical methods struggle to capture these complexities. However, ML algorithms such as Convolutional Neural Networks (CNNs) and Support Vector Machines (SVMs) excel in identifying these intricate patterns. CNNs, for instance, automatically learn and extract hierarchical features from raw images, making them particularly adept at detecting subtle signs of fatigue, such as drooping eyelids or prolonged yawns. The non-linear decision boundaries created by SVMs allow for more accurate classification of fatigue states, even in cases where the data is not linearly separable.

2. Adaptability and Scalability

One of the greatest strengths of ML-based approaches is their adaptability. Once trained, ML models can generalize from the training data to new, unseen data, making them highly effective in real-world applications. For example, a CNN trained on a diverse dataset of facial expressions and eye states can accurately detect fatigue across different individuals, lighting conditions, and environmental contexts. This adaptability ensures that the system remains robust and reliable, even when faced with new drivers or varying conditions. Moreover, ML-based systems can be continuously improved as more data is collected. This scalability allows the system to evolve and become even more accurate over time, unlike traditional methods that may require manual adjustments or redesigns to cope with new data.

3. Real-Time Detection and Intervention

ML models, particularly those optimized for real-time performance, can process and analyze data at speeds far beyond human capability. This real-time detection is crucial for fatigue detection, as it allows the system to intervene immediately when signs of drowsiness are detected, potentially preventing accidents. For instance, a CNN-based model can process video frames from a camera feed and provide instant feedback on the driver's state, alerting them to take a break if signs of fatigue are detected. In addition, advanced ML techniques like Recurrent Neural Networks (RNNs) can analyze temporal sequences of data, such as the duration and frequency of eye blinks, to predict the onset of fatigue before it becomes critical. This predictive capability is a significant advantage over traditional methods, which typically only detect fatigue after it has already occurred [13].

4. Precision and Accuracy

The precision and accuracy of ML-based fatigue detection systems are unparalleled. These systems can achieve high levels of accuracy by learning from large datasets that include various examples of both drowsy and alert states. For instance, a well-trained CNN can distinguish between a brief, intentional blink and the slow, prolonged closure of eyes associated with drowsiness. The ability to fine-tune these models to minimize false positives and false negatives is crucial for maintaining driver trust and system reliability.

Additionally, by leveraging techniques such as cross-validation and hyperparameter tuning, ML models can be optimized to perform exceptionally well across different scenarios. The use of metrics like precision, recall, and F1-score during the model evaluation phase ensures that the system is not only accurate but also reliable in real-world applications.

5. Integration of Multimodal Data

ML approaches excel at integrating data from multiple sources, such as facial expressions, head movements, and even physiological signals like heart rate. This multimodal integration provides a more comprehensive assessment of the driver's state, leading to more accurate fatigue detection. For example, combining data from a camera with data from wearable sensors can provide a fuller picture of the driver's alertness level, enabling the system to make more informed decisions.

6. Continuous Learning and Improvement

Machine learning models have the capability to learn continuously from new data, making them increasingly effective over time. As more data about different driving conditions, individual driver behaviors, and fatigue patterns are collected, these models can be retrained to improve their accuracy and reliability. This continuous learning aspect ensures that the system remains up-to-date with the latest developments in fatigue detection, unlike static traditional methods that might become obsolete over time [14].

CONCLUSION

Machine learning-based approaches are the best solution for detecting driver fatigue because they combine adaptability, real-time processing, high precision, and the ability to handle complex, non-linear relationships. These approaches provide a level of accuracy and reliability that traditional methods cannot match, making them essential for enhancing road safety and preventing accidents caused by driver fatigue. As the field of machine learning continues to evolve, we can expect even more sophisticated and effective fatigue detection systems, further solidifying their role as the gold standard in this critical area of public safety.

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INTEGRATING LARGE LANGUAGE MODELS WITH VISUAL DATA FOR ENHANCED HUMAN-OBJECT INTERACTION DETECTION

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Abstract. **In recent years, the widespread use of vision-based intelligent systems has significantly advanced image and video analysis technologies. One key research area within this field is human activity recognition. Recent studies have primarily concentrated on specific tasks such as human action recognition and human-object interaction detection, employing depth data, 3D skeleton data, image data, and spatiotemporal interest point-based methods. Most of these approaches rely on bounding-box techniques to recognize human-object interactions. However, limited research has been conducted on using language models for this purpose. In this paper, we propose a model that combines language and image data to detect human-object interactions and discuss the challenges and future directions in this domain.**

Keywords: **Human-object interaction, image analysis, interaction detection, interaction-language models, large language models, multimodal learning**

INTORDUCTION

The task of human-object interaction detection involves identifying people, object instances, and understanding the interactions between each person-object pair. Recent advancements in this area have largely followed the encoder-decoder framework introduced by detection transformers (DETR) [23]. In this approach, learnable queries are initialized with Gaussian noise at the beginning of training and gradually decoded into human-predicate-object triplets. Zhang et al. [10] introduced a more efficient two-stage detector with a lightweight decoder, refining query design through a more streamlined architecture, exploring different key/value pair compositions, and incorporating positional embeddings specifically designed for bounding box pairs. Chaofan Huo et al. [6] proposed a monocular human-object reconstruction method that operates on two fronts. First, they used a probabilistic model to infer spatial relationships as a distribution rather than through single-point regression, reducing the search space during post-optimization and yielding more reliable results. They also separated the inference process into two stages: human pose estimation and pose-conditioned spatial relation inference. In parallel, significant progress has been made with pre-trained large language models like BERT [14] and GPT [1, 18], leading to the convergence of image [15], mesh [22], and multimodal [30] modeling. Specifically, Biao Jiang et al. [4] developed a pre-trained motion-language model that generalizes across tasks, capturing deep motion-language correlations from more diverse motion and language data. However, a general pre-trained model capable of describing human-object interactions using language has yet to be developed. Moreover, bounding-box-based methods for learning human-object interactions have inherent limitations, as they lack the rich detail that language-based methods can provide about actions in specific contexts. To address this, we propose a pre-trained interaction language model that incorporates both human-object interaction image data and language data (Fig. 1).

A man carried a dog and loaded to a car

Fig. 1. Our model processes labeled images along with corresponding text data that describes the human-object interactions within the given context.

RELATED WORK

There is a vast body of research on human-object interaction detection. In [20], the authors established a solid baseline by improving the architectural design of one-stage interaction detectors. Yu et al. [25] utilized external linguistic knowledge and a distillation technique [11] to enhance model performance, while [27] approached visual relationship detection as a reinforcement learning problem. Zhang et al. [10] introduced two-stage detectors for human-object interaction recognition, whereas [23] and other researchers focused on single-stage detector transformers.

Dai et al. [3] proposed a multistage approach, which involves first running an object detector and then applying a lightweight network to select promising pairs of interacting objects. The spatial relationship between human-object pairs has been modeled using bounding box transformations [12, 13], two-channel interaction patterns [7], or by capturing the mutual contexts of human poses and objects [13, 17]. Recent advances emphasize incorporating contextual information to reduce ambiguity in predicting interactions, focusing on aspects such as pairwise body parts [8] or object parts, instance-centric attention [7], and message passing on graphs [24].

In [16], the authors introduced the concept of a grasping field, a continuous function mapping points in 3D space to two point-to-surface signed distances. For hand-object reconstruction, they employed a variational encoder-decoder network to learn from data, an idea also applied to human-scene and human-object interactions [26]. In 2D human-object interaction detection, spatial relations are encoded using relative 2D coordinates between human and object bounding boxes [20], two-channel mask maps of humans and objects, relative locations between human parts and the object's center point [5], and bi-directional spatial distributions between human body and object parts [19].

Additionally, [4] applied large language models to human motion captioning and motion synthesis, while authors in [30] used these models to describe human motion in multimodal contexts. Building on this prior work, we use large language models to describe interactions between humans and objects in images. We achieve this by integrating human-object interaction data with language data and encoding both within a unified vocabulary, making the relationship between interactions and language clearer.

There are extensive works in human-object interaction detection. In [20] authors established a strong baseline, focused to improve the architecture design of one-stage interaction detectors. Yu et al. [25] uses external sources of linguistic knowledge and the distillation technique [11] to improve modeling performance, while [27] formulates the task of detecting visual relationships as a reinforcement learning problem. Zhang et al. [10] applied two-stage detectors for human-obect interaction recognition, while [23] and many of the researchers focused on on-stage detector transformers. Dai et al. [3] propose a multistage relationship detection process, where they first run an object detector, and then apply a light-weight network for selecting promising pairs of interacting object detections. The spatial relationship between each human object pair relies on using the bounding box transformation between the agent and the object [12, 13], a two-channel interaction pattern [7], or modeling the mutual contexts of human pose and object [13,17]. Recent advances focus on incorporating contexts to resolve potential ambiguity in interaction prediction based on independent human-object pairs, including pairwise body-parts [8] or object-parts, instance-centric attention [7], or message passing on a graph [24]. In [16] authors propose the grasping field that is a continuous function mapping any points in 3D space to two point-to-surface signed distances. Towards hand-object reconstruction, they use a variational encoder-decoder network to learn it from data. This similar idea is also applied to human-scene interaction and human-object interaction [26]. In the 2D human-object interaction detection task, spatial relation is encoded using relative 2D coordinates between the human bounding box and the object bounding box [20], two-channels mask map of human and object, relative locations between human parts and the center point of the object [5] and two-direction spatial distributions between human body parts and object parts [19]. Additionally, [4] applied large language models to human motion captioning and human motion syntesis, authors in [30] used large language models to describe human motion in multimodal modelling. Following these previous works, we use large language models to describe interaction between the human and the object from images. To do this we integrate human-object interaction and language data together and encoding them within a single vocabulary, the relationship between interaction and language becomes more apparent.

METHOD

Our model processes both human-object interaction image data and corresponding language data, segmenting interactions into what we call "interaction tokens". We design an interaction tokenizer that comprises an encoder $\mathcal{E}$ and a decoder D. The encoder takes in a sequence of M frames representing the interaction, denoted as $\mathrm{m}^{1:\mathrm{M}} = \{\mathrm{x_i}\}_{\mathrm{i}=1}^{\mathrm{M}}$, and converts them into L interaction tokens tokens $\mathrm{z}^{1:L} = \{\mathrm{z_i}\}_{\mathrm{i}=1}^{\mathrm{L}}$, where $\mathrm{L} = \mathrm{M}/l$ and l is the temporal down sampling factor. The decoder reconstructs these tokens back into the original interaction sequence interaction $\widehat{\mathrm{m}}^{1:\mathrm{M}} = \mathrm{D}(\mathrm{z}^{1:\mathrm{L}}) = \mathrm{D}(\mathcal{E}(\mathrm{m}^{1:\mathrm{M}}))$.

Given a sentence $\mathrm{w}^{1:\mathrm{N}} = \{\mathrm{w_i}\}_{\mathrm{i}=1}^{\mathrm{N}}$ that describes a human-object interaction within a particular context, the model's goal is to generate an output sequence of L tokens $\hat{\mathrm{x}}^{1:\mathrm{L}} = \{\hat{\mathrm{x}}_\mathrm{i}\}_{\mathrm{i}=1}^{\mathrm{L}}$. This output can either be interaction tokens $\hat{\mathrm{x}}_\mathrm{m}^{1:\mathrm{L}}$ representing a sequence of interactions $\widehat{\mathrm{m}}^{1:\mathrm{M}}$, or text tokens tokens $\hat{\mathrm{x}}_\mathrm{t}^{1:\mathrm{L}}$ forming a description $\widehat{\mathrm{w}}^{1:\mathrm{L}}$ of the interaction.

To represent interactions as discrete tokens, we pre-train a tokenizer V using the Vector Quantized Variational Autoencoders (VQ-VAE) architecture [2]. The encoder $\mathcal{E}$ generates discrete, information-dense interaction tokens, while the decoder D is able to reconstruct interaction sequences from these tokens. This strategy allows us to efficiently express interactions as a form of language, enabling the seamless integration of interaction data with language for various interaction-related tasks.

The interaction encoder $\mathcal{E}$ first applies 1D convolutions along the time axis to frame-wise interaction features $\mathrm{m}^{1:\mathrm{M}}$, producing latent vectors vectors $\hat{\mathrm{z}}^{1:\mathrm{L}} = \mathcal{E}(\mathrm{m}^{1:\mathrm{M}})$. These latent vectors are then discretized through a quantization process, mapping each vector to its nearest codebook entry from a learned codebook $\mathrm{Z} = \{\mathrm{z_i}\}_{\mathrm{i}=1}^{\mathrm{K}} \subset \mathrm{R}^{\mathrm{d}}$, where K is the number of embedding vectors, each with dimension d. The quantization $\mathrm{Q}(\cdot)$ replaces each vector $\mathrm{z_i}$ with the closest entry $\mathrm{z_k}$ in the codebook, as follows:

$$z_i = Q(\hat{z}^i) := argmin_{z_k \in Z} \parallel z_i - z_k \parallel_2 \qquad (1)$$

After quantization, the decoder decoder D maps the tokens $z^{1:L} = \{z_i\}_{i=1}^{L}$ back to the original motion space, reconstructing the interaction sequence $m^{1:M}$over M frames.

We then combine the original text vocabulary $V_t = \{v_t^i\}_{i=1}^{K_t}$ with the interaction vocabulary $V_m = \{v_m^i\}_{i=1}^{K_m}$, which corresponds to our interaction codebook Z. The interaction vocabulary V_m also includes special tokens, such as indicators marking the start and end of interactions. Together, these form a unified text-motion vocabulary $V = \{V_t, V_m\}$, enabling us to handle diverse motion-related tasks in a uniform format where both input and output sequences are drawn from the same vocabulary (Fig. 2).

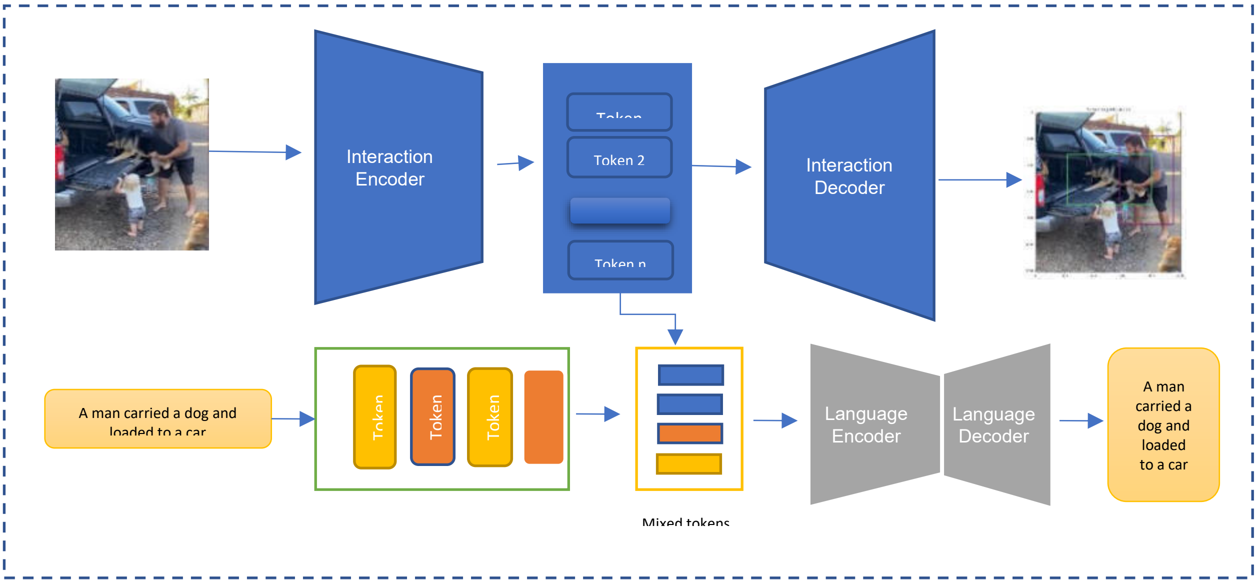

Fig. 2. Overall apperance of the model. We combine interaction tokens and text tokens, then learn interaction and language together

EXPERIMENTS AND RESULTS

We train our model on HICO-Det [29]. HICO-Det has 47, 776 images (38, 118 for training and 9, 658 for testing). It contains 600 classes of HOI triplets constructed by 80 object categories and 117 action categories. We train our model with a batch size of 16 on Tesla V100 GPUs and CUDA10.1 and for evaluation we use mean Average Precision (mAP). Here in Table 1 we compare our model with start-of-the-art models.

ethod	Detector	Backbone	Default			Know Object		
			Full	Rare	Non-Rare	Full	Rare	Non-Rare
AS-Net [21]	HICO-Det	ResNet-50	28.87	24.25	30.25	31.74	27.07	33.14
QPIC [20]	HICO-Det	ResNet-101	29.90	23.92	31.69	32.38	26.06	34.27
UPT[9]	HICO-Det	ResNet-101-DC5	32.62	28.62	33.81	36.08	31.41	37.47
GEN-VLKT [28]	HICO-Det	ResNet-50	33.75	29.25	35.10	36.78	32.75	37.99
Ours	HICO-Det	ResNet-50	31.99	27.72	33.26	34.88	31.04	36.06

Table 1. Performance comparison of our model with start-of-the-art models.

Our model achieved a mAP of 31.99, which places it slightly behind GEN-VLKT [28] (33.75) and UPT [9] (32.62). This indicates that while our model is robust, it falls short of the leading models in handling the full spectrum of interactions in the Default setting. However, it still surpasses AS-Net [21] (28.87) and QPIC [20] (29.90), demonstrating that our approach has a solid foundation, particularly when leveraging a ResNet-50 backbone. In the Rare category, our model scored 27.72 mAP, which is again competitive but lower than GEN-VLKT [28] (29.25) and UPT [9] (28.62). This suggests that while our model can effectively handle less frequent interactions, there is room for improvement in optimizing its ability to generalize across rare cases. Despite this, our model outperforms AS-Net [21] (24.25) and QPIC [20] (23.92), which indicates that it manages rare interactions better than some other established models. For Non-Rare interactions, our model performed with a mAP of 33.26, close to UPT [9] (33.81) but still trailing behind GEN-VLKT [28] (35.10). The smaller gap in performance compared to leading models highlights our model's proficiency in detecting more common human-object interactions. It outperforms AS-Net [21] (30.25) and QPIC [20] (31.69), reflecting its strength in handling non-rare scenarios effectively. In the Known Object setting, our model achieved a mAP of 34.88, trailing GEN-VLKT [28] (36.78) and UPT [9] (36.08). This performance indicates that while our model is quite effective in scenarios where object presence is known, it still requires further refinement to match or exceed the top-performing models. Nonetheless, it remains ahead of AS-Net [21] (31.74) and QPIC [20] (32.38), which demonstrates its competitive edge in this category. Our model reached 31.04 mAP in the Rare category under the Known Object setting. Although it performs slightly lower than GEN-VLKT [28] (32.75) and UPT [9] (31.41), the difference is marginal. This result suggests that our model has a solid capability for detecting rare interactions when the objects are known, but there's still potential for optimization. The score is notably higher than AS-Net [21] (27.07) and QPIC [20] (26.06), indicating a stronger performance in rare known-object interactions. Our model shines in the Non-Rare category with a mAP of 36.06, only slightly behind GEN-VLKT [28] (37.99) and UPT [9] (37.47). This performance indicates that our model is highly effective in detecting common interactions when the objects are known, reflecting its robustness in practical scenarios. It also surpasses AS-Net [21] (33.14) and QPIC [20] (34.27), further confirming its strength in non-rare interaction detection.

CONCLUSION

In this paper we presented an approach to human-object interaction detection by leveraging large language models in combination with visual data. Our method integrates human-object interaction image data with language data, creating a unified model that efficiently captures and represents interactions. The experimental results on the HICO-Det dataset demonstrate that our model performs competitively with state-of-the-art methods, particularly in handling non-rare interactions. However, there is still room for improvement, especially in rare interaction detection and scenarios where object presence is known. Our findings suggest that combining interaction tokens with language data is a promising direction for future research, offering a more detailed and context-aware understanding of human-object interaction.

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CLASSIFICATION OF MOVEMENTS OF ATHLETES ON THE BASIS OF ELECTROMYOGRAPHY BY USING MACHINE LEARNING ALGORITHMS

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A B S T R A C T **The classification of technical training exercises of athletes on the basis of machine learning algorithms is carried out in this scientific article. 4 technical training exercises of athletes were classified, and machine learning methods were compared in the process of classification.**

K E Y W O R D S machine learning, EMG signal, technical training exercise, FreeEMG, classification.

INTRODUCTION

Biosignals are considered signals which characterize any physiological processes which occur in the body on the basis of the movement of the human body and physical exercises. The biosignal is characterized by varying amplitude, frequency, and phase by time. EMG signals can be used in other applications to measure muscle strength, fatigue, and injury, or to develop biofeedback and rehabilitation programs [1,2]. They are considered very significant for studying the main mechanisms of muscle function and developing new treatments for muscle-related diseases. EMG signals are being used in sports, biomechanics, rehabilitation, medicine and many other fields.

EMG signals cannot be applied directly to the above mentioned areas because their amplitude is too small. The collected EMG signals are processed for application and separated into time, frequency, and time-frequency features [7]. The selection and extraction of feature with traditional methods are considered difficult and they are required more time. Together with this, it creates complexity in the combination of functions. This leads to increase the volume of work [13]. Therefore, various Machine Learning (ML) or Deep Learning (DL) techniques are used to classify the EMG signal. Various ML algorithms can be used for EMG classification, in particular, decision tree (DT), Support Vector Machines (SVMs), Convolutional Neural Networks (CNN), and Long-Short Term Memory (LSTM) algorithms. These algorithms are trained on large datasets of EMG signals which are marked with corresponding muscle activity. Then, it can be used to classify new EMG signals by using the trained data set. In addition to the above mentioned algorithms, another way to classify EMG signals is artificial neural networks (ANN). ANN is a classic ML algorithm; it is considered the algorithm which was inspired by the structure of the human brain. ANN is an effective tool for the classification of EMG signals, and we can achieve good results by using ANN [3]. ANN algorithms have been applied to various functions which are related to EMG signals, in particular, it is used for classifying muscle movements during technical training exercises, technical methods and classification of muscle movements during gait of athletes, and detecting specific hand gestures and muscle fatigue. In the next section, the use of ML and DL algorithms for the classification of EMG signals which were obtained from the muscles of athletes and the identification of movement types is presented.

METHODS

Each signal which was recorded from muscles in the human body has its own characteristics. Therefore, EMG signals can be divided into different human movements by using classification methods. As a result, we will be able to classify various technical training exercises and technical methods of athletes. The different ML algorithms are used to classify four technical training exercises of athletes in this paper.

Machine learning classification algorithms

Nowadays, ML is developing rapidly in many disciplines and applications. In the classification of EMG signals, the signals of ML algorithms are analyzed and divided them into different categories or classes. This can be useful for athletes to identify different types of technical training exercises such as swallow, walking in place, chair-rise, and Iron-cross [5].

ML methods usually consist of different steps to classify the data. Before classifying the EMG signal by using the ML algorithm, extracting relevant features from the raw data is considered an important step, and the selection of features depends on the specific classification task and the characteristics of the analyzed EMG signals. In addition to feature extraction, signal processing is required to classify EMG data. This includes filtering in order to remove noise and artifacts, and normalization in order to ensure the data which is in a consistent format. Signal preprocessing has a significant impact on working the ML algorithm [8]. After the ML algorithm is trained and tested on the dataset, its performance is needed to be evaluated in order to determine how well it classifies the EMG signals. It is done by using various indicators such as accuracy and remember.

Stability of EMG data collection in ML classification

Data stability must be taken into account when collecting EMG signals, because various factors can affect to the EMG signals. This affects the accuracy and reliability of the ML model. Installation of electrode is considered an important factor when working with EMG signals. The location of the electrodes on the skin affects the quality of the recorded signals and their noise level. The electrodes must be correctly installed in order to reduce the effects of motion artifacts and other sources of noise. When working with EMG signals, motion artifacts can affect the accuracy of the ML model. These artifacts are caused by the movement of the electrodes or the muscles which are being measured, and the noise and interference are added to the EMG signals. It is necessary to install the electrodes firmly on the skin and minimize excessive muscle movements during recording in order to reduce the effect of motion artifacts.

Muscle fatigue also affects the accuracy of the classification method when working with EMG signals. As the muscle fatigues, the character of the EMG signals which are generated by the muscle changes, this affects the accuracy of the model. It is essential that the muscles which are being measured are not overused or fatigued during the writing process in order to avoid the effects of muscle fatigue.

Collect EMG data

The signals from muscles in 8 body parts were recorded in order to classify the movements of athletes, and FreeEMG (BTS Company, Italy) 8-channel device was used to record EMG signals in this research. It has 16-bit license, 1 kHz signal recording frequency, wireless transmission technology(2.4GHz, standard IEEE802.15.4) (Figure. 1) [4,6]. The 8 sensors in the FreeEMG device were placed in 8 muscles of the athletes who were participating in this research (right upper arm, left upper arm, front right thigh, front left thigh, back left waist, back right waist, back left calf, back right calf) (Table1).

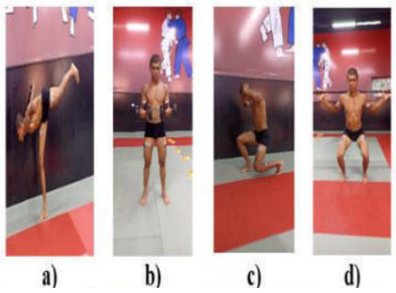
Table 1. Location of FreeEMG sensors

№	Sensor	Muscle name	Location of sensors in Body part
1	8-sensor	Right Biceps brachii caput brevis	In the upper part of the right arm
2	7-sensor	Left Biceps brachii caput brevis	In the upper part of the right arm
3	3-sensor	Right Rectus femoris	In the front right thigh
4	6-sensor	Left Rectus femoris	In the front left thigh
5	1-sensor	Left Erector spinae ileocostalis	In the back left waist
6	2-sensor	Right Erector spinae ileocostalis	In the back right waist
7	4-sensor	Left Gastrocnemius lateralis	In the back the left calf
8	5-sensor	Right Gastrocnemius lateralis	In the back the right calf

Fig. 1. 8-channel FreeEMG device

Data were collected from 28 volunteer athletes by using a FreeEMG device. The age, weight and height parameters of the participants are from 17 to 25, from 56 to 86 kg, from 170 to 185 cm, respectively.

The 4 technical training exercises were classified in this research; they are the swallow exercise or single-leg Romanian exercise (R), development exercise of arm muscle by using the dumbbell (DAMD) (Bitsoft), walking in place (WP) and Iron-cross by using the barbell (ICB) (Figure. 2).



a - the swallow exercise or single-leg Romanian exercise (the exercise which assesses the balance);

b - development exercise of arm muscle by using the dumbbell (Bitsoft);

c - walking in place;

d - Iron-cross by using the barbell.

Fig. 2. Diagram of technical training exercises which are performed by participants

During data collection, athletes were asked to perform each exercise 5 times. During performing exercise R, the participants had to raise their left leg parallel to the floor while leaning on their right leg and extending their arms to the sides for 4 seconds. The athletes had to go 10 m while sitting and walking for 10 seconds in the WP exercise. The athletes sat down with a 15 kg barbell on their shoulders in the ICB exercise. The participating athletes were given two 6 kg stones in their hands and asked to lift and lower the stones 5 times while standing in order to perform the DAMD exercise.

Using different ML algorithms for EMG classification

The several ML algorithms exist for classifying EMG signals. These algorithms can classify only 2-3 different movements with high accuracy from recorded EMG signals. The accuracy of the classification will decrease if the athletes' movements are a lot. It is necessary to separate the EMG signals into features in order to classify more movement with high accuracy. In this research, the data which were obtained from the EMG signals, are used in order to determine the best algorithm for classifying the EMG signals on the basis of the features which are listed in Table 2, they are classified by using different ML algorithms ANN, LSTM, K-Nearest Neighbor (KNN), Naive Bayes (NB), SVM, Random Forest (RF), and CatBoost(CB)) [9]. The EMG classification process by using FreeEMG is given in the Figure3.

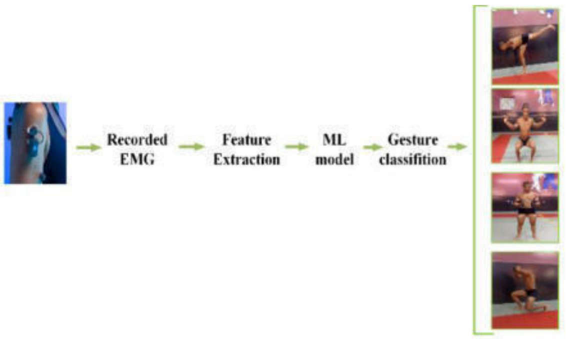


Fig. 3. The process of collecting and classifying EMG signals from the FreeEMG device.

Table 2.Results which were obtained in the form of a combination of parameters

№	EMG signal parameters	Mathematical expression
1	Simple square integral (SSI)	$SSI = \sum_{i=1}^{N} \lvert x_i \rvert^2$
2	4-Power (4POW)	$4POW = \sum_{i=1}^{N} x_i^4$
3	Mean absolute value (MAV)	$MAV = \frac{1}{N}\sum_{i=1}^{N} \lvert x_i \rvert$
4	Waveform length (WL).	$WL = \sum_{i=1}^{N} (x_i - x_{i-1})$
5	Average amplitude change (ACC)	$ACC = \frac{1}{N}\sum_{i=1}^{N-1} \lvert x_{i+1} - x_i \rvert$
6	Integrated EMG (IEMG)	$IEMG = \sum_{i=1}^{N-1} \lvert x_i \rvert$
7	Root mean square (RMS)	$RMS = \sqrt{\frac{1}{N}\sum_{i=0}^{N-1} x_i^2}$
8	Variance of EMG(VAR)	$VAR = \frac{1}{N-1}\sum_{i=1}^{N-1} x_i^2$
9	Difference absolute standard deviation (DASDV)	$DASDV = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N-1} (x_{i+1} - x_i)^2}$

EMG signal classification by using ANN involves identifying patterns in EMG signals which correspond to muscle motions. This involves entering the EMG data into the ANN and setting the parameters of the layers in the network so that the network can correctly classify the EMG signals [20].

If using the model ANN is too complex, the risk of over fitting will appear. Together with this, some algorithms on the basis of ANN complicate the classification process with many parameters [20]. A new algorithm on the basis of ANN is presented to overcome these limitations [11,20]. In this process, the ANN algorithm which includes several control parameters was designed. After the ANN was trained, a testing process was performed by observing its accuracy and loss function. This algorithm achieved 97.8% and 94% results in training and testing processes, respectively. The accuracy and loss function of ANN are shown in the Figure 4 and Figure 5.

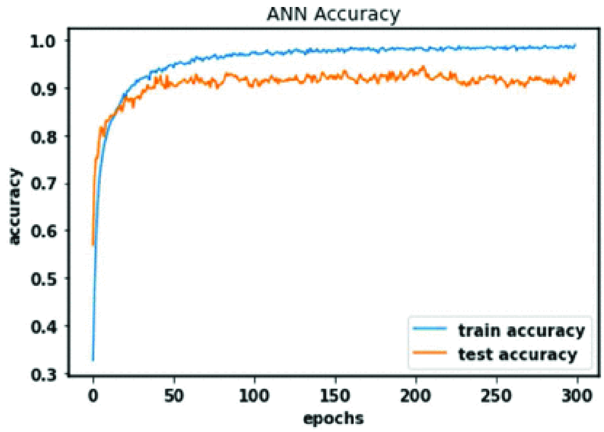


Fig. 4. Accuracy of ANN algorithm in EMG classification training process

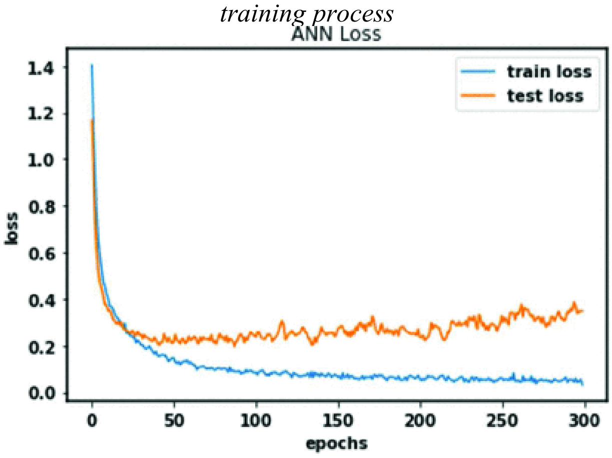


Fig. 5. Loss function in the EMG classification training process of ANN algorithm

Another model which was used in this research is Long Short-Term Memory (LSTM) networks; they are suitable for modeling sequential data, such as time series data. One advantage of using the LSTM network in order to classify EMG signals is that the LSTM network can capture long-range correlations in the data [12]. This is useful for classifying EMG signals which are associated with complex muscle movements or exercises, because these movements involve forms which include multiple time points. Another advantage of it is that the LSTM networks can handle input sequences of variable length. This helps to work with EMG signals which their lengths differ from each other. In this research, LSTM was implemented. 97% and 82% accuracy was obtained in the training and testing processes, respectively. The diagram of accuracy and loss function of LSTM model are shown in the Figure 6 and Figure 7.

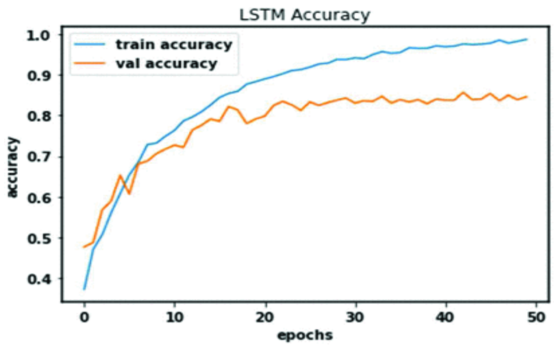


Fig. 6. Accuracy of LSTM model in EMG classification training process.

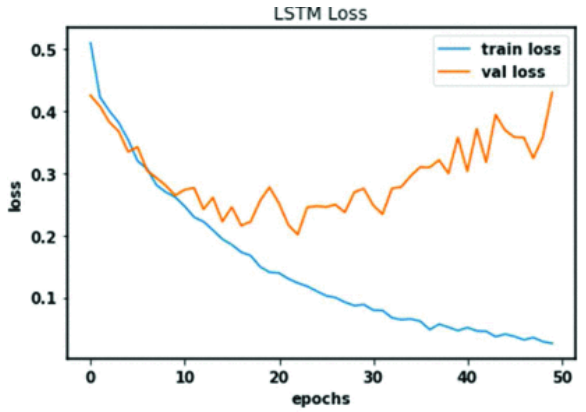


Fig. 7. The loss function in the EMG classification training process of the LSTM model

Together with this, other classification algorithms were tested in the research and the results were compared with the presented model. Naive Bayes algorithm was used for classification of EMG signals [14]. This is a simple and efficient ML algorithm; it classifies a given sample by using Bayes theorem. But some limitations exist in EMG classification of Naive Bayes. It assumes that all features are independent; this is not always true in EMG classification. In this work, the Naive Bayes model achieved 93% accuracy. However, this model may not always be the best choice depending on the characteristics of the data set.

When kNN algorithm was applied in order to solve this problem, 57% accuracy was achieved in EMG classification. This is not satisfactory result. KNN is a non-parametric method and does not make any assumptions about the distribution of the data [16]. Therefore, KNN may not capture more complex relationships in the data.

After that, the Support Vector Machine (SVM) algorithm was used and we got 88% accuracy in confirmation. SVM can manage complex non-linear relationships between high-dimensional data and features with target variables for EMG classification [18]. In addition, SVM is considered stable against over fitting.

We obtained 91% and 87% accuracy when the Random Forest and CatBoost algorithms were used, respectively. However, these two algorithms are complex and it is difficult to understand and interpret them. Both algorithms are prone to over fitting if the training dataset is small or contains many features [19].

In general, the ANN model achieved the highest accuracy of 97.8% despite being a simple model among these seven models.

CONCLUSION

In this study, classification of EMG signals for four technical training exercises (the swallow exercise or single-leg Romanian exercise, development exercise of arm muscle by using the dumbbell (Bitsoft), walking in place and Iron-cross by using the barbell) was presented by using ML algorithms. 97.8% and 94% accuracy was obtained from the ANN algorithm as the best result in the training and testing processes, respectively. Our goal is considered to compare different ML techniques for the classification of several technical training exercises. We compared the ANN model with LSTM, NB, KNN, RF, SVM and CB models, and their accuracies were 97%, 93%, 57%, 91%, 88%, and 87%, respectively. The new model on the basis of ANN has high accuracy than other models; it achieved 97.8% accuracy in experiments. In future researches, the method will be extended with different technical training exercises and technical methods. Also, classification of movements of athletes is carried out in real-time management.

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CLASSIFICATION OF HAND MOVEMENTS ON THE BASIS OF MACHINE LEARNING METHODS

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A B S T R A C T **The classification of some hand movements on the basis of machine learning methods was carried out in this article. The 6 active and 1 inactive hand positions were classified, and the process was performed in real time.**

K E Y W O R D S Machine learning, EMG signal, classification, accuracy, hand movements.

INTRODUCTION

We understand as biosignal that the signals were emitted by the human body. They can be a description of natural physiological phenomena which were occurring in the human body. Biosignals are considered the main object of biosystems. Nowadays, some types of biosignals exist such as electric, magnetic, optical, chemical, thermo, mechanical. In turn, these signals are divided into such types as endocrine, nervous, cardiovascular, visual, auditory, muscular, respiratory, gastrointestinal system signals according to the system of origin.

Nowadays, one of the most studied biosignals is considered the electromyography (EMG) signal. The EMG signal is considered a type of biosignal which evaluates the active potential state of the muscles.

Muscles in the human body can be divided into three categories: skeletal muscles, cardiac muscles, and smooth muscles. Each muscle type has its own unique parameters. For example, smooth muscles cannot be recorded, they work by themselves, and in return, small involuntary movements of some human organs occur. Such muscles are mainly composed of tissues which form the walls of hollow organs such as blood vessels and the stomach [1,2]. Skeletal muscle is considered an electrical biosignal which occurs as a result of muscle contraction and relaxation. Cardiac muscle is considered a signal which occurs when the heart contracts and relaxes as a result of controlling blood flow.

Skeletal muscles are composed of motor units (MTUs), which are the smallest muscle elements which are voluntarily involved in activity. Motor units consist of an anterior horn cell or motoneuron, an axon, and all muscle fibers which are stimulated by this axon. The number of muscle fibers which are belonging to one motor unit is called the innervation coefficient. The innervation coefficient for different muscles can vary from tens of units to hundreds of units. Muscle contraction is considered the collective result of the stimulation and contraction of several motor units. The muscle contraction mechanism is explained by the sliding filament theory, according to this, the contraction of each muscle fiber occurs as a result of the movement of thin fibers between thick fibers without changing the length of the fibers.

The action potential originates from the neuromuscular junctions and propagates in both directions through the tubular system within the muscle fibers. Each motor unit is stimulated by a neuronal signal and contracts; as a result, the electromyographic signal (EMG) is formed. Electromyographic signal (EMG) is considered the total action potential of all cells which are involved in this process.

The mathematical model of the EMG signal can be expressed in a simplified form by the following equation:

$$u(n) = \sum_{q=0}^{N-1} h(q)e(n-q) + w(n) \tag{1}$$

here, *u(n)* — EMG signal biopotentials, *h(q)* - action potentials of motor units, *e(n)* — simulation pulses, *w* — additive white Gaussian noise, *N* — the number of motor units which are involved in the contraction process.

EMG signals are low-frequency signals which are unresistant to noise. These signal classification methods have been used as medical devices or indispensable tools in various fields such as neuromuscular diseases, rehabilitation of movement functions of patients, diagnostic systems, human-machine systems. Also, devices or software which are formed on the basis of the EMG signal have been growing in the world market (Fig. 1).

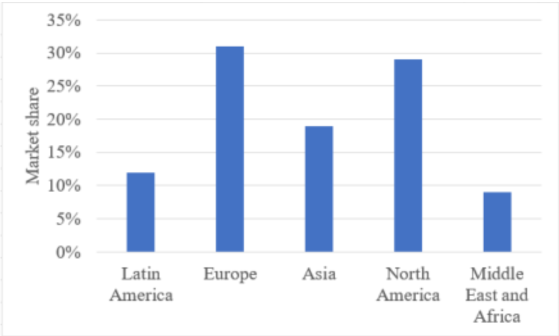

Fig. 1. Global market share of EMG devices (2021)

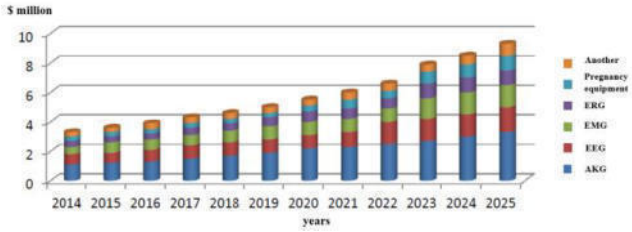

Fig. 2. Forecast chart of EMG devices market

According to another analysis (Figure 2), demand for EMG signal on the basis of medical devices and software is expected to continue to increase compared to other biosignal-based tools [3]. It can be seen from the analysis and prediction diagrams above that devices and software tools which were created by classifying the EMG signal have become an integral part of modern medicine.

MAIN PART

The EMG signals are a low-frequency signal, that's why, the devices which record them must also be sensitive and noise-resistant. Reliable devices for recording EMG signals have been developed over the years [4,5].

In our research, a signal was recorded from the muscles which are located in the wrist area during the classification of hand movements, and an 8-channel FreeEMG (BTS Company, Italy) device was used to record the EMG signal from the human hand. Its authorization is 16-bit, recording frequency is 1kHz, wireless transmission technology is 2.4GHz, (standard IEEE802.15.4).

The EMG signal changes over time and is subject to many distortions due to noise. It is important to correctly choose the methods of parameterization and classification in order to obtain its exact values, increase accuracy and reduce the need for calculations. Classification of the EMG signal is carried out in 5 stages (Fig. 3).

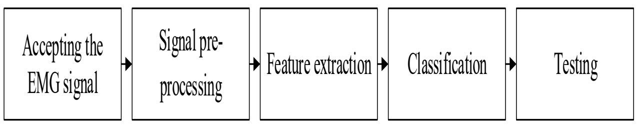

Fig. 3. General structure of EMG signal classification

The several neural networks for EMG signal classification exist, in particular, PNN, HMM, BN on the basis of ANN, BPNN, LLGMN, RLLGMN, LLGMN. However, the presented neural networks or classifiers can classify 2-3 hand movements with high accuracy. If hand movements are many, the classification accuracy will decrease. Development of classification algorithms on the basis of ML methods is suitable for our research, because the parameters of EMG signals are clear, the signal has low frequency, and the signal values which were obtained during each movement are close to each other, the main factors exist that promptness in the classification on the basis of EMG signals and the delay time is small.

Signal parameters mean extracting the necessary information from the initial signal data. Naturally, the parameters depend on the type of signal data available. This process is called characteristic engineering. Characteristic engineering is a time-domain parameter, it gives good results in classification, as presented in several of our previous researches [6,7] considering data, models, and tasks. The information about time-domain parameters of the EMG signal used for classification in this research are given below (Table 1).

Table 1.Time-domain characteristics of the EMG signal

№	**EMG signal parameters**	**Mathematical expression**
1	Simple square integral (SSI)	$SSI = \sum_{i=1}^{N} \lvert x_i \rvert^2$
2	4-Power (4POW)	$4POW = \sum_{i=1}^{N} x_i^4$
3	Mean absolute value (MAV)	$MAV = \frac{1}{N}\sum_{i=1}^{N} \lvert x_i \rvert$
4	Waveform length (WL)	$WL = \sum_{i=1}^{N} (x_i - x_{i-1})$
5	Average amplitude change (ACC)	$ACC = \frac{1}{N}\sum_{i=1}^{N-1} \lvert x_{i+1} - x_i \rvert$
6	Integrated EMG (IEMG)	$IEMG = \sum_{i=1}^{N-1} \lvert x_i \rvert$
7	Root mean square (RMS)	$RMS = \sqrt{\frac{1}{N}\sum_{i=0}^{N-1} x_i^2}$
8	Variance of EMG(VAR)	$VAR = \frac{1}{N-1}\sum_{i=1}^{N-1} x_i^2$
9	Difference absolute standard deviation (DASDV)	$DASDV = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N-1} (x_{i+1} - x_i)^2}$

The simple square integral (SSI) parameter is an index of energy. The 4 level of power (4POW) characterizes the change in power output of muscles over time. Mean absolute value (MAV) is one of the most popular parameters which were used for motion recognition. Wavelength (WL) represents the change of the amplitude of the EMG signal. It represents the average amplitude change (AAC), the integrated EMG (IEMG) parameter is commonly used to determine the onset of muscle activation and is used in experiments in clinical trials. The root mean square (RMS) parameter is used to estimate muscle fatigue during contraction. EMG signal variance (VAR) parameter characterizes the square of the average deviation of the signal. Parameters such as difference absolute standard deviation (DASDV) describe the complexity of EMG signal information.

According to our previous researches [7], time-domain features which are representing signal energy provide good results for EMG signal classification. Therefore, the classification was made on the basis of presented the 9 time zone parameters (Table 2).

Together with this, it seems from the sources that if the values which were included in the classification network are precise and the need for time and high accuracy exist as the main efficiency indicators, then it is appropriate for us to use machine learning algorithms.

The k-Nearest Neighbor (k-NN) [8,9], Support Vector Machine (SVM) [10,11], Random Forest (RF) [12,13] were used among machine learning methods in this research. These methods have provided high accuracy [14] and speed [15] in the classification of EMG signals.

The 32 healthy people, in particular, 5 women and 27 men who were aged 19 to 37 years participated in this experiment. Each subject performed the experiment 2 times. The movements which we classified are as follows: grasping the finger, fisting the hand, spreading the hand, motionless (free) position of the hand, bending the index finger, bending the middle finger, bending the ring finger (Figure 4).

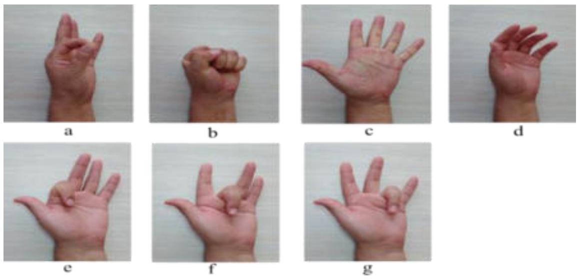

Fig. 4. Used hand movements (a – grasping the finger, b – fisting the hand, c – spreading the hand, d – motionless (free) position of the hand, d – bending the index finger, f – bending the middle finger, g – ring finger)

It can be seen from the conducted experiments that the set of parameters in the time-domain is sure to be higher than the set of parameters in the frequency domain both in accuracy and in fast calculation [7,8,15]. Due to the complexity of calculating the time-frequency domain parameters of the EMG signal, the response time is significantly different from parameters in other domains. This will certainly have a negative impact on real-time management systems.

The results of individual application of the parameters were found to be 40%-60% on average. Of course, this result is considered low. In order to get more accurate results, we compared the results by combining the parameters which we used in turn in the research process (Table 2).

Table 2. Results which were obtained in the form of a combination of parameters

Combination	**k-NN (%)**	**RF(%)**	**SVM(%)**
SSI+ACC	72	74	57
SSI+ACC+IEMG	85	86	71
SSI+ACC+IEMG+WL	93	96	88
SSI+WL+RMS	96	95	92
SSI+ACC+IEMG+WL+RMS	94	96	91
SSI+ACC+IEMG+WL+RMS+MAV	**99**	**99**	**95**
SSI+ACC+IEMG+WL+RMS+MAV+4POW	97	98	86
SSI+ACC+IEMG+WL+RMS+MAV+4POW+VAR	98	94	88
SSI+ACC+IEMG+WL+RMS+MAV+4POW+VAR+DASDV	98	97	91

An average accuracy of 99% was achieved for the k-NN classifier, 99% for the RF, and 95% for the SVM classifier

In this case, we can basically see that the results of the combination of two or more parameters are much higher than the initial (individual) results. This definitely improved the efficiency of EMG signal classification. Starting with the combination of five parameters, the results improved dramatically. The best result was shown in the combination of SSI, ACC, IEMG, WL, RMS and MAV parameters.

CONCLUSION

In this research, the classification of 7 hand movements was carried out, and the classification was carried out on the basis of the EMG signals which were obtained from the EMG wrists. Machine learning methods were chosen for biosignal classification, as real-time classification on the basis of precise parameters is effective in these methods.

The classification was carried out on the basis of time-domain parameters of the EMG signal and was used in combination form. The results of the classification which were used the combination form showed the highest result with 99% in SSI, ACC, IEMG, WL, RMS, MAV parameters. The result of this research will be widely used in the future in the creation of human-machine interface systems, remote control, development of rehabilitation devices, diagnostics.

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ANALYSIS OF THE CAPABILITIES OF SYSTEMS FOR DETECTING ABNORMAL STATES IN COMPUTER SYSTEMS

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A B S T R A C T **From year to year, the number of cybercriminals is increasing. These are those that are associated with the unpromising outflow of information from within can be costly for organizations. In preventing this, there are currently several ready-made security programs available. They will help prevent data from leaving without showing up by monitoring the actions of users in the organization. However, choosing the right one for the organization from within them can be a problem. This article covers the possibilities, advantages and disadvantages of such programs.**

K E Y W O R D S Information security, data leakage, intellectual method, confidential, data, insider, artificial intelligence, dlp, ueba, security systems, analysis

Security and reliability in computer systems are one of the important issues today. Timely detection and prevention of anomalies is of great importance for the effective and safe use of systems. Anomaly detection systems are one of the tools used for this purpose. Anomaly detection systems (ADS) are software designed to detect deviations from normal or expected behavior in computer systems. ADS are used in various fields, including ensuring the security of the information system in an organization, monitoring system performance, managing and monitoring the network, determining the non-destructive actions of users or other objects in the system, and other similar tasks. These systems are used separately as a complete program or a module of your security system. It is also possible to use systems like this by integrating them with other applications [1].

ADS protects computer systems from threats listed below:

- cyberattacks: anomaly detection systems can detect attacks before they cause damage, such as DoS and DDoS, which can know their attacks before they start.
- malware: can detect and block various malware such as worm, trojan horse, spyware etc.
- use of information without spirit: ADS can detect attempts to use information in the system without spirit. Through this, it prevents attacks such as data leaks without showing up, password hacking [2].

The mechanisms of operation of ADS are shown in table 1 below [3].

Table-1 mechanisms of operation of ADS

Title	Review	**Advantages and disadvantages**
Signature - based operation mechanism	Works on the basis of specified samples (template) of previously known attacks. If a match with the sample is found in the attack action, the system will start.	Advantages: high accuracy Disadvantages: inability to detect new attacks.
Working mechanism attached to anomalies	The system analyzes behavior and works on the basis of detecting unusual, anomalous phenomena that indicate an attack is taking place.	Advantages: ability to detect unknown attacks, flexibility. Disadvantages: the correct cases are considered incorrect.
Performance mechanisms based on hybrid systems	Using combining signatural detection and anomaly detection to improve efficiency.	Advantages: compensate for each other's shortcomings.

For a broader approach to system security and performance management, ADS is often integrated with security event and information management (SIEM) systems, monitoring systems, and analytical platforms. Then the tolerance of the system to various internal and external attacks is increased [4].

METHODS

Splunk User Behavior Analytics (UBA) is a program designed to analyze and detect abnormal user activity in an information system. This software uses artificial intelligence methods and big data analysis to detect suspicious behavior by users and prevent security incidents. The possibilities, advantages and disadvantages of the program are shown in the table below.

Table-2 main features of product.

capabilities	Advantage	Disadvantage
• ability to analyze user behavior. • use of machine learning method. • detection of anomalies in real time; • integration with other Splunk programs; • ability to detect and report incidents	• high accuracy; • integration and expansion; • ease of installation and adjustment; • flexibility; • possibility of visualization and analysis;	• difficulty of management; • the value of the price; • high demands on resources; • high number of false detections; • high dependence on the quality of data when forming the sample; • can be used only by qualified personnel;

In summary, Splunk UBA is one of the most powerful tools used to detect insider threats and analyze user behavior. Through the capabilities this software provides, organizations can significantly improve their security posture by preventing and quickly responding to insider threats. However, effective use of the system requires two things: a resource-rich sample and qualified personnel.

Varonis DatAdvantage is a powerful application that helps organizations monitor, analyze and protect data traffic. It manages data and ensures its security. Such a program provides complete information about data access rights, which users have access to the data, and potential threats, making this program an indispensable tool for information security. Its main features, disadvantages and advantages are listed in table 3.

Table-3 main features of product.

Capabilities	Advantages	Disadvantages
• analysis of data access rights; • monitoring of data usage; • detection of anomalies: • risk management; • audit and reporting; • automating the management of the right to use information;	• centralized management; • increase system security; • performance of compliance with regulatory documents; • simplified data access control: • possibility of integration with other security systems;	• very high price; • complexity of installing the program; • the program requires large resources for its full operation; • difficulty of training and support;

In summary, this product is a powerful yet flexible application that provides comprehensive control over data access and usage. Despite some disadvantages, such as the high cost and difficulty of installation, the program has many advantages, including increasing system security, meeting the basic requirements of the organization's information security policy, and automating the management of data access rights. This software is useful for large organizations, such as military organizations, that want to protect their data and minimize risk.

Forcepoint Insider Threat is a comprehensive solution for monitoring and analyzing user behavior to detect and prevent insider threats. The program is designed to prevent malicious or negligent actions by employees that can lead to data breaches, financial losses, or other security incidents. Its main features, disadvantages and advantages are listed in table 4.

Table-4 main features of product.

Capabilities	Advantages	Disadvantages
• monitoring of user activity; • User Behavior Analysis (UBA) • possibility of contextual analysis; • possibility of risk analysis • alerts and notifications; • the possibility of checking incidents;	• comprehensive approach to security; • ease of installation; • high accuracy; • possibility of integration with other security solutions; • ease of use;	• expensive price; • high resource requirements; • difficulty of adjustment and management; • privacy and ethical issues;

In conclusion, Forcepoint Insider Threat is a powerful tool to protect organizations from insider threats. It helps minimize risks associated with user behavior through monitoring, analysis, and data leakage prevention capabilities. However, like any program, it has its pros and cons, which should be taken into account before deciding on this program.

ObserveIT, now known as Proofpoint Insider Threat Management, is one of the most powerful solutions in the information security market for detecting and managing insider threats. This platform empowers organizations to monitor, analyze, and prevent suspicious activity from employees and other trusted users. Its main features, disadvantages and advantages are listed in Table 5.

Table-5 main features of product.

Capabilities	Advantages	Disadvantages
• monitoring of user activity; • behavior analysis; • contextual analysis; • event management; • security policy management; • the possibility of integration with other security programs;	• detailed monitoring and auditing; • detection of active threats; • possibility of contextual analysis; • ease of security policy management;	• high price; • difficulty of use; • existence of privacy issues; • learning difficulty;

In short, ObserveIT is a powerful insider threat prevention software that offers solutions for tasks such as monitoring, analyzing and responding to suspicious activity in the system.

Its advantages include monitoring, proactive threat detection, and contextual analysis of user activity. These possibilities cannot be found in all other similar analog programs. However, the complexity of use and potential privacy issues are important factors to consider when choosing this program.

LogRhythm SIEM (Security Information and Event Management) with User and Entity Behavior Analytics (UEBA) module is a powerful security tool that enables organizations to detect and prevent insider threats and cyber attacks. The UEBA module in LogRhythm is aimed at analyzing user behavior and suspicious activity of subjects in the system through machine learning methods and identifying anomalies. Its main features, disadvantages and advantages are listed in table 6.

Table-6 main features of product.

Capabilities	Advantages	Disadvantages
• analyzing the behavior of users and objects; • machine learning and analysis; • possibility of integration with other modules; • ability to analyze risks and prioritize incidents; • automatic response to events; • early detection of threats;	• possibility of high detection of risk; • integration and scalability; • automation of tasks and reduction of incident response time; • flexibility and simple settings; • support for cloud technologies;	• difficulty of installation; • high cost of the program; • high requirements for selection;

In summary, LogRhythm SIEM software with User and Entity Behavior Analytics (UEBA) module is a powerful and flexible security solution that enables effective detection and prevention of insider threats and cyber attacks. High accuracy, integration with other tools and feedback automation, cloud support capabilities make it a valuable tool for organizations of all sizes. However, the complexity of the installation and the high cost of the program can be serious factors to consider when choosing this program.

IBM Guardium Data Protection is a comprehensive tool developed to ensure system security and meet regulatory requirements. The software is designed to prevent unauthorized access to the system and data leakage, and to detect and respond to real-time security incidents. Its main features, disadvantages and advantages are listed in Table 7.

Table-7 main features of product.

Capabilities	Advantages	Disadvantages
• data activity monitoring; • audit and report; • system access control • detection and prevention of threat; • ability to integrate with other security systems; • real-time threat detection;	• high level security; • compliance with regulatory documents; • management through security policies; • flexibility and possibility of expansion; • integration with other solutions; • automation and analysis of the clock;	• difficulties in installation and management of the clock; • the cost of the price of the clock; • high resource consumption of space; • low cost of updates and support;

In summary, IBM Guardium Data Protection is a powerful and effective solution to track data movement in this system and protect them from leaving without a spirit. This program provides a high level of security in the organization and helps organizations comply with safety regulatory requirements. However, its complexity that is, difficulties in installation and management, the cost of its cost can be a problem for some organizations. However, for large enterprises (such as the military sphere) and organizations that want to ensure good data security, IBM Guardium is a reliable and effective choice.

Netskope Insider Threat Management (ITM) is a security application aimed at detecting, monitoring and preventing insider threats in corporate networks. The UEBA module within Netscape ITM assists organizations in protecting confidential information and being dispersed by employees or other trusts. Its main features, disadvantages and advantages are listed in table 8.

Table-8 main features of product.

Capabilities	Advantages	Disadvantages
• user activity monitoring; • analysis of the behavior of users; • prevent data leakage; • response to events; • integration with other security systems; • availability of reports and analyzes;	• comprehensive monitoring; • the high definition of events; • the possibility of integration with Netskope-owned DLP system; • automatic response to events; • flexibility and possibility of expansion;	• complexity of tuning; • the cost of the price of the clock; • let's show that the right events are wrong; • to use the system, it is necessary to undergo training;

In conclusion, this is a platform where there are several effective solutions to the security problems of this system. From this, the UEBA module in Netskope ITM is a powerful and flexible tool for detecting and preventing insider threats. User activity monitoring and their behavior analysis as well as integration with DLP systems allow this application to reliably track confidential information. However, like its other analogues, the high cost of the program and the complexity of the setup can be a hindrance for some organizations. Before implementing the Netscape ITM UEBA module, it is important to assess the needs and capabilities of the company to make the most of its capabilities.

After familiarizing ourselves with the capabilities, disadvantages and advantages of the above AATS, we can compare them through a number of requirements (criteria). The following requirements have been made to compare programs:

- Use of artificial intellect methods;
- Ease of setup and installation;
- Integration with other applications;
- Adaptability to new threats;
- Correct cases as incorrect;
- Ability to view reports;

Name	**Use of AI**	**Settings**	**Integration**
Splunk (UBA)	-	-	+
Varonis DatAdvantage	-	-	+
Forcepoint Insider Threat	-	+	+
ObserveIT	-	-	+
IBM Guardium Data Activity Monitoring	-	-	+
LogRhythm	+	-	+
Netskope Insider Threat Management:	-	-	+

Name	**Flexibility**	**Error**	**Reporting**
Splunk (UBA)	-	-	+
Varonis DatAdvantage	-	-	+
Forcepoint Insider Threat	-	-	+
ObserveIT	+	-	+
IBM Guardium Data Activity Monitoring	-	-	+
LogRhythm	-	-	-
Netskope Insider Threat Management:	-	+	+

Systems for detecting insiders through anomalies play an important role in ensuring the safety of organizations. The use of advanced methods of data analysis, machine learning, user and object movement analysis makes it possible to effectively identify and prevent insiders' threats. Nevertheless, the successful implementation of such systems requires careful planning, taking into account the confidentiality of information and constant updating in accordance with changing threats. It should be noted that the ADS should be used in conjunction with other security measures such as data use management, data encryption and staff training to increase their capacity.

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CLASSIFICATION AND PREDICTION OF LUNG DISEASES USING CHEST X-RAY IMAGES

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A B S T R A C T **In modern medicine, radiography techniques are crucial in diagnosing diseases and predicting their progression. Thoracic radiography (chest X-ray) is not only more affordable and efficient compared to other methods but also one of the most widely used medical imaging techniques. However, as in many fields, the shortage of qualified radiologists presents certain challenges in the application of this method. Current state-of-the-art approaches based on deep learning require extensive supervision, such as manually annotating specific objects with bounding boxes, which makes large-scale implementation impractical. We achieved results in classifying and predicting lung pathologies using thoracic X-ray images by employing a modified MobileNet V3 model, which was fine-tuned and optimized for the task. Additionally, we explored transfer learning with the leverage of existing metadata. Using the NIH Chest-Xray-14 dataset, we compared our approach with other state-of-the-art methods. The main comparison was conducted using the AUC (Area Under the Receiver Operating Characteristic Curve) metric, and we analyzed the differences between classifiers. The overall results indicate that reselecting the data set significantly improved the model's performance, with an average AUC of 0.99 and accuracy above 91.5%. Additionally, this work aimed to develop a model with low computational power requirements that is capable of being deployed on small IoT devices and learning and modification.**

K E Y W O R D S **convolutional neural networks; deep learning; lung disease x-ray images; mobilenet v3; multi-label classification**

INTRODUCTION

The Over the last five years, various lung diseases have significantly impacted people worldwide, with particular attention given to the issues arising from COVID-19. Lung diseases can be exacerbated by physical problems in the lungs and air pollution, which predispose individuals to these conditions. As a result, the normal function of healthy lungs is compromised. Some lung diseases, such as emphysema, asthma, pleural effusion, tuberculosis, and others, including aspiration fibrosis, pneumonia, and lung tumors, reduce the overall air volume needed by humans by impairing the lungs' adaptability to normal functioning. Lung diseases spread rapidly through the air, making it crucial to identify the problem and provide appropriate treatment for the patient. Radiologists primarily use chest X-ray images to detect and diagnose lung diseases. Chest X-rays can help identify and diagnose lung diseases and various other conditions, including bronchitis, infiltrates, atelectasis, pericarditis, fractures, etc. Chest radiography is one of the most widely used diagnostic methods globally, with over 5 million procedures performed annually[1].

This technology is essential and crucial for the examination, diagnosis, and treatment of chest diseases, as these are leading causes of increased mortality worldwide. Consequently, major global projects and international health programs require the use of computer systems to improve workflows and support clinical decision-making. In practice, this can play a significant role in many clinical settings. Significant advancements have been made in detecting and diagnosing lung diseases using artificial intelligence technology. In some cases, neural networks, such as multi-layer perceptrons, learning vector quantization, and recurrent neural networks (RNN), have been employed for diagnosing lung diseases. For example, Sahlol, Ahmed T., and others proposed a new hybrid method for detecting lung diseases. This method extracted features through transfer learning, then filtered features using a new artificial ecosystem-based optimization, achieving over 90% accuracy on two datasets. Chronic obstructive pulmonary disease (COPD) and pneumonia were diagnosed using a neural network. He-Xuan Xu et al. achieved state-of-the-art results with 94% accuracy in segmenting lung tumors. Additionally, Abdelbaki Souid also achieved good results using the MobileNet V2 model with the NIH Chest-Xray-14 dataset.

Deep learning and large datasets enable algorithms to achieve expert-level results in analyzing various medical images, such as detecting diabetic retinopathy, classifying skin cancer, and identifying metastases in lymph nodes. Interest in automated diagnosis of chest X-ray images is growing, and specific algorithms have been developed to detect lung nodules. Still, methods for simultaneously detecting other diseases, such as pneumonia and pneumothorax, have also been proposed. Nilanjan Dey and others developed a new method for detecting pneumonia based on features extracted from chest X-ray images using a modified VGGNet19 model, achieving 97.94% classification accuracy (Table 1). Until recently, the availability of computational power and large datasets allowed for the development of this approach. The National Institutes of Health (NIH) released the ChestX-ray14 dataset, which has led to numerous studies using deep learning approaches for analyzing chest X-rays[2-3].

A new classification method with an accuracy of over 90%.

Authors	Method	Accuracy (%)

Sahlol, Ahmed T et al. [14]	A novel method for detection of tuberculosis in chest radiographs using artificial ecosystem-based optimization of deep neural network features	Dataset 1: 90.2% Dataset 2: 94.1%
He-xuan Hu et al. [18]	Parallel deep learning algorithms with hybrid attention mechanism for image segmentation of lung tumors	94.61%
Nilanjan, Dey et al. [17]	Customized VGG19 Architecture for Pneumonia Detection in Chest X-rays	No Threshold filter: 95.70% Threshold filter: 97.94%
Sahlol, Ahmed T et al. [14]	A novel method for detection of tuberculosis in chest radiographs using artificial ecosystem-based optimization of deep neural network features	Dataset 1: 90.2% Dataset 2: 94.1%

Convolutional Neural Networks derived from ImageNet are among the most widely used methods today. Our goal is to deliver high accuracy while keeping the number of parameters and mathematical operations as low as possible, aiming to bring deep learning neural networks to mobile devices. MobileNet V2 is designed for more general use and performs well on devices with limited resources. However, the MobileNet V3 model, which we selected and modified for this study, is better suited for more complex and multidimensional analysis tasks, particularly on mobile and IoT devices. It is designed for various applications, such as computer vision and IoT applications used in multiple fields, including an AI diagnostic system for classifying fruits and ensuring high levels of fruit productivity[10-11].

METHODS

As the complications of COVID-19 and the spread of lung diseases increase, medical professionals face growing challenges in detecting and combating these illnesses, necessitating new, automated, and reliable methods. We obtained results using a selected and modified MobileNet V3 model to classify and predict lung pathologies from thoracic X-ray images.

This task aims to develop a robust and efficient deep-learning model for classifying chest X-ray images into two categories: Normal and Pneumonia. The model must accurately classify X-ray images as either showing signs of pneumonia or being normal. Additionally, it should be lightweight and optimized for deployment on devices with limited hardware capabilities. The model should generalize well across different datasets and X-ray imaging conditions to be effective in real-world scenarios[14-15].

The dataset used in this study is derived from the NIH (National Institutes of Health) Chest X-ray dataset, including 90,000 chest X-ray images. The images are divided into two main categories, Normal Chest and Abnormal Chest, with a separate folder for test data. The original dataset was obtained from the NIH Chest X-ray dataset, which initially contained over 112,000 images divided into 12 folders and labeled with 835 unique values. This dataset has been restructured and simplified to facilitate efficient training of machine learning models. To streamline and enhance the training process, the dataset has been simplified into two categories: Healthy and Unhealthy chest images.

Dataset Structure:

- Normal_Chest: Contains 42,539 images of healthy chest X-rays.
- Abnormal_Chest: Contains 40,236 images of unhealthy chest X-rays.
- Test_Data: Contains 3,650 images for testing, with 3,575 allocated respectively.

a) Abnormal

b) Normal

Figure 1. Chest X-rays of a) Abnormal b) Normal lungs

Even if we divide the dataset into 2 groups, the abnormal diseases are also divided into several groups, but the total sum is 40236 because one patient may have more than 2 diseases, so the number of diseases divided into groups will be large. Thus, a column chart (bar chart) showing the frequency of diseases is ready[8,16-17].

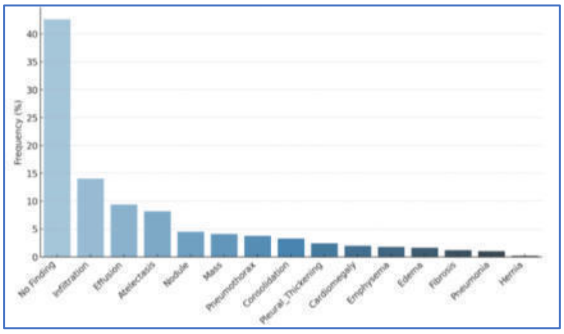

Figure 2. Adjusted frequency of diseases in patient groups

Now, I will analyze the age and gender of the patients. To do this, I create graphs that show the distribution of age and gender for each disease.

Graphs showing the distribution of diseases by age and gender of patients are ready.

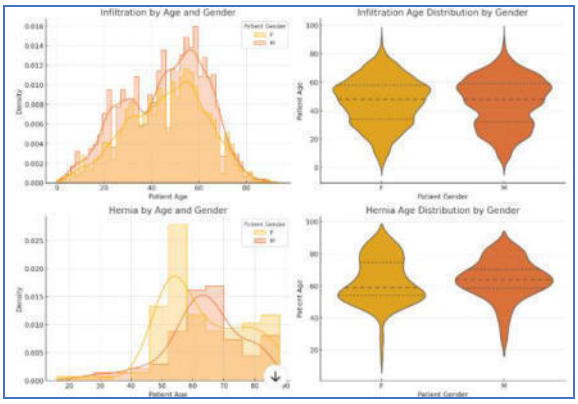

Figure 3. The age and gender of patients with Infiltration and Hernia diseases are analyzed in the above graph. The graphs on the left show the distribution of diseases by age (histogram) and how they differ between sexes. The graphs on the right show the age distribution (violin chart) for each gender.

Figure 4. Block diagram for the proposed architecture: We loaded the dataset and performed data selection and image augmentation. Next, we loaded the CNN model and MobileNet V3 pre-trained in ImageNet and added additional layers for training samples and validation samples. Next, we loaded the new weights and made predictions for the test samples. As a result, a test image with a predicted label was obtained.

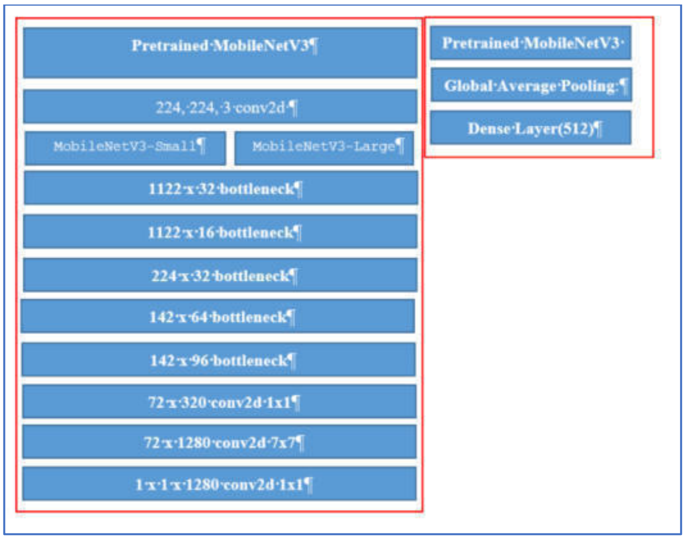

Figure 4. Convolutional neural network architecture: MobileNetV3 pretrained on imagenet with additional global average pooling and a single dense layer

To create a model similar to the architecture in the image you provided but based on MobileNetV3, we can design a neural network that leverages the improvements in MobileNetV3. MobileNetV3 is optimized for mobile and edge devices, offering a balance between performance and efficiency.

MobileNet V3 is a design suited for mobile and edge vision applications. Today, deep learning methods are used not only for computer vision but also in various fields such as robotics, IoT (Internet of Things), natural language processing (NLP), and medical image processing[4,5,18,19].

The customized MobileNet V3 architecture consists of a group of hidden layers based on the bottleneck residual block, which features depthwise separable convolution. This convolution type significantly reduces the number of parameters, creating a lightweight neural network different from standard convolution. Standard convolution is replaced with depthwise convolution, followed by pointwise convolution, also known as depthwise separable convolution.

MobileNet V3 architecture:

The bottleneck residual block mainly consists of three convolutional layers. As shown in Figure 4, the last two layers were already present in the first generation of MobileNet: a depthwise convolution layer that filters inputs and a 1×1 pointwise convolution layer. However, this 1×1 layer now serves a different purpose.

MobileNet V2 is one of the first mobile-centric deep learning architectures, providing high efficiency in a compact size. The main idea behind MobileNet is to replace the standard 3×3 convolution filters with operations split into depthwise separable 3×3 convolution filters followed by a 1×1 convolution. While achieving the same filtering and combining process as standard convolution, the new architecture requires fewer operations and parameters.

In MobileNet V2, pointwise convolution doubled the number of channels or kept them the same. In MobileNet V3, pointwise convolution works in reverse: it reduces the number of channels. Therefore, this layer is now known as the projection layer, as it projects high-dimensional data (channels) into a tensor with reduced dimensions, as illustrated in Table 2.

Original architecture of MobileNet V3

Input	Operator	t	c	n	s
2242 × 3	conv2d	-	32	1	2
1122 × 32	Bottleneck	1	16	1	1
1122 × 16	Bottleneck	6	24	2	2
562 × 24	Bottleneck	6	32	3	2
282 × 32	Bottleneck	6	64	4	2
142 × 64	Bottleneck	6	96	3	2
142 × 96	Bottleneck	6	160	3	2
72 × 160	Bottleneck	6	320	1	1
72 × 320	conv2d 1 × 1	-	1280	1	1
72 × 1280	avgpool 7 × 7	-	-	1	-
1 × 1 × 1280	conv2d 1 × 1	-	k	-	-

The first new feature that comes with MobileNet V3 is the expansion layer, which is a 1 × 1 convolution. Its role is to expand the number of channels in the image data before going to depth convolution. Therefore, the expansion layer always has more output channels than input channels because it works inversely to the projection layer.

The second new feature in the building block of MobileNet V3 is residual connectivity, shown in Figure 4. Our experiments tested MobileNet V3 with an input size of 224 × 224 with 0.5× and 1× channel multiplier. Creating a mathematical model to classify chest X-ray images into two groups (e.g., normal vs. abnormal) involves developing a function or algorithm to distinguish between the two classes based on the input image data. Here's a step-by-step outline to build a new model:

Represent the chest X-ray image as a matrix X of pixel intensities. Each image X can be of size m×n, where m and n are the height and width of the image. Assign binary labels yy to each image, where y=0, represents a normal chest, and y=1 represents an abnormal chest[9-10].

Apply a series of convolutional filters Wk to the input image. Each filter performs a convolution operation to extract local features from the image:

$$Z_k = f(XW_k + b_k) \qquad (1)$$

Here, denotes the convolution operation, bk is the bias term, and f(·) is an activation function like ReLU. After each convolutional layer, apply a pooling operation (e.g., max pooling) to reduce the spatial dimensions:

$$P_k = \max pool(Z_k) \qquad (2)$$

Flatten the output of the final pooling layer into a vector.

Fully Connected Layers: Feed the flattened feature vector into one or more fully connected (dense) layers:

$$h = f(W_h \cdot P + b_h) \qquad (3)$$

where Wh and bhb_hbh are the weights and bias of the dense layer, and f is an activation function.

The final layer should output a single value yˆ which represents the probability of the image belonging to the abnormal class:

$$y = \sigma(W_0 \cdot h + b_0) \qquad (4)$$

where σ(·) is the sigmoid activation function, which maps the output to a probability between 0 and 1.

Use the binary cross-entropy loss function to measure the difference between the predicted probability ŷ and the true label y:

$$L(y, y) = -\left[y\log(y) + (1-y)\log(1-y) \right] \qquad (5)$$

Update the model parameters W and bbb using an optimization algorithm like stochastic gradient descent (SGD) or Adam. The update rule for each parameter θ is:

$$\theta \leftarrow \theta - \alpha \frac{\partial L}{\partial \theta} \qquad (6)$$

where α is the learning rate.

Apply dropout to prevent overfitting by randomly setting a fraction of the activations to zero during training.

Add a regularization term to the loss function to penalize large weights, which helps in preventing overfitting.

Accuracy: Calculate the accuracy of the model by comparing the predicted labels with the actual labels on a validation set.

Plot the ROC curve and calculate the AUC to evaluate the model's ability to distinguish between normal and abnormal chest X-rays.

This model could be implemented using a deep learning framework such as TensorFlow or PyTorch, and trained on the NIH Chest X-ray dataset to classify the images.

Grad-CAM: Use Grad-CAM to visualize which regions of the X-ray images contributed the most to the classification, providing insights into the model's decision-making process.

RESULTS

The lack of computational power played a significant role in limiting the experiment. We used the free cloud service "Kaggle" to edit and test our model in this work. Although this cloud service offers free GPU and fifteen gigabytes of RAM, it was insufficient to train our model for more than ten epochs. However, we achieved good results (see Figures 8 and 9). We began by observing the model's accuracy, and in the first epoch, we obtained a training accuracy of 0.915 and a validation accuracy of 0.9144, with a difference of 0.99%. The remaining epochs followed a similar pattern

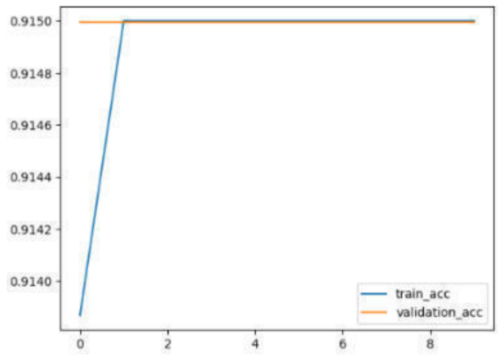

Figure 5. Model accuracy: comparison between training accuracy and validation accuracy over ten epochs.

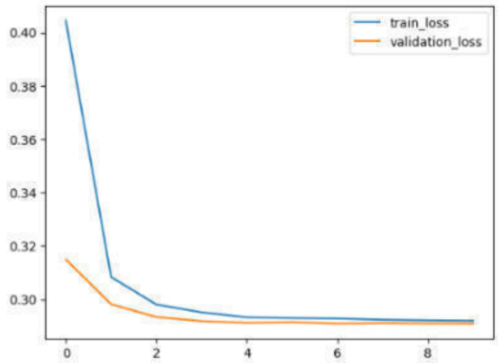

Figure 6. Model Loss: Difference between training phase loss and validation phase loss.

DISCUSSION

A convolutional neural network (CNN) was developed to detect lung diseases in chest X-ray images. The success achieved is largely due to the deep structure of the CNN, which utilizes its ability to extract features at various levels, leading to strong generalization capabilities (as shown in Figure 11, which illustrates some prediction results from the test set). The generalization ability and accuracy of CNN models like MobileNet V3 are significantly higher than other networks, and the results obtained demonstrate that the proposed CNN provided highly accurate results in detecting and classifying diseases in chest X-rays.

Figure 7. Result of a prediction attempt from the test set: two different samples with various index labels, where one or more diseases might be present.

Our optimized MobileNet V3 architecture achieved state-of-the-art results in six out of fourteen classes when compared with Baltruschat et al. (who had the best results in five classes in the official split). However, higher results have been reported in the literature for other approaches. Comparing the performance of different CNN methods presents unique challenges due to being evaluated on separate and random splits of their respective datasets. The model also faced difficulties checking the F1 score, which might necessitate model adjustment or cross-validation.

The model proposed in this study opens up possibilities for implementing lightweight neural network architecture in the medical field, which is crucial, especially when dependent on high-quality resources and in situations where it performs well (with an AUC of 0.99 on average and 91,5% accuracy). There is potential for even further implementation in future experiments. However, the model's sensitivity is relatively low, which could lead to false-negative classifications during predictions. The low sensitivity may arise from the misselected dataset (class distribution imbalance).

CONCLUSION

The results indicate that training a deep neural network in the medical field could be a viable choice, especially as more public datasets become available. However, the clinical application of deep learning remains an open topic. Specifically, for the ChestX-ray14 databases, the 10% higher tag noise level makes it challenging to evaluate the actual network. Thus, a clean test set without label noise is necessary to assess clinical effectiveness.

Future work may involve exploring other model architectures, developing new architectures to leverage label correlations, and incorporating segmentation data.

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AN ALGORITHM FOR FILTERING A MEDICAL IMAGE DATASET FOR MACHINE LEARNING USING ARTIFICIAL INTELLIGENCE

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A B S T R A C T **This article discusses effective methods for utilizing and processing medical images obtained through CBCT (Cone Beam Computed Tomography) in machine learning processes. A dataset of 3D reconstructed images in DICOM format from 2,200 individuals is analyzed. Various approaches are considered for reducing data size and extracting dental slices, including manual segmentation, range-based filtering, and automation using artificial intelligence. By leveraging AI for automated analysis and optimization of medical images, the diagnostic processes are accelerated, and the accuracy of the results is improved.**

K E Y W O R D S CBCT (Cone Beam Computed Tomography), DICOM, 3D, Magnetic Resonance Imaging (MRI), Computed Tomography (CT), Coronal slices, Sagittal slices, Axial slices.

INTRODUCTION

In machine learning, the quality of medical image datasets (or image datasets from other domains) directly impacts the construction of models. When it comes to human health, this is particularly crucial, as the quality of medical image datasets used in diagnostics and medical artificial intelligence (AI) or deep learning models can be a matter of life and death for patients.

Medical image analysis presents additional complexities due to the broader and more intricate formats and data layers than non-medical images. Therefore, in this field, it is critical to leverage AI, machine learning (ML), and deep learning algorithms to understand, interpret, and analyze the data in these image datasets. This article will discuss the challenges involved in creating high-quality datasets for training models on medical images.

Medical image datasets and their analysis play a vital role in modern medicine. Specifically, images stored in the DICOM (Digital Imaging and Communications in Medicine) format are widely used today. This format standardizes the storage of medical images and their metadata, making it easier to exchange information between different devices and software. DICOM is currently the most widely used standard for storing and sharing various medical images, including diagnostic images, X-rays, computed tomography (CT), magnetic resonance imaging (MRI), ultrasound images, and other types of medical visual data. It ensures the accuracy, security, and interoperability of data across devices, which is crucial in the diagnostic process.

METHODS

Medical Images Obtained via CBCT (Cone Beam Computed Tomography)

CBCT (Cone Beam Computed Tomography) technology is a modern imaging method widely used in medicine, particularly in dentistry and implantology. This technology allows for obtaining three-dimensional (3D) images and provides more information than traditional two-dimensional X-ray images. CBCT uses X-rays to create precise images of bones and soft tissues, greatly aiding surgical planning and diagnostic processes.

2.1 About CBCT (Cone Beam Computed Tomography)

Medical images obtained through CBCT technology are stored in DICOM (Digital Imaging and Communications in Medicine) format. The number of DICOM files generated by CBCT depends on capturing multiple images of various sections of the patient's head or body. Several factors affect the number of DICOM files obtained from one patient, including the volume scan, slice thickness, and image resolution. These three factors are the primary determinants for generating DICOM files. Typically, 100 to 900 slices may be taken from a single patient using the CBCT method, meaning the number of DICOM files associated with one patient can range within this spectrum.

The size of each DICOM file produced by CBCT also depends on the factors mentioned above. Generally, each DICOM file generated by CBCT machines can range from 5 KB to 1 MB, depending on the image size, resolution, and quality. The total length of DICOM files generated from a complete scan typically ranges from 10 MB to 1 GB. These values vary depending on the CBCT machine settings, scan area, and the complexity of the patient's anatomy.

Types of Slices in CBCT Images

CBCT images are three-dimensional and display the patient's anatomy from different directions. These images are divided into the following main types of slices: Axial slices, Coronal slices, and Sagittal slices, as shown in Figure 1.

This ability to visualize various anatomical sections enhances diagnostic accuracy and assists medical professionals in precise treatment planning.

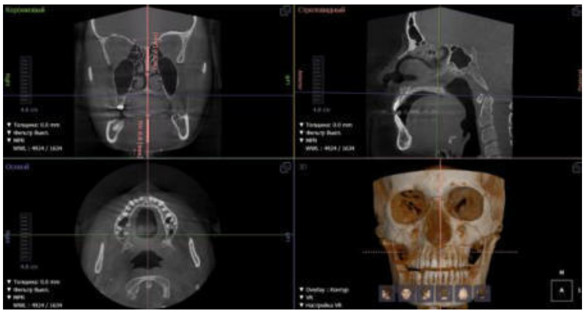


Figure 1. In the 3DViewer software, the upper jawbone of a human and its initial segment are marked and represented in three different slice types (Coronal slices, Sagittal slices, and Axial slices), along with three-dimensional reconstruction (3D reconstruction).

CBCT (Cone Beam Computed Tomography) Technology and Medical Images

As a modern imaging method, CBCT (Cone Beam Computed Tomography) technology is widely used in medicine, particularly in dentistry and implantology. This technology enables the acquisition of three-dimensional (3D) images, providing more detailed information than traditional two-dimensional X-rays. CBCT technology uses X-rays to create precise images of bones and soft tissues, significantly assisting in surgical planning and diagnostic procedures.

Coronal slices show the patient's body from front to back, generating images in a vertical direction.

Sagittal slices show the body from left to right or right to left, representing the body in a lateral plane.

Axial slices display the patient's body from top to bottom, illustrating horizontal cuts.

BCT images are typically obtained in all three slice types, allowing medical professionals to view the patient's anatomical structure more clearly and in greater detail. These images also enable three-dimensional (3D reconstructions), providing much more precise data for diagnostic purposes. This section focuses on working with 3D reconstructed images obtained through CBCT technology.

2.2 Overview of the Dataset

Currently, we have a dataset of 3D reconstructed images from 2,200 individuals, all stored in DICOM (Digital Imaging and Communications in Medicine) format. DICOM is a format commonly used for storing and exchanging medical images, and for each person, an average of 800 axial slices are saved from a single scan. Each file size is approximately 25 KB, and the total length of the complete 3D scan of one individual is around 20 MB. Consequently, the overall dataset exceeds 40 GB in size.

However, not all of the data is necessary for our purposes. The goal is to identify and extract only the images related to the teeth. Instead of processing all 800 axial slices, isolating only the sections relevant to the teeth is essential. This process reduces the need to handle excessive amounts of irrelevant data and optimizes the dataset's size.

Several methods can be employed to extract dental-related images from the dataset, each with its advantages and disadvantages:

Manual Extraction: In this method, a specialist manually reviews each axial slice to identify images containing teeth. While this approach is accurate and minimizes errors, it is time-consuming and inefficient given the large dataset. Manual extraction would require significant time and resources, with 2,200 individuals and 800 slices per person.

Range-Based Selection: A specific range of slices where the teeth are likely located can be specified, even though some inaccuracies may exist. For example, assuming that teeth are located in the middle sections of the axial slices, only images from that portion of the scan are extracted. While this method is faster than manual extraction, it may include some irrelevant images, requiring additional work during subsequent analyses.

Automation with Artificial Intelligence (AI): The third method I tested and used involves applying AI algorithms. In this approach, specialized models are employed to detect distinct teeth features. AI can automatically analyze the images and extract only the axial slices containing teeth. This method automates data processing and provides more accurate results. The AI system uses trained neural networks to identify the slices showing teeth, filtering out other irrelevant data.

Advantages of the AI Approach

Using AI to extract images enhances accuracy and shortens the lengthy manual extraction process. Furthermore, by automatically identifying slices related to the teeth, the dataset's size is significantly reduced, speeding up storage and processing tasks. Additionally, using AI minimizes human error, which can occur during manual processing, making it a highly efficient and cost-effective approach when working with large datasets.

DICOM files should be converted to JPG format to improve data processing efficiency further. When converted to JPG, the file size increases by three to four times compared to the original DICOM format. Therefore, it becomes necessary to develop software that can automatically convert all files while maintaining the quality and accuracy of the images. This software will facilitate broader and more straightforward analysis of the dataset, allowing for more streamlined and efficient medical image analysis processes.

In summary, working with large datasets obtained from CBCT technology requires efficient data handling techniques. AI-based automation in detecting and extracting relevant slices from the data significantly reduces the time and resources needed while improving the accuracy of medical analyses. These advancements not only optimize storage and processing but also enhance diagnostic accuracy in medical practices such as dentistry and implantology, where CBCT is extensively used.

RESULTS

Here is the automated process algorithm for handling DICOM images, mainly focusing on the conversion of CBCT (Cone Beam Computed Tomography) images into the more universally accessible JPG format while efficiently handling large medical datasets:

DICOM Image Processing Automation Algorithm:

Initialize Main Function: The algorithm starts by initializing the primary function, which manages the entire workflow. It prepares necessary directories and calls the functions required to process DICOM files.

Scan Input Directory: Once initiated, the system scans through all folders within the input_base_path. Medical images, including those from dental procedures, are typically stored in large quantities and organized in various subfolders.

Check for DICOM Files: For each folder, the system checks for the presence of DICOM files. These files are often stored in designated folders unique to each patient or procedure. If the folder contains DICOM files, the process continues. If not, the system skips to the following folder.

Create Output Directory: If DICOM files are found, the system automatically creates an output folder for the converted JPG files. This ensures that all converted files are stored in an organized manner.

Invoke Conversion Function: After creating the output structure, the system calls the function convert_dicom_folder_to_jpg, which handles the conversion of DICOM files into JPG format. JPG images are easier to access and share, and they can be used across various medical applications.

List All DICOM Files: The system creates a list of all DICOM files in the folder. Each DICOM file may contain one or more images, depending on the type of scan, such as CBCT or X-rays.

Task Distribution: A task is created to process each DICOM file. This step allows multiple files to be processed simultaneously, improving the speed of the workflow when dealing with large datasets.

Display Progress: Using the TQDM library, the system displays a progress bar, showing the user how much of the process has been completed. This feature is particularly useful when processing large datasets, allowing the user to monitor the progress without manual oversight.

CBCT Image Verification: If CBCT images are being processed (especially for dental applications), an additional step is performed. The system verifies whether the image is relevant to dental structures. If it is, the file is converted to JPG and saved; if not, it is skipped, preventing unnecessary data from being processed.

Save Converted JPG Files: For each processed DICOM file, the corresponding JPG file is saved in the designated output folder. These JPG files can then be used for clinical reviews, patient records, and other medical purposes.

Mark Folder as Processed: Once all files within a folder have been processed, the system marks the folder as complete. This prevents re-processing and helps save computational resources.

Summary of CBCT and DICOM Data:

CBCT (Cone Beam Computed Tomography) is widely used in medical and dental imaging to create detailed 3D representations of structures like teeth, bones, and soft tissues.

Number of DICOM Files: Each CBCT scan can generate between 100 to 300 DICOM files, depending on the scan resolution and coverage.

File Sizes: Each DICOM file typically ranges from 12 KB to several megabytes. A complete CBCT scan may require between 10 MB to 50 MB of storage space.

Planes of Scan:

Axial (horizontal)

Coronal (vertical, front-to-back)

Sagittal (vertical, side-to-side)

These planes offer comprehensive views of the patient's anatomy, facilitating accurate diagnosis and treatment planning.

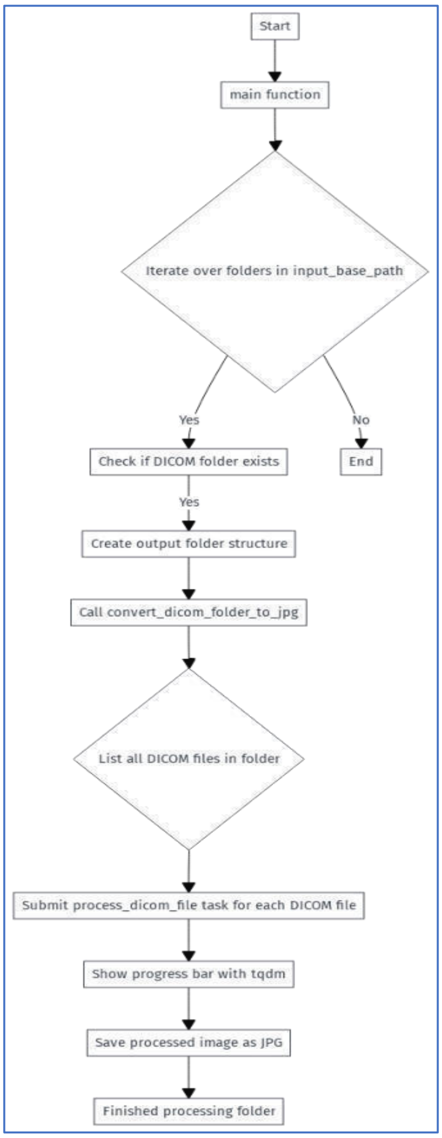
Benefits of Automation:

Speed: Automation reduces the time required for manual extraction and conversion of images.

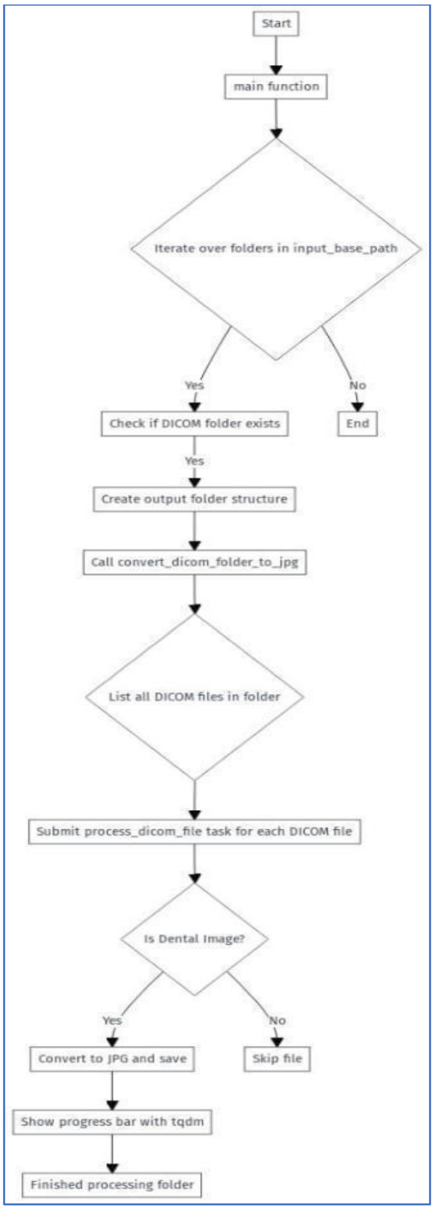
Accuracy: AI-based automation ensures that only relevant images, such as dental slices, are processed, reducing the need for manual intervention.

Resource Optimization: By automating the conversion and extraction processes, the system minimizes storage and computational requirements while ensuring accurate data processing.

This approach ensures that medical professionals have access to efficient and accurate tools for handling large datasets, especially in fields such as dentistry and implantology, where CBCT images are heavily used.



a)



b)

Figure 2. a) The process of converting an image to a DICOM file image in a block diagram. b) The process of automated processing of images, DICOM file images, and images with only teeth in a block diagram.

DISCUSSION

Analyzing DICOM files with the help of artificial intelligence and filtering methods allows for the efficient processing of large amounts of data. In this filtering process, only 200,000 important and high-quality files were selected from the original 1,400,000 DICOM files. As a result of this sampling process, data volume was significantly reduced, and quality improved. This optimized dataset allows for faster machine-learning processes and more accurate classification results.

Filtered and optimized datasets provide high-quality medical images, making machine learning significantly more efficient. Using the newly selected data set, the machine learning processes were accelerated and the classification results became more accurate, making it possible to achieve critical practical medical results.

V. CONCLUSION

Summing up from the above result, this study demonstrates the effectiveness of machine learning and artificial intelligence approaches in analyzing medical images obtained using CBCT technology. Automation techniques in the optimization of data volume and identification of relevant areas of teeth significantly speed up the diagnostic processes and increase the accuracy of the results. This technology can be widely used in clinical practice. It not only facilitates diagnosis but also helps develop individual treatment plans.

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AI ADOPTION IN MACROECONOMICS AND INTERNATIONAL TRADE ISSUES RESEARCH: MAPPING AND TRENDS

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A B S T R A C T **The application of artificial intelligence (AI), particularly machine learning (ML) and neural networks, has significantly impacted macroeconomics and international trade. This study employs a scientometric approach to map the diffusion of AI methods across time, regions, and subfields using data from Scopus and EconPapers. The analysis reveals positive correlations between prestigious institutions and AI-focused research, and an inverse relationship between the Human Development Index and the prevalence of learning-based AI methods in these fields.**

K E Y W O R D S ***Artificial Intelligence (AI), Macroeconomics, International Trade, Machine Learning, Scientometric Analysis, Economic Subfields***

INTRODUCTION

Artificial Intelligence (AI) has profoundly influenced many academic fields, including economics, especially in macroeconomics and international trade. The development of AI, rooted in philosophical and scientific advancements, began with early dreams of human-like machines, such as Leonardo da Vinci's robot knight and Vaucanson's duck. Landmark events, like the 1956 Dartmouth Project, marked the formal foundation of modern AI research [1]. This evolution mirrors broader developments in computer science and mathematics, which have shifted from symbolic reasoning to computational theories designed to solve complex problems more effectively.

In economics, AI introduces precision, especially in behavioral sciences. Pioneers like Herbert Simon used AI to model human decision-making, enhancing the rigor of economic theories [2]. Norbert Wiener's work on cybernetics laid the groundwork for applying feedback systems to economics, helping economists model adaptive economic processes without making rigid assumptions about economic dynamics [3].

By the mid-20th century, economics aligned more with engineering through the application of quantitative methods. This shift was crucial for the integration of AI into economic analysis [4]. Paul Samuelson's emphasis on mathematical rigor set the stage for incorporating machine learning and neural networks in economic modeling. In the 21st century, the widespread availability of Big Data further solidified AI's role in economics, especially in macroeconomic forecasting and international trade analysis. These advancements are seen as crucial to enhancing decision-making in complex and dynamic economic environments. Recent advancements in Big Data, machine learning (ML), and deep learning (DL) have enabled economists to make more accurate predictions and models, sparking debates on whether AI can resolve complex economic problems as Friedrich Hayek had argued were unsolvable [5]. This debate highlights a central issue: while AI offers new ways to analyze economic data, it cannot replace the theoretical frameworks that underpin economic thinking. Economists must remain critical of how AI is used, ensuring that predictions and models do not overlook the human elements of decision-making.

However, AI still faces challenges in addressing economic complexity. Both Simon and Hayek pointed out that while AI can improve data collection and predictions, it cannot fully grasp the nuances of human behavior or localized economic knowledge [6]. Economists must navigate the tension between applying engineering principles focused on efficiency and the broader, unpredictable nature of economics [7], which highlights a central issue: while AI offers new ways to analyze economic data, it cannot replace the theoretical frameworks that underpin economic thinking. Economists must remain critical of how AI is used, ensuring that predictions and models do not overlook the human elements of decision-making.

AI research has experienced periods of optimism and stagnation, known as "AI summers" and "winters." Despite setbacks in the 1970s and 1980s, the resurgence of AI in the 2000s, driven by advances in computational power and Big Data, has led to its widespread use in economics, particularly for prediction and classification [8].

This paper investigates the history and adoption of AI in economics through a scientometric approach, focusing on its application in macroeconomics and international trade. The study provides empirical insights into how AI methods have been incorporated into these subfields, the key researchers and institutions involved, and the evolving role of AI in economic calculation and planning.

METHODS

This study employs a bibliometric approach to analyze the use of AI in macroeconomics and international trade. Data were sourced from Scopus and EconPapers, focusing on AI-related articles in economics journals that aligned with specific JEL classification codes. Articles unrelated to these fields or with niche AI terms were excluded.

The study did not involve human subjects, focusing instead on bibliometric data such as institutional affiliations and author profiles. The Pybliometrics Python package was used to handle and process data from Scopus IDs and ISSNs. The analysis tracked AI methods (learning and non-learning-based) across time, regions, and subfields. It also examined the role of prestigious institutions in the diffusion of AI methods in economics [9]. A focus was placed on identifying key trends, geographical variations, and the influence of top-tier research institutions on AI adoption in economic research.

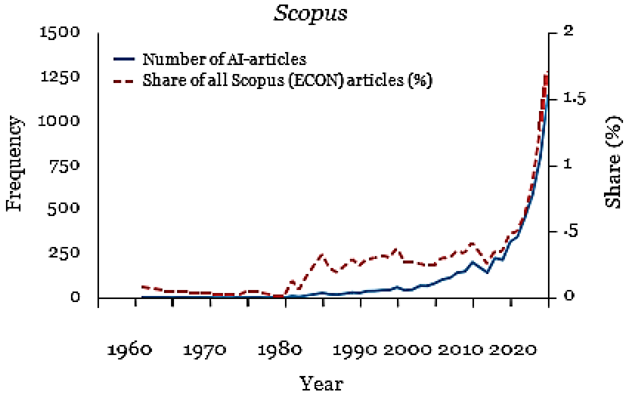
Additional qualitative analysis was conducted to understand the thematic evolution of AI research in these subfields. By analyzing the keywords and abstracts of relevant articles, the study identified shifts in research focus over time, such as the move from symbolic AI to machine learning. Co-occurrence analysis of JEL classification codes was used to track interdisciplinary research and collaboration, offering insights into how AI methods are being applied across various economic subfields. This provides a comprehensive overview of the integration and transformation of AI methodologies within macroeconomic and trade-related research.

RESULTS

AI-related publications in economics have steadily increased since 1986, with a significant rise in the share of papers focused on AI, from 0.13% to 2.4% between 1986 and 2021 [10]. This upward trend is closely tied to the growing availability of computational resources and the increasing complexity of economic challenges, which demand more sophisticated tools for analysis. The early stages of AI in economics were marked by a focus on expert systems and symbolic reasoning, but over time, more flexible and adaptive methods, such as machine learning, gained prominence.

Machine learning and neural networks emerged as crucial tools in economic analysis during this period, particularly in macroeconomics and international trade [11]. Early symbolic AI methods struggled to handle complex economic systems, but connectionist models and Big Data have revitalized AI's role in the field [12]. Newer models enable economists to tackle issues like economic shocks, international trade agreements, and global supply chain disruptions with greater precision. For instance, machine learning algorithms are now used to simulate trade scenarios, optimizing agreements between countries based on a range of economic indicators. This evolution illustrates the growing importance of AI in addressing both theoretical and practical challenges in economics.

Learning-based AI methods dominate AI research in economics. In EconPapers, 80.5% of AI-related papers between 2010 and 2020 focused on machine learning and deep learning, compared to 40%-55% in Scopus [13]. This suggests that recent advancements in AI have been primarily driven by machine learning techniques, which offer a more adaptable and efficient approach to handling economic data. The dominance of learning-based AI methods highlights the importance of prediction and pattern recognition in modern economic research, especially in macroeconomics and international trade.



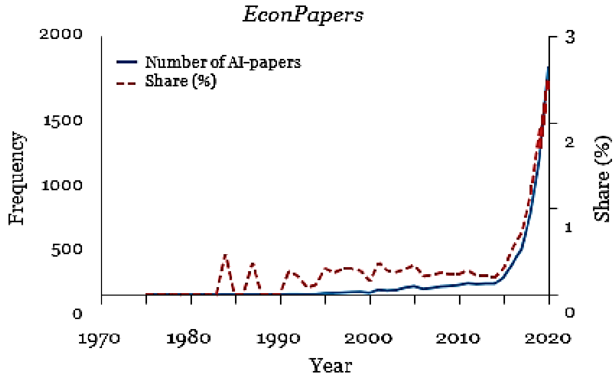


Fig. 1 *Growth of AI-related economics papers in Scopus and EconPapers and relative (%) to overall number of economics papers over time (courtesy: Bickley, S.J., Chan, H.F. & Torgler, B. Artificial intelligence in the field of economics. Scientometrics 127, 2055–2084).*

A smaller share of AI research in economics focuses on economic calculation and social planning, with the proportion of related papers remaining stable over the decades [14]. Ethical concerns regarding AI's role in economic decision-making have become more prominent in recent years, particularly as machine learning models are increasingly used for public policy and social planning. Issues such as data privacy, algorithmic bias, and the transparency of AI systems are critical for ensuring that AI contributes to equitable and responsible economic outcomes [15].

DISCUSSION

AI's application in macroeconomics and international trade has expanded, but its adoption remains slower compared to other economic subfields like environmental economics. Machine learning offers promising tools for enhancing policy-making and predictive accuracy, but traditional econometric methods still dominate in these fields [16]. The slower uptake in macroeconomics and international trade may be due to the complexity of modeling large-scale economic systems, where AI's advantages are not yet fully realized. However, the potential for AI to revolutionize these fields remains significant, particularly as more sophisticated models are developed.

The study also found underutilization of AI in financial economics and macroeconomic policy research, areas where AI could offer substantial benefits in handling complex data. The historical reliance on traditional econometrics may have hindered the adoption of AI in these areas, but growing market complexities suggest a need for AI tools [17]. AI ability to process and analyze massive datasets will likely lead to its wider adoption in these fields, especially as policymakers seek more accurate and timely insights into global economic trends.

AI has proven valuable in predicting economic trends and addressing global economic dynamics, but its full potential remains unrealized, particularly in areas requiring ethical oversight and localized knowledge. However, concerns over data privacy and the possibility of algorithmic bias must be addressed to ensure that AI's benefits are shared equitably. Future research should focus on developing transparent and ethical AI models that respect data privacy while providing accurate and actionable economic insights.

Additionally, the study revealed that AI's role in economic calculation and social planning is often limited by philosophical and ethical debates. While AI can improve the efficiency of economic models, it cannot fully replace human judgment in decision-making processes. Policymakers must carefully balance the use of AI in economic planning, ensuring that its implementation does not exacerbate existing inequalities or undermine democratic processes. These concerns are particularly relevant in the context of international trade, where AI-driven models could influence negotiations and agreements with far-reaching consequences.

CONCLUSION

AI's integration into macroeconomics and international trade is still developing. While AI has the potential to transform economic analysis, it also poses challenges, particularly in addressing ethical concerns. Future research should focus on integrating AI with traditional methods, improving its role in forecasting and policy-making, and exploring its application in international trade negotiations and economic shocks. By understanding the limitations and strengths of AI, economists can leverage these tools to enhance both theoretical and practical insights into complex economic phenomena.

Interdisciplinary collaboration will be essential for ensuring AI's ethical use in these fields. Additionally, the cultural and institutional factors influencing AI adoption across regions should be further explored to facilitate broader implementation. Future research could also investigate how AI might help resolve longstanding economic issues, such as predicting financial crises or optimizing trade agreements. As AI tools become more sophisticated, their application in macroeconomics and international trade may evolve, offering new opportunities for innovation in economic theory and practice.

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INTEGRATION OF AI AND BUSINESS FOR A SUSTAINABLE FUTURE

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A B S T R A C T **The integration of artificial intelligence (AI) into business operations presents transformative opportunities for promoting sustainability and efficiency. This paper investigates how AI technologies can be harnessed to advance sustainable business practices. Through a detailed literature review, methodological analysis, and discussion of results, this study aims to offer a robust framework for leveraging AI in pursuit of long-term sustainability goals.**

***K E Y W O R D S** Artificial intelligence, sustainable business practices, environmental impact, machine learning, corporate social responsibility, predictive analytics.*

INTRODUCTION

Artificial Intelligence (AI) encompasses a range of technologies designed to simulate human intelligence, including machine learning (ML), natural language processing (NLP), and robotics. AI enables systems to learn from data, make decisions, and perform tasks that traditionally required human intervention. Key AI technologies include:

- **Machine Learning:** Algorithms that allow systems to improve their performance based on experience.
- **Natural Language Processing:** Techniques for enabling machines to understand and respond to human language.
- **Robotics:** Automated systems that can perform tasks in physical environments.

Sustainability in business refers to practices that balance economic growth with environmental protection and social equity. The three pillars of sustainability include:

- Environmental Sustainability: Reducing carbon footprint, managing waste, and conserving resources.
- Social Sustainability**:** Ensuring fair labor practices, supporting community development, and promoting equity.
- Economic Sustainability: Achieving long-term economic growth while maintaining profitability and efficiency.

Integrating AI with business practices can enhance operational efficiency, reduce waste, and promote responsible resource use, thereby supporting sustainability objectives. The convergence of AI and sustainability has the potential to address pressing global challenges such as climate change, resource depletion, and social inequality.

Businesses face significant hurdles in adopting sustainable practices, including:

- **High Costs:** Initial investments in sustainable technologies and processes can be substantial.
- **Complexity:** Implementing and managing sustainability initiatives can be complex and resource-intensive.
- **Data Overload:** Managing and analyzing large volumes of data to drive sustainability can be challenging.
- AI offers solutions to these challenges by:
- **Enhancing Efficiency:** AI can optimize resource use and streamline operations.
- **Improving Decision-Making:** Data-driven insights can guide more effective sustainability strategies.
- **Driving Innovation:** AI fosters the development of new technologies and business models that support sustainability.

To analyze and demonstrate how AI technologies can be integrated into business operations to promote and achieve sustainability.

Specific Objectives:

- Evaluate existing literature on AI applications in business and their impact on sustainability.
- Propose methodologies for effectively integrating AI into business practices.
- Assess the potential benefits and risks associated with AI adoption for sustainable business operations.

METHODS

The analysis is guided by several theories and models:

- Technology Acceptance Model (TAM): Explains how users come to accept and use new technologies.
- Triple Bottom Line (TBL): Focuses on the three pillars of sustainability—people, planet, and profit.
- Resource-Based View (RBV): Considers how AI can be a valuable resource for achieving competitive advantage and sustainability.

Data Analysis Methods

- Qualitative Analysis: Thematic analysis of case studies and literature to identify key trends and insights.
- Quantitative Analysis: Statistical evaluation of empirical data related to AI impacts on sustainability metrics.

RESULTS

AI technologies are being applied across various business functions, including:

- Supply Chain Management: AI-driven predictive analytics optimize inventory levels and reduce waste.
- Predictive Maintenance: AI algorithms forecast equipment failures, minimizing downtime and maintenance costs.
- Customer Service: Chatbots and virtual assistants enhance customer interactions and streamline support processes.

Case Studies

- Walmart: Utilizes AI for optimizing supply chain operations, reducing waste, and improving sustainability.
- Tesla: Employs AI in energy management systems to enhance the efficiency of solar energy production and storage.

Environmental Impact

- **Energy Efficiency:** AI enables the optimization of energy use in manufacturing and facilities management.
- **Waste Reduction:** AI tools help in identifying and reducing waste generation through improved process management.

Social Impact

- **Labor Practices:** AI-driven automation can lead to job displacement but also creates opportunities for new roles and skill development.
- **Community Engagement:** AI applications can enhance corporate social responsibility initiatives by targeting social impact projects more effectively.

Economic Impact

- **Cost Reduction:** AI reduces operational costs through process automation and efficiency improvements.
- **Economic Growth:** AI-driven innovation can lead to new business models and market opportunities.

3.3 Methodologies for Integration

Implementation Strategies

- **Phased Approach:** Gradual integration of AI technologies, starting with pilot projects and scaling based on success.
- **Collaboration:** Partnerships with technology providers and sustainability experts to ensure effective implementation.

Challenges and Solutions

- **Data Privacy and Security:** Addressing concerns related to data protection and ethical AI use.
- **Skill Gaps:** Training and upskilling employees to work effectively with AI technologies.

DISCUSSION

4.1 Interpretation of Results

Synthesis of Findings The integration of AI into business operations has demonstrated significant potential for advancing sustainability goals. The case studies highlight the practical benefits and challenges of AI adoption, providing valuable insights into best practices and strategies.

Implications for Business Businesses that leverage AI effectively can achieve substantial improvements in sustainability performance, including reduced environmental impact, enhanced social responsibility, and economic benefits.

4.2 Theoretical and Practical Implications

Theoretical Contributions The study contributes to existing theories by illustrating how AI can be a strategic resource for achieving sustainability objectives. It extends the Technology Acceptance Model and Triple Bottom Line frameworks by incorporating AI-specific considerations.

Practical Recommendations

- **Strategic Planning:** Develop a clear AI strategy aligned with sustainability goals.
- **Stakeholder Engagement:** Involve key stakeholders in the AI adoption process to ensure alignment and support.
- **Continuous Monitoring:** Implement mechanisms for ongoing evaluation and adjustment of AI initiatives to maximize sustainability outcomes.

4.3 Limitations

Scope of Study

- **Literature Constraints:** Limited by the availability of empirical studies and case examples specific to AI and sustainability.
- **Generalizability:** Findings may vary across different industries and geographic regions.

Future Research Directions

- **Longitudinal Studies:** Conduct studies to assess the long-term impacts of AI on business sustainability.
- **Sector-Specific Research:** Explore AI applications and sustainability outcomes in various industry sectors.

CONCLUSION

The potential for AI to drive sustainable business practices is profound. As businesses continue to face increasing pressure to adopt more environmentally and socially responsible practices, AI offers a powerful tool for achieving these goals. By leveraging AI, companies can enhance operational efficiency, reduce their environmental impact, and foster social responsibility.

However, the integration of AI also presents challenges, including data privacy concerns, the need for skilled personnel, and potential ethical considerations. Addressing these challenges requires a thoughtful approach, including robust data governance policies, investment in employee training, and ongoing dialogue about the ethical use of AI technologies.

Moving forward, businesses must embrace AI not just as a technological innovation but as a strategic asset for sustainability. Companies that effectively integrate AI into their operations will not only benefit from improved efficiency and cost savings but will also position themselves as leaders in sustainable business practices.

In summary, the integration of AI into business operations is not merely a technological upgrade but a critical step towards achieving a more sustainable future. By aligning AI strategies with sustainability goals, businesses can contribute to a more resilient and equitable global economy, driving progress towards environmental stewardship, social equity, and economic prosperity.

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THE INFLUENCE OF INVESTMENTS ON INNOVATIVE ACTIVITIES IN ENTERPRISES ON THE PROFITABILITY OF ASSETS

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A B S T R A C T **The article analyzes the impact of investments in innovative activities on the profitability of the company's assets. The article examines the mechanisms of this effect, provides statistical analysis data, and develops recommendations for managing investments in innovation to increase the profitability of assets.**

K E Y W O R D S ***Innovations, Investments, Return on assets, Innovative activity, Financial management.***

INTRODUCTION

Innovation has become the main factor of business success in the period of accelerated scientific and technical development. Both developed and developing economies recognize the profound role of innovation in driving sustainable economic growth, creating competitive advantage, and driving firms to new heights of performance.

Investing in innovation is not just a choice; it has become a necessary strategy for companies seeking to survive and thrive in today's dynamic market economy. These investments, including funding for research and development, purchasing advanced technology, training employees, and more, are critical to spur innovation.

The relationship between investment in innovation and firm performance, particularly return on assets (ROA), is a topic of considerable research interest. While some studies have found a positive correlation, others have suggested that the impact varies by business type, size and sector, as well as the economic context, revealing a more complex scenario.

Thus, the article seeks to explore this complex issue. The study aims to investigate the impact of investment in innovation activities on the company's return on assets, providing empirical data that augments existing theoretical frameworks in this area. As such, it serves to fill gaps in the literature by offering greater insight and practical guidance for companies seeking to optimize innovation investment strategies to enhance profitability.

nnovative activity of enterprises is of great importance in achieving economic stability of the Republic of Uzbekistan. The more financially stable and highly liquid enterprises are, the more they can overcome the obstacles they face without a crisis. And this, in turn, is beneficial for the state. In this regard, wide opportunities have been created for business entities in our country. These include:

Tax exemptions, important laws and decisions to attract foreign investments, opening a wide path for export, facilities for importing new technologies, reliefs for high income have been created. Resources, in particular, financial constraints play the biggest role in the innovative activities of enterprises. It is shown that the main sources of financing in modern conditions are debt funds from the financial credit market, as well as self-financing of the enterprise at the expense of the company's profit and the issue of additional shares.

As shown, taking into account indicators such as solvency and financial stability allows the company to provide a high level of investment attractiveness in order to increase its ability to attract debt funds, and maintaining high levels of indicators such as profitability and business activity is improved. The effectiveness of financing innovative activities from the company's own funds. The main result of the research is the development of a system of key indicators that influence the increase of innovative activity of companies in the conditions of financial deficit. Timely consideration of these indicators and maintaining them at the required level leads to an increase in the efficiency of the enterprise's innovative and investment activities; this conclusion makes this work relevant.

METHODS

A combination of qualitative and quantitative methods was used in this research. Qualitative analysis includes a review of current scientific and specialized literature on the research topic, including academic journals, scientific articles, reports, and other reliable sources. This made it possible to form the theoretical basis of the research, to identify the main concepts, principles and models, as well as to identify the main trends and significant shortcomings in the existing theory.

Quantitative research methods include the collection, processing and analysis of statistical data. A statistical analysis of information on investment in innovation and return on assets of various companies was carried out. In addition, regression analysis was used to examine the relationship between investment in innovation and return on assets and to determine the extent of this effect.

Thus, the complex application of qualitative and quantitative research methods allowed a deep and objective understanding of the studied issues, as well as a reliable verification of the put forward hypotheses.Smirnov and Ivanov (2015) emphasized the important role of investment in innovation in strengthening the company's competitive advantages and financial performance. This scientific approach is supported by Petrov (2017), who showed a strong relationship between investment in innovation and return on assets. However, as noted by Kuznetsov (2018), the relationship between investment in innovation and return on assets may not always be positive, and the success of innovation largely depends on the market acceptability of the innovative product or service as a result of his research.

In her empirical study, Romanova (2019) found that the impact of investment in innovation on the return on assets is more pronounced in industries with rapid technological development. Miller and Davydov (2020) add that the regulatory environment also plays a role in the relationship between investment in innovation and financial performance.

Belova (2016) offered a different perspective, noting that the effectiveness of investment in innovation largely depends on the internal management and strategic planning of companies. As noted by Zelenov (2019), the impact of investment in innovation on return on assets can also be caused by external factors such as economic conditions and market competition.

Lebedeva and Mironov (2021) found that SME 's benefit more from investing in innovation than large corporations. Volkov (2020) emphasized the importance of continuous investment in innovation and pointed out that companies that continuously invest in innovation have higher return on assets in the long run.

Finally, Chernysheva and Sokolov (2018) recommended the use of robust measurement and evaluation methods to properly assess the impact of innovation investments.

RESULTS

The results of the study show that investments in innovation have a significant positive effect on the profitability of enterprise assets. In order to determine the relationship between the variables, we analyzed the activities of "Jizzahdon products" JSC and used statistical data

Variable	Average	Median	satandard	Minimum	maximum
ROA	0,12	0,11	0.03	0,07	0,19
Investment in innovation	5000	4800	800	3500	6500
Debt capital	20000	18000	3500	15000	25000
Age of the company	10	10	2	7	15
Equity	15000	14500	2000	12000	18000
Inventory turnover	6	6	1	4	8

1. ROA (return on assets): the average return on assets is 12%, which shows a very high efficiency of using the company's assets. However, there are significant differences between companies - the standard deviation is 3%.

2.Investment in innovation: the mean investment in innovation is 5000 (unit not shown), but the standard deviation is 800, indicating significant variability of this indicator between companies.

3. Debt capital: Average debt capital is 20,000, variance is 3,500. Here we see that there is a big difference between companies depending on their credit policies and capital structure.

4. Age of the company: The average age of the company is 10 years, the standard deviation is 2 years. This indicates that the sample includes companies with approximately the same service life on the market.

5.Equity: mean capital is 15,000, standard deviation is 2,000. This shows that the companies in the sample have different levels of capitalization.

6.Inventory turnover: The average value of this indicator is 6 times a year, the standard deviation is 1. It shows the difference in the efficiency of inventory management between enterprises.

In general, the data represent a variety of companies with different capital structures, different levels of investment in innovation, and different asset management performance.

DISCUSSION

Investments in innovative activities significantly impact the profitability of assets in enterprises, typically by improving operational efficiency, enhancing product offerings, and creating competitive advantages. Here's a breakdown of how these investments influence profitability:

4. 1. Enhancing Operational Efficiency

- Process Innovation: Investments in new technologies, automation, and improved processes can reduce production costs, improve efficiency, and enhance product quality. For instance, adopting advanced manufacturing techniques can lower waste and increase output, thereby increasing the return on assets (ROA).

- Resource Optimization: Innovative solutions such as AI-driven resource management or inventory control systems can optimize asset use, ensuring enterprises get more value from their existing resources.

4.2. Product and Service Innovation

- Higher Revenue Generation: Investing in product innovation can lead to the development of new products or services that meet market demands more effectively. Innovative products can command higher prices, open up new markets, and lead to increased sales, directly affecting profitability.

- Market Differentiation: Innovation often allows firms to differentiate themselves from competitors, creating brand loyalty and reducing price sensitivity. This differentiation can protect market share and enhance asset profitability.

4.3. Risk Reduction and Future-Proofing

- Sustainability and Long-Term Growth: Enterprises investing in innovation are better positioned to adapt to industry changes and market disruptions. This reduces the risk of asset depreciation or obsolescence, preserving their long-term profitability.

- R&D and Competitive Edge: Enterprises that consistently invest in research and development (R&D) can maintain a competitive edge, ensuring they stay ahead in a rapidly evolving market. A strong innovation pipeline ensures sustained revenue growth and consistent asset returns over time.

4.4. Scaling and Expansion

- Increased Productivity: Technological innovation enables businesses to scale their operations without proportionally increasing their costs. This results in better utilization of fixed assets (such as machinery or intellectual property) and improves the asset turnover ratio.

- Expansion into New Markets: Investments in innovation often lead to the exploration of new markets, providing enterprises with diversified revenue streams. This diversification spreads risk and can increase the overall profitability of the company's assets.

4.5. Increased Intangible Asset Value

- Intellectual Property (IP): Innovation can lead to the creation of valuable IP, such as patents, trademarks, and proprietary technologies. These intangible assets often have high profitability potential and can increase the company's overall asset base without proportional increases in physical investments.

- Brand and Market Position: Innovative companies often develop strong brands, which become valuable intangible assets contributing to long-term profitability.

CONCLUSION

During the research, it was found that investments in innovative activities have a significant positive effect on the profitability of the company's assets.

This confirms the hypothesis that innovation plays a key role in increasing financial efficiency and business stability.

Thus, based on the analysis, it can be concluded that investment in innovation not only helps to increase the competitiveness of the enterprise, but is also an important factor affecting its profitability. Therefore, managing investments in innovation should be a key element of a company's strategy to increase return on assets and achieve long-term financial success.

Therefore, the management of enterprises should pay special attention to the management of investments in innovation, not only to increase the volume of these investments, but also to optimize their distribution in order to get the maximum benefit from the assets.

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DEVELOPMENT OF THE SOFTWARE TOOL FOR GEOMETRIC MODELING OF FRACTAL STRUCTURES OF CONSTRUCTION AND ARCHITECTURAL OBJECTS

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A B S T R A C T This article is dedicated to the development of the software tool for geometric modeling of fractal structures of construction and architectural objects. The information about geometric modeling methods and algorithms is given in this article. The proposed "The Fractal Architect" software tool gives opportunity for quick visualization to develop complex fractals. The advantage of this program is that the program is not limited to two-dimensional fractal forms, but it allows to visualize three-dimensional complex fractal forms such as Menger's sponge, Serpin tetrahedron, on the basis of the hybrid method of integration of R-function and L-system methods, and 2D and 3D objects with fractal structures which contain complex fractal structures in construction and architectural objects, patterns, the building, and to construct many new shapes through geometric substitutions.

K E Y W O R D S Fractal, geometry, modeling, computer graphics, architecture

INTRODUCTION

The software tool which was developed for building complex 2D and 3D fractal structures as part of the research, has the workflow which was based the route which was the ideal for visual effects, because it allows users to create dynamic simulations and its special features to quickly visualize geometric models.

Initially, the geometrical models of two- and three-dimensional fractal structures of complex type were developed on the basis of the proposed and improved algorithms through the "C++" programming language. After receiving positive results, on the basis of the existing proposed and improved algorithms, the technology "C++" + "Qt 6" + "OpenGL" was used and the software tool was developed.

OpenGL is a set of commands which control the use of graphics devices. If the device consists only of an addressable frame buffer, then OpenGL must be fully implemented by using Central Processing Unit resources. Typically, a graphics device provides different levels of speed: from the generation of lines and polygons to the hardware implementation of complex graphics methods by using various operations on geometric data. OpenGL is considered a layer between the device and user levels, it gives opportunity to provide a uniform interface on different platforms by taking advantage of the capabilities of the devices. In addition, OpenGL can be viewed as a finite automaton, its state is determined by the current normal, color, texture coordinates and other attributes, values of symbols, and many values of special variables. All of this information is used to input the vertex coordinate graphics system in order to construct a figures which are displayed. Changing the states is done through commands which are used to run functions [1-3].

METHODS

The procedures for drawing elementary fields (sphere, cube, pyramid, prism, and others.) include representation by R-function, L-system and IFS in the block of geometric models [4]. Together with this, the functions and algorithms which perform operations such as three-dimensional geometric replacement (rotation, reflection, scaling, and displacement) of computer graphics in space exist [5].

The complex three-dimensional fractal visualization algorithm is implemented as follows by using the integration of the R-function and the L-system method (Fig. 1).

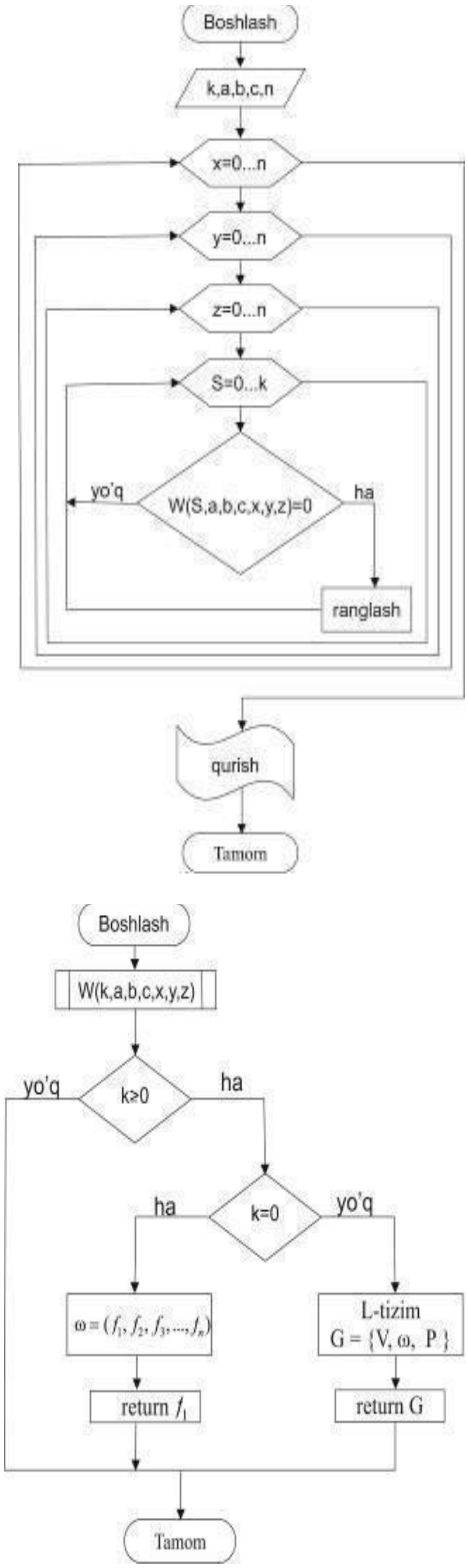


Fig. 1. Algorithm block schemes for constructing complex three-dimensional fractals by using R-function and L-system method integration

The rendering options which allow us to choose colors, change their contrast, choose and edit a background color, before or after constructing the complex fractal shapes exist.

The complexity of processing affects the formation of the price of 3D visualization, the longer it takes, and the more expensive it is to work on the project. If it is possible, designers simplify the rendering process, for example, they calculate individual moments or use other means to reduce rendering time without compromising its quality.

RESULTS

Interface and capabilities of a software tool for visualizing complex fractal structures. Complex fractal 2D and 3D shapes can be built by using "The Fractal Architect" software tool.

The views of the working graphic interfaces of the developed software tool are presented below.

The appearance of the main interface which appears on the screen when the software is started is shown in Figure 2. The development of real objects with a complex fractal structure was considered through specific examples in "The Fractal Architect" environment on the basis of the given theoretical information. This main interface contains the following section menus for controlling the tool:

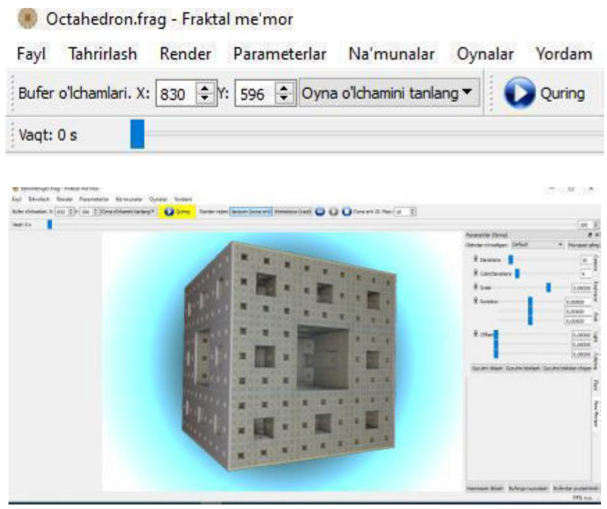


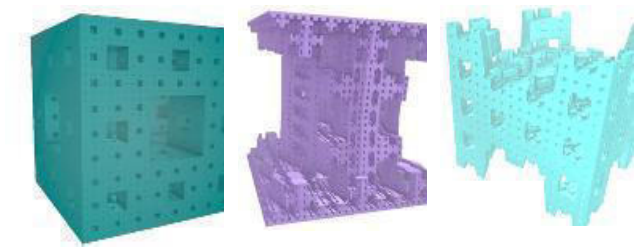
Fig. 2. The main working window of the software

"The Fractal Architect" software tool gives opportunity to quickly visualize in order to develop complex fractals. The advantage of this program is that the program is not limited to two-dimensional fractal forms, but it gives opportunity to visualize 2D and 3D objects with fractal structures which contain complex fractal structures in construction on the basis of the hybrid method of integration of R-function and L-system methods, three-dimensional complex fractal forms such as Menger's sponge, Serpin tetrahedron, and complex fractal structures in construction and architectural objects, patterns, , and to construct many new shapes through geometric substitutions. Before synthesizing the image of object, it is necessary to enter information about its structure (topology), geometry, texture (structural structure), visual properties and relationships between surrounding objects (location in space) into the graphic system. This information form the geometric model of the object. The depicted objects are represented in different coordinate systems at different stages of their transformation. The globe coordinate system is related to the geographic coordinate, and the image coordinate system is related to the position of the observer. The dynamics of scene objects are expressed as a whole in them. It is convenient to express the structure of objects in the object coordinate system, the objects remain unchanged. If different objects are created from the same primitives, then it is appropriate to represent these primitives in their own coordinate system - the primitives' coordinate system [6].

Using geometric substitutions in computer graphics, the program code converts the Cartesian coordinates of a point in space into spherical coordinates. As a result, the following complex fractal structures are obtained (Fig. 3).

DISCUSSION

The discussion section would interpret the results in light of the research question and relevant literature. It would discuss the implications of the findings, considering both the strengths and limitations of the study. Any unexpected or contradictory results would be addressed, and potential explanations or alternative interpretations would be explored. The section would also highlight the theoretical and practical implications of the study's findings, such as the potential for exercise interventions to be implemented in geriatric care settings. Finally, the discussion would conclude with suggestions for future research directions, such as investigating the long-term effects of exercise on cognitive function or examining the impact of different exercise modalities on specific cognitive domains.



(a)

(b)

Fig. 3. Initial state of Menger's sponge (a), Serpin's pyramid (b) and the shapes which were created after changing the parameters

The results are aesthetically appealing and a first step towards fractal art, the opportunities exist in order to further development of the idea and application to architecture (see Figure 4). Another important aspect which must be considered is considered the artistic control of fractal shapes. For example, it would be interesting to study how the architect can make changes in fractal space and when the shape of a fractal is defined. In short, it can be expected which it can be done by manually sketching over the fractal shape, but together with this, investigating semi-automatic ways of doing it will also be a direction for future research [7-11].

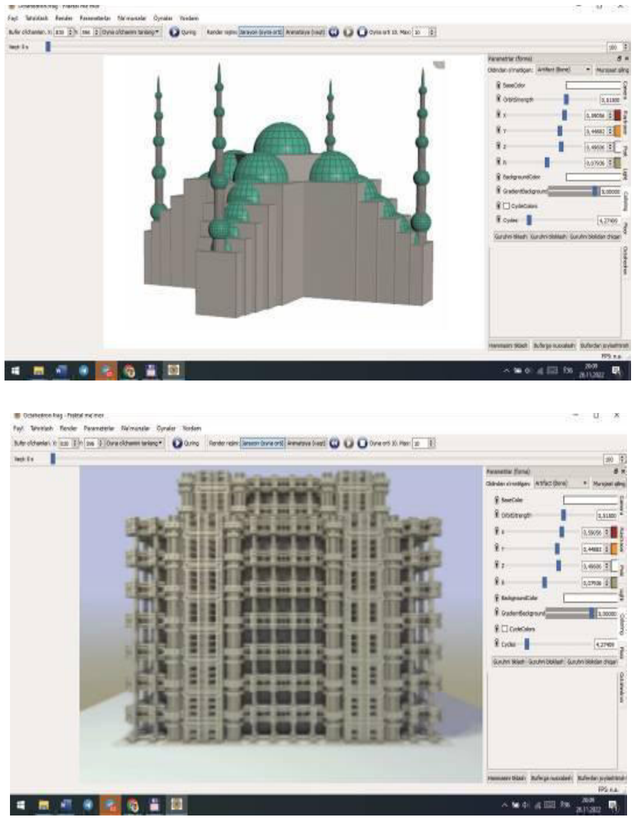


Fig. 4. Building architectural objects are visualized models of complex fractal structures

Table 1 shows the results of a comparative analysis of the software tool "The Fractal Architect" developed on the basis of existing and proposed geometric models and algorithms with other software tools for creating fractal shapes which exist nowadays.

Table 1.Comparative analysis of the software called "The Fractal Architect" with other software tools for creating fractal shapes

Software tools / **Characteristics**	Fractal architect	Mandelbulb 3D	Fractal Architect	Gnofract 4	Fractal Now	Incendia
Draw 2D fractals	+	–	+	+	–	–
Draw 3D fractals	+	+	+	–	+	+
Fractal library	+	–	+	+	+	–
Random Fractals	+	–	–	+	+	–
Enter fractal parameters	+	+	–	–	–	+
Rotate/zoom the image	+	+	+	+	+	+
Save the image of the shapes to the file	+	+	+	+	+	+
Save the fractal to the file	+	–	–	–	–	–
Save the video file	+	+	–	–	+	+

Technology	C++ Qt 6 OpenGL	Python 3 Qt 4	C++ + Qt 5 + OpenCL	Python 3 Pycairo GTK	Python 3 Qt 5	C++

As can be seen from this table, one of the advantages of the proposed software tool over the software tools which are listed in Table 1, is that it has the ability to automatically draw complex fractal 2D and 3D shapes (on the basis of mathematical formulas), and fractals with a new random appearance can be saved to a video file with the help of a combination of shapes. It should be added that the interface of the software tool is in Uzbek.

CONCLUSION

It can be seen from that the use of the software tool "The Fractal Architect" increased the volume of product production by 7-10%. Reducing costs, together with this, reducing costs with the same revenue, will lead to increase in gross and net profit. Increasing the efficiency of production processes, replacing expensive materials with cheaper ones, and using new technologies give opportunity to reduce costs, in turn; this led to increase in product profitability.

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TO THE QUESTIONS OF THE INFORMATION SUPPLY OF AQUIFER WATER LEVEL MEASURING DEVICES WITH RENEWABLE ENERGY USING SOLAR PANELS

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ABSTRACT **In the article was considered, for underground water measuring devices based on solar electric panels, i.e. measurement of regime-forming parameters of groundwater in wells monitoring groundwater flow in hydrogeological systems, fuzzy models of calculation, processing of groundwater with processing based on implementation algorithms introduction of automated measurement methods of remote control at control points. Opportunities, aspects and problems of creating and providing energy sources based on low-power alternative energy sources, the functional activity of innovative hardware and software tools that increase efficiency with their introduction are considered as an example.**

KEYWORDS ***Measuring devices, aquifer water level, energy sources, solar electric panels, fuzzy models, innovative hardware, software tools.***

INTRODUCTION

Providing the population with drinking water in the world, assessment of underground water resources and their rational use, determination of the laws of water exchange in the regional drinking water field based on automated measurement methods, especially in hard-to-reach places, improvement of the automated monitoring system and the improvement of scientific and practical methods for the use of high-tech software tools attention is paid. Particular importance is attached to determining the regime parameters and status of underground water in remote monitoring wells and energy supply of automated measuring devices at monitoring points. Among them, one of the main tasks is the development of algorithms and software tools for improving automated measurement methods in monitoring regime parameters of various hydrogeological conditions in developed countries, especially in countries such as the USA, Canada, France, China, the Netherlands, Denmark, Japan, and Russia.

Currently, as hydrocarbon sources of energy are running out and their extraction is becoming more complicated, the interest in alternative energy sources is increasing all over the world, including in Uzbekistan. Also, due to the increase in the population of the land and the improvement of their living conditions, the demand for electricity is increasing sharply. It is not possible to satisfy this demand by traditional methods, because the capacity of hydroelectric power stations operating on the basis of water resources is limited, and the conflicts in the supply of these resources are also increasing. The operation of thermal power stations depends on the sources of hydrocarbons. The events of Chernobyl (Ukraine) and Fokusimo (Japan) prove that power plants operating on the basis of nuclear energy are still a source of extremely high risk. In addition, the basis of this energy is semi-enriched uranium (a rare earth substance), the technology for its production is available only in some countries that are members of the "nuclear club", which means that there may be problems in many areas in terms of supply. [1-2].

However, in our country Uzbekistan, is an endless source of sunlight, an inexhaustible source of energy, and one second of energy coming out of it is equal to the energy generated by all mankind since its inception. It is also an environmentally friendly source of electricity. For this reason, this type of energy is being given great attention. These countries receive 20 percent of their energy production, or about 20 Gigawatts (20,000 Kilowatts) [1] per hour, from sunlight. Therefore, in our own sunny Uzbekistan, great attention is being paid to this unlimited source of energy.

Unlike wind and wave power plants, solar power plants are free from mechanical rotating parts, and the guarantee of operational reliability is more than 25 years [2, 4] (except for energy storage and conversion parts).

The object of research: as an automated measurement in hydrogeological wells is the energy supply of the device-software tool.

Subject of research: models, methods and algorithms of signal analysis and processing, i.e. development of energy supply of an automated device-software for measuring the level, temperature and electrical conductivity of underground water in observation wells for the study of hydrogeological processes.

The purpose of the work is to develop an experimental copy of the solar panel-based energy supply of the innovative equipment that remotely determines the level, temperature and electrical conductivity of underground water.

METHODS

In the process of the study, methods of digital signal processing theory, photo effect, time series, mathematical modeling, wavelet functions, digital filtering and spectral analysis were applied. Additionally, hardware and software, algorithms the cognitive assessments of sunlight used to measure cognitive function, providing information on their reliability and validity.

RESULTS

The photo effect is much higher in substances that have the property of semiconducting electric current. These substances include silicon, which makes up 80% [1, 4] of the earth's crust. The very high in quicksand (barchan sand in deserts, quicksand in swimming pools). The basis of systems that receive electricity from the sun is formed by crystalline cells (cells) made of silicon. Since silicon is brittle in nature, it is in the form of small particles (sand) and cannot be used in practice. By separating it from the sand composition, the crystalline structure (structure) in the form of a cylinder (parallelogram) with a diameter of 125-156 mm is brought to a uniform appearance. Depending on the purity of the composition, monocrystalline (purity up to 99.99%) and polycrystalline crystals with a mixture of other substances are grown. Cells are cut from this grown crystal with a thickness of 170-200 microns (Fig. 1).

The equipment being created was installed in geological-hydrogeological monitoring wells in field conditions, and its components were examined separately, and its advantages and functional capabilities were taken into account with independent energy supply from other battery-powered devices. The planned device is adapted to water level measurement for multifunctional and geological environment based on the new proposed measurement method [5].

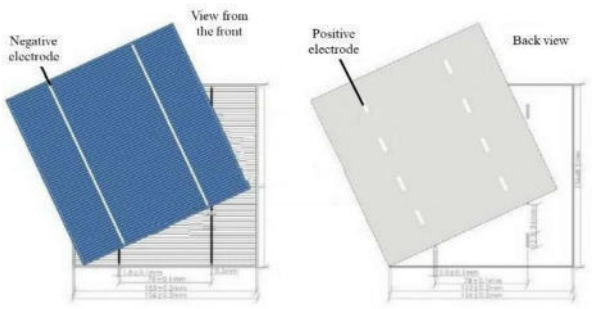

Fig. 1. A view of a silicon solar cell

A small amount of phosphorus is absorbed into the 180-micron-thick cells (plate) cut out of silicon flat on the face (front) side. This forms the N-layer (electron-rich layer). Boron is absorbed on the backside, and a P-layer rich in "holes" is formed. On both sides, with the help of silver transfer wires, tires are formed, matching them to tin (2 mm), negative and positive connection electrodes are formed. This process is carried out in a special, ultra-clean, factory environment designed for the production of microcircuits. The result is a multilayered pie-shaped product, solar cells, shown in Figure 2. The resulting N-P barrier is about 0.8(0.6) volts for silicon. Therefore, 18(36) of these cells are connected in series to generate the required voltage of 12(24) Volts (except for panels designed for large power plants). This potential difference (voltage) is adapted to the voltage of most used electric batteries for storing electrical energy.

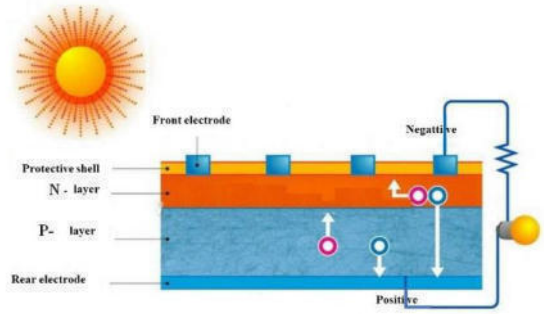

Fig. 2. Internal structure and operation of solar panel cells.

The resulting series set is in turn connected in parallel with another such set to form solar panels of the required power. The array of cells is laminated into a hermetic frame and is called a solar panel. Such panels protect the cells from weathering, brittle silicon cells from breaking, and are conveniently shaped for outdoor placement in the sun. Therefore, solar cells are raw materials and panels are finished products. Here, let's talk about the difference between monocrystalline and polycrystalline cells. Of course, the efficiency of monocrystalline cells useful coefficient (UC) is high, 18-24 percent. So, in such crystals, approximately 1/5 of the sunlight is converted into electrical energy, and the rest is spent on heating the cells (thermal energy) or other types of energy. UC is 15-17 percent for polycrystalline cells, but it is much simpler in terms of technological structure. Therefore, their cost is 30-50% cheaper than monocrystalline cells. So, with the help of panels created from monocrystalline cells, it is possible to get the required power from a panel that occupies a smaller area. The power of solar panels depends on the level of illumination, and of course, cloudy weather leads to a decrease in power, and in the dark of the evening, this power tends to zero.

While solar panels do the main job of getting electricity from the sun, it is often not enough by itself and requires a number of additional electronic devices [6].

1. To store energy - a battery of batteries.

2. An inverter is a device that converts the constant electric current generated by solar panels into a variable 220 V voltage 50 times per second (50 Hz) used in the electrical network.

3. Charging the battery and calculating the amount of energy in it, working from solar panels or the battery at the right time, calculating and controlling the amount of spent and collected energy - controllers.

The above electronic equipment and solar panels must be properly designed in order to obtain, collect and efficiently use solar power independently. The working mode of the device using an electric source is wake up, it has perfect efficiency, the measuring device works only when taking measurements, and does not consume energy at other times.

For example, in Figure 3, a 3,000-watt solar power plant project is presented for one family, intended for evening operation.

DISCUSSION

It is assumed that during the day the solar panels mainly charge the batteries and run the measuring equpment in the filde. Of course, in a short time (up to 1 hour) it is possible to use other devices that do not require more than 3000 W of power. In the evening, 1000 W of power will be able to ensure the operation of the devices that meet the demand for 5 hours.

We started the production of solar panels using solar cells, created a control controller. We are manufacturing inverters based on quality design and demand..

CONCLUSION

In order to improve the monitoring of underground waters in the hydrosphere, the scientific and methodological basis of energy supply for the geoinformation device measuring their level, temperature and electric conductivity was developed, data analysis and evaluation were carried out. As a result, the energy supply of the system of remote automated data measurement, recording, collection and processing during groundwater monitoring was launched.

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THE ROLE OF ARTIFICIAL INTELLIGENCE-BASED SOLUTIONS IN ANTI-MONEY LAUNDERING COMPLIANCE

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A B S T R A C T **In this study, we will explore the role of artificial intelligence-based solutions in tackling Anti-Money Laundering efforts of commercial banks with due focus on efficiency enhancement in solving various tasks. Particular attention will be paid on the applicability of AI-based solutions in Anti-Money Laundering Compliance units of commercial banks in conditions of Uzbekistan. The study will reveal that the use of AI-based technologies in AML Compliance enhances efficiency leading to decrease of time and costs while processing customer transactions and increase overall performance of these units in commercial banks.**

K E Y W O R D S Anti-Money Laundering, Compliance, AI-based solutions, real-time analysis, false positives, enhanced risk assessment, regulatory compliance.

I. INTRODUCTION

In today's dynamic world the role of artificial intelligence (AI) based solutions are playing an important role, which has not been observed ever before. This relates to almost every aspect of human life: starting from a birth of a child, his/her development and throughout their daily activity. AI-based solutions are replacing human manual work by entrusting these solutions to machine work with an aim to make human life easier, thus enabling to automate simple tasks made by humanity leading to further improvement of their health and well-being, also conducing to further decrease of human errors.

For example, the introduction and launch of ChatGPT in November 2022 has been having a huge positive impact on people's lives. Development of Generative AI technologies concerns some other topics, which the world has had on the main agenda since the start of the new millennium, such as global warming, human and nature interaction and etc., which have been the main focus on a broader scale. For instance, development of energy-efficient technologies (ex.: different kinds of robotics, electronic vehicles), the goal of which is to reduce the CO_2 (carbon dioxide) emissions harming the nature and leading to serious issues connected with humans' health and their well-being, and preservation of eco- and biosystems inter alia.

The global banking network is not an exception that has not faced these new AI-based introductions, which is also reflected in the development of commercial banking systems throughout separately given countries.

The importance of this research is to give general prospects of Anti-Money Laundering (AML) efforts in commercial banking with due focus on the recent developments towards application of AI-based solutions in daily banking activities. The research will also explore benefits of the development of AI-based solutions in tackling various AML related tasks, including but not limited to transaction monitoring, sanctions screening, risk assessment, etc.

II. METHODS

This research has been undertaken based on the methodology of scientific analysis of the available research works, empirical analysis of the development of AI-based solutions in different fields, including in AML compliance, analysis and synthesis, as well as induction and deduction methods.

III. RESULTS

The main findings of this study are that AI enhances AML compliance solutions by automating and improving processes such as transaction monitoring, customer risk assessment, and fraud detection. Key benefits include:

1. **Enhanced Detection Accuracy**: AI improves the identification of suspicious activities that might go unnoticed by traditional systems.

2. **Operational Efficiency**: Automation of routine tasks reduces manual effort, saving time and reducing costs.

3. **Scalability**: AI solutions can handle large volumes of data and transactions, suitable for growing financial institutions.

4. **Real-time Analysis**: Continuous, real-time monitoring helps in the swift detection and response to potential money laundering activities.

5. **Pattern and Anomaly Recognition**: Advanced algorithms identify complex patterns and anomalies that indicate fraudulent behavior.

6. **Reduction in False Positives**: AI refines the filtering process, decreasing the number of false alerts, thus allowing compliance teams to focus on genuine risks.

7. **Regulatory Compliance**: AI systems can adapt quickly to changing regulations, ensuring that institutions remain compliant.

8. **Enhanced Risk Assessment**: Improved customer profiling and risk scoring enhance decision-making processes.

Overall, AI strengthens the effectiveness and efficiency of AML compliance efforts.

DISCUSSION

AI in banking has evolved from rule-based systems in the 1980s to machine learning in the 2010s, enhancing fraud detection, customer service, and credit scoring. Recent advancements include NLP for chatbots, deep learning for predictive analytics, RPA for workflow automation, and blockchain for secure transactions. Overall, these technologies aim to improve security, efficiency, and personalization in banking services.

AI involves creating systems capable of performing tasks that typically require human intelligence, such as learning, reasoning, and problem-solving as per Russell & Norvig [1].

Key Technologies include machine learning, natural language processing (NLP), computer vision, robotics.

AI can be applied in healthcare such as diagnostics, personalized medicine, as well as in other fields like finance, specifically in fraud detection, automated trading according to Agrawal et al [2].

It also has ethical and social Implications:

- **Bias and Fairness**: Addressing algorithmic biases.
- **Transparency**: Explainability and accountability in AI decisions according to Binns [3].

Development of AI-based solutions has also been having a huge impact on the banking industry. Any commercial bank or other financial institution dealing with monetary funds and other assets tries to automate some functions of its daily activities. For instance, in AML Compliance they use sophisticated solutions that can automate certain tasks when dealing with huge volumes of data and transactions in order to exclude human error. This can be related to transaction monitoring, i.e. monitoring of transactions to detect suspicious activities from AML standpoint, as well as sanctions screening, which is screening of transactions and customers against certain sanctions lists published globally by leading sanctions issuing authorities as well as risk assessment, which includes risk rating and risk scoring of customers and transactions based on predefined scenarios and algorithms.

As it has been already noted, the use of AI-based solutions helps to improve the accuracy of detecting suspicious activities, to automate routine tasks by reducing manual effort, saving time and reducing costs. They also can handle large volumes of data and transactions, which would be impossible to perform by using manual work. Continuous, real-time monitoring of transactions helps in the swift detection and response to potential money laundering activities.

On the other hand, advanced algorithms identify complex patterns and anomalies that indicate fraudulent behavior.

AI refines the screening process, decreasing the number of false alerts, thus allowing compliance teams to focus on genuine risks.

Moreover, AI systems can adapt quickly to changing regulations, ensuring that institutions remain compliant.

The last but not the least, improved customer profiling and risk scoring enhance decision-making processes.

Overall, AI technologies in AML compliance are used to perform following functions:

- **Transaction Monitoring**: Detect suspicious patterns and anomalies in real-time.
- **Customer Due Diligence**: Automate Know Your Customer (KYC) processes for faster and more accurate verification.
- **Risk Scoring**: Evaluate risk profiles of customers using advanced analytics.
- **Pattern Recognition**: Identify complex money laundering schemes through deep learning and data mining.
- **Automated Reporting**: Generate and file Suspicious Activity Reports (SARs) efficiently.
- **Behavioral Analytics**: Analyze customer behavior to detect deviations indicating potential money laundering.

These applications enhance detection accuracy, reduce manual efforts, and ensure compliance with regulatory requirements.

CONCLUSION

To conclude, our study shows how AI-based solutions can enhance efficiency of any bank's AML compliance efforts, by reducing time and costs in transactions monitoring, sanctions screening and comprehensive risk assessment. The use of AI-based technologies in those fields is already the present stage of development. The ready-made AI-based solutions are developed by vendors known globally, which are tailored to the needs and requirements of any institution. We expect that AI-based solutions will enter the Uzbek banking system more swiftly in the nearest future, which is dictated by the evolution of modern banking technologies.

AI-based solutions significantly enhance AML compliance by improving the detection of suspicious activities, reducing false positives, streamlining regulatory reporting, and increasing operational efficiency. They enable faster, more accurate analysis of large datasets, ultimately helping organizations comply with regulatory requirements and mitigate financial crime risks more effectively.

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DIGITAL TRANSFORMATION AND ARTIFICIAL INTELLIGENCE IN UZBEKISTAN: CHALLENGES, INNOVATIONS, AND FUTURE TRENDS

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Abstract The digital transformation and integration of artificial intelligence (AI) are pivotal to the advancement of modern economies. Uzbekistan, a country in Central Asia, is making significant strides in these areas despite facing numerous challenges. This paper explores the current state of digital transformation and AI in Uzbekistan, identifies key challenges, highlights recent innovations, and discusses emerging trends. The findings suggest a growing emphasis on building digital infrastructure, fostering innovation, and creating a supportive regulatory environment, which are crucial for Uzbekistan’s economic and social development.

Keywords: Digital transformation, artificial intelligence (ai), uzbekistan, digital infrastructure, e-government, fintech, smart cities, educational reforms, innovation ecosystems, data governance, regulatory framework, skill development, international collaboration, technology adoption, economic development.

INTRODUCTION

The rapid advancement of digital technologies and artificial intelligence (AI) has become a pivotal force reshaping industries, economies, and societies worldwide. These technologies have the potential to drive significant innovation, efficiency, and economic growth. In this context, Uzbekistan, a country with a rich cultural heritage and a strategically important position in Central Asia, is actively pursuing digital transformation as part of its broader economic and social reform agenda.

Uzbekistan's journey toward digitalization is marked by a blend of opportunities and challenges. On one hand, digital transformation and AI can enhance the efficiency of public services, improve the quality of life, and foster economic diversification. On the other hand, the country faces significant barriers, including infrastructure limitations, a shortage of skilled professionals, and an evolving regulatory environment. These factors collectively shape the landscape of digital and AI adoption in Uzbekistan.

The government's strategic initiatives, such as the "Digital Uzbekistan 2030" program, reflect a commitment to leveraging digital technologies for national development. This program aims to modernize various sectors, including public administration, finance, education, and healthcare, through digitalization. It also seeks to position Uzbekistan as a hub for innovation and technology in the region.

This paper provides a comprehensive overview of the current state of digital transformation and AI in Uzbekistan. It examines the critical issues and challenges faced by the country, highlights recent innovations and achievements, and explores emerging trends and future directions. The analysis draws on a range of sources, including government reports, academic studies, and industry insights, to offer a nuanced understanding of the opportunities and challenges associated with digital transformation in Uzbekistan.

By understanding the current landscape, stakeholders, including policymakers, businesses, and educators, can better navigate the complexities of digital transformation. This understanding is essential for leveraging digital and AI technologies to foster sustainable economic growth and social development in Uzbekistan.

CHALLENGES IN DIGITAL TRANSFORMATION AND AI INTEGRATION

Digital transformation and the integration of artificial intelligence (AI) present numerous challenges for Uzbekistan, despite its aspirations for technological advancement. This section delves into the specific challenges the country faces in terms of infrastructure, skill gaps, regulatory and policy issues, and funding and investment constraints.

2.1. Infrastructure Limitations

Digital Infrastructure and Internet Penetration

The development of digital infrastructure in Uzbekistan is still in progress, with internet penetration being a major concern. In 2020, the World Bank reported that only around 60% of the population had access to the internet, which is below the global average. This limited access, particularly in rural and remote areas, poses a significant barrier to the adoption and utilization of digital and AI technologies. The uneven distribution of internet services also means that certain regions are left behind in the digital revolution, exacerbating regional inequalities.

Quality and Reliability of Internet Services

The quality and reliability of internet services vary greatly across the country. Urban areas, such as Tashkent, generally have better connectivity, but many regions still suffer from slow internet speeds and frequent outages. This inconsistency in service quality hinders businesses, educational institutions, and individuals from fully participating in the digital economy. Reliable high-speed internet is essential for applications such as cloud computing, online education, telemedicine, and the implementation of AI solutions.

Technological Infrastructure and Access to Advanced Technologies

The availability of advanced technologies, including those necessary for AI development, is limited. The high cost of importing such technologies, coupled with a lack of domestic production capabilities, restricts access. This limitation affects sectors that could benefit significantly from AI, such as healthcare, agriculture, and finance. Moreover, the availability of hardware and infrastructure, like data centers and high-performance computing systems, is insufficient to meet the growing demands of digital transformation.

Energy and Power Supply Issues

A stable and reliable power supply is critical for supporting digital infrastructure and AI technologies. While Uzbekistan has been working to improve its energy sector, power outages remain a problem, particularly in rural areas. Inconsistent power supply can disrupt digital services, data centers, and other critical infrastructure, limiting the potential for sustained digital growth.

2.2. Skill Gaps

Lack of Skilled Professionals

One of the most significant barriers to the adoption of AI in Uzbekistan is the shortage of skilled professionals. The country lacks a sufficient number of experts in fields such as data science, machine learning, and AI development. While the educational system is beginning to introduce relevant courses and programs, the pace of training is not keeping up with the rapid advancements in technology.

Educational System Adaptation

The adaptation of the educational system to include curricula in AI and related fields is still in its early stages. Many institutions lack the resources, faculty expertise, and infrastructure to provide high-quality education in these areas. This gap is reflected in international rankings; for example, the Global Talent Competitiveness Index (GTCI) 2020 placed Uzbekistan at 92nd out of 132 countries, indicating a need for significant improvements in education and skill development.

Brain Drain and Retention Challenges

Uzbekistan also faces challenges in retaining its skilled workforce. Talented individuals often seek opportunities abroad where the technology sectors are more developed and offer better career prospects. This brain drain exacerbates the skill shortage and hampers the country's ability to build a robust tech ecosystem.

2.3. Regulatory and Policy Challenges

Evolving Regulatory Landscape

The regulatory environment for digital technologies and AI in Uzbekistan is still developing. There are gaps in legislation regarding data privacy, cybersecurity, and the ethical use of AI. These areas require robust policies to protect consumers and businesses and to ensure responsible technology use. The absence of comprehensive regulations can lead to risks such as data breaches, misuse of AI, and erosion of public trust.

Regulatory Uncertainty and Impact on Investment

Uncertainty in the regulatory framework can deter foreign and domestic investment in the tech sector. Investors seek clarity and stability in regulations to make informed decisions. The lack of a well-defined legal structure can hinder innovation and slow the growth of digital and AI technologies in the country.

Challenges in Policy Implementation

Even where policies exist, there are challenges in implementation and enforcement. Limited administrative capacity and coordination among government agencies can lead to inconsistencies in applying regulations. This inconsistency can create confusion among businesses and hinder the development of a cohesive digital strategy.

2.4. Funding and Investment Constraints

Underdeveloped Investment Ecosystem

The investment ecosystem for technology and innovation in Uzbekistan is underdeveloped. While the government has launched initiatives to support startups and promote innovation, these efforts are still nascent. According to the Global Innovation Index (GII) 2021, Uzbekistan ranks 93rd, highlighting the limited access to funding and resources for tech startups. This ranking indicates challenges in attracting venture capital and private sector investment, which are crucial for fostering innovation and scaling new technologies.

Limited R&D Investment

Investment in research and development (R&D) is critical for advancing digital and AI technologies. In Uzbekistan, R&D spending is relatively low compared to global standards. This lack of investment affects the ability of universities and research institutions to conduct cutting-edge research and develop new technologies. Additionally, businesses often lack the resources to invest in R&D, which limits their capacity for innovation.

Need for Financial Incentives and Support Programs

To stimulate investment in digital transformation and AI, there is a need for financial incentives and support programs. These could include tax breaks, grants, and subsidies for startups and companies investing in technology. The creation of technology parks and innovation hubs could also provide a supportive environment for tech entrepreneurs.

In summary, while Uzbekistan is making progress in digital transformation and AI integration, significant challenges remain. Addressing infrastructure limitations, skill gaps, regulatory issues, and investment constraints is crucial for building a robust digital economy. By tackling these challenges, Uzbekistan can better position itself to leverage digital technologies for economic growth and social development.

INNOVATIONS DRIVING DIGITAL TRANSFORMATION

Uzbekistan is embracing various innovations to drive digital transformation across multiple sectors. These initiatives aim to modernize public services, enhance financial inclusion, improve urban living, and address the skills gap in emerging technologies.

3.1. E-Government Services

Streamlining Government Processes

The Uzbek government has made significant strides in digitizing public services through the "E-Government" initiative. This project aims to streamline bureaucratic processes, reduce paperwork, and improve the efficiency of government operations. By leveraging digital platforms, the government seeks to enhance transparency, reduce corruption, and provide faster service delivery to citizens.

Online Service Portal

A key component of the E-Government initiative is the development of an online portal where citizens can access various public services. This portal allows individuals to perform tasks such as tax filings, obtaining official documents, and accessing healthcare and educational services. The online platform is designed to be user-friendly, providing easy navigation and access to essential services from the comfort of one's home.

Digital Identification and Payment Systems

To support the E-Government services, digital identification systems have been implemented to verify citizens' identities securely. Additionally, digital payment systems are being integrated to facilitate the online payment of fees and taxes. These systems not only streamline processes but also reduce the need for physical visits to government offices, saving time and resources for both the government and citizens.

3.2. Fintech and Digital Banking

Expansion of Financial Services

The financial sector in Uzbekistan is experiencing a transformation through innovations in fintech and digital banking. These advancements aim to extend financial services to underserved populations, including those in rural and remote areas. By leveraging digital platforms, fintech solutions are making it easier for individuals to access banking services, loans, and payment systems.

Digital Payment Systems

The Central Bank of Uzbekistan has played a crucial role in supporting the development of digital payment systems. These systems enable cashless transactions, which have become increasingly important during the COVID-19 pandemic. The adoption of mobile banking and e-wallets has seen significant growth, allowing users to conduct transactions, pay bills, and manage their finances online.

Online Banking Platforms

Banks in Uzbekistan are investing in online banking platforms to offer a wider range of services to their customers. These platforms provide access to account management, fund transfers, and investment options. By embracing digital banking, financial institutions can reach a broader customer base and offer more convenient services, contributing to greater financial inclusion.

3.3. Smart Cities

Urban Management and Optimization

Smart city initiatives are being explored in Uzbekistan to improve urban management and enhance the quality of life for residents. These projects focus on utilizing the Internet of Things (IoT) and AI technologies to optimize resource management, traffic control, and public safety. By integrating these technologies, cities can become more efficient, sustainable, and responsive to the needs of their inhabitants.

Smart Traffic Systems

The city of Tashkent, as an example, is implementing smart traffic systems to address congestion and improve transportation efficiency. These systems use sensors and data analytics to monitor traffic flow and optimize signal timings. By reducing traffic jams and improving the overall transportation network, the city aims to enhance mobility and reduce environmental impact.

Public Safety and Environmental Monitoring

Smart city technologies also play a vital role in public safety and environmental monitoring. Surveillance systems equipped with AI can enhance security by detecting and responding to incidents in real time. Additionally, IoT devices can monitor environmental parameters such as air quality and water levels, providing valuable data for urban planning and disaster management.

3.4. Educational Reforms

Focus on STEM Education

To address the skill gap in emerging technologies, Uzbekistan is reforming its educational system with a greater emphasis on STEM (Science, Technology, Engineering, and Mathematics) subjects. The goal is to equip students with the knowledge and skills needed to thrive in a digital economy. This focus is essential for building a workforce capable of developing and implementing AI and other advanced technologies.

Introduction of AI and Data Science Courses

Universities and technical institutes are introducing courses in AI, data science, information technology, and related fields. These programs are designed to provide students with practical skills and hands-on experience in these areas. By fostering a strong foundation in these disciplines, Uzbekistan aims to cultivate a new generation of tech-savvy professionals.

International Partnerships and Expertise

To enhance the quality of education and bring in global best practices, Uzbekistan is establishing partnerships with international educational institutions. These collaborations involve exchange programs, joint research projects, and faculty training. By leveraging international expertise, Uzbek institutions can improve their curricula and better prepare students for the demands of the global job market.

EMERGING TRENDS

Uzbekistan's journey toward digital transformation is marked by several emerging trends that highlight the country's commitment to modernizing its economy and society. These trends include increased government support, the growth of startups and innovation ecosystems, international collaborations, and a focus on data governance.

4.1. Government Support and Policy Development

"Digital Uzbekistan 2030" Strategy

The Uzbek government has demonstrated strong support for digital transformation through the adoption of the "Digital Uzbekistan 2030" strategy. This comprehensive plan outlines the government's vision for a digital economy and sets clear objectives for infrastructure development, cybersecurity, and innovation. The strategy aims to create a conducive environment for technological advancement, attract foreign investment, and foster a culture of innovation.

Policy Frameworks and Funding

To support the digital transformation agenda, the government is developing policy frameworks that encourage investment in technology and innovation. These policies include incentives for tech companies, such as tax breaks and grants, to promote research and development. Additionally, the government is allocating funds to support the development of digital infrastructure, such as expanding broadband coverage and enhancing cybersecurity measures.

Public-Private Partnerships

The government is also actively engaging in public-private partnerships to leverage the expertise and resources of the private sector. These collaborations are crucial for implementing large-scale projects, such as smart city initiatives and the digitization of public services. By working together, the public and private sectors can accelerate the adoption of digital technologies and address key challenges, such as infrastructure gaps and skill shortages.

4.2. Growth of Startups and Innovation Ecosystems

Rise of Tech Startups

There is a noticeable increase in the number of tech startups in Uzbekistan, covering a range of sectors including fintech, health tech, e-commerce, and education technology. These startups are leveraging digital platforms to offer innovative solutions and services, often targeting underserved markets. The entrepreneurial spirit is growing, supported by a young and tech-savvy population eager to explore new opportunities.

Innovation Hubs and Incubators

To support the burgeoning startup ecosystem, several innovation hubs and incubators have been established across the country. These facilities provide essential services, such as mentorship, networking opportunities, and access to funding. The government and private sector are collaborating to create a supportive environment for startups, helping them to scale and succeed in both local and international markets.

Funding and Investment Opportunities

Despite challenges, there is a growing interest from investors in the Uzbek tech scene. Venture capital funds and angel investors are increasingly looking at Uzbekistan as an emerging market with significant potential. The government is also providing funding through various programs and initiatives aimed at fostering innovation and entrepreneurship.

4.3. International Collaborations

Partnerships with Leading Tech Companies

Uzbekistan is actively seeking partnerships with leading global tech companies to enhance its digital and AI capabilities. These collaborations facilitate the transfer of technology, knowledge, and best practices, helping to accelerate the country's digital transformation. For instance, partnerships with companies in the fields of telecommunications, software development, and AI research are bringing advanced technologies and expertise to Uzbekistan.

Bilateral and Multilateral Agreements

The country is also engaging in bilateral and multilateral agreements with other nations to promote technology exchange and cooperation. These agreements often include provisions for joint research, development projects, and the establishment of technology transfer centers. Such international collaborations are vital for building infrastructure, training professionals, and developing regulations aligned with global standards.

Academic and Research Collaborations

In addition to corporate partnerships, Uzbekistan is fostering academic and research collaborations with international universities and research institutions. These partnerships are aimed at enhancing the quality of education and research in digital and AI technologies. Joint research projects and exchange programs are helping to build local expertise and drive innovation in the country.

4.4. Focus on Data Governance

Enhancing Data Protection Laws

With the increasing digitization of services and the proliferation of data, Uzbekistan is focusing on improving its data governance frameworks. This includes the development and enhancement of data protection laws to safeguard personal and sensitive information. Strengthening these laws is essential for building public trust in digital services and ensuring compliance with international standards.

Data Security and Cybersecurity Measures

Data security is a critical concern in the digital age, and Uzbekistan is taking steps to enhance cybersecurity measures across various sectors. The government is implementing strategies to protect critical infrastructure from cyber threats and to secure sensitive data. This includes establishing national cybersecurity agencies, developing cybersecurity policies, and investing in advanced security technologies.

Ethical Use of AI and Data

As AI technologies become more prevalent, there is a growing focus on promoting the ethical use of AI and data. This involves ensuring that AI systems are transparent, fair, and accountable. The government is working on guidelines and regulations to address ethical concerns related to AI, such as bias, privacy, and the potential for misuse. These efforts are aimed at fostering responsible AI development and building public confidence in AI-driven solutions.

Promoting Data-Driven Decision Making

The government is also encouraging the use of data-driven decision-making in both the public and private sectors. By leveraging data analytics and AI, organizations can gain valuable insights and make informed decisions. This approach is being applied in various areas, including urban planning, healthcare, and education, to improve efficiency and outcomes.

CONCLUSION

Uzbekistan is embarking on a transformative journey toward a digitally empowered future, with artificial intelligence (AI) playing a pivotal role in this evolution. The country's strategic initiatives, such as the "Digital Uzbekistan 2030" strategy, reflect a strong commitment to leveraging digital technologies to drive economic growth and improve the quality of life for its citizens.

However, the path to digital transformation is not without challenges. Infrastructure limitations, skill gaps, regulatory and policy hurdles, and investment constraints are significant barriers that need to be addressed. The disparity in internet penetration and service quality between urban and rural areas highlights the need for targeted infrastructure development. Moreover, the shortage of skilled professionals and the evolving regulatory landscape pose additional challenges that must be overcome to fully capitalize on the potential of digital technologies and AI.

Despite these challenges, there are promising innovations and emerging trends that bode well for the future. The government's efforts to digitize public services, the rise of fintech and digital banking, the exploration of smart city initiatives, and educational reforms focused on STEM and AI are critical steps toward building a robust digital ecosystem. Additionally, the growth of startups and innovation ecosystems, coupled with international collaborations, provides a solid foundation for future advancements.

The focus on data governance, including enhancing data protection laws and cybersecurity measures, is also crucial in ensuring the safe and ethical use of digital technologies. As data becomes a valuable asset, Uzbekistan's proactive stance on data governance will help build trust and encourage broader adoption of digital solutions.

Looking ahead, Uzbekistan's continued efforts to create a supportive ecosystem, enhance education and skills, and foster international partnerships will be vital for realizing its digital potential. By addressing the existing challenges and leveraging emerging opportunities, Uzbekistan can position itself as a key player in the region's digital economy. The country's proactive approach to digital transformation and AI integration is likely to yield substantial economic and social benefits, paving the way for a more prosperous and technologically advanced future.

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IMPROVING THE USE OF ARTIFICIAL INTELLIGENCE IN ECONOMIC ANALYSIS OF THE REGION'S POTENTIAL FOR ATTRACTING FOREIGN INVESTMENT

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Abstract: The article cites the results of the use of modern methods of analysis in forecasting the prospects and future development of investment attraction and financing at the International and national level. On the basis of investment financing, proposals have been made that depend on the economic policy, legislation, development, level and economic situation of the country, the infrastructure for attracting investment.

Keywords: foreign investment in the national economy, financial mechanisms of investments, domestic investments, accelerator model, limited inclination to capital, capital efficiency, effective use of domestic investments.

Introduction. Referring to the fact that the future development of Uzbekistan and the world economy is largely dependent on investments today, almost every specialist and economic entity has realized, now the wider involvement of investments in the economy of our republic, in particular foreign investments, has become an important basis for ensuring the effective implementation of economic reforms taking place in their country. In the social, economic and political development of the country, the importance of foreign investments, including investments, is great. It is known that it is impossible for any state to develop without studying world experiences, without accepting the achievements of the leading countries of the world in the field of Science, Science and technology.

There are enough experiences in attracting and financing investments at the International and national levels. Investment financing will largely depend on the country's economic policy, legislation, development, level and economic situation of the investment attraction infrastructure. The presence of rich resources of quality raw materials in our country is evident in the extreme need to attract investments for our economy, and at the same time, the need for us to look at the production of finished products of the raw material resource base.

In the context of the globalization of the economy, a strictly competitive struggle for investments in the world continues consistently. Liberalization of foreign economic activity, improvement of legal, socio-economic and other conditions that ensure the involvement of foreign direct investments in the economy of our country, conducting open-door policies on foreign investments, the embodiment of funds in priority areas ensuring the economic independence of the country and in areas related to the production of competitive products are the main principles of investment policy.

It is impossible to carry out and modernize structural changes in the economy, re-equip enterprises with modern technology and establish competitive production without attracting foreign investments, especially without expanding the participation of foreign investments in leading industries. The involvement of foreign investment in the economy of the country is important in accelerating the expansion of its economic capabilities and ensuring the economic power of our state by employing domestic opportunities and reserves in all areas, mastering new technologies and technology, export-free goods, establishing their production.

President of the Republic of Uzbekistan Shavkat Mirziyoyev's address to the Supreme Assembly: "World experience shows that whichever state has pursued an active investment policy has achieved a steady increase in its economy. For this reason, investment is an economy driver, in Uzbek words, the heart of the economy, to say, will not be an exaggeration. We will only achieve the rapid development of our economy at the expense of active investment, the launch of new production facilities. Positive results in the economy, on the other hand, make it possible to systematically solve problems accumulated in the social sphere. We all need to understand this deeply and organize our work on this basis. We must take measures to fully demonstrate the investment potential of our country in order to attract foreign investment widely, which should be one of the most pressing issues that have taken place in our daily lives" [1], noting the exceptional importance of foreign investment in the development of the economy and the relevance of its involvement.

Method. Foreign direct investments entering the economy of Uzbekistan are distributed very unevenly between regions. This is due to both differences in the economic characteristics of the regions of Uzbekistan and at different levels of the effectiveness of regional authorities on attracting foreign direct investment. The assessment of the potential of the region to attract foreign direct investment can serve as an important guide for the assessment of the quality of work of regional authorities on creating conditions for attracting foreign investment in the region. The work is based on the construction and subsequent evaluation of an econometric model of foreign direct investment determinants at the regional level. The theoretical basis for the econometric model is the gravitational approach. Estimates obtained by the Poisson pseudomaximal probability method are used to calculate the potential for foreign direct investment. Using the data from 2023-2024, important factors affecting the flow of foreign direct investment at the regional level were identified in the Republic of Uzbekistan: the availability of Labor, the level of bureaucracy in the region, the level of population income, population density, as well as the financial results of organizations in the region. Based on the calculated investment potential, the successful and backward regions of Uzbekistan were determined by the volume of foreign direct investment attracted.

The analysis of the regions of Uzbekistan was carried out in the categories "volume of foreign direct investment attracted" and in the ratio "fact / potential" of incoming foreign direct investment. In terms of the level of acceptance of foreign direct investment, the largest regions of Uzbekistan have restrictions on the growth in the volume of foreign direct investment, since they exceed their potential level or are at a level close to potential. At the same time, more than half of the regions of Uzbekistan not only have a very low potential for attracting foreign direct investment, but are also below the potential level in terms of the actual level of foreign direct investment. A significant increase in the volume of foreign direct investment at the national level can lead to a small group of regions with high and medium levels of foreign direct investment, but with unrealized potential. The methodology for assessing the potential level of foreign direct investment of the region proposed in the article and comparing it with the actual level can be used to assign tasks to specialized bodies of regional authorities and then evaluate their work on attracting foreign direct investment.

The Global Innovation Index provides information on the multifaceted aspects of innovation-based economic growth. According to a 2023 report, 81 detailed measurement criteria were calculated for 131 States, making the Global Innovation Index one of the leading indicators that assess the innovative efficiency of economies. To date, the Global Innovation Index has become one of the most important comparative tools for policymakers, investors and other stakeholders to assess annual Innovation Progress.

Results: The new edition of the Global Innovation Index is a project that will be developed with the adoption of new data as well as the practical application of the latest research on the shortcomings in the assessment of innovations in previous reports. The Global Innovation Index is based on two sub-indices – the innovation input sub-index and the innovation output sub-index. The sub-indices in question are calculated as follows:

Sub-index "investment in innovation": five types of input components cover the elements that ensure the innovative activities of the national economy, which are: quality of institutions, human capital and R & D activities, infrastructure, market development and Business Development. These components define aspects of the environment that promote the development of innovation in the economy.

Sub-index "innovative products": the results of innovative activities are the result of innovative activities in the economy. Although the Garchan sub-index consists of only two components, it has the same weight as the sub-index when calculating the total estimate of the GII. Results of two activities: Science and technology and creative products.

The total global Innovation Index estimate is equal to the average value of the input and output sub-indices. Below we cite the top 10 of the Global Innovation Index of states [2] (Table 1).

Table 1.

Top-10 countries by" Global Innovation Index " ranking

GII rank	Economy	Score	Income group rank	Region rank
1	Switzerland	67.6	1	1
2	Sweden	64.2	2	2
3	United States	63.5	3	1
4	United Kingdom	62.4	4	3
5	Singapore	61.5	5	1
6	Finland	61.2	6	4
7	Netherlands (Kingdom of the)	60.4	7	5
8	Germany	58.8	8	6
9	Denmark	58.7	9	7
10	Republic of Korea	58.6	10	2

On September 29 of this year, the 2022 report of the Global Innovation Index was published. Uzbekistan ranked 122nd out of 141 countries in the Global Innovation Index in 2015, while in 2022 it ranked 82nd out of 131 countries, 40 points, and became the leader of Central Asia and 3rd among central and South Asian mamalakats, behind India and Iran. The following is a leap forward in the Global Innovation Index of the Republic of Uzbekistan (Table 2).

Table 2. The Republic of Uzbekistan Global Innovation Index

№	Components	2015		2023		Change
		Price	Place	Price	Place	(↓↑)
1.	**Quality of institutions**	49,0	106	57,3	63	**↑43**

2.	**Human capital and research activities**	27,0	76	30,8	65	**↑11**
3.	**Infrastructure**	29,0	101	41,7	74	**↑27**
4.	**Market development**	44,4	85	39,9	60	**↑25**
5.	**Business development**	20,0	138	25,3	74	**↑64**
6.	**Science and technology**	27,2	61	17,9	80	**↓19**
7.	**Creative products**	8,5	138	7,7	102	**↑36**

Discussion: In achieving this result, it is worth noting the large-scale reforms carried out in the field of Science and innovation in our country in recent years, as well as the special attention of the head of our state to the development of the field.

Each component is divided into three indicators, including each indicator divided into individual elements – a total of 81. Each nation was assessed on their respective normalized scores in the range 0 to 100.

The level of economic development of the country, the growth rates of investment activity are largely dependent on the investment environment. It is important that the necessary conditions are created to attract foreign investment to the economy of the Republic, which, when economic, political, social and legal conditions exist in which country (positive), can be imposed on the economy of that state [4]. The attractiveness of the investment environment is an important factor in increasing the flow of foreign investment. In turn, what is the investment environment itself? What does its attractiveness depend on? How to define an investment environment? In addition, what factors affect the investment environment? the birth of questions, such as, is natural.

From Economist-scientists A.Vakhabov, Sh.Khajibakiev, N.Muminovs note the following about the investment environment: "the investment environment is the sum of economic, political, legal and social factors that predetermine the degree of shocks of foreign capital investments and the possibility of their effective use in the country. The investment environment is a complex, multifaceted concept, with indicators such as national legislation, economic conditions (crisis, growth, stagnation), customs regime, foreign exchange policy, economic growth rates, inflation rates, exchange rate stability, level of external debt" [5]. Also, a set of economic, political, regulatory, social and other conditions affecting investment processes in the country means an investment environment.

The growth rate of the flow of foreign direct investment and loans has also strengthened in projects of territorial importance, the total volume of which in 2019 amounted to 4.8 billion dollars (of which in fixed capital – 4.2 billion dollars), increasing 4 times compared to the corresponding period of 2018 and 24 times compared to 2017. With the participation of foreign capital alone, 167 projects with a total cost of 858.5 million dollars were put into use in the regions. According to the investment program, in 2020, at the expense of all sources of financing, the main capital is about 233.2 trillion. the sum of capital investments is planned to be mastered, in which foreign direct investment and loans - 7.1 billion. dollars, foreign investments and loans under the state guarantee-2.7 billion. the dollar is planned to be appropriated. More than 2 thousand objects of social, infrastructure and production importance are planned to be put into use in Uzbekistan: 206 are large production facilities, 240 are regional production facilities, 1.6 thousand are objects of social and infrastructure importance [8].

According to the main trend and indicators of socio-economic development of Uzbekistan and forecasts for the coming years, one of the priorities is to form a more favorable investment climate in our country, primarily in order to increase the volume of foreign direct investment being attracted, create reliable guarantees for foreign investors and strengthen their trust.

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DEVELOPMENT OF AN AUTOMATED INFORMATION SYSTEM BASED ON THE MODELING OF EMPLOYMENT PROCESSES

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Abstract. It is important to use modern methods, in particular, simulation modeling approaches, in the coordination of labor market relations. The unstable state of the labor market can seriously affect the dynamics of the employment rate. Mathematical and probabilistic models are used to estimate the efficiency of the labor market and match supply and demand. The labor exchange is considered as a public service system and analyzed by indicators such as demand flow, waiting time, mathematical expectation of queued demands and system throughput. Based on the obtained data, it is possible to predict the employment of the population and optimize the labor market. Also, in the process of modeling, the functional states and probability indicators of the labor exchange are evaluated, and the production efficiency of the labor exchange is increased through probabilistic approaches to their coordination. These methods are important in making effective management decisions in the unstable situation of the labor market. It is aimed at ensuring the effective distribution of labor resources of Uzbekistan and stimulating economic growth and increasing the well-being of the population. Currently, the level of unemployment, labor migration and supply and demand for labor force in the labor market in Uzbekistan are increasing, and it is important to solve them. The role of the state in the process of coordination of labor market relations is important. In Uzbekistan, state strategies aimed at improving the skills of the workforce, creating new jobs and ensuring employment of the population are being implemented. In the coordination of labor market relations, factors such as innovative approaches, application of digital technologies and adaptation to global trends of the labor market are of urgent importance.

Key words: labor market, labor exchange, simulation modeling, probabilistic approach, employment level, supply and demand.

INTRODUCTION

The labor market is one of the most important components of the economy, and it plays an important role in managing population employment by ensuring the balance between supply and demand. In the conditions of economic instability and risk, the dynamics of the labor market face complex processes. Modern mathematical and probabilistic modeling methods are available to analyze these processes and optimize the labor market in the day widely used. Systematic through public service systems and probabilistic approaches analysis and the efficiency of labor exchanges can be increased. The labor exchange plays an important role in coordinating supply and demand in the labor market [1]. Current to the day indicators such as the functional state of the exchange , the speed of service and the flow of labor requirements are taken into account. By studying these processes, it is possible to improve the operation of the labor market and increase economic efficiency. The simulation modeling approach allows to make optimal management decisions in different situations of the labor market. With the help of this approach, the transferability of labor exchanges and the dynamics of the employment level of the population are analyzed, which serves to effectively manage relations in the labor market.

At the current stage of state development, in the conditions of constant economic instability and risk, simulation modeling approaches and methods are considered effective. In the conditions of the formation of a market economy, the unstable state of the labor market can lead to very complex transition processes and seriously affect the dynamics of the employment level. The obtained information about the dynamics of the employment level can be used to improve the activity of the labor exchange, which is one of the components of the functional-organizational structure of the labor market [2].

From the point of view of the public service theory, the labor exchange can be considered as a public service system that harmonizes the demand for the labor force. In this case, the flow of demands from the unemployed is a simple flow. The intensity of the system is the rate at which demand flows from the unemployed. Modeling of the labor market allows to assess the demand for labor force, the supply of labor force , as well as the coordination of demand and supply in the labor market [3].

Therefore, the main task of optimizing labor market relations is to improve the operation mode of the service system and manage events that occur during the service [4]. Optimization of the labor market can be carried out from the point of view: from the point of view of the employer or from the point of view of the unemployed receiving services. The methods of coordination of relations in the labor market allow to choose a rational structure of the public service system and to optimize it, taking into account all conditions and characteristics.

a Probabilistic approach to the coordination of labor market relations.

The labor market is considered as a public service system of the labor market, where the exchange departments are described as the channels of the labor market, the flow of demands from the unemployed is the flow of demands in the labor market, and the queue at the exchange is defined as the queue of demands in the labor market [5].

The flow of demands in OXKS in the form of a cocktail exchange has the characteristics of stationarity, simplicity, and intensity, and therefore it is a simple flow. Let's assume, T_{nx} – the sample service time of one request, $m_{t_{nx}}$ – the average time of service of one request, $\mu = const$ – the inverse parameter of the average time of service of one request, then the expression (1) is formed.

$$\mu = \frac{1}{m_{t_{nx}}}, \quad m_{t_{nx}} = M[T_{nx}]. \quad (1)$$

An unemployed person's request is queued and waiting for service. Waiting time is a certain period T_{kv} agreed with ; if the request is not accepted for service before the end of this period , then it leaves the queue . Waiting time T_{kv} is random and $v = \text{const}$ exponentially distributed with parameters . This where *v is* the parameter queue The average waiting time of is inversely proportional to and (2) equality holds.

$$v = \frac{1}{m_{t_{\text{kv}}}}, \quad m_{t_{\text{kv}}} = M[T_{\text{kv}}]. \quad (2)$$

Distribution of horse for waiting period In the exponential law , the throughput of the labor exchange does not depend on the order of processing requests .

Labor exchange *t* v at the moment of aqt x_k probability of being $p_k(t)$ $(k = 0, 1, ..., n, ...)$ in a state be defined .

Satisfies an infinite number of Kolmogorov differential equations $p_k(t)$ e probabilities also satisfy the following system of equations :

$$\left.\begin{array}{l}
\frac{dp_0(t)}{dt} = -\lambda p_0(t) + \mu p_1(t) \\
\frac{dp_1(t)}{dt} = -\lambda p_0(t) - (\lambda + \mu) p_1(t) + 2\mu p_2(t) \\
\dots\dots\dots\dots\dots\dots\dots\dots \\
\frac{dp_k(t)}{dt} = -\lambda p_{k-1}(t) - (\lambda + k\mu) p_k(t) + (k+1)\mu p_{k+1}(t), \ (1 \le k \le n-1) \\
\dots\dots\dots\dots\dots\dots\dots\dots \\
\frac{dp_n(t)}{dt} = -\lambda p_{n-1}(t) - (\lambda + k\mu) p_n(t) + (n\mu + v) p_{n+1}(t), \\
\dots\dots\dots\dots\dots\dots\dots\dots \\
\frac{dp_{n+s}(t)}{dt} = -\lambda p_{n+s-1}(t) - (\lambda + n\mu + sv) p_{n+s}(t) + [n\mu + (s+1)v] p_{n+s+1}(t), \\
\dots\dots\dots\dots\dots\dots\dots\dots \\
\sum_{k=0}^{\infty} p_k = 1.
\end{array}\right\} \quad (3)$$

It should be noted that in practice the probabilities *p,n* $_s$ *(t)* become significantly smaller as s increases, so the corresponding equations can be discarded.

The system of equations (3) in the stationary mode is as follows, since the workplace and labor force are unchanged at the moment of time under consideration.

$$\left.\begin{array}{l}
-\lambda p_0 + \mu p_1 = 0, \\
\lambda p_0 - (\lambda + \mu) p_1 + 2\mu p_2 = 0 \\
\dots\dots\dots\dots\dots\dots\dots\dots \\
\lambda p_{k-1} - (\lambda + k\mu) p_k + (k+1)\mu p_{k+1} = 0, \ (1 \le k \le n-1) \\
\dots\dots\dots\dots\dots\dots\dots\dots \\
\lambda p_{n-1} - (\lambda + k\mu) p_n + (n\mu + v) p_{n+1} = 0, \\
\dots\dots\dots\dots\dots\dots\dots\dots \\
\lambda p_{n+s-1} - (\lambda + n\mu + sv) p_{n+s} + [n\mu + (s+1)v] p_{n+s+1} = 0, \\
\dots\dots\dots\dots\dots\dots\dots\dots \\
\sum_{k=0}^{\infty} p_k = 1.
\end{array}\right\} \quad (4)$$

Probability indicators of the functional state of the labor exchange can be found from relations (4) as follows [7]:

1) p_k – the probability of the labor exchange being in the state at time x_n *t* (*k* departments are busy, there is no queue):

$$For \quad p_k = \frac{\lambda^k}{k!\mu^k} p_0, \quad optional \ k < n \quad (5)$$

2) p_n – the probability that the labor exchange will be in position at the time X_n *t* (all *n* sections are busy, there is no queue)

$$For \quad p_n = \frac{\lambda^n}{k!\mu^n} p_0, \quad optional \ k = n \quad (6)$$

3) p_{n+s} – the probability of the labor exchange being in a state at the time X_{n+s} *t* (*n* departments are busy, s requests are in the queue):

$k > n \quad (k = n + s)$ when optional for $s \ge 1$

$$p_{n+s} = \frac{\lambda^{n+s} p_0}{k!\mu^n \prod_{m=1}^{s} (n\mu + mv)}, \quad (7)$$

4) p_0 – the probability that the labor exchange will be in a state at the time x_{n+s} *t* (no department is busy, there is no queue)

$$p_0 = \frac{1}{\sum_{k=0}^{n} \frac{\lambda^k}{k!\mu^k} + \sum_{s=1}^{\infty} \frac{\lambda^{n+sk}}{n!\mu^n \prod_{m=1}^{s} (n\mu + mv)}} \quad (8)$$

If $\left.\begin{array}{l}\frac{\lambda}{\mu}=\alpha \\ \frac{\nu}{\mu}=\beta\end{array}\right\}$ the specification is accepted and where the parameter is $\alpha-$the average number of requests corresponding to the average service time of one request, the parameter $\beta-$ is the number of departures of queued requests corresponding to the average service time of one request, then (5), (6), (7) and (8) formulas take the following form:

p_k – of the labor exchange being in the state at time x_k – t (all k departments are busy, there is no queue):

$$For\ p_k=\frac{\frac{a^k}{k!}}{\sum_{k=0}^{n}\frac{a^k}{k!}+\frac{a^n}{n!}\sum_{s=1}^{\infty}\frac{a^s}{\prod_{m=1}^{s}(n+m\beta)}}\ optional$$
$$0\le k\le n \quad (9)$$

2) the probability of p_{n+s} – the labor market being in a state at time x_{n+s} t (exactly n departments are busy, s requests are in the queue):

For optional $k>n\ (k=n+s)$

$$p_{n+s}=\frac{\frac{a^n}{n!}\frac{a^s}{\prod_{m=1}^{s}(n+m\beta)}}{\sum_{k=0}^{n}\frac{a^k}{k!}+\frac{a^n}{n!}\sum_{s=1}^{\infty}\frac{a^s}{\prod_{m=1}^{s}(n+m\beta)}}; \quad (10)$$

3) the probability p_0 – of the labor market being in a state at time x_{n+s} t (no department is busy, there is no queue)

$$p_0=\frac{1}{\sum_{k=0}^{n}\frac{a^k}{k!}+\frac{a^n}{n!}\sum_{s=1}^{\infty}\frac{a^s}{\prod_{m=1}^{s}(n+m\beta)}} \quad (11)$$

may include the mathematical expectation of the number of requests in the queue m_s and the probability that a request leaves the exchange without being served . P_H

$$m_s=M[s]=\sum_{s=1}^{\infty}sp_{n+s}=\frac{\frac{a^n}{n!}\sum_{s=1}^{\infty}\frac{sa^s}{\prod_{m=1}^{s}(n+m\beta)}}{\sum_{k=0}^{n}\frac{a^k}{k!}+\frac{a^n}{n!}\sum_{s=1}^{\infty}\frac{a^s}{\prod_{m=1}^{s}(n+m\beta)}}. \quad (12)$$

The mathematical expectation of the number of requests in the queue is determined by the expression m_s (12).

Also, the probability of the request leaving the exchange without service P_H is determined by the following expression:

$$P_H=\frac{\beta}{\alpha}\frac{\frac{a^n}{n!}\sum_{s=1}^{\infty}\frac{sa^s}{\prod_{m=1}^{s}(n+m\beta)}}{\sum_{k=0}^{n}\frac{a^k}{k!}+\frac{a^n}{n!}\sum_{s=1}^{\infty}\frac{a^s}{\prod_{m=1}^{s}(n+m\beta)}}. \quad (13)$$

And the relative transferability q of the labor exchange is determined by the expression (12).

$$q=1-P_H \quad (14)$$

In the unstable state of the labor market, the labor market $(\beta\to 0)$ can be interpreted as a pure waiting system, since the increase in the number of requests from the unemployed leads to an increase in the waiting time. The possibility of leaving the labor market unsatisfied $P_H=0$, i.e. without a job, certainly waits for his demand to be served. $t\to\infty$ The stationary mode of the system begins when the average number of requests received during the service of one client does not exceed the number of service channels, otherwise the queue grows indefinitely.

If $\alpha<n$ when $\beta\to\infty$ and formulas (9), (10), (11) , (12) take the following form [23]:

p_k – Probability of being in the labor market at time x_k – t (k departments are busy, there is no queue) :

$$p_k=\frac{\frac{a^k}{k!}}{\sum_{k=0}^{n}\frac{a^k}{k!}+\frac{a^{n+1}}{n!(n-\alpha)}} \quad (0\le k\le n); \quad (15)$$

2) the probability of p_{n+s} – the labor exchange being in a state at time x_{n+s} t (n departments are busy, s requests are in the queue):

$$p_{n+s}=\frac{\frac{a^{n+s}}{n!n^s}}{\sum_{k=0}^{n}\frac{a^k}{k!}+\frac{a^{n+1}}{n!(n-\alpha)}} \quad (s\ge 0); \quad (16)$$

3) the probability that p_0 – the labor exchange is in a state at the time x_{n+s} t (no department is busy, there is no queue)

$$p_0 = \frac{1}{\sum_{k=0}^{n} \frac{a^k}{k!} + \frac{a^{n+1}}{n!(n-\alpha)}}; \qquad (17)$$

4) $m_s -$ The mathematical expectation of the number of requests in the queue is:

$$m_s = \frac{\dfrac{a^{n+s}}{n \cdot n! \left(1 - \dfrac{\alpha}{n}\right)^2}}{\sum_{k=0}^{n} \frac{a^k}{k!} + \frac{a^{n+1}}{n!(n-\alpha)}}. \qquad (18)$$

It is worth noting that the size of the solution space is naturally much larger according to the method of the given approximate approach.

In addition, the direct calculation of formulas 5-18 dramatically increases the time estimates of the algorithms due to the factorials of the series of natural numbers in the denominator. Using an empirical coefficient such as "average loading" leads to large errors. It is intended to use simulation modeling methods for calculation as a solution to overcome the indicated shortcomings [8-10]. p_0, p_k, p_{n+s}, m_s, P_H

EXPERIMENT RESULTS

The module for receiving information signals includes data recording and editing functions. In this case, a database is formed and the storage of data generated on the basis of models is organized. The interface of the information signal receiving module of the software application is as shown in Figure 1.

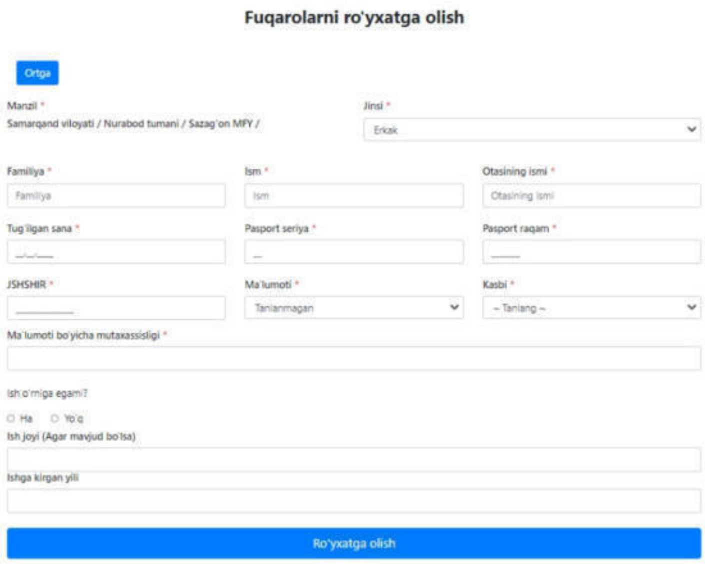
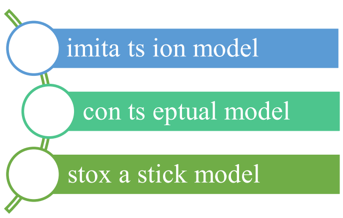


FIGURE 1. View of the module for receiving input data .

Initial input data is recorded to determine the employment status of the population in the cross-section of regions. In this case, the social status information of the adult population is formed and placed in the database. In the management part of the software complex, three models are placed in the module for regulating employment and labor relations of the population, these models serve to determine the state of unemployment in order to regulate employment in each region [11] . In the administrative part, the following models were built as part of the module for regulating employment and labor relations of the population:



The module for determining the professional employment status of the population will be in the form of Figure 2.

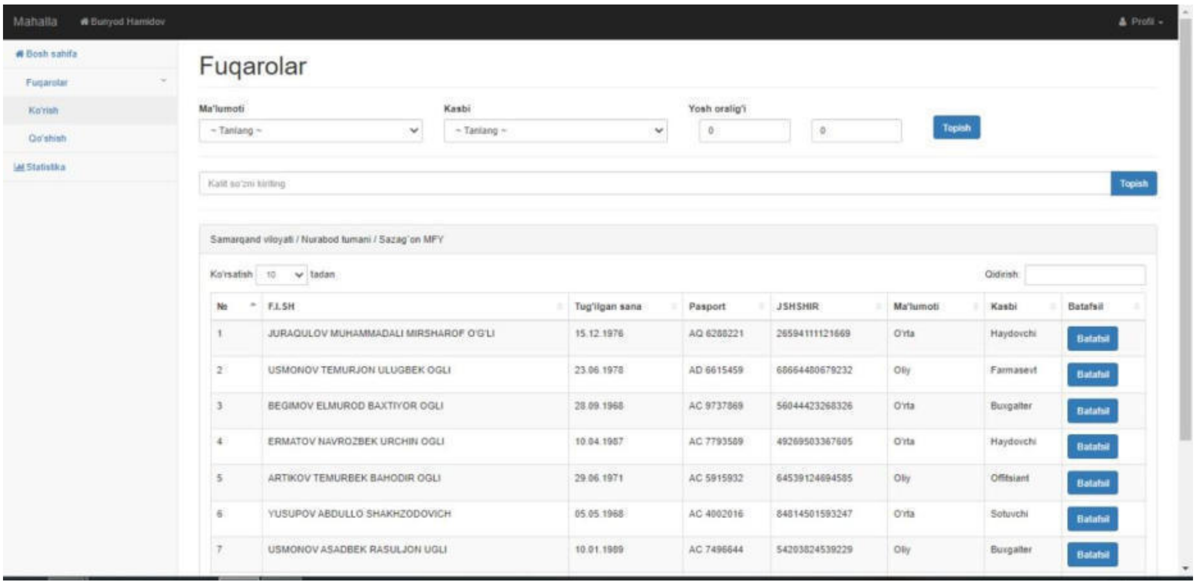


FIGURE 2. Module for determining the professional employment status of the population

Population based on developed models unemployment status and of the population professional information according to information known one area , that is region , district and neighborhood in the section to determine opportunity there is This Figure 3 of the process in the form of module done through is increased .

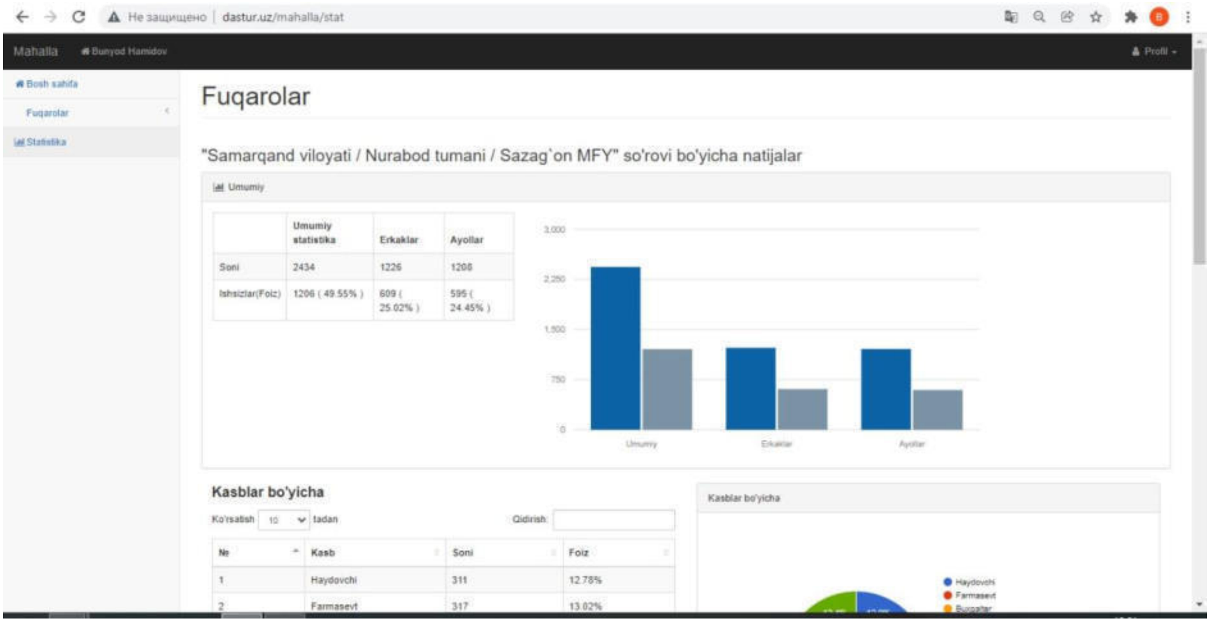


FIGURE 3 . of the population unemployment status and professional information to determine

Modules in pictures 2 and 3 above imita ts ion , con ts eptual , stoch a stic models based on of the population employment and work relationships in order to put done to increase service does [12].

In order to optimize the employment status of the population and labor relations, extimal and genetic evolution models have been developed. The developed models are placed as modules in the software package. On the basis of these modules, it is possible to optimize employment and labor relations of the population based on the determination of the next cases. This process is carried out through the module shown in Figure 4 .

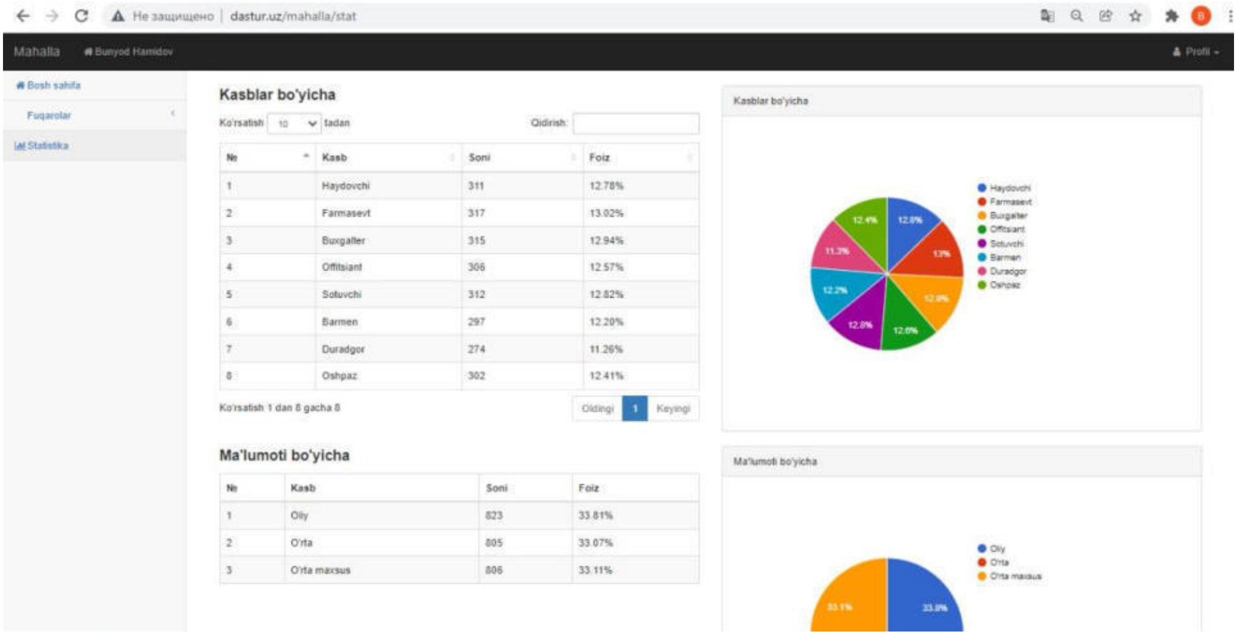
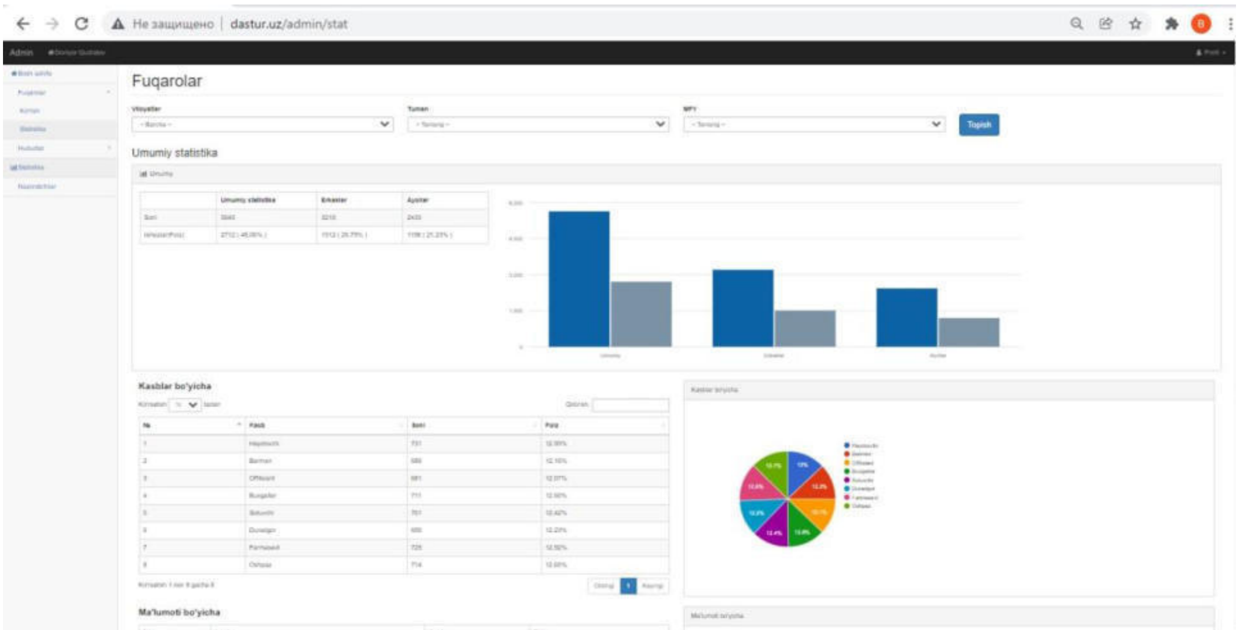


FIGURE 4. Module for determining the next state of employment of the population

The software package also includes a module for determining percentages of unemployment, employment, and professional data in a specific area, i.e., region, district, and neighborhood.

This process is carried out through the module shown in Figure 5 .

Functional tasks and capabilities of the modules of the software complex developed during the research were highlighted. The modules of the developed software complex serve to regulate and optimize employment and labor relations of the population [13-14].



5 - FIG. Module for determining unemployment, employment and professional data of the population in the percentage section

In addition to regulating and optimizing the employment situation and labor relations of the population in a certain area, the software complex also has technological tasks. The technological tasks of the software package include:

1. registration of users, supervisors and managers
2. monitoring of employment situations
3. perform data editing
4. perform the launch and overwriting of data
5. implementation of reports based on requests

In order to gain research experience, the developed software package was deployed and tested in cooperative organizations working with residents of neighborhoods and districts.

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MODERN METHODS OF REGULATING EMPLOYMENT RELATIONS

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Abstract. In the construction of new Uzbekistan, special attention is paid to glorifying human dignity, including providing every citizen with promising jobs. By optimizing the processes of finding a job in the labor market, it is possible to moderate the level of employment in the labor market. In the developed countries of the world, job search processes are carried out through automated systems, and this allows solving existing problems a little faster and more transparently. Each stratum of the population chooses available jobs based on their professional level, or finding a suitable candidate by redistributing the current job is one of the main directions of economic development. As a result of the experiments, it was determined by the optimization of the job search process that the time for finding a job is reduced and the time for predicting the demand of staff in some areas is reduced by several times.

***Key words: information system, modeling, employment, genetic algorithm, systematic analysis, artificial intelligence, prediction, conceptual model*.**

INTRODUCTION

In the world today, in the context of the development of the digital economy, attention is being paid to issues related to improving the standard of living of the population, creating jobs and increasing the level of employment with the rational use of existing jobs. In recent years, coordination of the population's employment situation and provision of the population's employment has become one of the most important issues in our country. Achieving the optimal balance between labor activity and social status is becoming important in such globalization conditions.

In the process of building a new Uzbekistan, it is becoming clear that the introduction of digital technologies in all areas of the economy, the use of them in increasing the level of employment of the population and the effective use of labor resources, the optimization of the labor force distribution in economic and social networks is significantly useful.

MAIN PART

In order to create an effective planning system for labor market development in the regions, it is necessary to develop an appropriate regional forecasting system. The forecasting system is one of the subsystems of the management entity. The purpose of forecasting is to inform the management decision-making process.

Regional Forecasting Subjects:

- • forecast consumers - regional authorities;
- • primary data suppliers - statistical bodies, information services;
- • Forecasters who directly implement the forecasting process are specialized divisions of the regional management structure.

The main tasks of forecasting [1-2] :

- • use for the formation of the annual regional order for personnel training in the system of higher and vocational education;
- • to determine the causal relationships between the components of the labor market and its separate sectors and external factors;
- • to identify possible alternative directions of development of the regional labor market and justify the choice;
- • multivariate calculation of quantitative indicators of demand and supply in the labor market;
- • to anticipate new directions and problems of the development of personnel policy in the region.

Information systems: Today, it is proposed to classify the software products that should be developed to provide information to the labor market and predict the training of highly educated specialists based on their needs into four groups:

The system is characterized by the ability to centrally store educational statistics data in a regional information center using various methods and technologies. In the complex, a convenient web interface was created based on the Internet, DataWarehouse, OLAP, GAT, and modules for multidimensional data analysis, connection of processed data to the area, and cartographic representation were developed.

As an example of programs used in employment services and recruitment agencies, software products of the St. Petersburg scientific production company "Katarsis", in particular, automated systems of "Labor market monitoring".

SPSS, VORTEX and STATISTICA programs for social and statistical data processing are used to solve business problems, work with any amount of data stored in any format and database, including corporate databases and stored on the Internet, provide variable properties in preparation for data analysis, repeat search for observations, reorganize files, perform statistical procedures such as correlation in data analysis, linear regression analysis, factor analysis, cluster analysis, create reports in the form of visual diagrams, present results using OLAP reports [3].

GPSS World (General Purpose Simulation System, "Minuteman Software"), Process Charter-1.0.2 ("Scitor"), Powersim-2.01 ("Modell Data"), Ithink-3.0.61 ("High Performance Systems"), Extend+BPR-3.1 ("Imagine That!"), ReThink ("Gensym"), Micro Saint ("Calspan Advanced Technology Center"), Pilgrim systems covering the fields of discrete and continuous computer modeling, comprehensive modeling with the highest level of interactivity and visual presentation of information, allows to evaluate the effectiveness of design decisions in highly complex systems, to monitor and record the internal mechanisms of model operation, to simultaneously study and control the processes of interactivity modeling. The functional model of the coordination of labor relations serves as the basis of the implementation of the stages of the ongoing research and the concept of the system of coordination of employment of the population in the labor market. Based on the modeling of the social situation of the population, the system of automated regulation of labor relations, the mathematical formulation of the management problem is expressed by the formula (1).

$$\begin{cases} F\left(N_1(t), N_2(t), u(t), \lambda\right) \to extr \\ N_1(t), N_2(t) > 0 \\ N_1(t) \to \max \end{cases} \qquad (1)$$

The total number of specialists employed $N_2(t)$ in setting the management issue ; $N_1(t)$ – number of employable and unemployed workers; $u(t)dt$ this is a parameter for optimizing the unemployed specialist's job search t from $t+dt$ time to time; $W_2(t)dt$ the possibility of dismissal of the specialist working λ from $t+dt$ this time; t external influences in labor relations. Based on this, $u(t)$ the condition is ensured on the basis of the management parameter, and labor force coordination in the labor market is carried out using the following formulas (2) and (3). $N_1(t) \to \max$

$$\frac{dN(t)}{dt} = \left(N_2(t)u(t) - N_1(t)W_2(t)\right) \qquad (2)$$

$$N(t) = \int_0^T \left(N_2(t)u(t) - N_1(t)W_2(t)\right)dt \qquad (3)$$

The functional scheme of the management problem is represented in the form of Figure 1

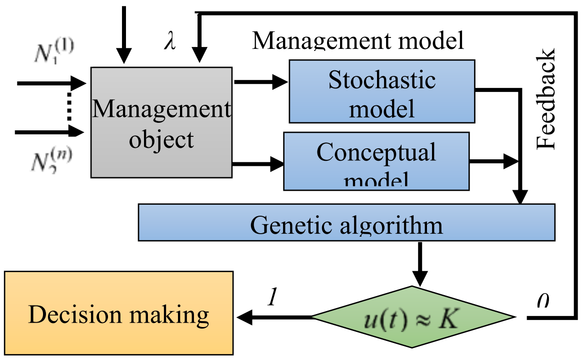

FIGURE 1. Management scheme of the labor market.

In managing population employment, $u(t)$ the control parameter controls the coordination of the job search process. In this case, with the improvement of the management parameter, the level of employment will improve and the probability of finding a job for qualified specialists will increase. Based on this, $u(t)$ since the control parameter depends on the probability of finding a job, $u(t)$ we introduce the following definition to the parameter. $W_1(t) = u(t)$ then the expressions (2) and (3) have the following form.

$$\frac{dN(t)}{dt} = \left(N_2(t)W_1(t) - N_1(t)W_2(t)\right)$$

$$N(t) = \int_0^T \left(N_2(t)W_1(t) - N_1(t)W_2(t)\right)dt$$

Issues of simulation modeling of the labor market: Simulation modeling of the labor market is considered as one of the main means of determining the nature of economic relations between workers and employers. In this case, a multi-agent simulation model is used, and the main element of the functional and organizational structure of the labor market is the labor exchange as an object of modeling.

The simulated model of the labor exchange under development allows:

- reflect the process of events in the labor market, the behavior and interaction of its objects on the basis of appropriate formalization;

- determination and coordination of a wide range of generalized indicators of the modeled labor exchange process;

- predicting the future behavior and interaction of labor exchange objects.

In addition, the proposed simulation modeling system will have the following features:

• use of simulation programs together with special economic-mathematical models and methods based on the theory of management of economic processes;

• demonstrative presentation of the results of the analysis of complex economic processes in the labor market;

• material supply within the framework of the single model of the labor market real-time modeling of actions, money circulation, information exchange processes;

• introduction of a mode of dynamic clarification of data during the reception of the result data of the labor exchange activity and the transfer of experience in extreme cases.

The use of simulation models creates new opportunities for conceptual analysis of labor market problems, shortening the time of development of prospective projects and organizing its effective operation.

Many economic processes are self-organizing, and economic objects are examples of complex self-organizing systems. The effectiveness of such objects is related to their certain level of stability and adaptability to external conditions. The application of the basic laws of self-organization allows for the purposeful design of artificial thinking environments, in which the necessary structures (stationary or dynamic in time) are formed with the help of self-organization processes [4].

In a formalized form, the property of self-organization is described as follows [5]. Let a given system $U = u_1, u_1, \ldots, u_p$ be represented in the form of a complex system with additional control inputs, and system B, depending on the value of the control quality indicator , W generates the values of the incoming signals , i.e. $u_1, u_1, \ldots, u_p$

$$\mathrm{U} = \Psi(W, \lambda),$$

where U is a set of control input signals designed to correct the results of the controller according to the W specified set of rules ;λ

Ψ - this W and λ a functional relationship that represents the connection between

It should be noted that λthe sets of rules and their relationship with the control quality indicator W, which forms the control signal *U , are determined by experts.*

Control signal *It adjusts the value of* the system control quality indicator $\alpha_1, \alpha_1, ..., \alpha_k$ in the desired direction. At the same time, the adjustment of the quality of management can also be related to the change in the structure of this system. Figure 2 shows the object model in the form of a complex system with self-organization [6-7].

If a simulation model is used that allows introducing any $\lambda_1, \lambda_2, ..., \lambda_s$ set of rules that adjust the quality of control W, then self-organizing systems are modeled without problems. $N_1^{(1)} \cdots N_2^{(n)}$, inputs, Y outputs, and state of the N model operate in the simulation model in normal mode and describe the object or process. Outputs Y of the system reflect parameters of management quality . They are entered into the B system, $\lambda_1, \lambda_2, ..., \lambda_s$ analyzed according to the existing set of rules, and U generates control signals[8-10].

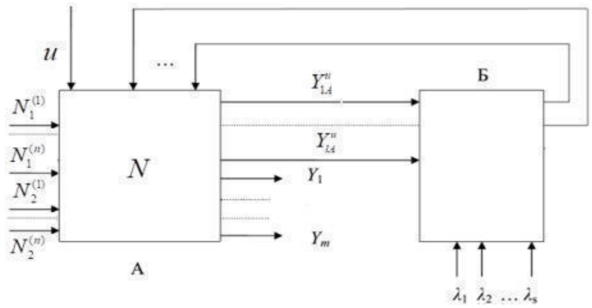

FIGURE 2 . A self- organizing object

Based on this approach, a model of the self-organizing labor market in a particular field is proposed, which allows analyzing the effectiveness of management decision-making and predicting the development of labor market events.

Genetic algorithm in labor market optimization: Effective strategic and rapid management of complex organizational structures requires solving large-scale multi-criteria optimization problems, but the use of existing stochastic methods cannot provide sufficient accuracy [11]. At the same time, simulation modeling methods and tools are usually used to design intelligent management systems of similar systems, and with their help, it is possible to describe the most important relationships between financial and material flows of a large company and to study the dynamics of key performance indicators depending on scenario conditions. Due to this, in the next stage of research, it was decided to integrate the simulation model of the enterprise with genetic optimization algorithms to support the optimal control mechanism [12]. A simplified functional diagram of the proposed evolutionary method -is shown in Figure 3. This scheme at the stage of choosing solutions allows to apply different criteria for ranking solutions, as well as to perform transition and mutation operations between representatives of different subsystems

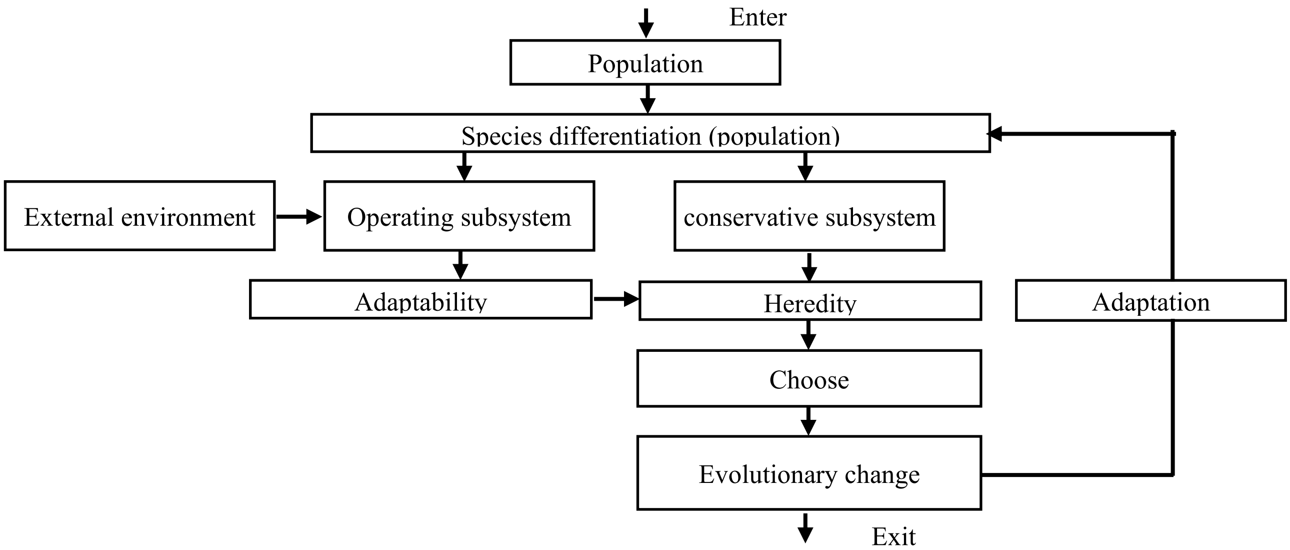

FIGURE 3. Conditional scheme of the evolutionary method

Based on the described method, a genetic algorithm (GA) was developed using the principles of the classical genetic algorithm, and it is used to solve both unconditional and conditional optimization problems [13].

For each sample that represents a particular solution of the problem according to the algorithm, it is required to store in memory the value of the parameters of the objective function, the type of the sample (S_k and S_0) and the period of activity of the sample (T_{life}). Initially, the population is divided into two types S_k and S_0 samples in a certain ratio. The value of the objective function, which controls the operation of the algorithm, changes according to the influence of the external environment. A set of genes (chromosomes) describing a specific value of the objective function is expressed as a one-dimensional array, and its size is equal to the number of genes. The reason for choosing such a description is that unsigned integers are the most effective among various ways of representing numbers in calculations [14].

There are a number of ways to account for constraints in genetic algorithms that affect both the final value of finding a solution to the objective function and the composition of the population . The method proposed in the research is based on the act of artificially reducing the level of compatibility of the solution vector found in cases of deviation from the specified restrictions. Let the conditions of the optimization problem (4) with respect to the objective function be defined as follows:

$$\begin{aligned} & f(t) \to \max_{W \in \Omega_W} \\ & N_k^{(i)}(t)_{\min} \le N_k^{(i)}(t) \le N_k^{(i)}(t)_{\max}, \\ & i = \overline{1,n},\ k = 1,2 \end{aligned} \tag{4}$$

Then the final fitness of the selected sample can be calculated according to the following formula:

$$\text{fitness}(t) = f(t) + \delta \cdot \lambda(x) \cdot \sum_{j=1}^{n} f_j^{\beta}(t), \tag{5}$$

where *x is* – current generation number;

$f_j(t)$ – avoidance of *j -numerical restrictions;*

β – real number, deviation rate indicator.

According to the method, $f_j(t)$ the value of is dynamically calculated according to the formula (6) for *the t* -th iteration depending on the degree of deviations and $\lambda(t) = (C \cdot t)^{\alpha}$.

$$f_j(t) = \begin{cases} \max\{N_1^{(i)}(t), i = \overline{1,n}, \} \\ \min\{N_2^{(i)}(t), i = \overline{1,n}, \} \\ \max\{W_1^{(i)}(t), i = \overline{1,n}, \} \end{cases} \tag{6}$$

$C = 0{,}5, \alpha = \beta = 2$ the recommended values of the parameters vary depending on the task and affect the efficiency of finding a solution.

To improve this method, it is possible to adaptively calculate the reduction of conformity due to deviation, which $\lambda(t)$ depends not only on the number of iterations, but also on the number of times the best representative of the population (population samples) touches the area of allowed values at each step (7).

$$\lambda(t+1, \beta) = \begin{cases} \dfrac{\lambda(t)}{\beta_1}, \text{агар } \vec{b}^{\,i} \in F \text{ учун барча } x - m \le i \le x, \\ \beta_2 \cdot \lambda(t), \text{агар } \vec{b}^{\,i} \in S - F \text{ учун барча } x - m \le i \le x, \\ \lambda(t), \text{акс хол} \end{cases} \tag{7}$$

where $\vec{b}^{\,i}$ is the best sample of the $\beta_1, \beta_2 > 1$, i - th population, and $\beta_1 \ne \beta_2$.

In this method, if the best representative of the population (in terms of the fitness function) belongs to the domain of allowed values in the last *m iteration, the fitness index is reduced in the next step.* If the best representative of the population deviates from the limits of the permissible area during the same period, the compliance index is increased.

Initial input data is recorded to determine the employment status of the population in the cross-section of regions. In this case, the social status information of the adult population is formed and placed in the database. In the management part of the software complex, three models are placed in the module for regulating employment and labor relations of the population, these models serve to determine the state of unemployment in order to regulate employment in each region [15]. In the administrative part, the following models were built as part of the module for regulating employment and labor relations of the population imitatsion model, contseptual model, stoxastick model.

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THE ROLE OF ARTIFICIAL INTELLIGENCE IN THE MECHANISM FOR TRANSPORT AND LOGISTICS FLOWS MANAGING IN THE CONTEXT OF DIGITAL TRANSFORMATION

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A B S T R A C T **The digital transformation of any business, including transport and logistics organizations, is today a trend that contributes both to the concept of the company's image and the increase in the efficiency of its activities. However, in order to achieve the effectiveness of digital transformation, it is necessary to implement it in stages and comprehensively. Only taking into account the phasing factor, it is possible to qualitively digitalize the transport and logistics organization.**

K E Y W O R D S The role of artificial intelligence in the mechanism for transport and logistics flows managing in the context of digital transformation, Belarus, Belarusian National Technical Universit.

INTRODUCTION

In the 21st century, the rational management of transport and logistics flows is an important task for the development of the logistics system of any state, the solution of which cannot be imagined without the use of modern information technologies. In the process of research, the emerging combination of various information technologies generates terms such as informatization, digitalization and digital transformation.

METHODS

The full description of the presented concepts is described in the Law of the Republic of Belarus "On Information, Informatization and Information Protection" dated November 10, 2008 No. 455-Z and STB 1693-2009 "Informatization. Terms and definitions". Thus, informatization is an organizational, socio-economic, scientific and technical process that provides conditions for the formation and use of information resources and the implementation of information relations [1, 2]. Digitalization is a new stage of automation and informatization of economic activity and public administration, the process of transition to digital technologies, which is based not only on the use of information and communication technologies to solve production or management problems, but also on the accumulation and analysis of big data with their help in order to predict the situation, optimize processes and costs, attract new contractors etc. [3]. Digital transformation is a manifestation of qualitative, revolutionary changes, consisting not only in individual digital transformations, but in a fundamental change in the structure of the economy, in the transfer of value creation centers to the sphere of building digital resources and end–to-end digital processes. As a result of digital transformation, a transition to a new technological and economic structure is underway, as well as the creation of new sectors of the economy [3].

RESULTS

Today, it is already generally recognized that the future development of the economy, and in the future of all mankind, is connected with the digital economy. In this regard, the attention of researchers is increasingly attracted to the theoretical and practical problems of digitalization.

The continuous process of digitalization development is associated with the endless growth of information flows. The constant growth in the volume of heterogeneous information, which can be received in numerous directions, has recently accompanied both large and fairly small transport and logistics organizations. All information flow entering the organization is subject to certain storage, evaluation, structuring, analysis and accounting. Without the use of specialized information systems, it is difficult and practically impossible to solve the above problem, and even with a huge amount of information. And since today the most important factor is the speed of response to incoming requests in doing business, organizations that want to work effectively need to radically improve the processing of information flows coming to them and coming from them. Digital technologies make it possible to accumulate huge amounts of information that companies not only can, but must use to make management decisions. The vast majority of human activities, including logistics, are subject to global automation. In other words, thanks to the development of digitalization, new opportunities have appeared for the creation and development of end-to-end management systems for material and related flows in the economy, which contributed to the formation of logistics as an activity for managing these flows based on pre-developed, controlled indicators.

A marketing study of the business services market by the consulting company Deloitte showed that only a third of all surveyed representatives of the largest companies are confident that they will be able to adapt to the conditions that the era of digitalization will set for them. In addition, Chambers' forecast reads as follows: in the next decade, of all the companies studied to date, only a slightly larger half of them (about 60%) will remain active in the economy, due to the companies' unwillingness to total digitalization of business [4].

Already today there are quite a lot of examples of brands that used to have a large share in the market share, but today their customer base has become invisible (Kodak, MySpace, Motorola, Blackberry, etc.). Having studied the reverse side of this phenomenon, it is necessary to note those corporations that, on the contrary, used this situation to improve their position in the market the market (Google, Apple, Microsoft, Amazon, etc.) [5].

McKinsey &Company experts argue that "in modern reality, business needs innovations not only to accelerate the pace of development, strengthen leadership and break away from competitors, but also to timely protect against damage to the industry in the event of the introduction of radical innovations that make entire business lines economically impractical" [6].

When managing transport and logistics flows, various factors arise that significantly affect the process under consideration. Such factors, according to the article by K.V. Kholopov, are divided into external and internal. To a greater extent, external factors impose ambiguity on the process of managing transport and logistics flows. Based on this, their research should be approached with a greater degree of responsibility and analyzed with a large number of experimental samples (examples) [7].

In the context of the economic development that modern society dictates to us, the management of transport and logistics systems and flows, as previously noted, is associated with the universal penetration of digital technologies.

Digitalization (TLP) makes it possible to optimize the transport and logistics process. Digital technologies guarantee an increase in the economic efficiency of business processes in logistics, increase the safety and quality of transport and logistics services, and provide a significant competitive advantage.

Today, there are already some models that systematize the process of digital transformation of an organization.

The first model is presented by the Center for Digital Business at the Massachusetts Institute of Technology. The essence of this model is that all its blocks and elements are interdependent. The first block is a block consisting of elements specific to working with clients, i.e. the relationship with the external environment. The second block characterizes the production process itself. The third block is the model itself, which must be achieved using the developments of the first and second blocks. The third block is the goal to be achieved [8].

The second model is Deloitte's Digital Maturity Model (DMF). This model evaluates the level of digital transformation using the following indicators:

- customer;
- Production process;
- Organization strategy;
- Production technology;
- structure;
- the culture of the organization.

At the initial stage, the organization's strategy is being investigated. According to the results of her research, further directions of the organization's development in the field of digital transformation are visible [9].

Such a task as the digital transformation of a process, or the business as a whole, and in this case, flow management, is in service with the vast majority of organizations among various types of economic activity. Being a fairly new direction that has replaced partial computerization and informatization of business processes, digitalization creates conditions for the growth of the number of companies that need to develop and implement their own digital software products. Thus, there is an increase in the innovative component of the business, which in turn contributes to the effective development of the economy and logistics.

It is important to note the opinion of T.G. Shulzhenko, which says that digitalization of transport and logistics flow management contributes to the emergence and further development of innovative production, growth of competitiveness in conditions where the role of individualization of consumer requirements for goods and services increases [10]. However, based on the above, logistics at the current stage of development is somewhat lagging behind such types of economic activities as banking, trade, telecommunications and communications, etc. In the vast majority of transport and logistics organizations, there are many manual operations when organizing the workflow, the assets of the organization are not fully used effectively, which slows down the process of digital business transformation. It is important to note that many scientific papers on digitalization have been written today, which define its conceptual apparatus, scope, technological component of digital transformation, etc., but it is difficult to find any recommendations that need to be followed by transport and logistics organizations implementing digitalization tools, which is due to some complexity of the process of perceiving such an abstract at the moment phenomena.

Thus, the significant role of flow processes in the activities of organizations contributes to the creation of a special mechanism for the development of digital transformation of transport and logistics activities, which would be standard for any, without exception, transport and logistics organization.

Artificial intelligence plays an important role in the management of transport and logistics flows. The vast majority of human activities, including logistics, are subject to global automation, in particular, the influence of artificial intelligence. In other words, thanks to the development of IT, opportunities have appeared for the creation and development of end-to-end management systems for material and related flows in the economy, which contributed to the formation of logistics as an activity for managing these flows based on pre-developed, controlled indicators.

DISCUSSION

Currently, it is very important to accurately determine the content and meaning of the concept of artificial intelligence, as well as its components, which must be present in this concept.

The author of the term "artificial intelligence" (AI) is D. McCarthy. In his article "What is artificial intelligence?" he gives the following interpretation of it: "AI is the science and technology of creating intelligent machines, especially intelligent computer programs" [11]. After him, many definitions were given by other scientists, some of them are presented below.

Thus, according to the definition of A.N. Averkin, "AI is the property of intelligent systems to perform creative functions that are traditionally considered the prerogative of man" [12]. In his work "Artificial Intelligence: the state of research and a look into the future" G.S. Osipov gives the following definition: "AI is a direction in computer science and information technology, the task of which is to recreate intelligent reasoning and actions with the help of computer systems and other artificial devices" [13]. Andreas Kaplan and Michael Henleins in their articles understand AI as "the ability of a system to correctly interpret external data, learn from such data and use the knowledge gained to achieve specific goals and objectives through flexible adaptation" [14]. Thus, it can be noted that all of the above definitions boil down to the fact that AI is a kind of ability to create programs during the process of self–learning to solve problems of a certain level of complexity and quickly solve these problems.

As noted earlier, AI is used in almost all spheres of human activity, logistics is no exception.

The constant complication of processes, the growth of information volumes and the increase in decision-making options lead to the fact that it is almost impossible for a person to cope with such tasks. To do this, it is necessary to use AI technologies, which will greatly simplify and streamline the work of employees.

In transport logistics, AI technologies allow the development of various traffic flow and vehicle management systems that can "function similarly to an experienced human operator when exposed to random factors, but exceeding its capabilities in terms of the volume of analyzed factors and response speed" [15]. In addition to flow control, there are a number of tasks that can be automated using AI. Among such tasks are:

– collection and analysis of information about the organization's finances (AI can optimize the cost of time and money in the processing and analysis of financial information);

– processing of customer information (separation and segmentation of customers, will allow you to find and calculate rational tariffs and select personalized offers to increase profits and profitability);

– customs clearance (instead of checking each document individually, AI technologies can process all documents at the same time);

– optimization of the logistics route (AI solutions allow decision makers to analyze existing routes, identify problem areas and find the best route. This reduces not only the time, but also the total cost of delivery) [16].

The main development in the field of AI technologies, which can be used in transport logistics, is the creation of unmanned vehicles, for example, the design of an unmanned vehicle, the formation of "smart" traffic management systems ("smart" passenger transport schedules, "smart" traffic lights and others) [17].

Speaking about the impact of AI on road transport, it should be noted that one of the main advantages noted by experts competent in this field is increased comfort of movement and, of course, safety on the road [18]. The absence of the human factor (which is predominant in making mistakes on the road) and the complete adherence of the car to algorithms can eliminate the likelihood of road accidents (accidents). However, since unmanned vehicles have not yet been put into widespread use, and all the previously described advantages of AI are based only on theoretical aspects and assumptions of scientists, the possible success of this concept during experiments in the future will contribute to the implementation of this idea in transport logistics.

In addition to the positive aspects presented, this system has its drawbacks:

– liability for significant damage;

– the use of AI can negatively affect the economy: the loss of a huge number of jobs by people who were employed in the industry in question, which will lead to global unemployment;

– unreliability of the software (software) on which human security depends [18].

In my opinion, unpredictable actions of pedestrians, vehicle drivers and other road users can become a serious problem for unmanned technologies in road transport. The use of AI is an obligation to comply with all traffic rules – compliance with speed limits, passing pedestrians at an unregulated pedestrian crossing, showing turns, and so on. But there are always those who exceed the speed limit, do not let pedestrians pass, continue to move despite the red traffic light – and all such violations can be listed endlessly. Due to the presence of such problems, it is very difficult to make predictions about the introduction of cars with AI technologies. If a driver is driving, he can immediately assess the situation and make the best or best decision based on the situation that has arisen. A person evaluates the risks, and only he is responsible for his decision, and the robot chooses the action that is provided by the algorithm [11].

CONCLUSION

Despite the presence of both advantages and disadvantages, it should be noted that today there is a certain interest in artificial intelligence, which is a trend in science, and it is obvious that the technology will continue to develop. However, the existing developments of scientists are still not enough to completely make the transport unmanned. Since AI works by "learning" from examples from the past, when a completely new and non-standard environment arises, its actions will become unpredictable, and this can become disastrous. In addition to the above, it is necessary to note the problem of information distortion as a result of machine-to-machine interaction, since no human development in the field of programming can be considered absolutely error-free. I would like to note that no matter how perfect and ideal the AI is, it should still be under the direct control of a person, and in no case vice versa. Based on theoretical assumptions, some systems can already move to full autonomy, but the responsibility for the error of such a system is too high, which does not allow this to be done. Perhaps in the near future there will be an organization that will be able to introduce its achievements into the transport industry.

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THE MECHANISM OF DEVELOPMENT OF DIGITAL TRANSFORMATION OF TRANSPORT AND LOGISTICS ACTIVITIES

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THE ADVANTAGES OF USING ARTIFICIAL INTELLIGENCE IN DETERMINING INSURANCE RISKSAUTHOR AFFILIATIONS

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A B S T R A C T **The insurance industry has long relied on data and statistical models to assess risks and determine appropriate premiums for policyholders. In recent years, the adoption of artificial intelligence (AI) has revolutionized this process, bringing enhanced precision, efficiency, and new capabilities. The advantages of using AI to determine insurance risks are significant, benefiting insurers, policyholders, and the industry as a whole.**

K E Y W O R D S ***Artificial Intelligence, Insurance Solutions, Insurance Risks, NLP, Faster and More Efficient Underwriting, Predictive Analytics for Emerging Risks, Improved Customer Experience***

INTRODUCTION

One of the most significant advantages of AI in insurance risk assessment is its ability to process vast amounts of data and identify patterns that humans might overlook. AI algorithms can analyze a wide range of factors, including historical claims data, driving records, social media behavior, and even satellite imagery, to create more accurate risk profiles. This enables insurers to:

Price policies more precisely: By understanding individual risk levels, insurers can offer more competitive premiums to low-risk customers and charge appropriate rates to high-risk customers.

Identify potential fraud: AI can detect anomalies in claims data, such as inconsistencies or patterns indicative of fraudulent behavior.

Proactively manage risks: By predicting potential risks, insurers can take preventive measures to mitigate losses and improve customer satisfaction.

METHODS

Improved Risk Assessment Accuracy

AI excels in processing large volumes of data rapidly and accurately, making it an invaluable tool for improving risk assessment models. Traditional methods of evaluating insurance risk primarily rely on historical data, which may not account for subtle patterns or emerging trends. AI, especially through machine learning (ML) algorithms, can analyze vast datasets and recognize intricate correlations that humans might miss. This allows insurers to predict potential risks with greater precision, resulting in more accurate pricing and underwriting.

For example, in auto insurance, AI systems can assess driving habits through telematics data, identifying risky behaviors such as hard braking, speeding, or erratic driving patterns. This granular approach enables insurers to offer usage-based insurance (UBI) policies, which more accurately reflect an individual's risk profile compared to traditional models based solely on demographic data.

Enhanced Fraud Detection

Insurance fraud is a costly issue for both insurers and policyholders, leading to higher premiums and inefficiencies. AI can play a crucial role in combating fraud by detecting suspicious claims and identifying fraudulent patterns more efficiently than human investigators.

Machine learning algorithms can be trained on historical claims data to recognize anomalies that indicate potential fraud. These systems can monitor real-time transactions and flag unusual activities, such as claims that deviate from typical patterns in terms of timing, location, or behavior. Natural language processing (NLP) can also assist by analyzing claim documentation for inconsistencies or deceptive language. This proactive fraud detection reduces the burden on human investigators and ensures legitimate claims are processed faster.

Personalized Insurance Solutions

AI empowers insurers to offer more personalized and flexible insurance products. By analyzing a wide range of factors—including an individual's behavior, preferences, and lifestyle—AI systems can tailor policies that better fit the needs of each policyholder. This approach, often referred to as micro-segmentation, moves beyond broad categories of risk, enabling insurers to create finely tuned pricing models and coverage options.

For instance, health insurance providers can utilize wearable devices and AI to monitor the health and fitness levels of policyholders, adjusting premiums based on their health metrics. Home insurers can use AI to predict which homes are at higher risk of natural disasters or accidents, offering customized coverage to address specific vulnerabilities. The result is a more personalized insurance experience that reflects the unique risks and behaviors of each customer.

Faster and More Efficient Underwriting

AI-driven automation streamlines the underwriting process, making it faster, more accurate, and cost-effective. Traditional underwriting often requires manual data collection, review, and analysis, which can be time-consuming and prone to human error. AI, on the other hand, can instantly gather and evaluate data from multiple sources—such as financial records, social media, and public databases—reducing the need for human intervention.

This automated process not only speeds up decision-making but also enhances consistency. AI can apply predefined rules and predictive models to ensure that each policy is evaluated objectively and fairly. The result is faster policy issuance, improved customer experience, and reduced operational costs for insurers.

Predictive Analytics for Emerging Risks

AI's ability to analyze vast datasets allows insurers to stay ahead of emerging risks in an increasingly complex world. With the integration of AI, insurers can harness predictive analytics to identify potential threats before they materialize, enabling proactive risk management. This is particularly relevant in areas such as cyber insurance, where risks evolve rapidly and new threats emerge frequently.

For example, AI can analyze global trends in climate change, economic shifts, and technological advancements to predict how these factors might impact the insurance landscape. By leveraging this predictive power, insurers can develop new products, adjust existing policies, and mitigate risks in real-time, ensuring they are well-prepared for future challenges.

Improved Customer Experience

AI doesn't just benefit insurers; it also enhances the customer experience. Chatbots and virtual assistants, powered by AI, can handle customer inquiries, claims processing, and policy management around the clock. This improves response times and provides a more convenient and efficient service for policyholders.

AI-driven personalization also allows insurers to recommend the most relevant products and services to customers, further improving the user experience. By leveraging AI, insurers can build stronger relationships with their customers, offering them more value and convenience than ever before.

RESULTS

AI enables insurers to make more informed, data-driven decisions across the board. The ability to analyze and interpret vast amounts of structured and unstructured data allows insurance companies to refine their strategies, improve risk models, and optimize their operations. This data-driven approach helps companies identify inefficiencies, discover new opportunities, and adjust their pricing models based on real-world insights.graphs, allowing for easy interpretation and comparison. The section will provide a summary of the main findings related to the effect of exercise on cognitive function, including any statistically significant improvements observed.

DISCUSSION

Artificial intelligence (AI) is rapidly becoming a cornerstone of the insurance industry, offering powerful tools that revolutionize how insurers assess and manage risk. By leveraging AI, insurers are able to gain deeper insights, enhance operational efficiency, and better serve their customers. Below, we discuss the key benefits of integrating AI into insurance risk determination.

The adoption of artificial intelligence in determining insurance risks has created significant opportunities for insurers to improve accuracy, enhance operational efficiency, and offer better customer experiences. By leveraging AI's capabilities in predictive analytics, fraud detection, personalized solutions, and automation, insurers can remain competitive in an increasingly data-driven world. As AI continues to evolve, its role in risk assessment will only become more vital, driving further innovation and transformation within the insurance industry.

CONCLUSION

Artificial intelligence is a powerful tool for transforming the insurance industry. By improving risk prediction, enhancing underwriting efficiency, and creating personalized customer experiences, AI can help insurers achieve significant benefits. As AI technology continues to advance, we can expect to see even more innovative applications in the insurance sector

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AN AI-DRIVEN APPROACH TO EMPLOYEE TASK AND TRAINING RECOMMENDATIONS USING MATRIX FACTORIZATION

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A B S T R A C T **Organizations are increasingly using AI techniques to boost employee performance in the era of data-driven decision-making. In light of employees' past performance and engagement data, this study provides a collaborative filtering-based recommender system that uses matrix factorization to make task and training program recommendations to staff members. Our algorithm predicts the best recommendations for upcoming tasks and finds hidden patterns in employee behavior by using Singular Value Decomposition (SVD) on employee-task matrices. The suggested method offers a scalable and personalized recommendation engine that can be linked into employee performance management systems to boost productivity and skill development.**

K E Y W O R D S Recommender system, collaborative filtering, matrix factorization, employee performance, AI, singular value decomposition (SVD)

INTRODUCTION

With the increasing volume of employee data generated by performance evaluation systems, there is a growing need for AI-driven tools that can assist employees in improving their skills and productivity. Employee task and training recommendations can play a crucial role in professional development, helping employees identify opportunities to enhance their performance. Traditional task allocation is often static and lacks personalization, limiting its potential for individual growth.

In this paper, we propose a collaborative filtering-based recommender system using matrix factorization to provide personalized task and training recommendations. Matrix factorization methods like Singular Value Decomposition (SVD) are highly effective for finding latent patterns in user-item interactions, making them ideal for identifying tasks that will likely benefit employees. By integrating such a system into existing employee performance platforms, organizations can offer targeted recommendations to employees, increasing both engagement and productivity.

Recommender systems have been extensively studied and implemented in various fields such as e-commerce (e.g., Amazon), content streaming (e.g., Netflix), and online education platforms (e.g., Coursera). The two primary methods used in recommender systems are content-based filtering and collaborative filtering.

The development of recommender systems, particularly in the context of employee performance and task recommendation, has garnered significant attention in recent years. Recommender systems leverage machine learning algorithms to provide personalized suggestions based on user preferences and behavior. The following section explores related work in areas such as collaborative filtering, matrix factorization, employee performance evaluation, and the application of artificial intelligence (AI) in human resource management.

Collaborative filtering (CF) is a widely used technique in recommender systems that relies on user-item interactions to provide personalized recommendations. The idea behind CF is that users with similar preferences in the past will have similar preferences in the future. CF can be classified into two main approaches: user-based and item-based filtering.

In user-based collaborative filtering, recommendations are made by identifying users who have similar interactions with items (e.g., tasks, products) and suggesting items that similar users have rated highly. Meanwhile, item-based collaborative filtering recommends items that are similar to those the user has already interacted with.

Sarwar et al. [1] pioneered the application of collaborative filtering using item-based techniques to improve the scalability and accuracy of recommendation systems. Their work provided the foundation for large-scale implementations of collaborative filtering, which remains a popular approach in domains ranging from e-commerce to human resources.

However, user-based collaborative filtering may suffer from sparsity in the data matrix, leading to challenges when predicting scores for employees who have interacted with only a few tasks. Matrix factorization techniques, such as Singular Value Decomposition (SVD), have emerged as a powerful solution to this issue.

Matrix factorization has become a core method in modern recommender systems due to its ability to handle large, sparse matrices, such as employee-task matrices. The method reduces the dimensionality of the matrix by extracting latent factors that represent underlying patterns in the data[2-4].

AI techniques have become an essential tool for evaluating employee performance in modern organizations. Recommender systems powered by AI help identify employee strengths and areas for improvement, facilitating personalized development plans. The HR analytics field, which involves the application of data-driven algorithms to HR processes, has seen a growing interest in AI-based systems for performance management[5-7].

Task recommendation systems are a specific application of AI in employee development, where the goal is to match employees with tasks that align with their skills and performance history. Such systems help employees improve their productivity, job satisfaction, and overall career growth by focusing on tasks they are likely to succeed in[8-10].

While collaborative filtering and matrix factorization are powerful techniques, hybrid recommender systems that combine multiple algorithms have been shown to improve recommendation accuracy. Hybrid systems leverage the strengths of different recommendation approaches, such as content-based filtering and collaborative filtering, to provide more robust recommendations[11,12].

METHODS

This section describes the process of developing a task recommender system for employees using Collaborative Filtering (CF) and Singular Value Decomposition (SVD) for matrix factorization. The methodology involves the following steps:

1. Data Collection: Gathering employee-task interaction data.
2. Matrix Construction: Creating an employee-task matrix.
3. Collaborative Filtering with SVD: Applying SVD for matrix factorization and prediction.
4. Task Recommendation: Generating recommendations based on predicted task scores.
5. Each step is detailed below with supporting tables and diagrams.

Data Collection

In this study, a dataset was created that captures employees' engagement with various tasks. Each employee is evaluated on a set of tasks, with a numeric score representing their performance or engagement level on each task. A score of zero indicates that the employee has not yet attempted that task.

The dataset includes the following information:

- Employee ID: Unique identifier for each employee.
- Task ID: Unique identifier for each task.
- Score: Numeric value representing the employee's performance on the task.

Table 1: SAMPLE EMPLOYEE-TASK DATA

Employee ID	Task ID	Score
1	1	5
1	3	3
2	1	4
2	4	2
3	2	3
3	3	5
4	3	4
4	4	3

The Employee-Task matrix is then constructed using this data, where each cell represents the score of an employee for a particular task.

The proposed system uses an employee-task matrix where:

- Rows represent individual employees.
- Columns represent tasks or training programs.
- Matrix values represent the level of engagement or performance scores on specific tasks (ranging from 0 to 5), where a score of 0 indicates the employee has not yet engaged with the task.

An example of this matrix structure is shown in Table 1:

TABLE I. EMPLOYEE-TASK MATRIX

Employee	Task 1	Task 2	Task 3	Task 4
1	5	0	3	0
2	4	0	0	2
3	0	3	5	0
4	0	0	4	3

Matrix Factorization with Singular Value Decomposition (SVD)

We apply Singular Value Decomposition (SVD) to decompose the employee-task matrix into three components: employee features, task features, and singular values. SVD effectively reduces the dimensionality of the matrix while retaining the most important latent features.

The decomposition results in two matrices: a matrix for employee latent factors and a matrix for task latent factors. These matrices can be used to approximate the original matrix and predict missing entries (i.e., tasks that an employee has not yet engaged with but is likely to benefit from).

The SVD process can be represented as:

$$R \approx U \sum V^T$$

Where:

R is the original employee-task matrix.

U is the employee latent factor matrix.

V^T is the task latent factor matrix.

Predicting Missing Task Scores

Block of targets the main component of a complete system.

The product of $U \sum V^T$ reconstructs the original matrix with predicted values for missing tasks. These predicted values represent the likelihood that an employee will perform well on a task they have not yet completed. Based on these predictions, we can recommend tasks with the highest predicted scores.

Algorithm Implementation

The following Python implementation demonstrates the application of SVD to the employee-task matrix for task recommendation:

```
import numpy as np
from sklearn.decomposition import TruncatedSVD
# Example employee-task engagement matrix
employee_task_matrix = np.array([
    [5, 0, 3, 0],
    [4, 0, 0, 2],
    [0, 3, 5, 0],
    [0, 0, 4, 3]
])
# Apply matrix factorization using SVD
svd = TruncatedSVD(n_components=2)
# Reduce to 2 latent factors
decomposed_matrix = svd.fit_transform(employee_task_matrix)
# Reconstruct the matrix to predict missing values
reconstructed_matrix = np.dot(decomposed_matrix, svd.components_)
# Recommend tasks with the highest predicted scores for Employee 1
employee_id = 0
# Employee 1
predicted_scores = reconstructed_matrix[employee_id]
completed_tasks = employee_task_matrix[employee_id] > 0
# Completed tasks
recommended_task_id = np.argmax(np.where(completed_tasks, -np.inf, predicted_scores))
print(f"Recommended task for Employee {employee_id + 1}: Task {recommended_task_id + 1}")
```

RESULTS

The collaborative filtering model using Singular Value Decomposition (SVD) was applied to a sample dataset, consisting of employees' engagement with various tasks. The matrix factorization process allowed us to predict missing values in the employee-task matrix, thereby recommending tasks that an employee has not yet engaged with but is likely to benefit from.

The input data used for training the recommender system consists of an employee-task matrix, where each row corresponds to an employee and each column corresponds to a task or training program. The matrix values represent employee performance or engagement with tasks, while a score of zero indicates the employee has not yet interacted with the task.

The matrix in Table 1 illustrates how each employee has interacted with the four available tasks. For example, Employee 1 has completed Task 1 with a score of 5 and Task 3 with a score of 3, but has not yet engaged with Task 2 and Task 4 (represented by zeroes).

Using SVD, the original matrix is decomposed into three matrices:

- U: Matrix representing employees and their latent factors.
- Σ (Sigma): A diagonal matrix of singular values that represent the strength of each latent factor.
- V^T: Matrix representing tasks and their latent factors.

This decomposition reduces the dimensionality of the data, enabling us to predict values for the missing entries (i.e., tasks that an employee has not yet completed).

The number of latent factors chosen for the decomposition was two, which means we reduced the employee-task interaction data to two hidden features that capture the relationships between employees and tasks.

After factorizing the matrix, the reconstructed matrix provides predictions for missing entries in the employee-task matrix. This matrix allows us to estimate which tasks an employee is likely to engage with or excel at, based on patterns learned from other employees.

Table 2: RECONSTRUCTED EMPLOYEE-TASK MATRIX

Employee	Task 1	Task 2	Task 3	Task 4
1	5.00	2.69	3.00	2.08
2	4.00	2.38	2.99	2.00
3	2.77	3.00	5.00	2.46
4	3.21	2.67	4.00	3.00

In Table 2, the non-zero values in the original matrix remain the same (e.g., Task 1 for Employee 1 remains 5), while missing values are filled in with predicted scores. For example, Employee 1, who hasn't completed Task 2 or Task 4, is predicted to score 2.69 on Task 2 and 2.08 on Task 4 based on the model's learning.

Based on the reconstructed matrix, we generate task recommendations for each employee. The system recommends tasks that the employee has not yet completed, starting with the task with the highest predicted score.

Table 3: TASK RECOMMENDATIONS FOR EMPLOYEES

Employee	Recommended Task	Predicted Score
1	Task 2	2.69
2	Task 3	2.99
3	Task 1	2.77
4	Task 1	3.21

From Table 3, we can see that:

- Employee 1 is recommended to complete Task 2, which has a predicted score of 2.69.
- Employee 2 should complete Task 3, with a predicted score of 2.99.
- Employee 3 is encouraged to engage with Task 1, which has a predicted score of 2.77.
- Employee 4 is recommended to start with Task 1, with the highest predicted score of 3.21.

These recommendations are based on the patterns learned from similar employees' task performance and interactions.

A visual representation of the task recommendations can help explain how the system makes predictions. Below, we provide a diagram showing the process of matrix factorization and recommendation generation.

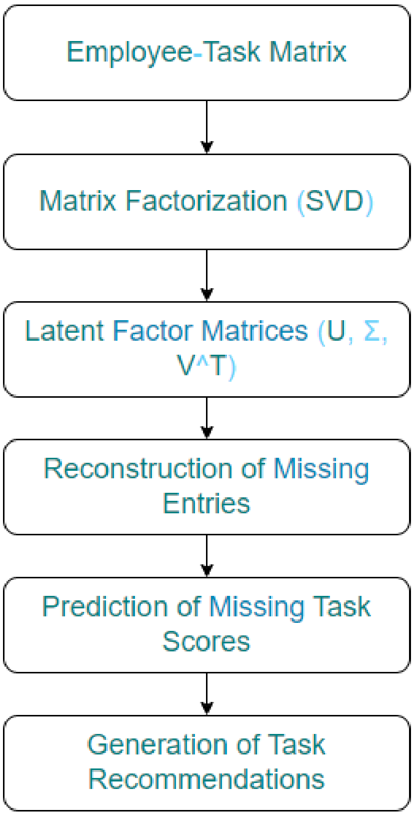

Figure 1: Collaborative Filtering Model Flowchart

The following heatmap visually represents the predicted task scores for each employee from the reconstructed matrix:

Figure 2: Predicted Task Scores Heatmap

This heatmap highlights how different employees are predicted to perform on tasks they have not yet completed, making it easier to identify the best recommendations based on predicted scores.

The recommender system's performance can be evaluated using standard recommender system metrics like Mean Squared Error (MSE) between the predicted and actual scores (where available). In this prototype, we used a small dataset with hypothetical values. The accuracy of predictions can be further improved by:

- Incorporating more employee data.
- Adding additional contextual features such as employee roles, departments, and specific skills.
- Using hybrid recommender systems that combine collaborative filtering with content-based techniques.

One limitation of collaborative filtering is the cold start problem, where it struggles to make recommendations for new employees or tasks with insufficient historical data. To mitigate this issue, we could combine matrix factorization with content-based filtering, where recommendations are made based on the task's attributes (e.g., task descriptions, required skills).

DISCUSSION

The matrix factorization method using SVD proved to be effective in generating personalized task recommendations for employees based on historical task performance data. The system identifies latent patterns that reveal which tasks are likely to be beneficial for an employee, given the performance of other similar employees. This approach can help organizations optimize employee development by aligning task assignments with individual strengths and areas for improvement.

CONCLUSION

In this paper, we have demonstrated how matrix factorization using Singular Value Decomposition can be applied to employee-task data to build a recommender system. The system provides personalized task and training recommendations based on historical employee performance, helping organizations improve productivity and employee development.

Future work can expand on this model by incorporating hybrid techniques, such as deep learning-based approaches, to further refine the recommendation process. Additionally, integrating business-specific rules and incorporating more complex user-item interactions will enhance the system's applicability to real-world employee performance management.

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ARTIFICIAL INTELLIGENCE IS A KEY FACTOR IN THE DEVELOPMENT OF THE TOURISM INDUSTRY

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A B S T R A C T **The tourism industry is experiencing a significant transformation due to the integration of artificial intelligence (AI) technologies. This research paper explores the various applications of AI in tourism, focusing on how AI enhances customer experiences, optimizes operational efficiencies, and revolutionizes marketing strategies. By examining current trends, case studies, and future projections, this paper aims to provide a comprehensive overview of the impact of AI on the tourism sector.**

K E Y W O R D S Artificial intelligence, chat bots, travel planning, tourism industry.

INTRODUCTION

The tourism industry is a vital sector of the global economy, contributing significantly to GDP, employment, and cultural exchange. It encompasses a broad range of services and experiences, including travel, accommodation, food and beverage, entertainment, and cultural activities. The advent of digital technology has brought profound changes to this industry, enabling greater connectivity, improved customer experiences, and enhanced operational efficiency. Among these technological advancements, artificial intelligence (AI) stands out as a transformative force, driving innovation and shaping the future of tourism.

Artificial intelligence refers to the simulation of human intelligence processes by machines, particularly computer systems. These processes include learning (the acquisition of information and rules for using the information), reasoning (using rules to reach approximate or definite conclusions), and self-correction. In the context of the tourism industry, AI encompasses a wide range of applications, from machine learning algorithms that predict customer preferences to chatbots that provide instant customer service.

The integration of AI in tourism is not merely a trend but a necessity for maintaining competitiveness in an increasingly digital world. AI technologies offer numerous benefits, including enhanced customer service, personalized travel experiences, improved operational efficiency, and data-driven decision-making. These advancements enable tourism businesses to meet the evolving needs of travelers, optimize their operations, and make informed strategic decisions.

According to statistics from Statista, the global artificial intelligence market in the tourism and hospitality industry was valued at $81.3 billion in 2022 and is projected to reach $423.7 billion by 2027, with a CAGR from 2022 to 2027 35% [1].

LITERATURE REVIEW

The concept of smart destinations involves integrating AI with the Internet of Things (IoT) to manage tourist flows, optimize resources, and enhance the overall visitor experience. Research by Buhalis and Amaranggana [2] highlights the role of AI in developing smart tourism ecosystems, where data from various sources (e.g., sensors, social media, mobile devices) is analyzed to improve decision-making and service delivery. For example, AI can predict peak tourist times and suggest alternative routes or attractions to manage overcrowding.

Konstantinos Solakis [3] delineated essential customer-oriented factors and technological advancements that affect the value co-creation process through artificial intelligence (AI) and automation within the hospitality and tourism sector. AI-powered technologies, such as chatbots, virtual assistants, and predictive models, elevate customer engagement by offering customized recommendations and streamlining service provision. Popesku [4] analyzed using of chatbots in tourism industry, particularly customer service travel bots, Facebook chatbots, AI empowered travel bots.

Tsaih [5] endeavored to present a conceptual framework for a digital business strategy in smart tourism, incorporating artificial intelligence. Artificial intelligence encompasses several functions, including (1) cognitive engagement, such as voice and pattern recognition, (2) cognitive process automation through robotic process automation (RPA), and (3) cognitive insight, which involves forecasting and providing recommendations.

According to Brown, [6] artificial intelligence enhances the accuracy of demand forecasting in the hospitality industry, while issues regarding data privacy and security remain significant concerns. Moreover, Peter [7] analyzed that by using AI in hotel business there is observed increase in operational efficiency and guest satisfaction.

Turner [8] confirms that artificial intelligence aids in sustainable tourism by utilizing data analytics for conservation efforts, leading to minimized environmental impact in tourism operations.

AI technologies and various methods of their application will soon become prevalent in the tourism industry. The study underlines the importance of using neural network technologies for analysis and forecasting in the hospitality and tourism sector.[9]

García-Madurga [10] made bibliometric analysis of research papers dedicated to applying AI in tourism. He divided research articles into 4 categories: forecasting, improving operational efficiency, enhancing customer experiences and sustainability.

METHODS

In this research paper there are used such methods like: information collection, comparative analysis, induction, deduction. To determine the positive and negative sides of using AI in tourism industry there is done SWOT analysis.

ANALYSIS AND DISCUSSION.

The introduction of artificial intelligence allows hotels to personalize indoor temperature, lighting, and music based on guest preferences. The integration of AI technologies has significantly enhanced customer service quality by providing real-time support and optimizing pricing strategies. The influence of next-generation artificial intelligence (Gen AI) on the tourism industry is rapidly growing, affecting both tour operators and travelers.

Promising applications for tour operators include using AI for advertising strategies, creating marketing content, and personalizing services. Additionally, many providers are exploring ways to optimize basic operational functions with AI, increase efficiency, and improve the overall travel experience.

About one in ten travelers uses artificial intelligence to plan their vacation trips, despite the fact that the technology has been widely available for only a year. This indicates the rapid adoption of artificial intelligence among travelers as a valuable planning tool.

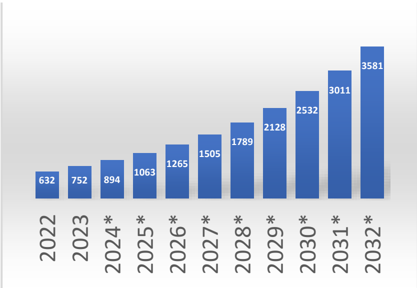

Fig. 1. The size of the generative artificial intelligence market in the tourism industry. (millions of US dollars)

Source: Precedence research. [11]

The global market for generative artificial intelligence in tourism is estimated at US$ 632.18 million in 2022, and is expected to reach about US$ 3,581.95 million by 2032, with an average annual growth rate of 18.94% during the forecast period from 2023 to 2032. It is worth noting that, according to the forecast, the volume of the artificial market will increase 5.5 times. All this highlights the importance of artificial intelligence in the development of tourism. In 2022, among the developed countries, North America dominated the market with the largest market share. But it is predicted that over the next decade, a significant share of the market will belong to the Asia-Pacific region. In the context of related industries in the tourism and hospitality industry, in 2022, the segment of air transportation and accommodation services with the largest market share was leading the market.

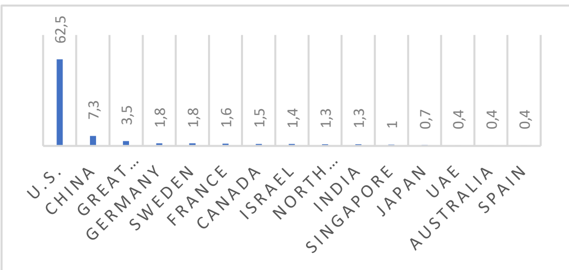

Fig. 2.Investments in AI by country in 2023 (billion euros).

Source: AI Index Report for 2024. Stanford University [12]

The global AI market, which exceeded 130 billion euros in 2023, is expected to grow significantly and potentially reach almost 1.9 trillion euros by 2030[13]. Currently, private investment plays an important role in AI financing. In 2023, the United States was the leader with private investment of 62.5 billion euros, followed by China with investments of 7.3 billion euros (Figure 2.). During the same year, the European Union and the United Kingdom jointly attracted 9 billion euros of private investment. Between 2018 and the third quarter of 2023, European companies in the field of artificial intelligence attracted investments of almost 32.5 billion euros, while American companies in the field of artificial intelligence received more than 120 billion euros. Recent large investments in American artificial intelligence companies such as Openal and Anthropic have further widened the investment gap between the EU and the US. Public investments in artificial intelligence are also increasing: 2.1 billion euros are provided for the development of artificial intelligence from 2021 to 2027 within the framework of the EU Digital Europe program.

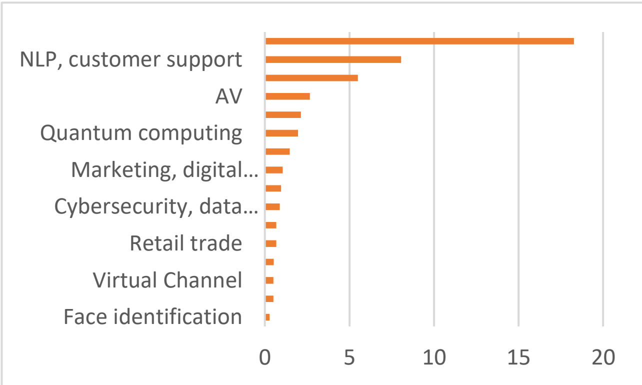

Fig. 3. Private investments in artificial intelligence by priority areas for 2023. (USD billion)

Source: Source: AI Index Report for 2024. Stanford University [12]

According to Picture 3, more than $18 billion has been allocated to the development of artificial intelligence infrastructure. The artificial intelligence infrastructure provides platforms that enable companies to develop intelligent applications. These applications have properties such as forecasting with minimal need for human intervention.

It is also worth noting that one of the priorities of private investment in 2023 is investment in the tourism industry, namely investments in virtual reality, digital advertising, customer support and face recognition. The total amount of investments directed at this industry is almost 10 billion US dollars. These indicators indicate that artificial intelligence is one of the key factors in the development of digitalization of the tourism and hospitality industry.

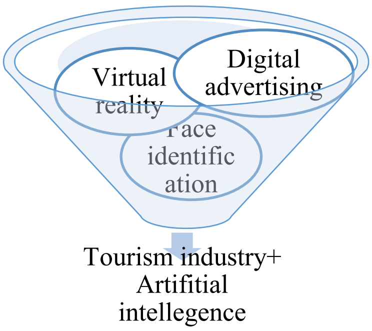

Fig. 4. Related industries of the tourism industry and artificial intelligence.

Source: Compiled by the author

The largest countries investing in artificial intelligence are the United States of America, the European Union (the United Kingdom is the dominant among the EU countries) and China. The following table provides information on the priority areas of investment in artificial intelligence by country for 2023.

SWOT analysis on the application of artificial intelligence in the tourism industry:

Strengths:

1.Artificial intelligence provides personalized recommendations, virtual assistants and chatbots, increasing customer satisfaction and engagement;

2.Automating repetitive tasks such as booking, check-in and customer service can lead to cost savings and increased efficiency;

3.Artificial intelligence can analyze large amounts of data to determine trends, preferences and customer behavior, which allows you to make targeted marketing and strategic decisions;

4.Companies using artificial intelligence technologies can outperform competitors by offering innovative services and personalized experiences;

5.Predictive models based on artificial intelligence allow you to predict demand, optimize pricing strategies and improve revenue management, maximizing profitability;

Weaknesses:

1.The introduction of artificial intelligence systems requires significant initial investments in technology, training and infrastructure.

2.The collection and analysis of customer data raises privacy issues that require careful handling to comply with regulatory requirements and maintain trust.

3.Dependence on artificial intelligence systems can lead to vulnerabilities such as system failures, cyberattacks or data leaks, which will negatively affect work and reputation.

4.Automation of tasks can reduce the need for people, which can potentially lead to job changes and obsolescence of skills.

5.Integrating AI into existing systems and processes can be difficult and time-consuming, requiring expertise and resources.

Opportunities:

1.The tourism industry is experiencing rapid growth, opening up opportunities for AI-based solutions to meet the changing needs and preferences of customers.

2.Artificial intelligence-based platforms and digital marketing strategies enable travel companies to reach a global audience, expanding market reach and potential revenue.

3.Continuous progress in artificial intelligence technology opens up opportunities for innovation in areas such as augmented reality (AR), virtual reality (VR) and voice recognition, which improves the travel experience.

Threats:

1.Dependence on third-party artificial intelligence providers or platforms can lead to dependency problems, service failures, or contract disputes.

2.The introduction of AI may lead to job cuts in certain positions, which will lead to resistance from the workforce and potential socio-economic problems.

CONCLUSION

The integration of AI in tourism offers numerous benefits, including enhanced customer experiences, improved operational efficiency, and innovative marketing strategies. However, the adoption of AI also presents challenges, such as data privacy concerns, the need for continuous technological updates, and potential job displacement. Addressing these challenges requires a balanced approach, involving robust data protection measures, ongoing investment in AI technologies, and strategies to manage workforce transitions.

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[13] https://www.europarl.europa.eu/RegData/etudes/ATAG/2024/760392/EPRS_ATA(2024)760392_EN.pdf

CREATION OF INTELLIGENCE SYSTEMS RELATED TO INFORMATION-LIBRARY ACTIVITIES

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In this article, the need for adaptive learning platforms for students of higher education institutions is analyzed, the issues of creating an information model and functional structure of an adaptive learning platform that provides electronic literature, taking into account the indicators of students' mastery, are researched.

Keywords: adaptive educational platforms, electronic library, intelligent systems, programming technologies, database, search systems.

The research was carried out within the framework of the practical project No. ALM-202310132635 "Smart Academy - creation of an integrated information-educational platform" supported by the Innovative Development Agency under the Ministry of Higher Education, Science and Innovation.

The relevance of adaptive educational platforms to improve the quality of education in higher education institutions. The daily development of new technologies requires the introduction of new developments in the educational system that increase the effectiveness of education based on innovative approaches. The sudden increase in the volume of information on the Internet slows down the process of finding the most necessary information for students, and in some cases, this causes of studying the sources of information more than necessary. In such a situation, the development of methods of creating adaptive educational platforms that recommend suitable and most necessary information sources for students is considered an urgent issue. Adaptive education is a general teaching and learning practice aimed at more precisely adapting the educational course to the individual needs of students. Many research scientists have conducted scientific studies in the direction of increasing the effectiveness of the use of adaptive educational platforms in educational processes. In particular, the issue of classification of adaptive learning systems and creation of adaptive hypermedia systems are studied by Elena Verdu. Luisa M. Regas and Juan Pablo de Castro[10], Nikita S. Pauline is studied the issue of cutting-edge technologies in e-learning and teaching [11]. Chitij Sharma, Andy Nguyen and Yvonne Hong [12] are studied Self-Control Methods of Cooperative Learning System in Adaptive Digital Learning Environment, Arun Qatar and Umeng Patwardhana analyzed development of a research tool to measure the inclusiveness of adaptive methodologies in engineering education [13]. Dobriča V.P., Gorushkin Y.I are analyzed questions of introduction of intelligent adaptive platforms in education [14]. Questions of models, algorithms and software of adaptive evaluation of situations in educational systems was investigated by C.M. Khidítrovs [15]. No matter how much adaptive learning technologies are studied, their implementation methods need to be improved over time. Methods of creating an adaptive educational platform based on integrated systems. One of the most important aspects of organizing educational processes in higher education institutions is the task of providing students with information resources. This task is carried out in various educational institutions through various methods. It is known that for the effective operation of adaptive learning systems, information obtained according to many criteria is of great importance. To obtain such factors, integrated systems and the ability to obtain information about students from various sources must be available. We can show the "interactive lesson schedule" system as one of such adaptive educational platforms. This system was created by integrating the electronic journal system and the electronic library system, which records the indicators of students' mastery grades of the higher education institution, and by developing a software module that intelligently analyzes the information obtained from these systems. Information from both systems, which are technically integrated, is obtained based on the REST API technology.

In simpler terms, the main task of this system is to recommend literature that explains complex tasks in short ways for a student with a high mastery level. On the contrary, it is considered to create a literature recommendation system where easy tasks are explained in detail through several examples for students with low learning rates. One of the unique aspects of the system is that the information received from both systems is processed by the method of machine learning neural networks. Based on the results, available literature is distributed to students. The general architecture of the system is presented in Figure 1.

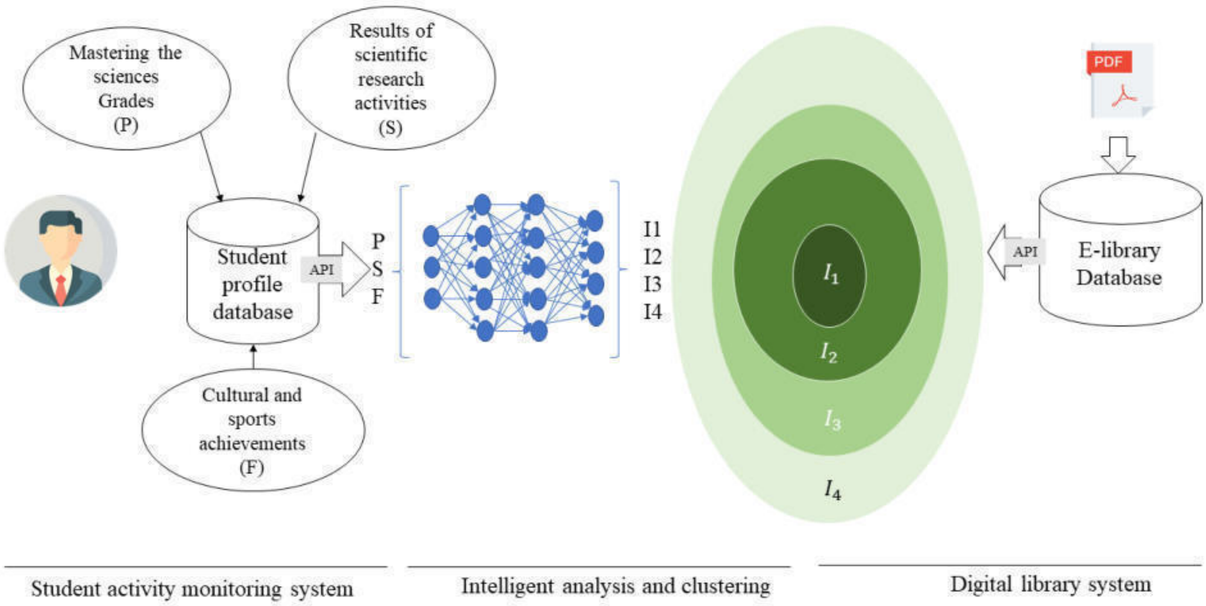

Figure 1. “Interactive lesson schedule” adaptive educational system architecture

This integrated information and analysis system aims to provide an adaptive electronic library service by recommending the scientific and educational literature necessary for students, taking into account the indicators of learning subjects. The system can be created in a very simple interface for users, and its approximate appearance is presented in the table below.

Table. 1

The structure of the user interface of the adaptive educational system of electronic literature recommendation

Week	Monday *(date)*	Tuesday *(date)*	Wednesday *(date)*	…
Lesson 1	09:00–10:20 Seminar Subject name Lesson topic Lecture file Teacher name Auditorium number	09:00–10:20 Seminar Subject name Lesson topic Lecture file Teacher name Auditorium number	09:00–10:20 Seminar Subject name Lesson topic Lecture file Teacher name Auditorium number	…
Lesson 1	10:30–11:50 Seminar Subject name Lesson topic Lecture file Teacher name Auditorium number	10:30–11:50 Seminar Subject name Lesson topic Lecture file Teacher name Auditorium number	10:30–11:50 Seminar Subject name Lesson topic Lecture file Teacher name Auditorium number	…
	…	…	…	…

The user interface is presented in the form of a timetable, the days of the week are listed at the top. The information in the lesson schedule is obtained from the electronic journal information system of educational institutions and the electronic library system. In the field named "name of the subject" of the schedule, the text of the lecture on the topic that will be taken on this day is placed in the form of an electronic file.

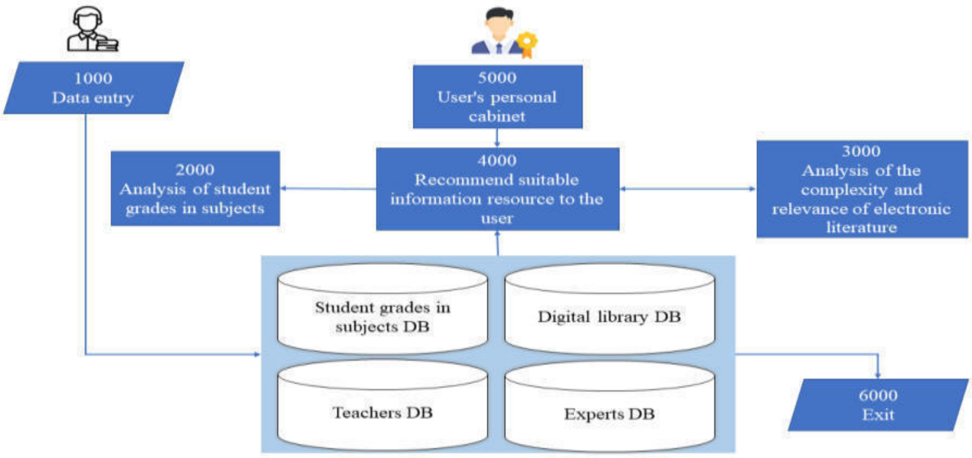

Figure 2. Adaptive learning software module functional structure

The adaptability aspect of this system is that the system recommends different levels of lecture materials and accessible literature for students with different levels of mastery who enter the personal office. This software module serves for students to get information quickly and conveniently through reliable information, and to master subjects in a high-quality manner.

Summary

Adaptive learning platforms have paved the way for significant advances in education by providing individualized, flexible learning experiences. They have made it possible to transform traditional teaching methods, making them more effective and accessible for all students. As AI technologies develop, they will continue to evolve and improve, creating new opportunities in the world of education.

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USING ARTIFICIAL INTELLIGENCE TO COMBINE PSEUDO-RANDOM SEQUENCE GENERATOR FOR CYBERSECURITY

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A B S T R A C T **As for the generators of random numbers and bit series, the most common and popular are the generators of sequences with a uniform distribution in the market of pseudorandom generators. Thus, the requirements for the implementation and the quality of the generator's output sequence may differ depending on the specific application. In this article, the structures of the classical additive Fibonacci generator, as well as the modified additive Fibonacci generator, were optimized when used in combination. We determined the set of initial conditions (seeds) for such generators, which makes their statistical properties of the output pseudorandom sequence acceptable and opens up new opportunities for their use in cybersecurity. The analysis of the statistical features of the modified additive Fibonacci generator pointed to the close relationship between them and the signal from the integrated output of the logic circuit. This showed that when the module of the recurrence equation is an odd value, acceptable statistical characteristics of both the modified additive Fibonacci generator and the combined generator based on this are received. It has been found that the output signal of the combined generator possesses tolerable features with varied initial settings for the altered and conventional additive Fibonacci generators. From the perspective of information security, it is relevant to state that for modern encryption and security systems, pseudorandom number and bit sequence generators, as well as the methods used to develop them, are important and, in fact, critical components.**

K E Y W O R D S* pseudo-random number; pseudo-random sequence generators; authentication; encryption of information, PRNG, additive Fibonacci generator, PRBSG, Internets of Things (IoT)

INTRODUCTION

The PRNG and PRBSG, hereinafter jointly referred to as PRSG, find a very wide range of applications in various scientific and technological fields [1–2]. Their significance is in simulating various processes, solving industrial problems, and meeting cybersecurity challenges. The relevance of cybersecurity has been growing year after year, and all activities attributed to data encryption, secret key generation, authentication, and maintenance of information confidentiality and integrity become of particular importance. These cannot be effectively solved without PRNG and PRBSG being used.

In [3], a text algorithm was proposed for the PRNG-based watermark used in cryptography. The method had good invisibility, and reliability in bearing removal, modification attack, etc., and finds its use in cloud computing for hiding information. An interesting approach is presented in [4], where random numbers are generated making use of the reinforcement learning attributes that identify the most promising behavior considering all possible states that lead to the termination of the episode, hence ensuring the randomness of these numbers that will be generated.

Testing the quality of PRNGs and PRBSGs necessarily involves statistical tests that use a variety of randomization algorithms to provide in-depth testing of the pseudo-random sequences that are generated. Organizations such as NIST of the ANSI, the ISO, as well as national standardization organizations, are developing evaluation methodologies, specifications, and standards related to PRNG and PRBSG. The quality tests can be done using the NIST statistical test suite, which is widely accepted [5–6]. In case of sequences generated for cryptographic use, cryptographic testing is a must. A great team of specialists is engaged in the design and development, quality evaluation, and application of PRNG and PRBSG. It is accepted that the novelty of this work, when compared to the existing ones, consists in the optimization of parameters of MAFG which provided an opportunity for realizing an arbitrary modulus value in a recurrent equation of generated polynomial. Further, the characteristics of the pseudo-random generator output signal were enhanced by combining the MAFG with classical AFG.

METHODS

The generalized scheme of joint work of AFG and MAFG is given in Figure 1, and the corresponding detailed structure scheme is given in Figure 2.

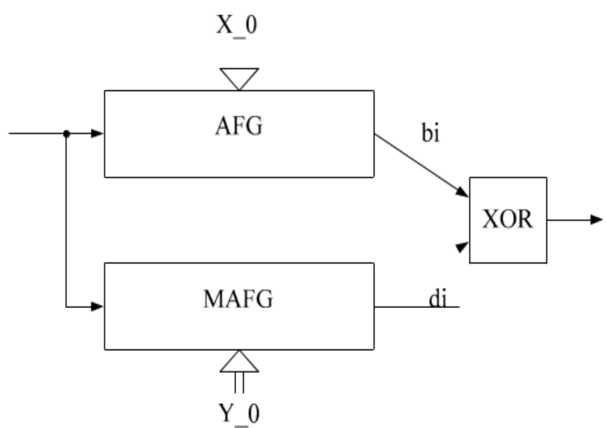


Figure 1. *Generalized scheme of the joint work of AFG and MAFG.*

The generated pseudo-random bit sequences from the AFG (bi) and MAFG (di) are merged through an XOR logic gate, resulting in the ultimate output bit sequence (bd_i). Both the AFG and MAFG are supplied with clock pulses (fc) as their input. Before commencing operation, initial values, referred to as seeds, are stored in the memory registers of the AFG (X_0) and MAFG (Y_0), correspondingly. Though the AFG is constructed on a primitive polynomial basis, this investigation will look into the attributes of the device.

$$GF\ 2^{30} = x^{30} + x^{23} + x^2 + x + 1, \quad (1)$$

and MAFG is constructed according to the primitive polynomial

$$GF\ 2^{20} = y^{20} + x^3 + 1, \quad (2)$$

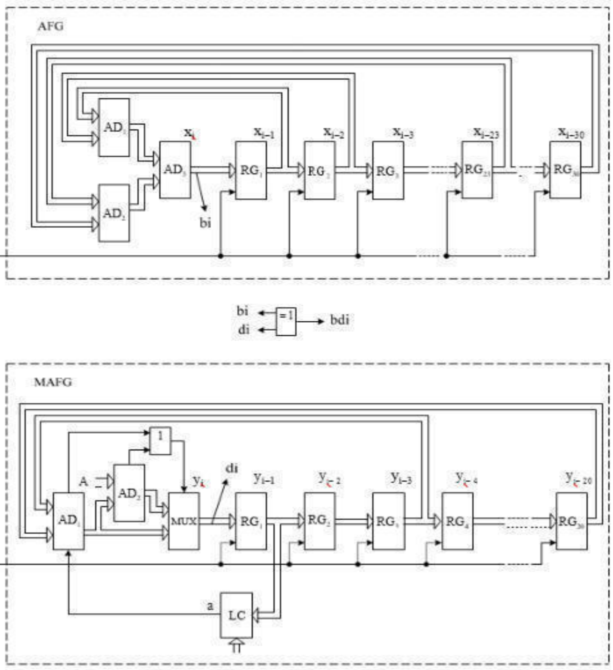


Figure 2. *Structure scheme of the joint work of AFG and MAFG.*

After considering several alternative possibilities, polynomials (1) and (2) were selected to obtain adequate statistical properties in the resultant pseudo-random signal over the full range of potential X_0 and Y_0 values, while keeping hardware requirements as low as possible. The AFG comprises three adders, designated AD1 to AD3, and thirty memory registers, designated RG1 to RG30, as shown in Figure 2. With the use of polynomials, the AFG acts according to a recursive relation.

$$x_i = (x_{i-30} + x_{i-23} + x_{i-2} + x_{i-1}) mod m, \quad (3)$$

In this equation, x_i is the output of adder AD_3, and x_{i-1}, x_{i-2}, x_{i-23}, x_{i-30}, are outputs from registers RG_1, RG_2, RG_{23}, and RG_{30}, respectively. The modulus m in the recurrent equation is determined based on the number of binary bits in the structure elements of the AFG.

RESULTS

Block The basic role of the AFG, when combined with MAFG, is to maintain a constant repetition interval of the output pseudo-random sequence for all initial values X_0 stored in its registers over the entire spectrum. According to [6], AFG achieves its maximum output sequence period when it is based on a primitive polynomial for its implementation. As previously articulated in this manuscript, the selected classical arbitrary finite generator (AFG) adheres to primitive polynomial (1), and consequently, recurrent Equation (3) is applicable. Specifically, when m = 2, the output signal's repetition period of the AFG is established as 2^{30} 1 for any given initial value of X_0 [7].

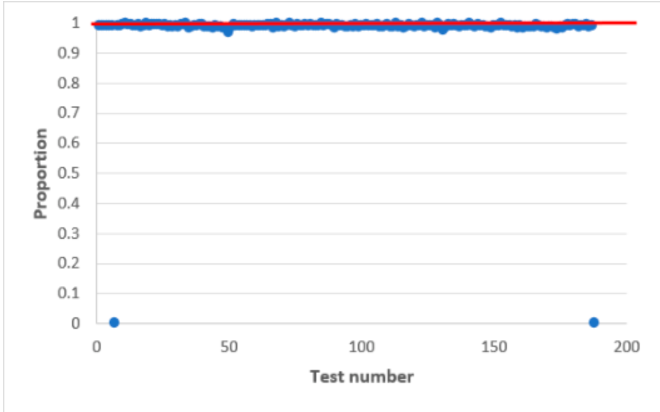


Figure 3 shows the statistical properties of the output signal produced by the AFG. Those are extracted from NIST statistical tests [8–9]. The results are represented by statistical spectra. The spectra are presented as an mq matrix, where m is the number of binary sequences analyzed and q is the total number of statistical tests applied [8].

Figure 3. *Statistical portrait of the AFG output sequence.*

According to the obtained statistical portrait, the proportion of sequences that passed each statistical test is determined. For this, setting the significance level α and the probability values p exceeding the established level α are calculated for each q tests.

This work will explore the properties of MAFG acting in line with primitive polynomial (2). Figures 4 and 5 illustrate the dependences of repetition periods T from initial values Y_0 in registers RG1 to RG_{20}. The following relation defines the value of Y_0:

$$Y\_0 = h^{19}y_{i-1}(0) + h^{18}y_{i-2}(0) + h^{17}y_{i-3}(0) + \ldots + hy_{i-19}(0) + y_{i-20}(0), \quad (7)$$

where $y_{i-1}(0)$, $y_{i-2}(0)$, . . . , $y_{i-20}(0)$ are the initial values of the numbers in registers $RG_1, RG_2, \ldots, RG_{20}$.

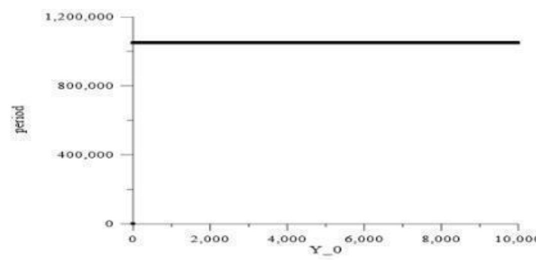


Figure 4. *Dependencies of repetition periods for X_0, h = 2 and a = 0.*

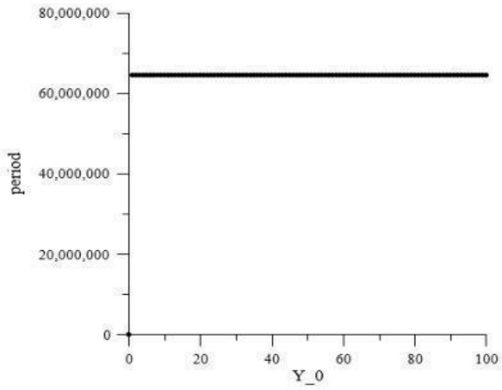


Figure 5. *Dependencies of repetition periods for X_0, h = 3 and a = 0.*

The dependences were obtained only for two values of h and one value of the LC output signal a, because for the other values of these quantities, obtaining the dependences requires a sharp increase in computational resources and machine time.

It should be emphasized that the constancy of the repetition period of the MAFG output sequence for the whole array of initial values Y_0 is guaranteed only for the case when h=2 and a = 0.

Investigations have demonstrated that for other h and a value, the repetition period significant.

But still highly depends on Y_0, getting under certain Y_0 small results, that creates so-called "weak keys".

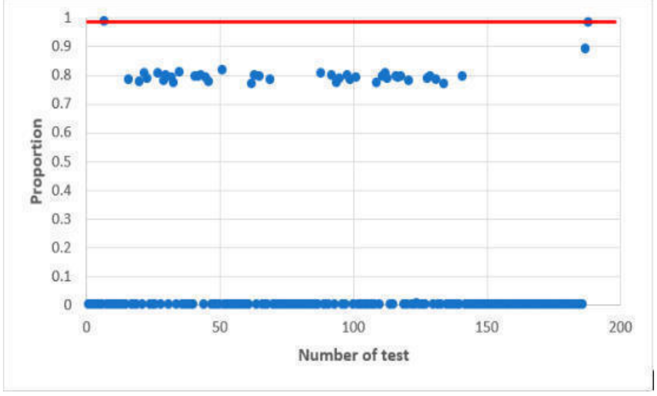
This is the main reason for further research under the circumstance that the MAFG works in conjunction with the classic AFG, which guarantees acceptable minimum values of the period for any values Y_0.

Thus, the statistical properties of the MAFG output signal allow the following conclusion to be made.

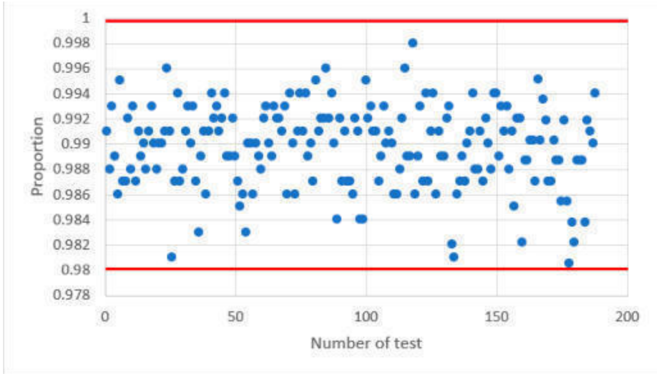
Indeed, the even values of h have much better statistical properties than the odd values. It has its basis in the certain asymmetry exhibited during the formation of the MAFG output signal di for the odd values of h.

Supporting this claim, Figure 6 gives the statistical representations of MAFG output signal when Y_0 is set to be 7Y.

The following figures show statistical plots of two generators. Figure 6a shows that the tested sequence is not random, as it has passed only 2 out of the 15 tests, namely Cumulative Sums and Serial, described in Table 2 of the NIST suite. On the other hand, Figure 6b indicates that all the P-values lie within the accepted confidence intervals, which further points to the fact that this sequence is really random.



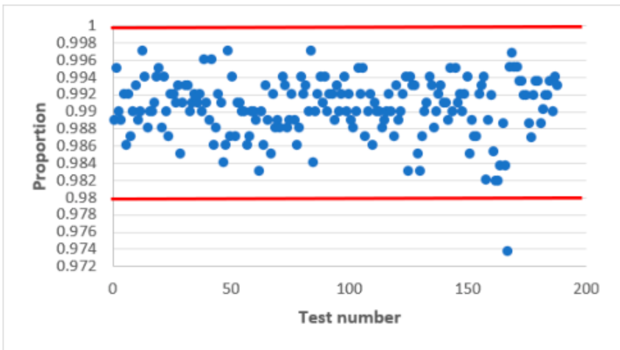
(a)



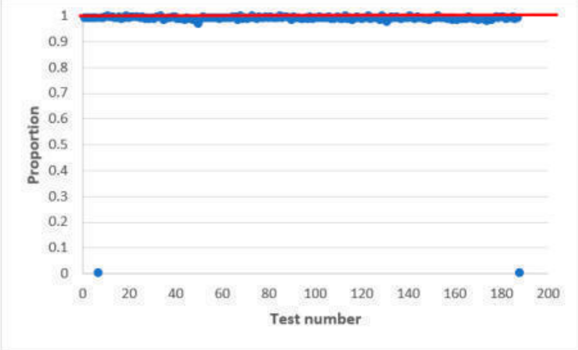
(b)

Figure 6. *Statistical portrait of the MAFG output sequence: **(a)** with an odd value h = 9, **(b)** at an even value h = 10.*

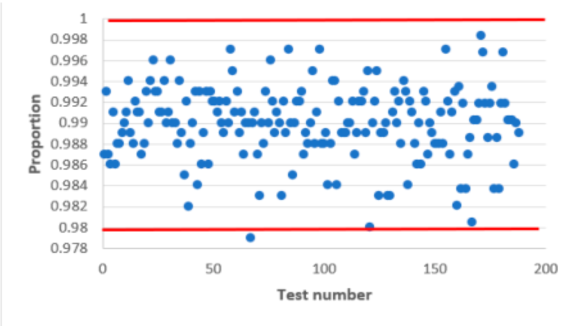
In confirmation of this, Figures 7 and 8 shows statistical portraits of the MAFG output signal for $h = 8$, variable initial values $Y\_0 = 7, 32, 100$ and different values of the LC output signal: $a = a_0 \oplus a_1$ (Figure 7) and $a = a_0 \oplus a_2$ (Figure 8).



(a)



(b)



(c)

Figure 7. *Statistical portrait of the MAFG output sequence for h = 8, a = a_0 ⊕ a_1 with initial values:* ***(a)*** *Y_0 = 7,* ***(b)*** *Y_0 = 32,* ***(c)*** *Y_0 = 100.*

Further research proved that acceptable statistical characteristics of the output signal of the combined generator could also be provided with odd values of h, but in narrower ranges of initial values of X_0 and Y_0. This is confirmed by the statistical portraits in Figure 8.

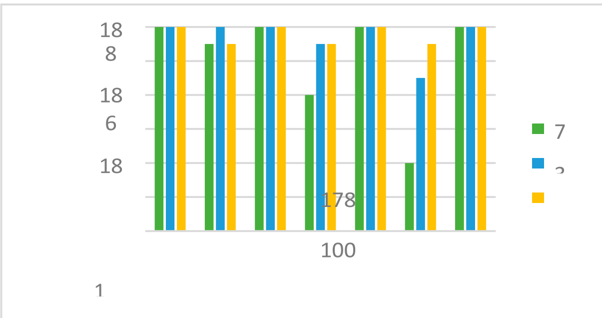
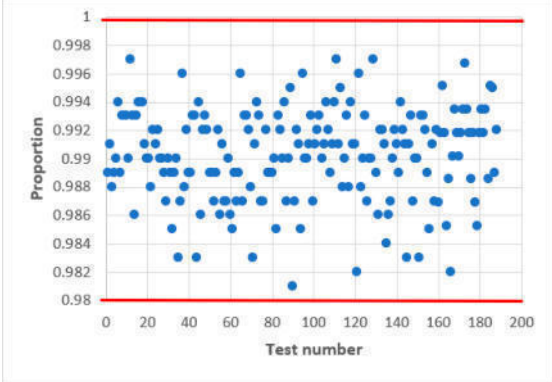
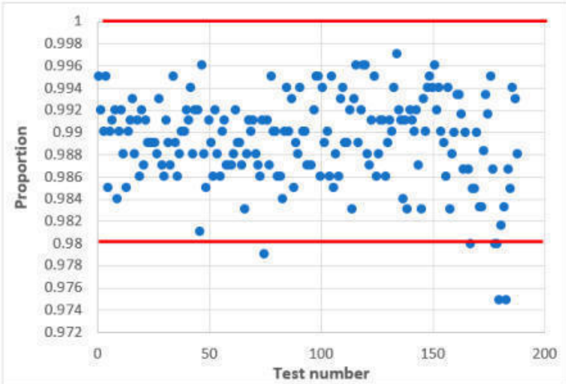


Figure 8. *Results of passing the NIST tests with the combined generator*



(a)



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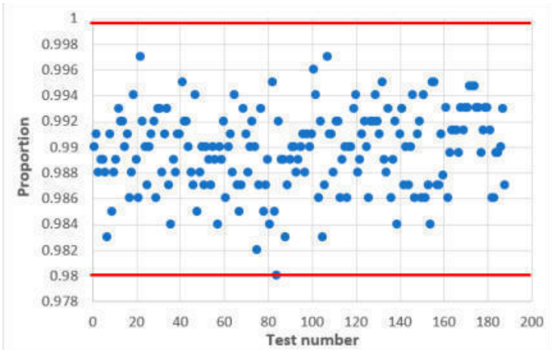

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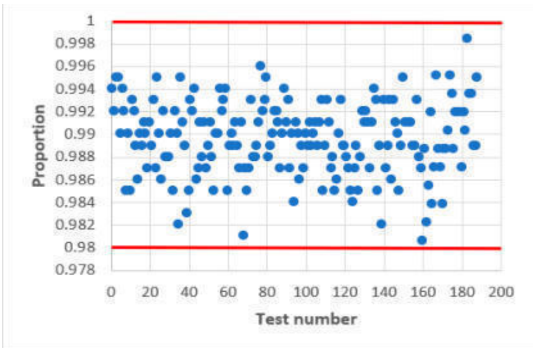
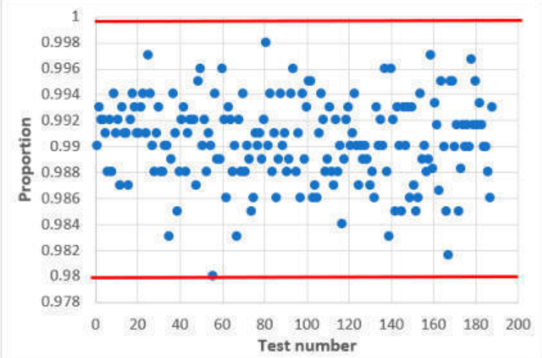
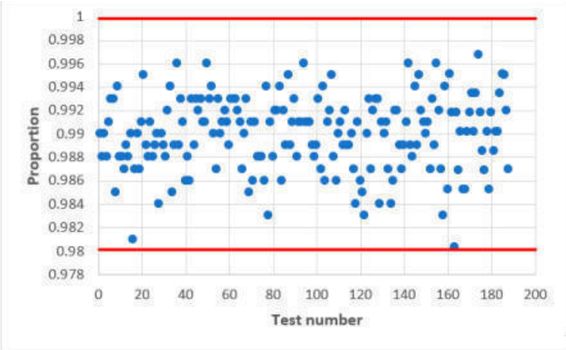


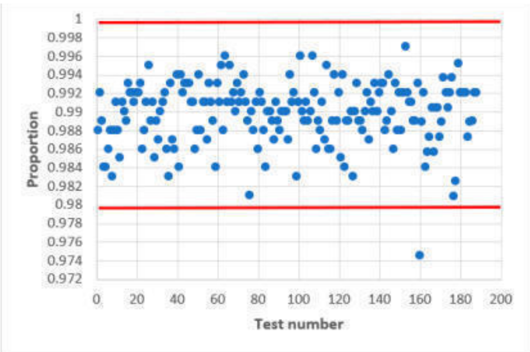
(d)



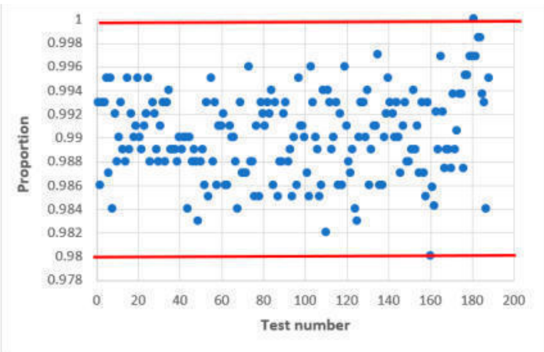
(e)



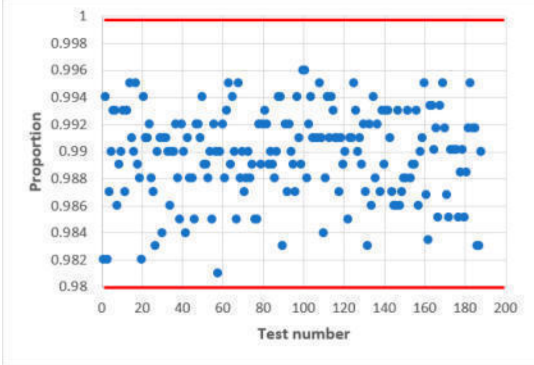
(f)



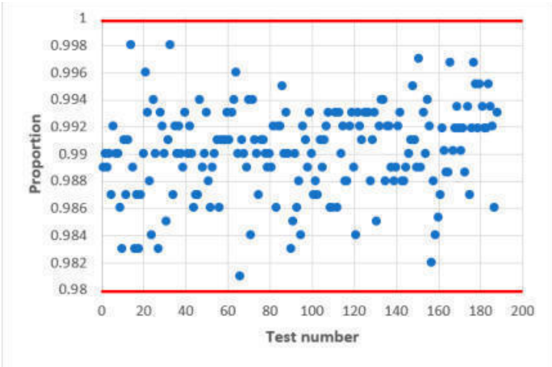
(g)



(h)



(i)



(j)

Figure 9. *Statistical portrait of the combined generator for h = 9, $a = a_0 \oplus a_3$ with initial values:* ***(a)*** *X_0 = 7, Y_0 = 36;* ***(b)*** *X_0 = 32, Y_0 = 36;* ***(c)*** *X_0 = 7, Y_0 = 64;* ***(d)*** *X_0 = 32, Y_0 = 64;* ***(e)*** *X_0 = 7, Y_0 = 71;* ***(f)*** *X_0 = 32, Y_0 = 71;* ***(g)*** *X_0 = 7, Y_0 = 100;* ***(h)*** *X_0 = 32, Y_0 = 100;* ***(i)*** *X_0 = 7, Y_0 = 1004;* ***(j)*** *X_0 = 32, Y_0 = 1004.*

Figure 8 shows that the combined generator with h = 9 has the worst statistical properties. On the other hand, with more processing, for example, by modifying the initial values of X_0 and Y_0 with the constraint that $a = a_0 \oplus a_3$, we have been able to make all NIST tests pass.

The results of the experiments are shown in Figure 9, where on the left side the integrated generator is represented for starting parameters X_0 = 7, and variable values Y_0 = 36, Figure 9a, 64, Figure 9c, 71, Figure 9e, 100, Figure 9g and 1004, Figure 9i. To the right, the integrated generator is presented with a value of X_0 equal to 32 together with the variables Y_0 corresponding to 36 (Figure 9b), 64 (Figure 9d), 71 (Figure 9f), 100 (Figure 9h), and 1004 (Figure 9j).

DISCUSSION

This study presents a novel design for a combined generator, which includes the traditional AFG and a modified version, MAFG. The output pulse sequence of the combined generator is created by taking the modulo 2 sum of the output sequences from both AFG and MAFG.

At certain AFG parameter values, the internal settings maximize the repetition period of the output sequence for all possible initial configurations X_0 of the structural elements, ensuring the repetition period of the combined generator's output signal meets or exceeds a specified value.

It has been demonstrated that the statistical properties of both the MAFG output signal and the combined generator are generally satisfactory when the parameter h (based on the number of bits in the MAFG registers) is odd. This is achieved by constructing a logic circuit where the input signals are drawn from the most and least significant bits of one of the MAFG registers. The statistical characteristics of the combined generator's output signal remain acceptable over a wide range of initial settings for both the AFG X_0 and MAFG Y_0.

CONCLUSION

The novelty of this paper lies in the further optimization of the MAFG structure with an arbitrary modulus in the recurrent equation—a working principle that the authors proposed in earlier studies—and the exploration of its compatibility with the classical AFG. This approach significantly enhances the key characteristics of additive Fibonacci generators. Importantly, the development focuses on hardware implementation, ensuring high-speed performance for these generators.

Future research will focus on providing practical guidelines for selecting the parameters of the combined generator based on the specific requirements of cryptographic or other technical applications. Another potential avenue for future research is exploring new structures that combine multiple AFG and MAFG generators in different configurations.

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IMPROVING AND ASSESSING THE EFFECTIVENESS OF ARTIFICIAL INTELLIGENCE-BASED DECISION-MAKING IN DIGITAL BANKING SYSTEMS

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A B S T R A C T **This article explores the application of artificial intelligence (AI) in digital banking systems, focusing on improving and assessing the effectiveness of AI-based decision-making processes. It discusses the current state of AI in the banking industry, the methods used to enhance AI-driven decision-making, and the results of implementing these methods**

K E Y W O R D S artificial intelligence, digital banking, decision-making, effectiveness, Uzbekistan

INTRODUCTION

The banking industry has undergone significant transformations with the advent of digital technologies, and artificial intelligence (AI) has emerged as a key driver of innovation in this sector [1]. AI-based systems have the potential to revolutionize decision-making processes in digital banking, improving efficiency, accuracy, and customer experience [2]. In Uzbekistan, the adoption of AI in the banking sector is gaining momentum, with financial institutions recognizing the benefits of AI-driven solutions [3]. This article aims to explore the methods for improving and assessing the effectiveness of AI-based decision-making in digital banking systems, with a focus on the context of Uzbekistan.

METHODS AND LITERATURE REVIEW

To understand the current state of AI in digital banking and identify methods for improving AI-based decision-making, a comprehensive literature review was conducted. Relevant articles, research papers, and industry reports were sourced from reputable databases, including IEEE Xplore, ScienceDirect, and Google Scholar. The literature review focused on key themes such as AI applications in banking, machine learning algorithms, data analytics, and performance metrics for AI systems.

The literature suggests that AI can be applied in various areas of digital banking, including fraud detection, risk assessment, customer service, and personalized recommendations [4]. Machine learning algorithms, such as neural networks and decision trees, are commonly used to train AI models for these applications [5]. Data analytics plays a crucial role in improving the effectiveness of AI-based decision-making by providing insights into customer behavior and market trends [6].

RESULTS

The literature review revealed several methods for improving the effectiveness of AI-based decision-making in digital banking systems. These methods include:

Data Quality and Preprocessing. Ensuring the quality and integrity of data used to train AI models is essential for accurate decision-making. Data preprocessing techniques, such as data cleaning, normalization, and feature selection, can improve the performance of AI algorithms [7].

Model Selection and Optimization. Choosing the appropriate AI model for a specific banking application is crucial for effective decision-making. Techniques such as cross-validation and hyperparameter tuning can help optimize model performance [8].

Explainable AI. Implementing explainable AI techniques, such as rule-based systems and decision trees, can enhance the transparency and interpretability of AI-based decisions, building trust among stakeholders [9].

Human-AI Collaboration. Integrating human expertise with AI-based systems can improve decision-making effectiveness. Collaborative approaches, such as human-in-the-loop learning, allow for the refinement of AI models based on human feedback [10].

ANALYSIS AND DISCUSSION

The analysis of the literature and the identified methods suggests that improving the effectiveness of AI-based decision-making in digital banking requires a holistic approach. Data quality, model selection, explainability, and human-AI collaboration are key factors that contribute to the success of AI implementations in the banking sector.

In the context of Uzbekistan, the adoption of AI in digital banking is still in its early stages. However, the government and financial institutions are increasingly recognizing the potential of AI to transform the banking landscape [3]. Implementing the identified methods can help Uzbekistan's banking sector harness the benefits of AI while ensuring the effectiveness and reliability of AI-based decision-making.

One of the primary challenges faced by Uzbekistan's banking sector in implementing AI is ***the lack of a comprehensive data infrastructure*** [4]. Effective AI-based decision-making relies on the availability of high-quality, diverse, and representative data. Uzbekistan's banks need to invest in data collection, storage, and management systems to ensure the reliability and integrity of the data used to train AI models [5].

Another challenge is ***the shortage of skilled professionals in the field of AI and data science*** [6]. Uzbekistan's educational institutions need to adapt their curricula to include courses on AI, machine learning, and data analytics to build a talent pool capable of driving AI adoption in the banking sector. Collaboration with international universities and research centers can help bridge the skills gap and facilitate knowledge transfer [7].

The regulatory framework governing the use of AI in Uzbekistan's banking sector is also evolving. The Central Bank of Uzbekistan has recognized the need for guidelines and standards to ensure the responsible and ethical use of AI in financial services [8]. Policymakers should work closely with industry stakeholders to develop a comprehensive regulatory framework that balances innovation with consumer protection and financial stability.

The application of AI in digital banking presents both challenges and opportunities. While AI has the potential to streamline processes, reduce costs, and enhance customer experience, there are concerns regarding data privacy, algorithmic bias, and the ethical implications of AI-based decisions. Addressing these challenges requires a collaborative effort from policymakers, financial institutions, and technology providers.

Uzbekistan's banking sector can benefit from the experiences and best practices of other countries that have successfully implemented AI in digital banking. Collaboration with international organizations and technology partners can help accelerate the adoption of AI and ensure its effective use in decision-making processes.

One of the key opportunities for Uzbekistan's banking sector is ***the potential for AI to increase financial inclusion***. AI-based systems can help banks reach underserved populations, such as rural communities and small businesses, by automating credit assessment and loan approval processes. This can help reduce the cost of financial services and improve access to credit for traditionally marginalized groups.

Another opportunity is ***the use of AI to enhance customer experience and personalization***. AI-powered chatbots and virtual assistants can provide 24/7 customer support, while machine learning algorithms can analyze customer data to offer personalized product recommendations and financial advice. This can help banks build stronger relationships with their customers and increase customer loyalty.

However, the adoption of AI in Uzbekistan's banking sector also raises ethical concerns. AI algorithms can perpetuate biases present in historical data, leading to discriminatory decisions in areas such as credit scoring and loan approval. Banks must ensure that their AI models are transparent, explainable, and subject to regular audits to detect and mitigate bias.

Data privacy is another critical concern. As banks collect and process vast amounts of customer data to train AI models, they must implement robust data protection measures to safeguard sensitive information. Compliance with international data protection regulations, such as the General Data Protection Regulation (GDPR), can help build trust and confidence among customers.

On balance, the effective implementation of AI in Uzbekistan's digital banking sector requires a multi-faceted approach that addresses technical, regulatory, and ethical challenges. By investing in data infrastructure, talent development, and collaborative partnerships, Uzbekistan's banks can unlock the full potential of AI to drive innovation, improve customer experience, and promote financial inclusion. However, this must be balanced with a commitment to responsible and ethical AI practices that prioritize transparency, fairness, and data privacy.

V. CONCLUSIONS

This article has explored the methods for improving and assessing the effectiveness of AI-based decision-making in digital banking systems, with a focus on the context of Uzbekistan. The literature review and analysis have highlighted the importance of data quality, model selection, explainability, and human-AI collaboration in ensuring the success of AI implementations in the banking sector.

As Uzbekistan continues to embrace digital transformation in the banking industry, it is crucial to prioritize the effective use of AI in decision-making processes. Future research should focus on developing industry-specific guidelines and frameworks for AI implementation, addressing the challenges associated with AI adoption, and fostering collaboration between stakeholders.

By leveraging the power of AI and implementing best practices for effective decision-making, Uzbekistan's digital banking sector can drive innovation, improve customer experience, and contribute to the overall economic growth of the country.

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ARTIFICIAL INTELLIGENCE AND ITS CAPABILITIES

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Abstract: Artificial Intelligence (AI) is rapidly transforming our world, revolutionizing industries and impacting everyday life. AI encompasses a range of capabilities, including machine learning, natural language processing, computer vision, robotics, and expert systems. These capabilities empower AI to perform tasks that typically require human intelligence, leading to advancements in healthcare, finance, manufacturing, transportation, education, and customer service. However, AI also presents challenges, including potential job displacement, bias and fairness concerns, privacy issues, and the development of autonomous weapons systems. A collaborative approach involving researchers, policymakers, and the public is crucial to ensure that AI is developed and deployed responsibly for the benefit of society.

***Keywords:** Artificial Intelligence (AI), Machine Learning, Natural Language Processing (NLP), Computer Vision, Robotics, Expert Systems, Healthcare, Finance, Manufacturing, Transportation, Education, Customer Service, Job Displacement, Bias, Privacy, Security, Autonomous Weapons Systems*

INTRODUCTION

Artificial intelligence (AI) is no longer a futuristic concept; it is rapidly becoming an integral part of our daily lives and transforming industries across the globe. Defined as the ability of computer systems to perform tasks that typically require human intelligence, AI is revolutionizing the way we work, live, and interact with the world around us. [1, 2] This transformative technology encompasses a broad range of capabilities, from understanding and responding to human language to making predictions, solving complex problems, and even creating art. [3, 4]

The impact of AI is evident in various sectors, from healthcare, where it assists in diagnosis and treatment planning, to finance, where it enhances fraud detection and risk assessment. AI is also revolutionizing manufacturing, transportation, education, and customer service, creating new possibilities and driving innovation at an unprecedented pace.

However, alongside these advancements come challenges and ethical considerations that must be addressed. The potential for job displacement, biases in AI algorithms, concerns about privacy and security, and the development of autonomous weapons systems raise critical questions that require careful consideration.

This paper aims to explore the capabilities of artificial intelligence, examining its diverse applications and the profound impact it is having on society. We will delve into the various subfields of AI, highlighting key capabilities and exploring the challenges and opportunities they present. Furthermore, we will discuss the ethical considerations surrounding AI development and deployment, emphasizing the need for a responsible approach to ensure that this transformative technology benefits humanity as a whole.

MATERIALS AND METHODS

This research will utilize a combination of approaches to explore the capabilities of artificial intelligence:

1. Literature Review:

• A comprehensive review of academic literature, industry reports, and news articles will be conducted using a combination of keywords, including "artificial intelligence," "machine learning," "natural language processing," "computer vision," "robotics," "expert systems," and "applications of AI."

• The search will be restricted to peer-reviewed journals, reputable industry publications, and reliable news sources.

• Relevant research will be selected based on predefined inclusion criteria, focusing on works that provide insightful analysis of AI capabilities, applications, and ethical considerations.

2. Case Study Analysis:

• Selected case studies will be examined to illustrate the practical applications of AI in various sectors, showcasing its impact and potential benefits.

• Case studies will be chosen to represent a diverse range of industries and applications, demonstrating the breadth of AI's influence.

3. Ethical Analysis:

• Ethical considerations surrounding AI development and deployment will be explored through a critical analysis of relevant ethical frameworks, guidelines, and debates.

• The analysis will examine key concerns such as bias, privacy, job displacement, and the development of autonomous weapons systems.

4. Synthesis and Discussion:

• Findings from the literature review, case study analysis, and ethical analysis will be synthesized to provide a comprehensive overview of AI capabilities, applications, and challenges.

Discussions and Results:

While AI presents immense potential for societal progress, it's crucial to engage in open discussions regarding its impact and address potential risks. Here's a breakdown of key areas for discussion and potential results:

1. Bias and Fairness:

Discussion: AI systems are trained on data, which can reflect existing societal biases. This can lead to discriminatory outcomes in areas like loan approvals, hiring processes, and criminal justice.

Results:

• Data Audits and Mitigation Strategies: Developing methods to identify and mitigate bias in training data, ensuring fairness in AI applications.

• Transparency and Explainability: Making AI decision-making processes more transparent to understand and address potential biases.

• Human Oversight and Regulation: Establishing ethical guidelines and regulatory frameworks to address fairness and bias in AI development and deployment.

2. Job Displacement:

Discussion: Automation driven by AI could displace workers in certain sectors, raising concerns about unemployment and economic inequality.

Results:

• Reskilling and Upskilling Programs: Investing in education and training to prepare workers for the changing job market.

• New Job Creation: AI-driven industries are creating new jobs in areas like data science, AI engineering, and ethical AI development.

• Universal Basic Income: Exploring policies like a guaranteed basic income to address potential job losses and economic insecurity.

3. Privacy and Security:

Discussion: AI applications rely on vast amounts of data, raising concerns about data privacy, security breaches, and potential misuse.

Results:

• Data Privacy Regulations: Enforcing stricter data privacy laws and regulations to protect individual information.

• Secure AI Development Practices: Implementing robust security measures to safeguard AI systems from cyberattacks and data breaches.

• Ethical Data Governance: Establishing ethical frameworks for data collection, use, and sharing to ensure responsible AI development.

• A discussion will be presented, offering insights into the potential of AI, its impact on society, and the importance of responsible development and deployment.

Type of AI	Key Features	Applications	Advantages	Disadvantages
Machine Learning	Learns from data without explicit programming; identifies patterns and makes predictions.	Fraud detection, medical diagnosis, personalized recommendations, image recognition, natural language processing, and more.	Adaptable to new data, can handle complex patterns, continuously improves with more data.	Requires large datasets for training, can be biased if trained on biased data, may not explain its reasoning.
Natural Language Processing NLP	Enables computers to understand, interpret, and generate human language.	Machine translation, text summarization, chatbots, voice assistants, sentiment analysis, and more.	Allows for human-computer interaction, can process large volumes of text data, facilitates communication.	Can struggle with nuances of language, may generate inaccurate or biased outputs, requires large amounts of data.
Computer Vision	Allows computers to "see" and interpret images and videos.	Facial recognition, object detection, medical image analysis, self-driving cars, visual search, and more.	Enables machines to perceive the world, can analyze vast amounts of visual data, facilitates automation in visual tasks.	Can be inaccurate or biased, susceptible to adversarial attacks, requires significant processing power.
Robortics	Combines Al with physical systems to create robots with advanced capabilities.	Manufacturing, surgery, exploration, logistics, agriculture, and more.	Performs tasks autonomously, improves efficiency and safety, can work in hazardous environments.	Can be expensive to develop and maintain, requires careful programming and safety protocols, may displace human jobs.
Expert Systems	Mimics the decision-making processes of human experts.	Medical diagnosis, financial analysis, legal research, troubleshooting technical issues, and more.	Provides specialized knowledge and guidance, can access vast amounts of data, helps make informed decisions.	Limited to specific domains, may not be able to handle unexpected situations, requires extensive knowledge engineering.

• This table provides a general overview of different AI capabilities.

• You can expand upon this table by adding more specific examples of applications, advantages, and disadvantages within each type of AI.

• Be sure to cite your sources when discussing specific examples or research findings.

• Consider adding a column for "Ethical Considerations" to address potential biases, privacy concerns, or societal implications associated with each AI capability.

CONCLUSION

Artificial intelligence is a powerful force reshaping our world. From revolutionizing healthcare and finance to optimizing manufacturing and transportation, AI's capabilities are vast and growing. While challenges remain in areas like bias, job displacement, and ethical concerns, the potential benefits of AI are undeniable.

The future of AI holds immense promise. Continued advancements in hardware, algorithms, and integration with other technologies will unlock even more innovative applications. Navigating this evolving landscape requires understanding both the transformative potential and the ethical considerations surrounding AI. Ultimately, harnessing the power of AI responsibly and ethically will be key to building a better future for all.

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REVOLUTIONIZING CLASSROOMS: THE ROLE OF AI IN PERSONALIZED LEARNING AND STUDENT ENGAGEMENT

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A B S T R A C T **This paper explores the transformative impact of artificial intelligence (AI) on education, specifically focusing on personalized learning and student engagement. By analyzing recent advancements, practical applications, and challenges, it aims to illustrate how AI can revolutionize classroom experiences. This study employs a mixed-methods approach, including literature review, case studies, and expert interviews, to provide a comprehensive overview of AI's role in modern education.**

K E Y W O R D S *Artificial intelligence (AI), personalized learning,student engagement,adaptive learning systems,educational technology*

INTRODUCTION

Background

Traditional education often follows a one-size-fits-all approach, which can fail to meet the diverse needs of students. As classrooms become increasingly diverse, there is a growing demand for methods that cater to individual learning styles and paces. The advent of AI has introduced new possibilities for personalized education, with technologies capable of adapting content and teaching methods to suit each student's unique requirements.

AI technologies, such as machine learning algorithms, natural language processing, and data analytics, are revolutionizing various sectors, including education. These advancements promise to address longstanding issues in education, such as disengagement and unequal access to resources.

Problem Statement

Traditional educational systems often struggle with providing individualized instruction and maintaining high levels of student engagement. Large class sizes, varied student abilities, and limited resources can hinder effective teaching. AI offers potential solutions by enabling personalized learning experiences and enhancing engagement, but its integration into existing educational frameworks presents several challenges.

Objectives

To analyze how AI technologies can facilitate personalized learning by tailoring educational content to individual needs.

To assess the impact of AI on student engagement, including motivation, participation, and academic performance.

To identify and address the challenges and limitations associated with integrating AI into classrooms.

Significance

AI's potential to transform education lies in its ability to address educational disparities, optimize learning experiences, and support teachers in delivering effective instruction. Understanding AI's role in education is crucial for stakeholders seeking to leverage technology for improved educational outcomes.

METHODS

Research Design

A mixed-methods approach was employed to provide a comprehensive analysis of AI's impact on education. This included a review of academic literature, analysis of case studies, and interviews with educators and AI experts.

Data Collection

Literature Review: Academic journals, research reports, and online databases were reviewed to gather information on AI applications in education.

Case Studies: Selected schools and institutions were examined to showcase real-world applications of AI, including both successes and challenges.

Interviews: Semi-structured interviews were conducted with educators, AI developers, and policymakers to gain insights into practical experiences with AI in educational settings.

Data Analysis

Qualitative Analysis: Thematic analysis was used to identify common themes and insights from interviews and case studies.

Quantitative Analysis: Statistical methods were applied to measure improvements in academic performance and engagement metrics before and after AI implementation.

Comparative Analysis: Data from different educational settings were compared to evaluate the effectiveness of various AI tools and strategies.

RESULTS

AI Technologies in Education

Adaptive Learning Platforms: Tools like DreamBox and Smart Sparrow use AI to adjust the difficulty of lessons based on a student's performance. For example, DreamBox's adaptive learning technology personalizes math instruction by analyzing student responses and adapting lessons in real-time.

Intelligent Tutoring Systems: Systems such as Carnegie Learning's MATHia provide personalized feedback and support, guiding students through problem-solving processes with tailored hints and explanations.

AI-Driven Analytics: Platforms like Knewton and Pearson's REVEL utilize AI to analyze student data and provide actionable insights to educators, helping them understand student needs and track progress.

Case Studies

Example 1: The "AI Classrooms" Project in China: In a pilot project, AI-powered systems were implemented in several Chinese schools, resulting in a significant increase in student engagement and academic performance. The AI tools provided personalized learning paths and real-time feedback, which helped students grasp complex concepts more effectively.

Example 2: Georgia State University's AI Implementation: Georgia State University used AI to predict which students were at risk of dropping out. By providing targeted interventions and personalized support, the university saw a notable increase in student retention and graduation rates.

Example 3: The "Classcraft" Platform in North America: Classcraft incorporates AI-driven gamification to enhance student engagement. By turning classroom activities into interactive games, students are more motivated to participate and excel in their studies.

Challenges and Limitations

Technical and Logistical Issues: Implementing AI systems can be costly and require significant infrastructure upgrades. Schools may face challenges related to hardware, software, and technical support.

Data Privacy and Security: The use of AI involves collecting and analyzing vast amounts of student data. Ensuring the privacy and security of this data is a major concern, and schools must adhere to stringent data protection regulations.

Resistance to Change: Educators and students may be hesitant to adopt new technologies. Professional development and training are essential to help stakeholders understand and effectively use AI tools.

DISCUSSION

Impact on Personalized Learning

AI facilitates personalized learning by offering customized educational experiences that cater to individual student needs. Adaptive learning platforms adjust lesson difficulty based on real-time performance, ensuring that students receive appropriate challenges. For instance, if a student struggles with a specific math concept, the AI system provides additional practice and tailored explanations until the student masters the topic.

Recommendations:

Invest in Professional Development: Teachers should receive training on how to effectively use AI tools to support personalized learning.

Encourage Collaboration: Schools should foster collaboration between AI developers and educators to ensure that AI tools are aligned with curricular goals and teaching strategies.

Enhancement of Student Engagement

AI tools such as gamified learning platforms and interactive simulations can significantly boost student engagement. Gamification elements, like rewards and leaderboards, create a dynamic learning environment that motivates students to participate actively. AI-driven feedback systems also keep students informed about their progress, helping them stay engaged and motivated.

Recommendations:

Integrate Gamification: Schools should explore ways to incorporate gamification into the curriculum to make learning more interactive and enjoyable.

Utilize Real-Time Feedback: Implement AI tools that provide instant feedback to students, helping them track their progress and stay motivated.

Addressing Challenges

Overcoming technical and logistical barriers requires careful planning and resource allocation. Schools should conduct feasibility assessments before adopting AI technologies and seek funding or partnerships to support implementation. Data privacy concerns can be addressed by adhering to best practices for data protection and ensuring transparency with stakeholders.

Recommendations:

Develop Clear Policies: Schools should establish clear policies regarding data privacy and security to build trust with students and parents.

Provide Support and Training: Ongoing support and training for educators and IT staff are crucial for successful AI integration.

Future Directions

Emerging AI technologies, such as virtual reality (VR) and augmented reality (AR), offer new possibilities for immersive learning experiences. AI-driven VR environments can simulate real-world scenarios, providing students with hands-on learning opportunities. Continued research and development in AI will likely lead to even more innovative applications in education.

Recommendations:

Explore Emerging Technologies: Schools should stay informed about new AI advancements and consider integrating emerging technologies into their teaching practices.

Promote Research and Evaluation: Ongoing research is needed to assess the long-term impact of AI on education and refine AI tools based on feedback and outcomes.

CONCLUSION

AI has the potential to revolutionize education by offering personalized learning experiences and enhancing student engagement. Through adaptive learning platforms, intelligent tutoring systems, and gamified environments, AI can address many challenges faced by traditional education systems. However, successful integration requires addressing technical, logistical, and ethical challenges. By investing in professional development, fostering collaboration, and exploring emerging technologies, educational institutions can harness AI's full potential to improve learning outcomes.

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DEVELOPMENT OF CREATIVE THINKING IN STUDENTS USING THE SCAMPER METHOD

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Abstract: **This article describes the use of the Scamper method in the development of creative thinking in students of higher education institutions. Through creativity, the level of mental development of a person, i.e. scientific or technical knowledge, which is inextricably linked with science today, methods of effective use of the method are presented.**

Keywords: Scamper method, creative thinking, creative thinking, substitute, combine, adapt, modify, put to other uses, eliminate, rearrange

The level of intellectual development of any person, scientific or technical knowledge, which is inextricably linked with science today, is determined by the ability to think creatively. That's why, in the present time, when science and technology are rapidly developing, and social relations are being renewed, the issues of teaching young people to creative thinking, creativity, and the formation of creative individuals are of particular importance.

Creative thinking professionals are in high demand in every field. Not only scientists, engineers, professors, poets, writers, artists, actors, architects, editors, designers, but even small experts based on performance, need creativity. Experts of the world famous software products, mobile phone production companies are asked for a new idea every day. As the demand for creative thinking professionals is increasing in the labor market, it is an urgent task to form and develop this ability of students in the educational process. Still, many approaches and methods in the education system are not creative thinking, but interpretation and analysis, that is, to understand the given information correctly, to be able to correctly deliver it, and if it goes further, to summarize the given information. , aimed at drawing conclusions.

In order to fully understand the general nature of the process of developing creative qualities in a person, it is necessary to first understand the meaning of the concept of "creativity". According to Ken Robinson, "creativity is a set of original ideas with their own value" (Azzam, 2009). And Gardner explains the concept in his research: "creativity is a practical action performed by a person, which should reflect a certain novelty and have a certain practical value."

In the practice of the educational system of foreign countries, many methods and strategies are used that serve to form or develop the creative qualities of a person. The didactic value of these methods and strategies is that they force students and learners to think deeply about the learning materials. Therefore, these methods and strategies cannot be effectively used in the process of working with learners and students with extremely low creativity.

To develop the qualities of creativity in a person, it is first necessary to define the meaning of the concept of "creativity". The word creativity is derived from the English word "create", which means to create. Creativity means a person's creative ability to create new things and solve problems. It is based on originality, practicality, unusualness and freedom. Also, creative thinking means comprehensive thinking about a specific issue, being able to look at the same point from different angles.Creativity as a personality-developing category is an integral part of human thinking and spirituality, it is not in the multifaceted nature of knowledge possessed by a person, but in the pursuit of new ideas and the reformation and change of established stereotypes, in the process of solving life problems. manifests itself in making unexpected and unusual decisions.

That is, creativity cannot be achieved by repeating the given knowledge, the main condition is the emergence of a new thought, a new idea in the process of creative thinking.

Among the methods that serve to develop creativity in students, the SCAMPER method is also effective in the educational process.

The SCAMPER method was developed by Bob Eberle (1997), but the idea of using a broader checklist was given by Alex Osborne. He suggested using this method to stimulate new ideas, modify existing products and processes, and find alternative solutions. The technique is based on the idea that each new thing is a modification of something that already exists.

The "SCAMRER" style is a scheme of asking certain questions that stimulate the creation of new ideas, in other words, it is a style of creativity.

"SCAMRER" is:

S— Substitute, this phase involves searching for possible replacements for elements or ideas to improve the result or add new functionality. For example, if you are working on a still life, you can replace the apple in the vase on the table with another citrus fruit or garlic.

C— In the Combine phase, we look for opportunities to combine different elements, ideas, or concepts to create something new and unique. For example, still life and portrait can be combined.

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M— In Modify/Magnify (modification, enlargement), size, shape, color are changed. At this stage, we explore the possibility of changing aspects of an object or process to improve its features or functionality. For example, you describe an apple that is not the usual size, an extra large or small apple, a pink variety rather than blue or red.

P— Put to Other Uses Here we look for opportunities to apply the object or process to new contexts or areas of activity. In this you can create a picture of an artist painting a still life.

E—Eliminate means to remove something. This step involves finding elements or steps that can be removed to simplify the object or process, for example, instead of apples, depicting apples with their pods removed or a vase with apples lying on a table also adds creativity to the design pattern.

R—Rearrange/Reverse, the last step, means to reverse. Here we explore the possibility of changing the order or direction of actions to achieve new results or effects. In our example, the image can be drawn obliquely. This type of work is different from the usual still lifes and attracts special attention of people.

The purpose of technology: an effective scheme to help find new ideas for solving complex problems. The origin of this technology was caused by the observation that all new ideas or thoughts are modified forms of old ones.

Technology implementation procedure:

- participants are offered a final conclusion or idea related to the topic;

- each participant will be distributed papers with the stages of the "SCAMRER" technology:

- the relations of the participants are presented in group order.

The "SCAMRER" method is the basis for faster and successful assimilation of professional-theoretical knowledge by the participants based on practical exercises and existing experiences.

SUBSTITUTE - thinking about what and how to replace a part of an existing problem, process, order of actions, which leads to the emergence of new ideas.

This method is a teaching method aimed at mastering all stages of problem-research activity of students, developing research skills, analytical and creative abilities. All stages of problem-research activities are carried out by the student, he actually implements the research process and obtains an objective new result.

As a result of the analysis of the studied literature, it can be said that the organization of the educational process based on innovative approaches helps to develop students' creative abilities:

- The teacher should periodically exchange new and up-to-date information with interested persons and organizations on pedagogy and other related subjects.
- It is necessary to use methods aimed at developing creativity based on innovative approaches in the teaching of pedagogic sciences in the training of future education workers.
- The teacher must maintain professional and creative relations with students, colleagues, graduates, public organizations, higher educational institutions, and scientists.
- The teacher must encourage his students to participate in various competitions, exhibitions, Olympiads held with their peers in other higher educational institutions, other regions and countries.

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THE USE OF ARTIFICIAL INTELLIGENCE IN EDUCATION AND ITS IMPACT ON EDUCATION

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A B S T R A C T **In this article, we will analyzes the potential advantages and disadvantages of AI in education, as well as the extent to which AI has an impact on education, improved assessment, teacher and student convenience, i.e. new learning opportunities. the introduction of teaching methods using technologies is studied. Drawing on various studies and perspectives, the article argues that while AI has its own risks and drawbacks, its benefits in education are significant. The article suggests the need for more empirical research on the impact of AI on education, and for educators to collaborate with experts in the creation of AI.**

K E Y W O R D S Artificial intelligence, education, student, teacher, chatgpt, intelligence

INTRODUCTION

By the 21st century, science has developed to such an extent that it has become impossible to imagine a single day of our life without scientific achievements and techniques. Especially in recent years, the information society and the development of artificial intelligence (AI) have become a part of our daily life.

Education shapes the minds of our future generation, gives knowledge and empowers them. The use of artificial intelligence in education provides several advantages, namely flexible learning mechanisms to make the quality of education more effective. AI is the product of a unique intelligence capable of delivering everything from lesson plans to automated assessment to a system that has the potential to power our teaching and learning[1-2].

METHODS

Before analyzing the role of AI in education and its impact on education, if we define Artificial Intelligence in a general sense, Artificial Intelligence allows machines to perform tasks that traditionally require human knowledge. Artificial intelligence-based programs and devices can make decisions, solve problems, understand and imitate natural language.

Artificial intelligence (AI) can transform education by improving the learning process and outcomes. For example, OpenAI released ChatGPT - a natural language processing chatbot - in the fall of 2022 - the first time AI has gained much attention. However, AI tools have been part of the tech landscape for years. If you've ever played chess against a bot, consulted a virtual assistant like Siri or Alexa, or even scrolled through your social media feed, you've already interacted with an AI.

RESULTS

Artificial intelligence (AI) has the potential to analyze large amounts of data and significantly impact education in a number of ways.

1. Personalized Individual Learning: AI can provide personalized learning experiences tailored to the needs of individual students. It can adapt to different learning methods, providing useful suggestions and feedback to the student. It helps students learn at their own pace and increases their understanding and engagement.

2. Intelligent training systems: training systems based on artificial intelligence can act as virtual teachers, providing the necessary knowledge and feedback to students. Through these systems, students can study challenging fields and foreign languages, the sciences and the humanities through tailored explanations, practice problems, and resources.

Picture 1. AI in education

3. Assessment system: AI can assess by providing flexible and dynamic tests. It can analyze student responses in real-time and adjust the difficulty level of questions based on their performance. This approach provides a more accurate and comprehensive assessment, not only identifying what students know, but also identifying their weaknesses.

4. Intelligent content: AI can help extract educational content through automated productions, translations and simplifications. It can analyze large volumes of data and produce training programs and identify software to support training programs.

5. Data analysis and targeted support: AI can analyze student data to identify trends that may indicate learning difficulties or potential risk of dropping out. This saves teachers time, allows them to provide targeted support to struggling students, and prevents learning gaps from widening.

6. Accessibility and Inclusion: AI can improve accessibility by providing adaptive technologies for students with disabilities. For example, it can help visually impaired readers by converting text to speech or providing alternative formats. AI can also support multilingual education by providing real-time translation and language learning tools.

DISCUSSION

We are still learning how AI technologies will evolve and integrate into education, and we don't yet have a full picture of how AI will affect critical issues of ethics, equity, and data security. However, we are already supporting several applications of artificial intelligence in education. With the increasing use of artificial intelligence in the classroom today, it is important for students, teachers and schools to monitor the responsible use of these technologies. For example: The importance of teaching and monitoring that chatbots such as ChatGPT are capable of distinguishing between correct and incorrect information when using them and the potential for deception and misrepresentation among teachers. also, the increased use of artificial intelligence may mean that students become more dependent on virtual worlds and less human interaction. For this reason, it is more appropriate and effective for experts to work with pedagogues while analyzing the negative and positive effects in creating AI.

CONCLUSION

Although artificial intelligence offers many advantages, there are also concerns and issues that need to be addressed, such as data privacy, ethical considerations, and the need for human oversight and intervention. It is important to ensure that AI technologies are implemented ethically and responsibly, with the best interests of students and teachers in mind.

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THE FACTOR OF USING ARTIFICIAL INTELLEGIENCE IN THE STUDY OF WORKS DEDICATED TO THE IMAGE OF WOMEN IN ENGLISH AND UZBEK LITERATURE

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Abstract. The use of artificial intelligence (AI) offers exciting possibilities for analyzing the image of women in English and Uzbek literature. This article highlights how different modern AI tools can help researchers explore various aspects of this complex study, enabling deeper insights and broader perspectives.

Key words: artificial intelligence, literature, image of women, English and Uzbek literature

Artificial intelligence (AI) is a branch of computer science that aims to create intelligent agents, which are systems that can reason, learn, and act autonomously and it has already made our life more easier. In other words, AI is creating machines that can think and act like humans. Development of artificial intelligence has advanced the way we learn and investigate literature by giving great chance for analysis of literary works.

The highest creature in nature is the woman. Women are the pillar of our personal, social, political life. Reverence for women is one of the most important aspects of any nation [1] However, regrettably, there are times when women's honor and dignity are violated. In middle ages according to the social order English women were behind the men. Mainly, their roles were wives, mothers, and daughters. Only some noblewomen were able to receive basic literacy at that times when access to education was extremely limited for poor and ordinary women as their main task were giving a birth, upbringing of children and doing household chores. Women were considered their husband's property so, they had few legal rights and could not own land or hold political office.

In many previous works, the woman has not been revealed as a person, as a person with an inner world. Even Ophelia (Shakespeare's "Hamlet"), who was considered a perfect example of the image of a woman in her time, is a pure girl who, though loved and cherished, suffocated by the traditions of the modern world.[2] Regarding how women are portrayed in national literature nowadays, that depends on the culture and national character of that country. Consequently, people that behave in the same ways under identical circumstances are embodied differently in each literary work.

Conversely, we are able to observe in the literature on anthropology the representation of women who have suffered from abuse and had their ambitions crushed. We might examplefied Zebi from the well-known author Abdulhamid Cholpon's book "Night and Day". With his elegance, grace, and distinct gift, Zebi will captivate the heart of any reader. Zebi is terrified of her father, who is the closest person in the world. But she doesn't hate him. At her father's request, she was forced to give up all his dreams and marry Akbarali, who was equal to her father but more ignorant. She succumbs to fate, and at the end of the work, she becomes an innocent culprit.

The Uzbek people proud of the image of Barchin in the epic "Alpomish", and Tomaris who were symbols of fidelity, devotion, courage and bravery. It is noteworthy that "Arafah" section of Dante's "Divine Comedy" dedicates to the the bravery of Tomaris, the Queen of Turan. Shakespeare depicted Tomaris as an inspiration for European women, and Tomaris is honored in French literature as the national heroine of France, Jeanne d'Arc.y" There wouldn't be any literature without women. Writing is mostly produced by women for women, to appeal to them, to comprehend what they desire, and to know what a woman is.[2]

In english literature M Drabble, in Uzbek literature O'tkir Hoshimov are famous for creating different image of women as mother, sister, lower, wife, friend in their works. We tried to do comparative analysis of women in their works. M. Drabble's novels are known for their realistic and complex portrayals of women. Her characters are often strong and intelligent, but they also struggle with the challenges of love, marriage, family, and career. They are nuanced and multifaceted, showing the full range of human emotions and experiences. Drabble's work frequently explores the societal constraints and expectations placed on women. She often depicts the difficulties women face in balancing their personal desires with societal expectations and the challenges of navigating a male-dominated world. For example in her novel "The Millstone," the protagonist, a single mother, confronts societal judgment and the challenges of raising a child alone. Her next work"The Needle's Eye" explores a woman's struggle to find her own path in a society that restricts women's choices. Hoshimov is known for his realism and his ability to depict the nuances of human relationships and social dynamics. He doesn't shy away from portraying the challenges and complexities women face. Hoshimov presents a range of women, each with their own unique personalities, experiences, and struggles. Some are strong and independent, while others are more traditional and submissive. Many of the women in his novel are confined by traditional expectations and societal norms. They face limitations in education, employment, and personal freedoms. Some characters fight for their right to self-determination and challenge the patriarchal structures that limit them. This struggle is often intertwined with economic hardship and social pressures. Hoshimov uses these female characters to explore the broader social and political issues of his time. He critiques the limitations placed on women and calls for greater equality and empowerment. In the work of "Affairs of the world" O'. Hoshimov use his mother to create kind, gentle, benovolent image of Uzbek women. Also we can come across different image of women in his next work, "Between two doors". For example the character of Robiya portrayed the image of good-natured daughter, loyal fiancee, kind mother (stepmother) and docile wife.

Comperative analysis of English-Uzbek literary works requires hard work, patience, strong knowledge and long time. However, the introduction of artificial intelligence (AI) into literature and language marks a dramatic change in the way we create, assess, and interact with literary works. Artificial Intelligence (AI) has brought advanced machine learning algorithms and natural language processing methods that have fundamentally altered the literary environment. These algorithms have altered not only how new works are created but also how they are interpreted and distributed.[4] Researchers can now study vast corpora of literary texts at a speed and accuracy never before possible thanks to computational methods like sentiment analysis and natural language processing (NLP). Artificial intelligence (AI) algorithms can uncover hidden patterns, linguistic nuances, and obscure themes that are invisible to traditional literary analysis techniques, leading to new insights into the composition, style, and meaning of literary works. Researchers can now explore literary movements, authorial influences, and cultural trends in previously unimaginable ways, further expanding our understanding of literature and its social significance.

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THE EXECUTION OF DIGITAL TRANSFORMATION IN HIGHER EDUCATION INSTITUTIONS

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Abstract. This article examines the role of digital transformation and technologies in higher education. It assesses the influence of digital transformation on the sector, discussing its benefits and drawbacks, while also identifying the challenges that hinder the effective implementation of distance learning via digital technologies and proposing strategies to address these obstacles. Additionally, the article highlights how digital solutions serve as reliable tools for university management, improving communication between educators and students, supporting the supervision of the educational process, and enabling data-driven decision-making. The discussion emphasizes the importance of combining direct interactions between faculty and students with the strategic integration of advanced digital tools in both teaching practices and university governance.

Keywords: digital transformation, digital transformation trends, digital technologies, digital teaching and learning system, distance platforms, Internet network.

Introduction. The integration of digital transformation is increasingly pivotal within contemporary educational frameworks. Higher education establishments are incorporating digital solutions to optimize the learning environment and enhance student engagement. The utilization of digital technology in higher education yields numerous benefits, such as heightened flexibility, enhanced data accessibility, and improved collaborative opportunities. The integration of digital transformation in higher education institutions holds the promise of fundamentally reshaping the entire educational landscape. Technological applications enable institutions to craft tailored and engaging learning experiences for students [10]. For instance, adaptive learning platforms can monitor student progress, dynamically adjust content difficulty levels, and deliver personalized educational interactions.

Simultaneously, the adoption of digital tools can bolster collaboration between students and educators, facilitate remote learning, and ensure the utilization of diverse educational resources. This not only elevates the educational standard but also broadens access to education for individuals unable to partake in traditional institutional settings due to geographical or financial constraints[11].

While the advantages of digital transformation in higher education are evident, institutions face significant challenges that require resolution. Among these challenges, one of paramount importance is the financial implications associated with implementing digital transformation. Institutions are required to make substantial investments in technology, infrastructure, and training of personnel, posing a considerable economic burden.

Moreover, institutions must confront issues concerning data privacy and security, accessibility, and inclusivity. The deployment of digital tools has the potential to exacerbate a digital divide, wherein marginalized students may not have equal access to resources compared to their more privileged counterparts.

Another obstacle involves the necessity for institutions to keep pace with the rapid advancements in technology. Institutions must continually invest in technological upgrades, modernize their infrastructure, and deliver optimal learning experiences for students [27].

Research methodology. The research methodology for digital transformation in higher education encompasses the incorporation of technological tools across various facets of the academic setting. Key methodologies involved in this transformation include the utilization of online educational management systems, digitalized textbooks, and collaborative platforms. These tools facilitate the development of a more adaptable and customized learning environment. Furthermore, digital solutions enhance access to educational materials, empowering students to engage in self-paced learning within their preferred settings.

Analysis and findings. The integration of digital transformation within the realm of higher education has produced a multitude of favorable outcomes. A primary advantage lies in the augmentation of student engagement. Through the integration of digital tools within the educational framework, students exhibit heightened levels of participation and motivation, consequently yielding improved academic outcomes. Moreover, digital solutions empower educators to monitor student advancement and pinpoint areas necessitating additional assistance.

The adoption of digital technology in higher education has further resulted in an enhanced accessibility to learning. Individuals previously impeded by educational obstacles, such as individuals with disabilities or those residing in remote locales, now possess the ability to access educational materials and partake in courses from any location with internet connectivity. Additionally, digital solutions have engendered financial savings for both students and educational institutions, as the utilization of digital textbooks and online courses obviates the requirement for costly physical textbooks and supplementary materials [13].

The SWOT analysis method demonstrates its utility as a foundational tool for evaluating the strengths, weaknesses, capacities, and risks associated with the integration of digital transformation within higher education establishments. Through this assessment, the merits, drawbacks, prospects, and challenges inherent in executing digital transformation were scrutinized, leading to the subsequent findings:

Strengths:

- Enhanced educational experiences: Leveraging digital tools enables educational institutions to craft tailored and engaging learning experiences for students.

- Enhanced collaboration: Digital tools streamline collaboration among students and faculty, facilitating seamless communication, resource sharing, and group project collaboration.

- Enhanced educational access: Digital tools broaden educational access for students unable to physically attend traditional institutions due to geographical or financial barriers.

Weaknesses:

- Financial Implications: The integration of digital transformation necessitates substantial investments in technology, infrastructure, and staff training, posing a significant financial challenge for educational institutions.

- Access and Equality: The adoption of digital tools and platforms may exacerbate a digital gap, restricting access for disadvantaged students who may not have the same resources as their more affluent counterparts.

- Training for Faculty and Staff: Effective implementation of digital transformation mandates educating professors and staff on utilizing digital tools and platforms, presenting a crucial obstacle to overcome.

Opportunities:

- Enhanced student engagement: Utilization of digital tools can furnish students with interactive and captivating learning encounters that enhance their engagement and drive.

- Sophisticated data analytics: Digital tools enable educational institutions to gather and analyze data on student interactions, which can be utilized to enhance pedagogical practices and strategies.

- Augmented flexibility: Digital tools empower institutions to provide adaptable learning alternatives like online and blended learning to accommodate diverse student learning styles and preferences.

Threats:

- Cybersecurity risks: the implementation of digital tools and platforms can expose institutions to cybersecurity risks such as data corruption and cyberattacks. - Technological obsolescence: the pace of technological change is fast and institutions must keep track of new developments so that they remain relevant. - Resistance to change: some teachers and staff may oppose the implementation of digital transformation, which can lead to difficulties in acceptance and implementation .

Discussion. Despite the many advantages of digital transformation in higher education, some difficulties and limitations must be taken into account. One potential problem is the need to constantly invest in technology infrastructure and support services. In addition, implementing digital solutions may require significant changes in teaching methods and course design, which may be difficult for some teachers to adapt [16].

The pressing problems of digital transformation of the educational environment of the University are an important topic for research in modern society. In the process of introducing digital technologies, the main problems faced by higher education institutions were analyzed [1].

One of the main problems is the lack of a unified strategy for introducing digital technologies into the educational process. It is advisable for each individual educational institution to develop its own plan for the introduction of digital technologies, which will prevent the possibility of causing inconsistencies and contradictions in the process of interaction of various systems and programs.

Secondly, it was considered a shortage of qualified personnel in the field of digital technology. The fact that some university faculty and administrative staff do not have enough knowledge and skills to effectively use modern digital technologies in the educational process leads to various difficulties.

Third, limited use of digital technology may be the cause. More precisely, considering the fact that most students live in the province, the internet infrastructure does not cover remote and remote areas of the provinces, that is, the speed of operation does not even reach 0.5 Mb/s [2]. This, in turn, is a hindrance in the use of high-speed Internet and modern computers, leading to restrictions on the possibility of using digital technologies in the educational process.

However, despite these problems, the introduction of digital technologies into the educational process of universities has a number of advantages. One of the main advantages is to improve the quality of Education. The use of modern digital technologies makes it possible to improve the quality of training and increase the interactivity of the educational process [23].

The second advantage is to improve access to education. The digital transformation of the educational environment makes it possible to learn remotely without being tied to place and time, which has found its proof especially in the context of a pandemic. At the same time, this advantage opens up opportunities for training a wide range of people, including those who cannot attend face-to-face activities such as distance location or disability.

The third advantage was found to be a reduction in training time. Digital technologies accelerate learning and optimize the process of mastering the material. For example, the use of online courses allows you to study materials at your own pace, as well as repeat difficult topics without spending time on face-to-face activities.

The fourth advantage is an increase in the effectiveness of teachers. The introduction of digital technologies allows the automation of many processes related to the assessment and control of students ' knowledge, which takes time to work more creatively and efficiently. In addition, the use of online platforms allows you to reduce the time of preparation, distribution of educational materials and reduce the cost of paper documents.

Finally, the fifth advantage is to improve the quality of interaction between students and teachers. Digital technologies make it possible to carry out interactive and dynamic activities that increase student motivation and contribute to more effective learning. In addition, online platforms allow teachers to receive quick feedback from students and analyze their development in real time [21].

Developed countries have been able to master digital technologies early in the field of higher education, and their experiences have gained notable experience in the possibilities and problems associated with this process.

For example, in the United States, digitalization is associated with the need to improve the quality of education and increase access to educational resources. The use of digital tools such as online education management systems, digital textbooks, and collaboration tools has allowed institutions to create a more flexible and personalized learning experience for students. In addition, the use of online resources such as open educational resources has caused institutions to increase access to educational resources and reduce educational costs.

The use of digital technology in higher education in the UK has been linked to the need to improve efficiency and reduce costs. The use of digital tools such as cloud-based storage and collaboration tools has paved the way for institutions to simplify administrative tasks and improve communication and cooperation between faculty, staff and students. In addition, the use of online resources gave institutions the opportunity to reduce educational costs and increase access to educational resources [18].

The use of digital technology in higher education in Australia has been linked to the need to enhance student experience and improve academic performance. The use of digital tools such as online learning management systems, digital textbooks, and collaboration tools has allowed institutions to create a more engaging and interactive learning experience for students. In addition, the use of online resources has provided facilities to increase access to educational resources and improve academic performance.

Despite the manifold benefits of digitization within higher education, developed nations have encountered challenges in this transition. These include substantial investments in technological infrastructure, the imperative of training and supporting faculty and staff, and the imperative of mitigating privacy and data security risks [26].

To surmount these hurdles, developed nations have formulated comprehensive digital transformation strategies that prioritize fostering a supportive institutional culture through stakeholder engagement, encompassing ongoing evaluation and surveillance, fostering innovation, and cultivating expertise.

Through the aforementioned scrutiny, it becomes apparent that notwithstanding the array of challenges entailed in integrating digital technologies into university education, the merits outweigh the indisputable drawbacks. It aligns with the notion that each university should strike a balance between traditional pedagogical approaches and contemporary digital technologies to furnish effective and high-quality education for its students. Equally imperative is the provision of training for educators in utilizing new technologies, alongside vigilant attention to the imperatives of data security and fortification against cyber threats.

Trends in digital transformation in higher education. The trajectory of digital transformation within higher education is a pressing and highly discussed subject within academic spheres. This discourse is propelled by the significant contributions of eminent scholars, university leaders, and representatives of analytical entities engaged in higher education. Their endeavors delineate the future of higher education through the identification of key trends, technologies, and practices. These technological trajectories harbor the potential to broaden the horizons of universities, enhancing competitiveness and international recognition, while simultaneously tackling intricate challenges such as redefining educator roles and optimizing institutional financial structures [3].

Technology itself serves as a potent catalyst for educational metamorphosis, fortifying and enriching the teacher-student dynamic, fostering innovative learning paradigms and collaborative frameworks, and remedying longstanding deficiencies in educational practices. This transformation endeavors to adapt educational processes to cater to the diverse needs of all participants within the educational milieu, leveraging existing knowledge and experiences [4].

Within the realm of digital transformation in higher education, two primary domains of activity emerge: services and processes. The former entails the creation of novel services and the modification of existing ones, exemplified by transitions to online programs or electronic publications. Meanwhile, the latter focuses on the complete digitization of processes such as course enrollment and resource allocation monitoring [5].

Drawing from the advanced experiences of developed nations, it is imperative for higher education institutions to evolve into crucibles of research and innovation, fostering adaptability among professors in the pursuit of novel knowledge. Collaboration with students in continuous skill acquisition and domain-specific knowledge enrichment is essential [6].

As a vanguard in the digital economy, the United States stands as a prominent exemplar, offering invaluable insights garnered from research and analytical endeavors conducted by preeminent companies and organizations in the domain of higher education development. Concurrently, leading universities across Europe and Asia demonstrate robust utilization of such technologies and the implementation of digital transformation strategies [7].

Institutions must remain cognizant of contemporary trends and advancements to avoid falling behind the zeitgeist. Among the pivotal trends in digital transformation within higher education, personalization emerges as a cornerstone. Leveraging digital tools and platforms, institutions can furnish tailored learning experiences, attuned to the individual needs, preferences, and cognitive styles of students. Such personalized approaches hold promise for enhancing student engagement and motivation, thereby fostering improved educational outcomes [22].

Artificial Intelligence (AI): The integration of artificial intelligence into higher education is becoming increasingly prevalent. AI-driven tools and platforms have the capacity to offer personalized recommendations to students, automate administrative functions, and facilitate more efficient data analysis. Consequently, this advancement is poised to enhance both learning and teaching processes while streamlining institutional operations [19].

Mobile Learning: Mobile education represents another significant facet of digital transformation within higher education. With the ubiquity of mobile devices, institutions must ensure the accessibility and portability of their digital resources and platforms to accommodate mobile communication. This affords students the flexibility to engage in learning activities anytime, anywhere, and across various devices, thereby fostering greater adaptability and accessibility [14].

Gamification: The adoption of gamification as a digital transformation trend involves the integration of game-like elements into the learning experience. This approach holds promise for enhancing student engagement and motivation while fostering collaborative and competitive dynamics among learners.

Virtual Technologies: Virtual technologies are increasingly pervading higher education settings. These technologies facilitate immersive and interactive learning experiences, such as virtual tours, simulations, and virtual laboratories. Such innovations have the potential to augment student engagement while furnishing practical, hands-on learning opportunities [23].

Conclusions and suggestions.

A Methodological Approach to Cultivating a Novel Digital Culture in Higher Education.

Given the pervasive integration of digital technologies and the identified trends, there arises a necessity to imbue new competencies not encompassed within current educational curricula. Hence, the development of a novel educational paradigm and personnel training program, characterized by a revamped architecture aligned with the objectives and principles of fostering a new digital culture within the framework of the digital economy, emerges as pivotal for institutional adaptation. This initiative is essential for addressing the evolving landscape of digital education in tandem with the authentic demands of the labor market [8].

The research methodology in this domain is predicated upon the recognition of the potential of higher education and scientific endeavors as catalysts for catalyzing profound transformations commensurate with the exigencies of the contemporary era. This methodology is instrumental in aiding the attainment of strategic objectives for higher education development within a specific locale [9].

Furthermore, the adoption of pertinent methodologies and approaches within the educational framework facilitates the acquisition of fundamental competencies by students. This encompasses not only the integration and utilization of various technologies (digital, instructional, etc.) within university settings but also entails the incorporation of theoretical and practical guidelines aimed at the systematic advancement of educational content and the enhancement of educational and training provisions under optimal conditions. The deployment of the "transformation engineering" approach within the higher education system emerges as a pivotal catalyst for catalyzing significant shifts in the educational milieu, ushering in a multitude of opportunities [24]. This approach markedly broadens the technical acumen of educators, students, and all stakeholders within the higher education ecosystem. In delineating the pathway for enhancing the higher education system amidst the backdrop of digital transformation, it is imperative to consider two key components:

Ensuring Educational Quality and Capacity Enhancement in Higher Education;

A study conducted at Ihio University underscores the pivotal importance of these dual facets in delineating a university's status and strategic direction vis-à-vis digital transformation. Within the contemporary educational landscape, ensuring quality assurance in the digital era necessitates a critical examination of the foundational principles governing educational systems, encapsulated by two key inquiries:

-What are the requisite knowledge, skills, and values?

-How can educational systems efficaciously cultivate these competencies?

This perspective directly addresses the challenges endemic to education and assumes a paramount role in institutional-level quality assurance, influencing educational outcomes.

The proposed methodology's role lies in delineating the prerequisites for educational programs, assessing their alignment with international benchmarks and technological trajectories, determining revision timelines, and elucidating the structural and conceptual interrelationships among diverse disciplines.

Moreover, the role and significance of higher education in addressing national economic challenges and augmenting institutional capacity play a decisive role in facilitating a seamless transition towards elevated levels of innovation and intensive development, particularly in developing nations. Ongoing endeavors worldwide are focused on bolstering human resource capabilities and instituting educational programs within higher education institutions. Such initiatives are aimed at equipping personnel with the requisite expertise to navigate decision-making processes essential for upgrading infrastructure, enhancing operational efficiency, and optimizing resource utilization [17, 28].

Based on the above, the following innovative decisions should be applied as an approach to transformation:

- formation of the institutional infrastructure of education and training on the basis of innovative technologies;

- development of innovative education;

- integration of Education;

- integration of Education, Science, production and business (through stakeholder relations);

- improving the education system through digital technologies;

- encourage a creative approach to teaching, initiatives

- exchange of experience between teachers;

- assistance in ensuring the quality of teachers ' activities, educational content, teaching methods.

Summarizing the above transformation trends and the main provisions of the methodology, it is worth mentioning the need for modernization in order to further improve the higher education system in relation to Uzbekistan, since it is necessary to adapt to the country's growing national economic need for highly qualified personnel. This task is repeatedly outlined in government decisions and is provided with appropriate measures at different levels of activity of all stakeholders of the higher education system. However, there are some issues that need to be considered at the governmental and institutional levels. For example, no Uzbek higher education institution is currently represented in the ranking of the 500 most common universities in the world [15]. There are many positive changes in the higher education system, both structurally and in terms of content, while it is advisable to take into account the rules specified in the justification and preliminary (at the launch stage) description of the proposed methodology.

In general, it is necessary to ensure quality education in modern educational programs in accordance with international requirements. The process of improving the effectiveness of Higher Education requires constant updating of teaching programs and skills of professors in order to maintain the quality of education within the framework of existing requirements. The level of quality of Education provides the institution with the possibility of continuous service and Development [20].

In particular, the following is expected to be provided as part of a modernized curriculum on courses obtained as a result of the application of the methodology:

- the best relationship with modern trends in research and development in a particular area;

- interaction between the education and production sector through education, training, joint research activities and publications;

- opportunities to have individual training schemes according to the needs and requirements of stakeholders [15];

- support capacity building initiatives;

In conclusion, we can say that the digital transformation of the educational environment of the university is a necessary step in the modern world to meet the needs of students and improve the quality of Education. At the same time, the introduction of new technologies is accompanied by a number of problems that need to be taken into account when using them. It is important that institutions carefully consider these advantages and disadvantages before implementing a digital transformation to ensure that it maximizes its advantages while minimizing them.

At the same time, there are difficulties and restrictions that need to be considered, including the provision of constant investments in technology infrastructure and obstacles that are faced when accessing digital resources from all regions of the Republic. Despite these difficulties, the digital transformation in higher education will continue to develop and play a decisive role in shaping the future of Education.

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CREATION OF MOBILE APPLICATIONS BY USING ARTIFICIAL INTELLIGENCE TECHNOLOGIES

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A B S T R A C T **Creation of mobile applications by using artificial intelligence technologies is studied in this article. Artificial intelligence technologies play a decisive role in the development of mobile applications. Both mobile applications and artificial intelligence are very popular industries; they have experienced huge growth in a relatively short period of time and are expected to grow even more in the near future.**

The limited nature of mobile devices required a more hands-on approach to providing app functionality. Nowadays, machine learning and artificial intelligence (AI) are revolutionizing mobile app development. Due to machine learning, apps can now recognize speech, photos and gestures and translate voices with high accuracy. In this regard, the potential of artificial intelligence in mobile application development is explored in this article. This article include the tools of artificial intelligence which are based on applications, text recognition, voice recognition, recorded photo-video images, real-time people, their gestures, mood and speech intonation, the expansion of potentially useful and interesting mobile applications, the advantages of AI in mobile application development, operational principles of the research, the general scientific principles of integrity and specificity.

K E Y W O R D S mobile applications, artificial intelligence, recognition technology, machine learning, AI integration, mobile development innovation, intelligent mobile systems, mobile education, mobile learning (ML), intelligent tutoring systems (ITS).

INTRODUCTION

In the past few decades, artificial intelligence (AI) has been widely researched all over the world. Mobile learning (ML) is particularly important in teaching and learning in order to increase the effectiveness of using AI.

The field of artificial intelligence in mobile learning has existed for nearly 40 years and has operated under various other names in various fields, the most common of them is Intelligent Tutoring Systems (ITS).

Artificial Intelligence (AI) is revolutionizing the way which we live and work, and mobile app development is not exception. The artificial intelligence is making mobile apps smarter, more responsive, and more personalized experiences for users with the ability to analyze large amounts of data and make decisions based on that data. The AI gives opportunity to make mobile apps more intuitive and suitable for users from chat bots to predictive maintenance and language translation and holds great potential for future mobile app development.

Nowadays, programs which are created with the help of artificial intelligence are widely used [1-2]. Artificial Intelligence (AI) is currently being used in many industries such as healthcare, retail, finance, real estate, insurance and others. The potential of this technology is limitless in all business sectors, and mobile application development is certainly not exception. Artificial intelligence is a technology which is designed to replicate human cognitive functions and solve problems and make decisions. This is an interdisciplinary field; it relies on the principles of computer science, data analysis, and algorithmic processing to perform actions faster and more accurately than traditional human methods. Artificial intelligence includes a number of areas.

AI can be used to collect user data and create a personalized experience for each user. For example, the application which is based on Artificial intelligence, can learn user preferences and offer content, products or services which are tailored to their needs. The chat bots which are driven the artificial intelligence and virtual assistants can be integrated into mobile applications to provide customer support, answer user questions, and perform other tasks without human intervention.

AI can be used to analyze user behavior and predict user behavior, it helps mobile app developers make decisions on the basis of data about app features, design, and functionality. The voice recognition technology which works on the basis of the artificial intelligence can be used to enable voice commands and controls within mobile apps; it makes them more accessible and comfortable for users. Artificial intelligence can be used to enable features such as image and object recognition and classification, augmented reality and object identification within mobile applications.

MAIN PART

Nowadays, artificial intelligence opens up many opportunities for mobile application development, not only through machine learning, but also through recognition technologies, biometrics and voice technologies. If machine learning technologies can be considered and evaluated mainly by application developers, any mobile application user can use recognize, biometric and voice technologies [3-4]. Biometric is considered the technology which is designed to simplify the detection and analysis of human behavior (size, structure, shape, and other physical aspects of the human body). Mobile app developers use artificial intelligence in order to collect biometric data for voice recognition, gesture control, and biometric data generation (traditional passwords, Face ID, and many other features). Nowadays, software capabilities interpret human emotions by recording a few changes in the sound waves of a person's voice and body signals by processing the image and sound. Companies can use these analytics to improve customer service by determining customer sentiment and interest in a product or service.

Image recognition for mobile applications opens up many possibilities. This technology identifies the object in photos and videos or through a digital platform [5-6]. This technology can be used in almost any field. Image recognition technology helps diagnose diseases, identify car numbers, search for desired goods or services, and search for people and objects in photos. Together with the recognition technology, the active development of various bots, which can include several artificial intelligence technologies at the same time, has begun. Using chat bots in mobile applications or web applications can significantly give opportunity to save customers time and money for companies which serve any services. Due to this technology, anyone can get help to solve their problem within 24 hours; this also eliminates a number of errors which are made by operators due to the human factor. Voice technologies have not escaped the attention of mobile application developers. Advanced text-to-speech technology provides clear voice functionality for text input into the app, enhances the functionality of the mobile app, together with this, they help visually impaired users navigate and use the app without any limitations. As technology improves, users can convert books into audio-books very quickly; this eliminates the human factor [7-8]. Voice technologies also involve the reverse process of converting information from voice commands to text. The typing programs are being developed on the basis of them. The most important thing in using voice technologies of artificial intelligence is considered to synthesize all their capabilities in one application. Many AI capabilities rely on large amounts of data which are regularly collected in mobile applications; it makes them a great opportunity to develop various AI functions. The implementation of artificial intelligence in mobile app development is still relatively new, that's why, many conflicting opinions exist, but the number of benefits which this alliance can bring, outweighs any potential risks.

Using mobile learning materials in open learning universities (MLMs) allows students to work on their materials while protecting data via mobile devices.

In addition, teachers can re-develop options for materials. The students can connect contexts through portable materials by these changes for portable learning (Words, Images, Graphics, and Shapes).

Using the artificial intelligence (AI) in the creation of mobile applications allows to significantly increase efficiency and functionality. The three main categories of benefits which AI can improve in application development: efficiency, automation, and user experience (Table 1) exist.

TABLE 1. CATEGORIES OF BENEFITS OF AI IN MOBILE APPLICATIONS

Category name	Description
Efficiency	The mobile apps which are based on the AI, can offer much higher productivity than the average human, it includes many different potential tasks – from managing workflows to processing data and even answering customer questions.
Automation	The enterprise solutions automate many different activities and tasks with the introduction of artificial intelligence. Automation eliminates errors in certain areas and ensures more accurate results.
User experience	In general, the user experience can be further personalized by introducing artificial intelligence, this suggests products and services deemed useful for each user (through sentiment analysis).

The benefits of mobile app development cannot be relevant to just one specific category out of the three. For example, the ability of artificial intelligence to help developers in the actual development phase by writing elements of code also belongs to the categories of "efficiency" and "automation" (with examples like TabNine, Github Copilot, and others.). This unique feature includes not only the generation of code snippets, but also automated testing, automated deployment, and many other benefits. Below, we give information on the methods of using artificial intelligence in the development of mobile applications (Table 2).

TABLE 2. THE METHODS OF USING ARTIFICIAL INTELLIGENCE IN THE DEVELOPMENT OF MOBILE APPLICATIONS

Category name	Description
Personalization and Recommendations	Recommendation System: The AI can be used to recommend products or content to users on the basis of their interests. For example, e-commerce applications analyze the user's previous purchases and suggest products which suit their needs. Personalization: The AI algorithms can learn the user's data and change the app's interface and functions according to the user's needs.
Natural Language Processing (NLP)	Chat bots: The chat bots which work on the basis of the AI can automatically respond to user inquiries and automate customer service. Accept Voice Commands: Mobile apps can be voice-controlled, this improves the user experience. The

	example of this can be Siri or Google Assistant.
Image and Video Processing	Object detection: AI can be used to identify, classify and edit objects in photos. For example, it is possible to improve the quality of photos by adding filters or automatically analyzing the photo. Facial detection and recognition: Facial recognition technology is widely used to improve mobile security systems, such as unlocking smart phones.
Data Analysis	Predictive analytics: AI can predict future trends and needs by analyzing user behavior. It helps in making business decisions. Data Segmentation: The efficiency of applications can be improved by segmenting large volumes of user data.
Automation and Gamification	Gamification: Artificial intelligence automates methods to engage and motivate users through games. This helps increase user loyalty. Application testing: Automated testing of application is done by using AI, then the process of identifying and fixing errors are speeded up.
Cyber Security and Fraud Prevention	Security systems: The methods to protect user data and detect fraud in applications are being improved by using AI. For example, AI systems can monitor unusual activity and respond to it in a timely manner.
Smart Camera and Sensor Features	Integration with IoT: It gives opportunity users to control smart home systems with smart sensors and cameras which work on the basis of AI. Automatic image analysis: For example, diagnosis by automatic analysis of photographs and X-ray images in the medical field.

Artificial intelligence technologies help make mobile applications more intelligent, comfortable and efficient for users. This approach expands business opportunities and takes user experience to a new level.

The specific advantages of using artificial intelligence in mobile application development are presented in Table 3.

TABLE 3.THE SPECIFIC ADVANTAGES OF USING AI IN MOBILE APPLICATION DEVELOPMENT

Advantages of using artificial intelligence	Description
Automation:	The tools and algorithms on the basis of the artificial intelligence can automate time-consuming and repetitive tasks; it gives opportunity developers to focus on more important areas of application development.
Improved efficiency	AI enables mobile apps to perform tasks faster than humans in many cases. Whether it is processing data, responding to customer inquiries, or managing workflows, the AI provides enterprises the tools which help to improve their efficiency.
Personalization	AI helps create personalized app experiences on the basis of user data and behavior; it leads to increased user satisfaction and engagement.
Real-time translation	You can integrate AI translators into your mobile applications by using the artificial intelligence technology; they also work in real-time and offline mode. Such apps help people communicate across the globe without any hassle.
Application security and user authentication	Mobile apps need to stay ahead of technological advancements when it comes to user security and authentication. AI helps reduce the perception of threats and vulnerabilities to prevent user data from being stolen from cybercriminals or hackers. This helps authenticate the user seamlessly without worrying about data leakage.

The artificial intelligence has the potential to improve automation and facilitate intelligent interactions, not only for web apps, but also mobile apps as well. The possibilities of what AI can achieve in a mobile application are vast from chat bots and digital assistants to personalized experiences [9-10].

Artificial intelligence in mobile apps are considered computer programs which can "think" and "learn" like humans. AI makes apps smarter and more useful. For example, it allows virtual assistants in apps to understand voice commands. Together with this, it also allows applications to recognize objects in photos and provide relevant information. Many applications use machine learning which is one of the type of AI. ML gives opportunity applications to automatically improve on the basis of experience and data. For example, a fitness app can use machine learning to provide personalized exercise recommendations for each user. In mobile games, AI controls the actions of the opponents or characters who you play. Together with this, AI also helps with targeted advertising in apps. The advertisements are tailored on the basis of your interests and activities. Many popular apps like Gmail, Maps, and virtual assistants also use artificial intelligence. Artificial intelligence for mobile app development provides human-like capabilities to improve mobile apps. It gives opportunity applications to adapt, perceive their environment, learn, solve problems, and deliver intelligent features and experiences. AI represents a major breakthrough in mobile technology.

The several ways exist to use artificial intelligence in Machine Learning mobile apps. This AI technique gives opportunity applications to learn from data and improve. Apps can recognize patterns and make predictions. For example, recommendation engines and voice assistants. AI can detect and process images and videos in applications while watching the computer. It provides facial recognition, object detection and augmented reality functions. NLP gives opportunity applications to understand and respond to human language and voice commands. This AI capability gives opportunity chat bots and virtual assistants to work within apps. AI can predict user needs and behavior by researching user data. Then the apps can deliver personalized content, offers and messages which are tailored to individual users. The developers for artificial intelligence first collect training data in the desired domain in the development and implementation of mobile applications [11-12]. Then they use this data to create machine learning models. Mobile applications combine trained models. The use of artificial intelligence in applications provides intelligent features and user experience. The skills in data science and ML are need for developers in order to use AI effectively.

The use of artificial intelligence (AI) programs in the creation of mobile applications gives opportunity the development process to be efficient, interactive and comfortable for users (Table 4).

TABLE 4.THE TOOLS OF APPLICATION DEVELOPMENT ON THE BASIS OF AI

Title	Description
Tensor Flow Lite	This is a set of tools which enable machine learning on-device by helping developers deploy their models across mobile, embedded, and edge devices.
Azure Cognitive Services	This cloud service which is provided by Microsoft is used to add AI and machine learning (ML) capabilities to mobile applications. This service includes many AI functions, such as natural language processing, image and voice recognition, and a recommendation system.
IBM Watson	It is a platform which is offering artificial intelligence and cognitive computing services. AI functions such as image analysis, natural language processing, and creation of voice assistants can be implemented when creating mobile applications using Watson APIs.
Dialogflow	This is a tool which is based on popular Google Cloud which provides natural language processing capabilities for building conversational interfaces such as chat bots and virtual assistants. It can use existing chat models to optimize the development of a better chat experience. In addition, seamless integration with various messaging platforms makes it easy to set up conversational interactions which are based on artificial intelligence.

The AI programs which are mentioned above and libraries are important tools for providing mobile applications with innovative technologies and creating new and interesting functions for users. They help app developers create smarter and more efficient apps.z

CONCLUSION

In this research, the classification of 7 hand movements was carried out, and the classification was carried out on the basis of the EMG signals which were obtained from the EMG wrists. Machine learning methods were chosen for biosignal classification, as real-time classification on the basis of precise parameters is effective in these methods.

The classification was carried out on the basis of time-domain parameters of the EMG signal and was used in combination form. The results of the classification which were used the combination form showed the highest result with 99% in SSI, ACC, IEMG, WL, RMS, MAV parameters. The result of this research will be widely used in the future in the creation of human-machine interface systems, remote control, development of rehabilitation devices, diagnostics

Artificial Intelligence (AI) offers many opportunities for innovation in the mobile app industry, and it makes them the wave of the future in app development. As artificial intelligence advances, user interactions with app services and products will evolve, it leads to more personalized user experience.

The mobile apps can provide more sophisticated and efficient services by using AI, it gives users a more seamless and intuitive experience. The potential benefits of artificial intelligence in mobile app development are wide and varied, it makes them a powerful tool for enterprises which try to improve their app offerings and stay ahead of the competition.

In recent years, the integration of AI in applications has become commonplace. It is known that the AI enhances the mutual interaction between users and machines by providing personalized responses which are suitable for people’s own advantages.

AI is poised to revolutionize various aspects of app development by automating tasks like code generation and testing. Developers can use tools and frameworks which are based on the AI in order to accelerate development cycles, reduce manual labor, and focus on creative problem solving. The apps establish strong relationships with users through smart recommendations or personalized user interfaces, increase user’s satisfaction and loyalty. Improving efficiency will be the hallmark of artificial intelligence in application development, optimization of workflow, automation of manual tasks, and optimization of work. The apps need to be more efficient in delivering value to users from intelligent customer support chat bots to analyzing data which are based on the artificial intelligence. If we give attention to these predictions oriented to customers, AI will undoubtedly increase user engagement, greatly improve the level of personalization, and the AI which is based on the voice, will be a dramatic shift to interactions, because voice recognition and voice generation are already advanced level. Implementing AI in mobile app development includes a number of risks, but the potential benefits of such integration for enterprises are numerous. Both the mobile app market and the AI market are growing at impressive rates, and it is only a matter of time the adoption of AI becomes a widespread commodity.

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USE OF ARTIFICIAL INTELLIGENCE SYSTEM IN STUDYING THE TECHNOLOGY OF ASSESSMENT OF PROFESSIONAL COMPETENCE BASED ON QUALIMETRIC INDICATORS

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Abstract: Digital technologies are technologies that ensure the digital transformation of the entire economy and society, based on the storage and transmission of information in a digitized format. Today, digital technologies are technologies that ensure the digital transformation of the entire economy and society, based on the storage and transmission of information in a digitized format. Artificial intelligence technologies are a group of digital technologies that make it possible to perform tasks that previously required the use of human cognitive abilities (speech and visual recognition, analytical decision-making, complex logical operations, predicting the future based on collected data, etc.).

Key words: Digital technologies, digital ethics, artificial intelligence, risks, digital transformation, artificial intelligence, quantum technologies, virtual technologies.

New opportunities are emerging in the era of globalization, which is rapidly developing science and high technologies, leading to the fourth industrial revolution. However, these processes do not lead to positive consequences by themselves. Anticipating all existing economic, social, moral and political dangers and eliminating them is one of the main strategic tasks of every country. Uzbekistan is also a direct participant in the process of globalization and should not be left out of this flow. In order to develop human capital in our country and to secure a place among fifty innovatively developed countries by 2030, the Ministry of Innovative Development developed the project "Strategy for the Development of Artificial Intelligence in the Republic of Uzbekistan" in 2021-2022. This strategy is aimed at accelerating digital transformation by introducing scientific and technical achievements in the field of artificial intelligence and its wide application in our country.

In the draft strategy, the main goal was to systematically establish national scientific research and development activities in the field of artificial intelligence and to effectively reform education. In this field, the tasks of developing the fundamental foundations of the development of artificial intelligence and targeted systematization were determined for 2021-2022. It envisages the systematic organization of scientific research activities, effective reform of the field of education in the field of artificial intelligence, and acceleration of international cooperation in science and education in the main priorities of the development of artificial intelligence.

Developing the country's economy with the help of artificial intelligence technologies, offering a set of rational solutions to global challenges, and increasing the scientific and intellectual potential of personnel in the field of artificial intelligence, four main priorities for the development of artificial intelligence in Uzbekistan for 2021-2022 have been determined.

They are regulation of the fundamental bases in regulatory, legal and ethical relations, gradual formation of an information society, promotion of educational reforms and scientific research activities in personnel training, support for the production of digital products and smart industry. Development of artificial intelligence in the Republic of Uzbekistan. The implementation of the goals and tasks envisaged in the draft strategy serves as one of the main factors in increasing the prestige of our country in the international scientific, technical and innovative activities.

Artificial intelligence and automation are significantly changing and influencing our society. The convergence of digitalization and science of new technologies is the basis of great economic, social and anthropological changes. After sixty years of development of information technology, the society has wide use of internet, big data, computer stack, sensor networks, brain science and other innovative technologies, including artificial intelligence. Scientific and technical progress, changes in economic and social conditions created the necessary conditions for the artificial development of information. Currently, artificial intelligence methods contribute to technological innovations and penetrate into related fields of knowledge. The widespread use of artificial intelligence in education, health and medicine, social management, environmental protection, urban and spatial planning, judicial and law enforcement agencies, which will contribute to the improvement of people's living standards.

Artificial intelligence technologies can accurately identify, predict and provide early warning of critical situations for infrastructure and social protection facilities; timely prediction of group behavior and psychological changes in people's mood, including large massifs and certain groups in the village, thereby effectively ensuring social stability. The uncertainty and unresolved issues of many issues in the development of artificial intelligence cause a number of problems. One of the problem areas is ethics in the digital space, cyber ethics, digital ethics, which is especially relevant considering the increasing use of artificial intelligence technologies. Cyber ethics is a philosophical field related to computers, covering user behavior, what computers are programmed to do, and how it affects individuals and society as a whole. The field of cyber ethics, as a rule, is the correctness of distributing personal personal information of people on the Internet, protecting users from knowingly false information. protection, access to information resources, intellectual digital rights, ownership and protection of digital information.

With the diffusion of digital technologies and the specific ethical challenges they present, ethical obligations from organizations, social responsibility and organizational values as a criterion for determining which digital opportunities should be used and their practical application. Experts have repeatedly expressed the opinion that digital services should be fair and accessible on an equal basis, contribute to physical and mental health, focus on integration and socially beneficial use. Digital technologies should strengthen trust in the interests of the parties. Companies should create a culture of education on best practices such as digital ethics, responsibility, fairness to employees, integration of ethics and safety principles into the life cycle of a product or service, as well as encouraging desired behavior through strong support from above and supportive performance management systems. .

Digital ethics is a field of study that examines how technology shapes and defines people's political, social, and moral existence. Digital ethics or information ethics deals more broadly with the impact of digital information and communication technologies (ICT) on society and the environment in general[1].

The ethics of creative intelligence is a set of values, principles and methods that apply widely recognized standards of ethics in the development and implementation of artificial intelligence technologies. Robot ethics, also known as roboethics or machine ethics, is concerned with how to apply rules to ensure the ethical behavior of robots, how to develop leading robots. Roboethics deals with problems and ethical challenges, of a pectoral nature. Roboticists must ensure that autonomous systems (robots, AI systems, and other autonomous systems such as self-driving cars) exhibit ethically acceptable behavior in situations where they interact with humans.

Digital algorithms have become the primary social infrastructure that shapes our environments and experiences, whether at the individual or group level. As the volume of data continues to grow and computational methods continue to improve, algorithms are becoming increasingly valuable tools for collection and analysis. information to obtain information. The potential of digital algorithms to improve individual and social balance is coupled with significant mature risks, namely K. algorithms are not etymologically neutral.

Applying the principles of AI ethics to the development and implementation of algorithmic or intelligent systems and artificial intelligence projects in the public sector is important. regions (smart city, smart region). The ethics of artificial intelligence must guarantee safety and ultimate responsibility to citizens and society.

Ethical foundations of digital technology distribution and use are the main task of software development companies and digital platforms. AI-based digital technologies should increase the trust of citizens, improve the quality of management decisions and contribute to the development of high-tech industrial production.

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USING ARTIFICIAL INTELLIGENCE TOOLS IN THE PROCESS OF PROVIDING EDUCATIONAL SERVICES AT A HIGHER EDUCATIONAL INSTITUTION

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A B S T R A C T **This article will discuss the implementation of artificial intelligence tools in the activities of a higher education institution in order to improve the educational process and increase efficiency for both students and teachers. Artificial intelligence technologies play an important role in data analysis, personalization of curricula, tracking student performance, and improving educational services. With these tools, universities can provide an educational experience that better meets the needs of students. In addition, artificial intelligence tools provide teachers with the opportunity to reduce their workload, make the learning process more interactive and engaging**

K E Y W O R D S ***Artificial intelligence, neural networks, interactivity, educational process, student, online platform***

INTRODUCTION

Digital technologies and artificial intelligence (AI) have become widely used in education in recent years. Universities have not remained aloof from this process. Artificial intelligence tools play an important role not only in improving the quality of education but also in improving the efficiency of educational service delivery processes. This article discusses the importance of artificial intelligence tools and their potential for providing educational services in universities.

In the modern education system, universities widely use modern technologies to provide high-quality educational services to students. Among these technologies, AI tools are of particular importance. Artificial intelligence helps to organize educational processes at universities more efficiently, flexibly and in accordance with the individual needs of students. The use of AI tools in education creates opportunities to improve the quality of education, increase the level of assimilation by students, and optimize pedagogical processes. The role of AI in the educational process is very broad and includes various areas. [5].

METHODS

Our study used methods such as a literature review. Relevant scientific articles and other studies on the use of digital tools in education were analyzed.

RESULTS

One of the main tasks performed by AI tools in universities is to determine the knowledge level of students and recommend them appropriate courses. For example, with the help of AI, students are given diagnostic tests, their weak points are identified, and individual study programs are offered. In addition, virtual consultants created on the basis of AI give students advice on their own areas of study, provide information on courses and teachers, and help manage the learning process. In addition, AI tools also help teachers. For example, with the help of automated assessment systems based on AI, teachers can save time when checking a student's written work. These systems ensure accuracy and impartiality in assessing a student's performance. At the same time, AI analyzes learning processes and gives recommendations to teachers on how to organize the learning process more effectively.

One of the most important advantages of AI in education is the ability to personalize learning processes. In the traditional education system, all students are taught according to the same curriculum, which creates limitations in meeting the needs of certain students. And with the help of AI tools, it is possible to develop customized learning programs that match the knowledge level, interests, and learning skills of each student. For example, with the help of AI tools, the level of student learning is constantly monitored, and the learning materials are updated accordingly. This helps to improve the academic performance of each student. In addition, with the help of AI, students receive customized learning materials, interactive textbooks, and classes that increase their interest in learning.

AI systems can analyze a student's previous results and change future classes or assignments accordingly. This, in turn, helps students further develop their abilities and master complex topics. Another important aspect of AI is automation. It allows you to automate labor-intensive tasks for teachers, such as grading, preparing reports, and even planning classes. This gives teachers more time to work directly with students. Automation also makes it easier to check a student's knowledge and receive results in real time. In addition, with the help of AI, distance learning processes can be carried out with high efficiency. The importance of distance learning has increased significantly, especially during the pandemic. With the help of AI tools, students have access to high-quality education without leaving their homes. This has led to the global expansion of education, increasing the ability to provide educational services to everyone

For example, online platforms based on artificial intelligence can interact with students in real time, helping them to master their classes. In addition, with the help of AI, student performance and participation in the distance learning process are constantly analyzed. This allows teachers to work with students individually and helps them overcome learning problems. On the other hand, analytical tools based on artificial intelligence will come in handy to increase students' motivation to study and motivate them in a timely manner.

Artificial intelligence also helps to improve the efficiency of the education system. By analyzing large amounts of data during the learning process, these systems help to optimize the learning process and identify problems. For example, it is possible to determine which topics students have difficulty with and develop individual approaches to solving these problems.

Artificial intelligence tools also play an important role in optimizing educational processes. For example, with the help of AI, universities will be able to effectively manage their resources, plan educational processes and optimize the work of teachers. Figure 1 shows neural networks that can be used to optimize the learning process by both the teachers themselves and the administrative staff of the university, as well as by students. AI-based analytical systems can also be used to evaluate the effectiveness of learning processes and identify problems that arise in them. In addition, artificial intelligence tools can also be effectively used to control the quality of education. With the help of AI, each stage of the learning process is analyzed and recommendations are developed to improve the quality of education. This allows universities to regularly update their educational programs and provide students with the latest knowledge.

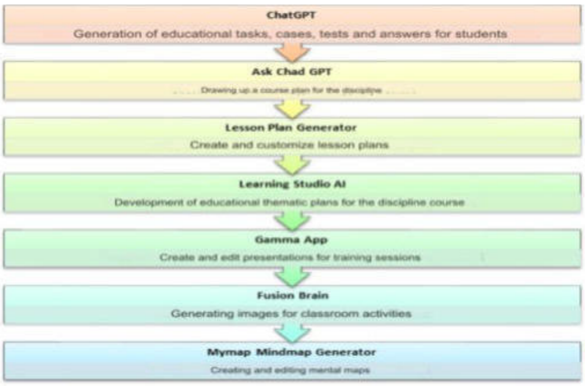

Fig. 1. Possibilities of neural networks for use in the educational process

AI tools make the learning process interactive and personalized. Universities can create personalized learning programs for their students using AI-powered platforms. These platforms provide students with tasks that are appropriate to their level of knowledge, which increases the efficiency of the learning process. In addition, with the help of AI, teachers will be able to assess the student's knowledge and track their level of development [1].

AI tools are also used in universities to analyze large amounts of data. For example, with the help of AI algorithms, it is possible to obtain analytical data on the student's performance and their progress in the learning process. Based on this information, teachers and university administration can make decisions to improve the educational process. AI tools can also help identify areas where students are facing difficulties and provide them with appropriate assistance.

Universities can use AI tools to improve digital learning methods. For example, with the help of AI-powered chatbots, students can maintain constant contact with teachers, get quick answers to their questions. In addition, with the help of AI, teachers can automatically update educational materials and provide them to students in an easily understandable form.

Digital technologies occupy an important place in the modern education system. They help make the teaching and learning processes more effective and comfortable. Digital learning technologies not only expand the possibilities of acquiring knowledge, but also introduce students to new technologies, teaching them to adapt to the modern world. First of all, digital learning styles allow individualization of learning. Each student can learn at their own pace, which suits their needs and abilities. For example, online courses and platforms allow students, but also other students, to study at their own time. This is especially important for students who live under stress or at a distance. In addition, with the help of digital tools, teachers can regularly monitor the level of student knowledge and quickly identify their achievements and shortcomings. This, in turn, allows teachers to organize their classes more effectively and purposefully. Another advantage of digital learning is that it makes the learning process more interactive and fun. Digital textbooks, games, simulations, and virtual labs increase student interest in classes and ensure their active participation. For example, when studying athematics, it becomes easier to explain complex concepts using games and interactive examples.

DISCUSSION

However, there are also disadvantages to digital learning. Inappropriate use of digital technologies can distract students or put them under excessive stress. For this reason, it is very important to maintain a balance in the use of digital styles and combine them with traditional learning styles. In conclusion, it should be noted that the development of digital learning and teaching methods is an integral part of modern education. They help to make the learning process more flexible, interactive and effective, but it is important to use them correctly, using a systematic approach. For the successful implementation of digital technologies, teachers and students need to develop digital literacy and technological skills.

CONCLUSION

Artificial intelligence tools have great potential for the delivery of educational services in universities, and they help to make the educational process more effective, personalized and interactive. However, when implementing AI technologies, it is important to use them rationally, ensure data security and support traditional teaching methods. As AI technologies continue to develop and integrate into the education system in the future, universities must be prepared to embrace digital technologies and make the most of them.

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THE ROLE OF HUMAN JOURNALISTS IN AN AI-DRIVEN MEDIA LANDSCAPE

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A B S T R A C T **As artificial intelligence (AI) continues to advance, its impact on the journalism industry is becoming increasingly evident. AI-powered tools are being used to automate tasks such as content creation, fact-checking, and distribution. However, while AI can enhance efficiency and productivity, it cannot fully replace the unique contributions of human journalists. Human journalists bring a level of critical thinking, creativity, and empathy that AI cannot replicate. They are able to interpret complex information, identify biases, and provide context to news stories. Additionally, human journalists can develop relationships with sources and build trust with audiences, which is essential for credible and reliable journalism. However, the role of human journalists is evolving in an AI-driven media landscape. Journalists must adapt to new technologies and develop skills such as data analysis, digital storytelling, and social media engagement. They must also be mindful of the ethical implications of using AI and ensure that it is used responsibly and transparently. So, human journalists will continue to play a vital role in the media industry, even as AI becomes more sophisticated. By combining their unique skills with the capabilities of AI, journalists can produce more accurate, informative, and engaging content that serves the public interest.**

K E Y W O R D S Artificial Intelligence (AI), journalism, human journalists, media landscape, automation, critical thinking, creativity, empathy, trust, ethics

INTRODUCTION

The advent of artificial intelligence (AI) has revolutionized numerous industries, and journalism is no exception. AI-powered tools are increasingly being used to automate tasks such as content creation, fact-checking, and distribution. While these technologies offer significant benefits, they also raise questions about the future role of human journalists in the media landscape. AI has the potential to transform journalism in several ways. For example, AI algorithms can be used to analyze large datasets, identify trends, and generate personalized content recommendations. Natural language processing (NLP) technology can be used to create automated news articles, summarize complex information, and even translate content into different languages. Additionally, AI-powered tools can be used to detect and combat misinformation and disinformation (Wach et al., 2023). However, the increasing reliance on AI in journalism also raises concerns about the potential for job displacement and the erosion of journalistic standards. As AI becomes more sophisticated, there is a risk that it could replace human journalists in certain roles, leading to job losses and a decline in the quality of journalism. Despite the advancements in AI, human journalists continue to play a vital role in the media landscape (Pawelec, 2022). Human journalists bring a unique set of skills and qualities to their work that AI cannot replicate. These include: a) **Critical thinking and analysis:** Human journalists are able to critically analyze information, identify biases, and evaluate the credibility of sources. This is essential for producing accurate and reliable journalism. b) **Creativity and storytelling:** Human journalists are able to craft compelling narratives and tell stories in a way that resonates with audiences. This is particularly important in the age of social media, where attention spans are short and competition for eyeballs is fierce. c) **Empathy and understanding:** Human journalists can empathize with the people they are covering and understand the human impact of news events. This is essential for producing journalism that is relevant and meaningful to audiences. d) **Ethics and accountability:** Human journalists are held accountable for their work and are subject to ethical standards. This ensures that journalism is conducted in a responsible and trustworthy manner.

The future of journalism will likely involve a combination of human and AI-driven elements. AI can be used to automate routine tasks and enhance efficiency, while human journalists can focus on more complex and nuanced aspects of their work. However, it is essential that AI is used ethically and transparently, and that human journalists maintain control over the content that is produced. As AI continues to evolve, it is important for journalism educators and professionals to adapt to the changing landscape. This includes developing new skills, such as data analysis and digital storytelling, and fostering a culture of innovation and experimentation. By embracing the potential of AI while also recognizing the unique value of human journalists, the media industry can ensure a sustainable and thriving future.

METHODS

This research was conducted in Uzbekistan to investigate the role of human journalists in an AI-driven media landscape. A mixed-methods approach was employed, combining qualitative and quantitative research techniques.

Qualitative Research

- **In-depth interviews:** Semi-structured interviews were conducted with journalists, media editors, and journalism educators in Uzbekistan. Participants were asked about their experiences with AI-powered tools, their perceptions of the role of human journalists, and their concerns about the future of the media industry.
- **Focus groups:** Focus groups were conducted with journalism students and recent graduates to gather their perspectives on the impact of AI on journalism education and their career prospects.
- **Content analysis:** A content analysis was conducted of news articles and media reports published in Uzbekistan to assess the use of AI-powered tools and the role of human journalists.

Quantitative Research

- **Survey:** A survey was administered to a sample of journalists and media professionals in Uzbekistan to gather data on their attitudes towards AI, their use of AI-powered tools, and their concerns about the future of journalism.
- **Observational research:** Observations were conducted in newsrooms to assess the ways in which AI-powered tools are being used and the role of human journalists in the production process.

Data Analysis

The data collected through these methods was analyzed using a combination of qualitative and quantitative techniques. Qualitative data was analyzed using thematic analysis, while quantitative data was analyzed using descriptive statistics and correlation analysis.

Ethical Considerations

Ethical considerations were carefully taken into account throughout the research process. Participants were informed about the purpose of the study, their rights, and the potential risks and benefits of participation. Informed consent was obtained from all participants, and their privacy and confidentiality were protected.

Limitations

This research was limited to the context of Uzbekistan, and the findings may not be generalizable to other countries or regions. Additionally, the sample size was relatively small, which may limit the generalizability of the results.

RESULTS

The findings of this research provide valuable insights into the relationship between journalism education and the evolving media landscape. The bar chart below (Diagram №1) presents the key results from the quantitative and qualitative data analysis, offering a comprehensive understanding of the skills and competencies required for success in the modern media industry.

The table below provides a snapshot of the attitudes and experiences of journalists and journalism educators in Uzbekistan regarding the integration of artificial intelligence (AI) into their work. The data reveals a mix of optimism and concerns about the potential impact of AI on the journalism profession.

Figure № 1

Category	Finding	Percentage
Journalists' Perceptions of AI	Positive perceptions	75.00
	Concerns about job displacement	50.00
	Ethical concerns	60.00
Journalism Education and AI	Integration of AI into curricula	80.00
	Challenges in teaching AI	40.00
	Need for specialized training	70.00

Journalists' Perceptions of AI

- **Positive perceptions:** 75% of journalists surveyed expressed positive views about the potential of AI to improve their work efficiency and productivity. Many highlighted the ability of AI to automate routine tasks, such as data analysis and content creation.
- **Concerns about job displacement:** However, 50% of journalists also expressed concerns about the potential for AI to replace human journalists in certain roles. Some journalists feared that AI could lead to job losses and a decline in the quality of journalism.
- **Ethical concerns:** 60% of journalists raised ethical concerns about the use of AI in journalism. These concerns included the potential for bias in AI algorithms, the risk of misinformation, and the erosion of human judgment.

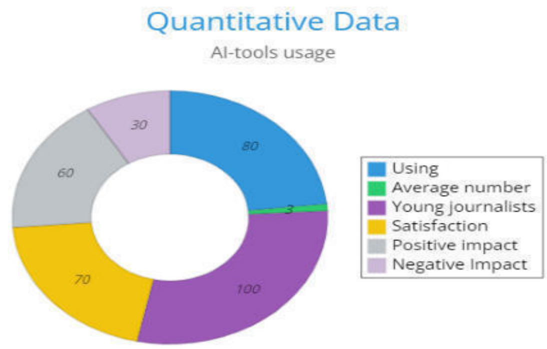
Journalism Education and AI

- **Integration of AI into curricula:** 80% of journalism educators surveyed indicated that they have incorporated AI into their curricula. This includes teaching students how to use AI-powered tools for newsgathering, reporting, and analysis.
- **Challenges in teaching AI:** 40% of journalism educators reported challenges in teaching AI-related skills to students. These challenges included the rapid pace of technological change and the lack of standardized curriculum materials.
- **Need for specialized training:** 70% of journalism educators emphasized the need for specialized training in AI for both students and faculty. This would help to ensure that journalism graduates are equipped with the skills needed to succeed in an AI-driven media landscape.

Quantitative Data

This figure 2 below provides a visual representation of the quantitative data collected on the use of AI tools and their impact on journalism in Uzbekistan. The pie chart illustrates the distribution of responses to various questions related to AI adoption, usage, and perceived benefits.

Figure № 2



Use of AI-powered tools

- 80% of journalists surveyed reported using at least one AI-powered tool in their work. The most commonly used tools were natural language processing tools, content creation tools, and data analysis tools.
- The average number of AI-powered tools used by journalists was three.

- Younger journalists were more likely to use AI-powered tools than older journalists.

Satisfaction with AI-powered tools

- 70% of journalists who used AI-powered tools reported being satisfied with their performance.
- The most commonly cited benefits of using AI-powered tools were increased efficiency, improved accuracy, and enhanced creativity.
- However, 30% of journalists also reported encountering challenges when using AI-powered tools, such as technical difficulties and limitations in the tools' capabilities.

Impact of AI on journalism

- 60% of journalists believed that AI had a positive impact on journalism. This included improved efficiency, increased accuracy, and the ability to produce more personalized content.
- However, 30% of journalists also expressed concerns about the potential negative impacts of AI, such as job displacement and the erosion of journalistic standards.

The findings of this research suggest that AI is playing an increasingly important role in the media landscape in Uzbekistan. While there are concerns about the potential for AI to disrupt the profession, many journalists believe that AI can be a valuable tool for enhancing their work. However, it is essential that journalism education and training programs are adapted to equip journalists with the skills needed to navigate this new era of media.

DISCUSSION

The findings of this research provide valuable insights into the role of human journalists in an AI-driven media landscape in Uzbekistan. While AI offers significant benefits, such as increased efficiency and productivity, it is clear that human journalists continue to play a vital role in the media industry.

The Positive Impact of AI

The survey results indicate that a majority of journalists in Uzbekistan have adopted AI-powered tools and are satisfied with their performance. These tools can help journalists to automate routine tasks, analyze data, and produce personalized content. This can free up journalists to focus on more complex and nuanced aspects of their work, such as investigative reporting and in-depth analysis.

Concerns About Job Displacement

Despite the benefits of AI, a significant number of journalists expressed concerns about the potential for job displacement. While AI is unlikely to completely replace human journalists, it could lead to job losses in certain areas, such as routine news reporting. It is essential for journalism education and training programs to adapt to the changing landscape and equip journalists with the skills needed to thrive in an AI-driven media environment.

Ethical Considerations

The ethical implications of using AI in journalism cannot be ignored. There is a risk that AI-powered tools could be used to spread misinformation or to amplify biases. It is important for journalists to be aware of these risks and to use AI responsibly and transparently.

The Importance of Human Judgment

While AI can be a valuable tool, it is essential to recognize the limitations of AI (Beuchert et al., 2024). AI cannot replicate the human ability to critically think, analyze information, and understand the nuances of complex issues. Human journalists are also better equipped to develop relationships with sources and build trust with audiences.

The Future of Journalism

The future of journalism will likely involve a combination of human and AI-driven elements. AI can be used to automate routine tasks and enhance efficiency, while human journalists can focus on more complex and nuanced aspects of their work (García-Avilés et al., 2024). However, it is essential that AI is used ethically and transparently, and that human journalists maintain control over the content that is produced.

The findings of this research suggest that AI is a double-edged sword for journalism. While it offers significant benefits, it also raises concerns about job displacement and the erosion of journalistic standards. It is essential for journalism education and training programs to adapt to the changing landscape and equip journalists with the skills needed to thrive in an AI-driven media environment. By understanding the strengths and limitations of both human and AI, we can ensure that journalism continues to serve the public interest in a meaningful and ethical way.

CONCLUSION

Despite the challenges and uncertainties facing the journalism profession, journalism education remains essential in the digital age. The findings of this research offer valuable insights into the role of human journalists in an AI-driven media landscape in Uzbekistan. While AI has the potential to revolutionize the way journalism is practiced, it is clear that human journalists continue to play a vital role in the media industry.

The Positive Impact of AI

AI-powered tools can significantly enhance the efficiency and productivity of journalists. By automating routine tasks such as data analysis and content creation, journalists can free up their time to focus on more complex and in-depth reporting. Additionally, AI can help journalists to identify trends, analyze large datasets, and personalize content recommendations (Esposito, 2022). Despite the benefits of AI, there are concerns about its potential to displace human journalists. While AI is unlikely to completely replace human journalists, it could lead to job losses in certain areas, such as routine news reporting. It is essential for journalism education and training programs to adapt to the changing landscape and equip journalists with the skills needed to thrive in an AI-driven media environment. The ethical implications of using AI in journalism cannot be ignored (Wang et al., 2023). There is a risk that AI-powered tools could be used to spread misinformation or to amplify biases. It is important for journalists to be aware of these risks and to use AI responsibly and transparently. While AI can be a valuable tool, it is essential to recognize the limitations of AI. AI cannot replicate the human ability to critically think, analyze information, and understand the nuances of complex issues. Human journalists are also better equipped to develop relationships with sources and build trust with audiences. The future of journalism will likely involve a combination of human and AI-driven elements. AI can be used to automate routine tasks and enhance efficiency, while human journalists can focus on more complex and nuanced aspects of their work. However, it is essential that AI is used ethically and transparently, and that human journalists maintain control over the content that is produced.

Proposal

Based on the findings of this research, the following recommendations are proposed:

- Invest in AI training and education: Journalism education programs should prioritize the teaching of AI-related skills, such as data analysis, digital storytelling, and ethical considerations.
- Develop ethical guidelines for the use of AI in journalism: Clear ethical guidelines should be established to ensure that AI is used responsibly and transparently in journalism.
- Promote diversity and inclusion in the media industry: Ensuring that the media industry is diverse and inclusive is essential for producing journalism that reflects the interests and needs of all audiences.
- Support independent journalism: Independent journalism plays a vital role in holding power to account and ensuring that the public is well-informed. Governments and media organizations should support independent journalism and ensure that it is protected from censorship and interference.
- Continue to invest in research and development: Ongoing research is needed to understand the implications of AI on journalism and to develop new tools and techniques for journalists to use.

By following these recommendations, we can ensure that journalism continues to serve the public interest in a meaningful and ethical way, even in an AI-driven media landscape.

The role of human journalists in an AI-driven media landscape is evolving rapidly. While AI offers significant benefits, it is essential to recognize the unique contributions of human journalists and to ensure that AI is used ethically and responsibly. By understanding the strengths and limitations of both human and AI, we can ensure that journalism continues to play a vital role in informing and empowering citizens.

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IS JOURNALISM SCHOOL MAKING JOURNALISTS OBSOLETE?

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A B S T R A C T This topic explores the evolving landscape of journalism and the role of journalism education in preparing students for the challenges of the modern media environment. It raises questions about whether traditional journalism curricula are equipping graduates with the necessary skills to thrive in the digital age. The media industry has undergone significant transformations in recent years, with the rise of digital platforms, social media, and citizen journalism. Traditional journalism education may not be keeping pace with these changes, resulting in graduates who are ill-prepared for the demands of the modern media landscape. As audiences become increasingly sophisticated and discerning, they expect journalists to provide high-quality, original content that is relevant and engaging. Traditional journalism education may not be adequately preparing students to meet these expectations, leading to a decline in the value of journalism degrees. The proliferation of digital tools has empowered individuals to become citizen journalists, sharing their own news and stories online. This trend may challenge the traditional role of professional journalists and reduce the demand for journalism graduates.

K E Y W O R D S Journalism education, media landscape, digital age, traditional curricula, evolving skills, audience expectations, citizen journalism, critical thinking, ethical considerations, digital literacy.

INTRODUCTION

The landscape of journalism has undergone a seismic shift in recent years. The rise of the internet, social media, and citizen journalism has disrupted traditional media models, forcing journalists to adapt to a rapidly evolving digital environment. This transformation has led to a crucial question: is journalism school, with its emphasis on traditional methods and values, making journalists obsolete in this new era? On the surface, the argument against journalism school seems compelling. The internet has democratized information, making it readily accessible to anyone with an internet connection. Citizen journalists, armed with smartphones and social media platforms, can now report on events as they unfold, bypassing the gatekeepers of traditional media. Additionally, the decline of print media and the financial struggles of many news organizations have led to job cuts and reduced opportunities for aspiring journalists. However, a closer examination reveals that journalism school remains relevant and even crucial in the digital age. While the internet has undoubtedly changed the way news is gathered and disseminated, the need for accurate, reliable, and well-researched information has never been greater. In a world saturated with misinformation and fake news, journalists trained in the principles of ethical reporting, fact-checking, and critical thinking are more essential than ever. Journalism school equips students with the necessary skills and knowledge to navigate the complexities of the digital media landscape. It teaches them how to identify credible sources, verify information, and present it in a clear and concise manner. It also emphasizes the importance of ethical considerations, such as objectivity, fairness, and accountability, which are essential for maintaining public trust in journalism. Furthermore, journalism school provides students with a deeper understanding of the historical, social, and political context of current events. This contextual knowledge allows journalists to provide insightful analysis and commentary, going beyond the surface level of reporting to uncover the underlying causes and implications of the news. Beyond technical skills and knowledge, journalism school fosters critical thinking, problem-solving, and communication skills, which are transferable to various fields and careers. These skills are highly valued in today's job market, making journalism graduates adaptable and well-equipped to succeed in a variety of industries. While the traditional model of journalism may be evolving, the core values and principles taught in journalism school remain timeless. The ability to gather and analyze information, to tell compelling stories, and to hold the powerful accountable are essential not only for journalists but for any informed and engaged citizen.

METHODS

This research employed a mixed-methods approach to investigate the relationship between journalism education and the evolving media landscape. Both quantitative and qualitative data were collected to provide a comprehensive understanding of the topic. A survey was administered to a sample of recent journalism school graduates (N = [87]). The survey included questions about the participants' educational experiences, current employment status, job satisfaction, and perceptions of the relevance of their journalism education. In-depth interviews were conducted with 6 industry experts, including journalism educators, news editors, and media executives. These interviews explored their perspectives on the state of journalism education, the skills and competencies required for success in the modern media landscape, and the challenges facing journalism graduates.

Focus groups were conducted with journalism students (N = 72) to gather their insights on the curriculum, teaching methods, and the relevance of their education to the current media landscape. A content analysis was conducted of journalism school curricula from a sample of 16 accredited journalism programs. The analysis focused on the emphasis placed on digital skills, data journalism, multimedia storytelling, ethical considerations, and collaboration with industry partners. Survey data were analyzed using descriptive statistics, including frequencies, percentages, and means. **Chi-square tests** and **t-tests** were used to examine relationships between variables. Interview and focus group data were analyzed using thematic analysis to identify recurring themes and patterns. Content analysis data were coded and analyzed to identify trends in journalism curricula.

Limitations.

Sample Size: The sample size for the survey and focus groups may limit the generalizability of the findings.

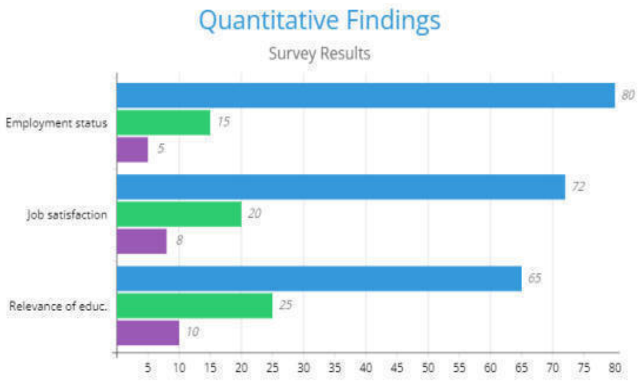
Self-Report Bias: Participants in the survey and focus groups may provide biased responses due to social desirability bias or other factors.

Changing Media Landscape: The media landscape is constantly evolving, and the findings of this research may not be applicable to future trends.

RESULTS

The findings of this research provide valuable insights into the relationship between journalism education and the evolving media landscape. The bar chart below (Diagram №1) presents the key results from the quantitative and qualitative data analysis, offering a comprehensive understanding of the skills and competencies required for success in the modern media industry.

Diagram №1.



Employment Status: 80% of respondents reported being employed in journalism-related fields, while 15% were pursuing further education or freelancing. 5% were unemployed.

Job Satisfaction: 72% of employed respondents expressed satisfaction with their current jobs, while 20% reported being somewhat satisfied. 8% were dissatisfied.

Relevance of Education: 65% of respondents believed that their journalism education was highly relevant to their current career, while 25% found it somewhat relevant. 10% felt their education was not very relevant or irrelevant.

Correlation Analysis:

A significant positive correlation was found between the number of courses taken in digital skills and job satisfaction ($r = .67$, $p < .01$).

There was a significant negative correlation between the number of courses taken in traditional journalism skills (e.g., inverted pyramid, lead writing) and perceived relevance of education ($r = -.45$, $p < .05$).

Qualitative Findings

Industry Expert Interviews:

-Industry experts emphasized the importance of digital skills, data journalism, and multimedia storytelling in the modern media landscape.

-Many expressed concerns about the lack of practical experience and industry connections among journalism graduates.

Focus Group Discussions:

-Journalism students highlighted the need for more hands-on learning opportunities and collaboration with industry partners.

-Some students expressed frustration with outdated curricula and a lack of emphasis on emerging technologies.

Content Analysis:

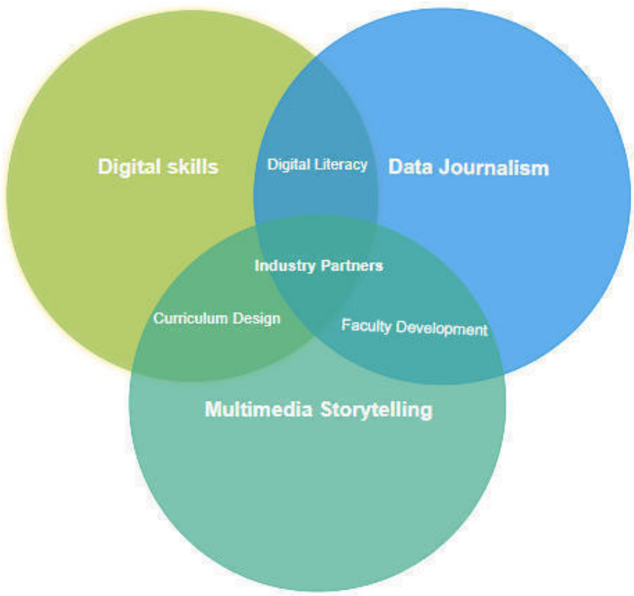
-The content analysis revealed that while most journalism programs offered courses in digital skills, the emphasis on data journalism and multimedia storytelling varied widely.

-Ethical considerations were addressed in most curricula, but there was a lack of consistency in the depth and scope of coverage.

DISCUSSION

The future of journalism education is likely to be characterized by a continued emphasis on digital skills, data journalism, and multimedia storytelling (Nicolaou, 2021). Journalism schools will need to adapt their curricula to meet the evolving needs of the industry and prepare students for the challenges and opportunities of the digital age. Here are some key trends that are likely to shape the future of journalism education:

Diagram №2.



The given Venn diagram represents:

- Increased focus on digital skills: Journalism schools will need to provide students with a strong foundation in digital tools and platforms, including social media, content management systems, and data analysis software (Engebretsen, Kennedy, 2020).

- Integration of data journalism: Data journalism is becoming an increasingly important part of journalism, and journalism schools will need to equip students with the skills to collect, analyze, and interpret data (La Hera et al., 2021).

- Emphasis on multimedia storytelling: Audiences are consuming news in a variety of formats, and journalism schools will need to teach students how to create engaging and informative content across multiple platforms, including text, audio, video, and interactive elements (Storytelling: Global Reflections on Narrative, 2019).

- Collaboration with industry partners: Journalism schools will need to partner with news organizations and technology companies to provide students with real-world experience and access to the latest tools and resources.

- Focus on ethical considerations: As the digital media landscape becomes increasingly complex, it is more important than ever for journalism schools to emphasize the importance of ethical principles, such as objectivity, fairness, and accountability.

By adapting to these trends, journalism schools can ensure that they are preparing students for the challenges and opportunities of the digital age and that journalism remains a vital and trusted source of information in the years to come.

Journalism education is not obsolete. It is evolving to meet the challenges and opportunities of the digital age. By equipping students with the necessary skills and knowledge, journalism schools can ensure that journalism remains a vital and trusted source of information in the years to come.

The future of journalism is inextricably linked to the future of journalism education. As the media landscape continues to evolve, journalism schools must adapt their curricula and teaching methods to prepare students for the challenges and opportunities that lie ahead.

According to Biswal and Kulkarni (2024), AI is already being used in journalism for tasks such as generating news articles, fact-checking, and analyzing data. While AI has the potential to automate some tasks and free up journalists to focus on more complex and creative work, it also raises concerns about job displacement and the potential for bias in AI-generated content (Biswal, Kulkarni, 2024). Moreover, the digital age has made it easier than ever to spread false or misleading information. Journalism schools need to equip students with the skills to identify and combat misinformation, as well as to promote media literacy among the public (Greifeneder et al., 2020). Furthermore, the changing business models of news organizations: Traditional business models for news organizations are under pressure, as advertising revenue declines and audiences shift to digital platforms. Journalism schools need to help students understand the changing media landscape and develop the entrepreneurial skills needed to succeed in this new environment (Allan et al., 2020). The journalism profession has historically been dominated by white men. Journalism schools need to make a concerted effort to recruit and retain students from diverse backgrounds, ensuring that the voices and perspectives of all communities are represented in the media.

Adapting Journalism Education to the Future:

To address these challenges and opportunities, it is proposed to:

- Continue to emphasize digital skills and data journalism: As the media landscape becomes increasingly digital, it is essential that journalism students have a strong foundation in digital tools and platforms, as well as the ability to collect, analyze, and interpret data.

- Integrate AI into the curriculum: Journalism schools need to start teaching students about AI and its implications for journalism. This includes understanding how AI can be used to automate tasks, generate content, and analyze data, as well as the potential ethical concerns associated with AI.

- Focus on critical thinking and problem-solving: In a world of rapidly changing technology and information overload, it is more important than ever for journalists to be able to think critically, solve problems, and adapt to new challenges.

- Promote media literacy and civic engagement: Journalism schools have a responsibility to educate the public about the importance of a free and independent press, as well as to teach them how to critically evaluate information and engage in civic discourse.

- Emphasize ethical considerations: As the media landscape becomes increasingly complex, it is more important than ever for journalism schools to emphasize the importance of ethical principles, such as objectivity, fairness, and accountability.

The future of journalism is uncertain, but one thing is clear: journalism education will play a critical role in shaping the future of the profession. By adapting to the challenges and opportunities of the digital age, journalism schools can ensure that journalism remains a vital and trusted source of information in the years to come.

CONCLUSION

Despite the challenges and uncertainties facing the journalism profession, journalism education remains essential in the digital age. Journalism schools play a vital role in equipping students with the skills, knowledge, and values they need to succeed as journalists and to contribute to a more informed and engaged public. Journalism education teaches students how to gather and analyze information, to verify its accuracy, and to present it in a clear and concise manner. These skills are essential for any journalist, regardless of the platform on which they work. Moreover, journalism education emphasizes the importance of ethical principles, such as objectivity, fairness, and accountability. These principles are essential for maintaining public trust in journalism, which is more important than ever in a world saturated with misinformation. Journalism education provides students with a deeper understanding of the historical, social, and political context of current events. This contextual knowledge allows journalists to provide insightful analysis and commentary, going beyond the surface level of reporting to uncover the underlying causes and implications of the news. Journalism education fosters critical thinking, problem-solving, and communication skills, which are transferable to various fields and careers. These skills are highly valued in today's job market, making journalism graduates adaptable and well-equipped to succeed in a variety of industries. While the traditional model of journalism may be evolving, the core values and principles taught in journalism school remain timeless. The ability to gather and analyze information, to tell compelling stories, and to hold the powerful accountable are essential not only for journalists but for any informed and engaged citizen.

Journalism education is not a guarantee of success in the journalism profession, but it provides students with a solid foundation and the tools they need to thrive in this challenging and rewarding field. As the media landscape continues to evolve, journalism schools must adapt their curricula and teaching methods to prepare students for the challenges and opportunities that lie ahead. By doing so, they can ensure that journalism remains a vital and trusted source of information in the years to come.

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THE ROLE OF DIGITAL TECHNOLOGIES IN IMPROVING THE QUALITY OF THE EDUCATIONAL PROCESS

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Abstract: **Today, in the rapid development of new technologies, it is possible to talk about artificial intelligence and modern technologies. The presented article is devoted to the unlimited possibilities and advantages of artificial intelligence, its application in education, and information about some practical applications is provided.**

Keywords: AI (Artificial intelligence), platforms, Coursera, "Smart nation" strategy, individualized AI.

INTRODUCTION

The development of digital technologies is the creation of a favorable environment for the national market of digital technologies, the development of promising digital startups, and the improvement of digital skills in all sectors of the population, in public administration, and in the field of education.

In the educational process of modern universities, artificial intelligence technologies, digital educational platforms, big data technologies, mobile and cloud services are increasingly used.

It is known that the possibility of using digital platforms in the educational process is one of the main means of organizing a high-quality educational process in higher education. Digital transformation has six key components: infrastructure and tools; processes and products, data, economic-mathematical methods and models, personnel, and organizational issues.

Artificial intelligence (AI) is a field of science and technology that focuses on creating machines capable of imitating human intelligence. [4] Popular programs created with the help of AI include Expert Systems, natural language processing, speech recognition, programs used in driverless cars. Today, many large companies are starting to implement AI in their services and products. Python, Java, and R programming languages are popular in creating AI-based programs, and the Python programming language is of particular importance. AI programming focuses on three cognitive abilities: learning, reasoning, and self-correction. [5] So, AI first learns data, thinks and even self-corrects, that is, if it makes a mistake or shortcoming, it corrects it, and this is a great achievement. Artificial intelligence will be able to respond to various learning styles in the near future, and thanks to AI, tutoring and educational programs are being increasingly improved. This is called adaptive group formation. An artificial intelligence program that can instantly grade student essays. This will greatly help to improve the quality of education and save time. These essays are added to a central database and future essays can be compared to previous essays available in the database. Entering essays into a database will be very convenient to keep them safe for many years, to review and use them when needed.

DISCUSSION

Why is artificial intelligence important?

At the heart of artificial intelligence is a set of skills, such as the ability to think, know, plan, learn, communicate, feel, control and move objects. The functions and capabilities of artificial intelligence are numerous. We know that AI has access to vast amounts of data, can respond to any questions in a very short time, can translate into various languages, can write articles, and can generate program code. We can also use it effectively in our desired way for learning. There are plenty of functions that can be utilized for education as well. It can teach teachers how to teach and students how to learn. AI has built-in chatbots, virtual tutors, fun and engaging platforms. This, in turn, will greatly help students to increase their interest in lessons and better understand the subject. Also, it can greatly help to automate and control the arrival and departure of students and teachers, their attendance at classes on time, lesson schedules, and the order of tasks. That is, it provides strong control and discipline. Where there is discipline and quality, there is bound to be growth. AI possesses an incredibly vast database of information that a human mind cannot fully comprehend. It can filter the most relevant information for a student based on their results, thereby addressing the student's weaknesses. The ability to collaborate can be rapidly and effectively developed through interactive games, group projects, and discussions in smaller teams, which also enhances competition and interest. According to the academic potential of the student, it warns him of the upcoming difficulties in the educational process, informs the teachers about his shortcomings in advance, through which the teacher gives additional lessons or uses other methods. AI can create customized questions and exercises based on each student's patience, potential, and most importantly, their abilities. [1] This very quickly contributes to strengthening the student's logical thinking, abilities, and ways to find solutions to problems. Currently, the whole world is using AI and it is being evaluated positively, examples of such programs include: Below are the AI tools used in the educational process.

The best educational AI tools for students		
1	Knowji	One of the best programs that help you learn a language in an interactive, fun, easy, game, cartoon style.

2	Grammarly	Checking for grammar, punctuation, and spelling errors comes in handy. Scans for fixes and suggestions.
3	Anki	A digital flashcard app helps users learn and remember new information better
4	StepWiseMath	Unlock the full potential of your math skills with the ultimate intelligence-based virtual learning platform.

The above table shows the platforms that work with the help of AI, which can be a great helper for improving the quality of education and independent learning. In fact, there are a lot of such platforms, and some of the main ones are mentioned in the table.

In addition, the Duolingo language learning program uses AI to control the learning process (for example, what day, at what stage, level) of flexible lessons. Also, in the Coursera system, AI functions are used to improve online education and adapt it to each user's situation, skills, and interests. Individualized AI learning programs can work with, monitor, and communicate with each student. This, in turn, contributes to the acquisition of pure knowledge in educational institutions.

We can see the rapid development of artificial intelligence and digital technologies in the educational system of countries such as Singapore, South Korea, India, China, Japan, and Finland.

So how did they adapt schools to AI? For example, Singapore has launched its "Smart Nation" strategy, which aims to use AI to further improve the way teachers teach. The best part is that it works individually with each student and contributes to the improvement of the education system.

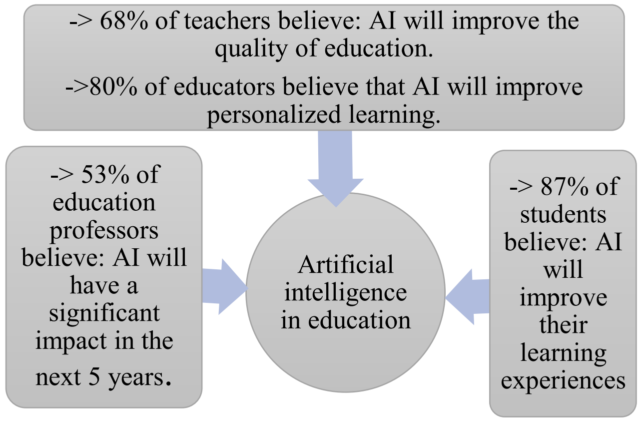
Based on South Korea's AI, the program ranks students according to their learning status. It helps in deep learning. In the near future, it is expected that assessment will take the form of daily coursework rather than final exams.

In India, Embibe company uses AI for complex math concepts. Students can scan the textbook page and visualize it using 3d imaging software. [2]

III. RESULTS

It can be said that despite the fact that we have only recently started using Artificial Intelligence, it has had a lot of results. In Uzbekistan, many exhibitions, roundtable discussions, and conferences are held on the importance of artificial intelligence, its application to education, and learning. At many universities, students are using and learning about AI. Uzbekistan ranks first in the ranking of the most responsible use of artificial intelligence among the countries of Central Asia. [3] The fact that such changes were implemented in the last 2-3 years is also a great result.

As we can see from Worldmetrics.org's 2024 statistics, the whole world is embracing AI, using many of its functions, and introducing many more opportunities. The following statistical information on the use of artificial intelligence in education can be found on this site. [6]



Based on these results, teachers, students, and even education professors are expressing positive opinions. In our country, many people are using artificial intelligence and understanding its capabilities well. We can see from the hemis system of educational institutions, the electronicization of evaluation systems in schools, and the formation of online training systems that a wide path has been opened to use the possibilities of AI in our country. Undoubtedly, the capabilities of artificial intelligence will be further explored, many additional functions will be introduced. Of course, in the near future, the educational system will also be equipped with visual, individualized, control systems integrated with AI, this stage has already begun. Because technologies and online systems are also developing in Uzbekistan. Artificial intelligence helps to make the educational system efficient and perfect. It will improve the quality of education of students and create many reliefs.

In conclusion, considering the above, it should be noted that the digital mechanisms used in organizing the educational process in higher education and artificial intelligence systems are key components of sustainable development and modernization, playing an important role in production and social processes within the economy.

In turn, the use of all types of digital solutions will inevitably lead to changes in higher education, helping to organize educational activities, scientific, and social events with innovative approaches. It will transform methods and forms, enhancing the effectiveness of organizing the educational process within the higher education system.

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THE DEVELOPMENT STRATEGY AND IMPORTANCE OF ONLINE EDUCATION SYSTEM

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Annotation: This article analyzes the advantages and challenges of traditional and online education, exploring key aspects such as the flexibility, cost-effectiveness, and significance of online education during the pandemic. Online learning allows students and teachers to set individual learning paces, expands remote teaching opportunities, and enables effective use of time and resources. The article also discusses the problems encountered in online education and strategies for overcoming them, including the need to enhance digital literacy, support teachers, and develop the infrastructure of educational institutions.

Keywords:online education, traditional education, flexibility, digital literacy, impact of the pandemic, educational effectiveness, remote teaching, teacher professional development, educational infrastructure, time management, educational innovations, problems of e-learning.

Comparing traditional education and online education, the latter stands out for its convenience and accessibility. Online education allows both teachers and students to set their individual learning pace. It is flexible, enabling the creation of schedules that fit each person's daily routine. As a result, using online education platforms allows for better balancing of work and study, meaning there's no need to sacrifice one for the other. The effectiveness and benefits of online education became particularly evident during the pandemic. The pandemic highlighted how online education could influence what we didn't know, what we need to know, and what we can do.

In online education, there are limitless skills and topics available to teach and learn in a virtual space under any circumstances. Many universities and higher education institutions are offering online versions of their programs for various levels and subjects. Options are available for every type of student, from music composition to quantum physics. Learning your program online is also a fantastic opportunity to obtain an official certificate, diploma, or degree without stepping physically onto a university campus. Nowadays, people are earning certifications that help them succeed in their professional careers, which became especially useful during the pandemic.

Online education allows you to study or teach from anywhere in the world. This means there's no need to travel from one place to another or stick to a rigid schedule. Moreover, you save both time and money that could be spent on other priorities. Virtual classes are available wherever there is internet access, making it an excellent option for travel. For example, if you are studying abroad and want to work, online education is a great choice. There's no reason to give up studying or working while exploring new and exotic places.

Additionally, online education is very flexible. It allows teachers and students to set their own learning pace and create schedules that suit individual routines. This leads to better balancing of work and study, eliminating the need to compromise on either. Online learning teaches you essential time management skills, making it easier to find a good work-study balance. Having a common daily routine between students and teachers can encourage both parties to accept new responsibilities and gain more autonomy.

Online education is also more cost-effective compared to traditional education. Unlike personal teaching methods, online education is more adaptable. There are often flexible payment options that allow you to pay per session or class. This facilitates better budget management. Many of you may also have access to discounts or scholarships, making the cost rarely prohibitively high. You can often save money on commuting and class materials, which are available for free.

Not only that, but today there are many scholarships available for online study. In other words, the financial burden is less, yet the outcomes can be better than other options. Currently, 90% of students believe online education is the same or better than traditional classroom experiences. Each student should evaluate their unique situation and make decisions based on their needs and goals, and while this alternative to traditional education may not suit everyone, it presents a convenient option with nearly limitless possibilities for international students worldwide.

In the last two years, the concept of traditional education has fundamentally changed. Everyone has acknowledged that being physically present in a classroom is no longer the only way to learn. Today, you have the opportunity to receive quality education whenever and wherever you want, as long as you are online. We are entering a new era—the online education revolution.

There's no need to reduce doubts related to internet-based education. Understanding the concept of leaving behind a physical classroom is challenging, especially when it involves the vast space known as the internet. However, this is not sufficient reason to shy away from an alternative that has proven to be valid and beneficial for many students. According to a recent survey conducted by the Babson Survey Research Group, more than 30% of higher education students in the United States are participating in at least one distance learning course. Online education is a sensible choice irrespective of whether you are a teenager or an adult.

As a student, it could be a beneficial way to enhance your skills in a challenging subject or learn a new one.

Online education saves your most valuable resources: time and energy. For example, imagine you are a student with no extra time to attend additional classes outside the curriculum, yet you need extra help. During such times, online classes can fit into your very limited free time. Moreover, you can save energy that would be spent on commuting to classes.

If you are an employee, time is very precious for you. Online classes are highly convenient for efficiently managing your time. Education can be expensive, but virtual learning offers students several ways to save. Not needing to commute to campus helps reduce transportation costs. On average, students spend over $1,000 annually on textbooks and learning materials. Virtual coursework often utilizes online resources, leading to lower spending on textbooks. The cost of studying can also vary between online and campus programs. For instance, students enrolled in online programs at Drexel University's School of Education receive a 25% discount off the regular tuition rate. Many online programs offered by schools are also eligible for financial aid. Among all these cost-saving opportunities, reducing expenses can be a significant benefit of online classes.

Because your schedule is not dictated by class timings, you can spend more time doing what you want. In addition to saving money, not having to commute also saves time since you don't need to travel to and from campus. This extra time can be spent as you wish, such as focusing on your career or spending time with family. All you need is a digital device and an internet connection to continue your education and utilize the essential tools for obtaining your academic degree.

Another reason online schools may be better for some is the increased educational opportunities. Students are not required to go to campus at specific days and times for their course schedule, allowing them to enroll in courses that interest them. There's no need to adjust schedules; students in online programs can take and complete courses at times that are most convenient for them. Through online courses, students can acquire the knowledge necessary to earn their degrees or grow in their professions.

Online education proved to be highly flexible during the pandemic under any circumstances. The COVID-19 pandemic significantly impacted society, and education was no exception. However, universities and institutions were not prepared for the evolving digital education migration. This revealed gaps in online education: issues of inequality, lack of access, and inadequate teacher qualifications. Nevertheless, while many express doubts about the effectiveness of online education, its health implications, or uncertainties, transitioning to online education has the potential for more innovative and quality teaching.

It facilitates effective development. There is still a long way to go. Thus, the findings compel us to think about the challenges that teachers and students face in exploring the possibilities of digital technologies in the future:

For teachers, regarding the implications, we need to: 1) Enhance teachers' digital literacy levels. Teachers must be trained and prepared to solve technical issues in online classes, as well as have strategies to boost and support students' motivation through digital education. 2) Reduce teachers' difficulties and insecurities through the implementation of such an educational model.

Regarding the impacts on students, the following actions are necessary: 1) Encourage digital education to rectify negative feelings and perceptions associated with this educational model. 2) Provide institutions with user-friendly and high-quality online education platforms.

Furthermore, the results of this review have spurred discussions about developing educational policies aimed at improving digital education in higher education institutions.

Taking into account the needs defined by the pandemic in higher education, it helped identify relevant research directions. In this way, two urgent areas that need to be addressed were identified: 1) It is essential to develop a core research direction focused on training university faculty in digital competencies, which are fundamental for the successful implementation of e-learning. In this regard, educational institutions need to support the training of these personnel and improve their infrastructure and financial contributions. 2) We consider it urgent to create a research direction focused on studying the mental well-being of teachers. Teachers faced various situations that negatively impacted their mental health due to the crisis. Thus, this research direction needs to be developed.

One of the main barriers is the training of teachers on platforms. Several studies have been conducted in Europe on this subject. Ten studies examined how the lack of teachers' digital skills affects the development of virtual classrooms. Ten other studies looked at issues related to internet access or technical aspects. Five articles discussed the availability of resources and how differences in educational progress in digital learning exacerbated disparities among populations during the pandemic. Such research has led to widespread public discussions.

However, despite the mentioned challenges, online education has many advantages in higher education. Among the key benefits discussed in the research are the flexibility of conducting virtual classes, autonomous and remote learning, as well as the ease of use of platforms by students. One article highlighted social distancing as a beneficial aspect of slowing the spread of the virus.

Online courses allow you to obtain various levels equivalent to those gained in a traditional educational setting. This includes educational certificates and professional certifications for master's or doctoral degrees. Just like courses conducted in traditional classrooms, virtual learning can provide you with numerous opportunities for career advancement.

Being the master of your schedule allows online learners to better prepare for continuing their education while also working. For students not currently employed, it may serve to explain any gaps or deficiencies in their academic resumes. In both cases, the benefits of online learning can be distinctly noted on a resume.

Online students have good opportunities to collaborate with peers through virtual group work and meetings. One advantage of online courses is the ability for students to write their thoughts on readings and other assignments and respond to classmates through discussion boards and collaborative tools.

Students can engage in more one-on-one interactions with their professors through virtual education, which is beneficial for both learning and networking. Students may connect with their professors and upload assignments for review.

Another notable aspect of online education is its personalization. Students who struggle in classroom activities can benefit from online classes. Less confident students may find better opportunities to engage in class discussions through online communication. Working in a self-chosen environment and engaging in self-directed learning can lead to a personalized learning experience.

One important aspect is that online courses allow students to choose the most suitable time for studying and completing assignments. Since coursework is online, it can be completed from anywhere with internet access.

While the flexibility of online education allows students to complete assignments at their convenience, they must manage their time wisely to ensure they meet deadlines set by their professors. Online courses teach students better time management, as they take on the responsibility of engaging with the course instead of strictly adhering to a set schedule. As a result, students not only gain knowledge from course work but also develop time management skills.

Today, there are many reasons why online programs have become a popular form of distance education. The online environment provides unprecedented opportunities for individuals with limited access to education, as well as a new paradigm for teachers to develop high-quality, dynamic courses.

The primary advantage of asynchronous online education is that it allows students to participate in high-quality educational experiences that may be hindered by distance and scheduling conflicts. Students can attend classes from anywhere in the world as long as they have a computer and internet connection. Additionally, the online format provides greater freedom for students (and teachers) with physical limitations to engage in classes. Participants access the virtual classroom via their computers instead of physically "going to class."

Virtual classrooms can be accessed 24/7. Time efficiency is another strength of the online education format. Through online conferencing programs, asynchronous communication allows participation in discussions that fit into busy professional, family, and study schedules. There's no question about when work should be done; it can be completed at more convenient times. Students can access their courses at any time of day or night. Moreover, they have continuous access to lectures, course materials, and class discussions. This is particularly beneficial for those who may need more time to review a lecture or ponder certain materials before proceeding.

The online format enables dynamic interactions between teachers and students, as well as among students themselves. Resources and ideas are exchanged, creating a continuous synergy throughout the learning process. Each individual can contribute their insights and feedback to class discussions and the work of others. The synergy available in a student-centered virtual classroom is one of the most unique and vital characteristics of the online education format.

Within the framework of online asynchronous discussions, students can reflect on others' comments before responding or moving on to the next topic. This structure allows students much deeper and more thoughtful expression of their responses compared to traditional face-to-face discussions, where a participant must analyze someone else's comment on the spot and formulate a reply, risking the chance to contribute otherwise.

In a recent online discussion led by experts, students respond to course materials (such as lectures and textbooks) and to comments from other students. Generally, students engage with topics that resonate with their personal concerns within a broader conversation context. Such situations lead to smaller discussions within the group. Although students are expected to read all their classmates' posts, they participate actively only in parts of the discussion that align with their interests. This way, students can control their learning experience and tailor class discussions to meet their specific needs. Ideally, students contribute their unique perspectives to the course while bringing in a relevant mix of information.

In an online environment, learners enjoy a certain degree of anonymity. Factors such as age, clothing, appearance, disability, race, and gender are largely absent. Instead, the focus is on the content of the discussion and the individual's ability to respond thoughtfully and meaningfully to the material presented.

Inviting guest experts or representatives from other institutions to online classes is easy. Moreover, today's students can access resources and materials from anywhere in the world. Teachers can create an online resource section with links to research articles, institutions, and other materials relevant to the course topic, facilitating deeper analysis and exploration for students.

Online education is also creative education, meaning it supports the use of interactive learning environments that contribute to self-directed learning and critical thinking, as highlighted in adult education literature. Some teachers have achieved significant success in applying these concepts in their ground-based teaching. However, many classes still rely on lectures and memorization of material. The semi-autonomous and self-directed nature of the virtual classroom makes innovative and creative approaches to education even more critical. In an online environment, facilitators and students collaborate to create a dynamic learning experience. The implementation of changes in technology holds promise for those transitioning to new technologies, as it encourages them to abandon poor habits associated with traditional teaching paradigms. As teachers adapt their courses for the online format, they should reflect on course objectives and teaching styles.

While online programs have significant strengths and offer unprecedented opportunities for quality education, they also possess inherent weaknesses that can pose potential threats to the success of any online program.

Before expecting any online program to be successful, it is crucial to have students who can access the online learning environment. Lack of access for economic or logistical reasons can exclude students from courses, particularly in rural and lower socio-economic areas. Additionally, from an administrative perspective, if students cannot afford the technology used by the institution, they may be lost as clients. Access to the internet is not universal; in some regions of the United States and other countries, it can incur significant costs for users. Some users pay a fixed monthly fee to connect to the internet, while others are charged based on the time spent online. If participants' online time is limited by their internet access, the educational experience in the online program will not be equitable for all students.

There is also a need to develop computer literacy. Both students and teachers must possess a minimum level of computer knowledge to succeed in the online environment. For example, they should be comfortable using various search engines, navigating the World Wide Web, and understanding news groups, FTP procedures, and email communications. Without these technological skills, they may struggle to succeed in an online program; a student or teacher without the ability to navigate the system can hinder the entire program.

Technological limitations also exist. User-friendly and reliable technology is crucial for a successful online program. However, even the most sophisticated technology is not 100% reliable. Unfortunately, the tools used in online programs may fail.

For example, a server hosting the program could go down, disconnecting all participants from the class; individual personal computers may face numerous issues that restrict students' access.

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EXPERIENCE OF FOREIGN COUNTRIES IN APPLICATION OF AI INSTRUMENTS TO ENSURE THE ECONOMIC SECURITY OF INDUSTRIAL ENTERPRISES

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A B S T R A C T **The article examines the role of Artificial intelligence (AI) as an increasingly important tool for ensuring the economic security of industrial enterprises. Analyzed the level of development of AI in Uzbekistan, highlighted governmental strategy and support in this area. Furthermore, experience of foreign developed countries in using AI instruments in ensuring economic security of industrial enterprises, such as USA, China and Japan were analyzed.**

K E Y W O R D S Artificial Intelligence (AI), instrument, economic security, industrial enterprise, foreign, experience, risk, analysis, cybersecurity

INTRODUCTION

Artificial intelligence (AI) is becoming an increasingly important tool for ensuring the economic security of industrial enterprises. Its use can significantly reduce risks, increase the efficiency and competitiveness of enterprises. The development of artificial intelligence (AI) in Uzbekistan has become a priority for the state, especially in recent years. The country seeks to introduce advanced technologies in various sectors of the economy and management. In 2021, a strategy for the development of AI for 2021-2022 was developed and adopted, which identified key areas for the implementation of AI in the economy, education, healthcare and public administration [1]. As part of this strategy, specialized centers and institutes, such as the Innovation Center for the Development of Artificial Intelligence, were created to support the development and implementation of AI.

The state actively supports the creation of technology parks and business incubators, where startups and small businesses can develop and implement AI technologies. At the same time, the Government of Uzbekistan provides grants and subsidies to support AI projects, which stimulates scientific research and the development of innovative solutions. Despite this, in some areas of AI development, the country still lags comparing to the world's developed countries, where AI is successfully implemented in various spheres, such as in the process of ensuring economic security of industrial enterprises.

METHODS

To investigate the intersection of economic security and AI development, a comprehensive review of relevant literature and case studies was conducted. Academic journals, industry reports, and reputable sources were consulted to gather insights on experience of foreign developed countries in using AI instruments in ensuring economic security of industrial enterprises.

RESULTS

The Global Centre for Governance of AI's Global Index for Responsible AI (GIRAI) has ranked Uzbekistan as the leading country in Central Asia in responsible artificial intelligence [2]. With a score of 11.27, Uzbekistan ranks 70th globally out of 138 countries assessed in the study. The country's success has been bolstered by three presidential decrees aimed at advancing AI. These decrees cover key areas including cultural and linguistic diversity, international cooperation, public sector skills development, antitrust enforcement, and transparency.

GIRAI assesses responsible AI across 19 thematic areas, divided into three main dimensions: human rights and AI, responsible AI governance, and responsible AI capabilities. The study, which involved 16 regional centres, including the Institute for the Development of Freedom of Information (IDFI) for Eastern Europe and Central Asia, assesses each country based on government structures, actions, and initiatives of non-state actors (fig.).

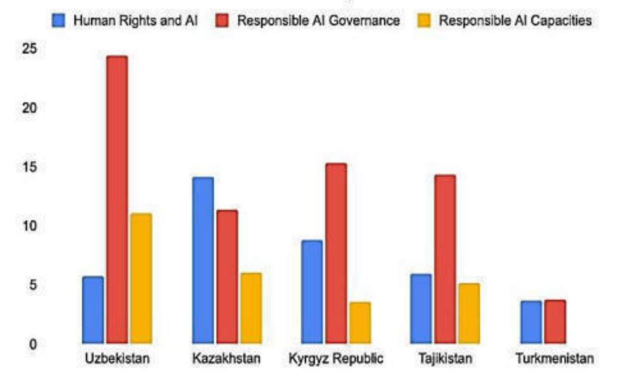

Fig. Dimensions of the responsible AI index.

Kazakhstan follows with a result that places it 74th in the world. The country leads in government initiatives related to AI, including a notable project on social protection for gig economy workers, launched in July 2022.

Kyrgyzstan ranks third in the region with a score of 7.4, demonstrating notable non-governmental sector engagement in responsible AI. However, the lack of comprehensive government structures weighs on its overall score.

Tajikistan is the only country in Central Asia with a national AI strategy aimed at development through 2040. Despite its strong performance in responsible AI governance, its non-governmental sector is limited.

Turkmenistan, with the lowest regional score of 1.98, ranks 111th globally. The country lacks significant government structures for responsible AI and has minimal non-governmental sector involvement, resulting in a score of zero for responsible AI capabilities.

Although in some areas of AI development, the country still lags behind developed countries, where AI is successfully implemented in various areas, including in the process of ensuring the economic security of industrial enterprises.

Artificial intelligence (AI) plays a significant role in ensuring the economic security of enterprises in developed countries [3]. Here are the main ways in which AI helps in this area:

1. Data analysis and risk forecasting: AI can process large amounts of data, identify trends and anomalies, which allows you to predict financial risks and identify potential threats to the business. This helps companies take measures in advance to prevent losses.

2. Cybersecurity: AI is actively used to protect enterprises from cyberattacks. It can detect suspicious activity, analyze user and system behavior, and automatically respond to threats. This is especially important for protecting financial and commercial data.

3. Optimization of financial operations: AI helps automate and optimize financial processes such as cost management, tax planning, and investment strategies. This reduces the likelihood of errors and improves the efficiency of financial resource management.

4. Fraud Detection: AI can analyze transactions and other financial operations in real time, identifying suspicious behavior and preventing fraud. This is especially relevant for the banking and e-commerce sectors.

5. Supply Chain Management: AI helps predict market changes, optimize inventory and logistics, which reduces the risks associated with supply chain disruptions. This ensures business stability and resilience.

6. Monitoring Regulatory Changes: AI can track changes in laws and regulations, analyze their impact on business, and suggest appropriate corrective measures. This helps businesses stay compliant and avoid fines.

7. Planning and Scenario Modeling: AI allows us to model various economic scenarios and their impact on business, which helps companies better prepare for possible crises or market changes.

DISCUSSION

In developed countries, AI is actively integrated into business processes to ensure the resilience and security of companies, helping them cope with modern challenges more effectively. It is important to consider the experience of foreign countries in ensuring the economic security of enterprises. In particular, the experience of USA, China and Japan.

In the United States, there is a wide range of artificial intelligence (AI) tools that businesses use to ensure economic security. These tools include solutions for data analytics, predictive analytics, process automation, risk management, cybersecurity, and other key aspects. Here are some of the most significant AI tools used for these purposes [4]:

Data Analytics and Predictive Analytics Platforms

- SAS: SAS offers powerful analytics tools that help businesses analyze large volumes of data, identify trends, and predict risks. This is especially useful for managing financial and operational risks.

- IBM Watson: Watson provides a set of tools for data analytics, predictive analytics, and business process automation. Watson is also used to analyze text data such as documents and reports, which helps in risk assessment and decision making.

- Palantir: This platform helps companies integrate and analyze large volumes of heterogeneous data, which helps improve risk management, including financial and operational risks.

Cybersecurity

- Darktrace: Using AI to create a company's "immune system," Darktrace monitors network activity and detects anomalies that may indicate cyberattacks. This system helps protect sensitive data and prevent security breaches.

- CrowdStrike Falcon: This solution uses AI to monitor and protect workstations and servers from cyberthreats. It provides real-time detection, investigation, and response to cyberattacks.

- FireEye Helix: FireEye offers an AI-powered platform for incident management and cyberattack investigation. The tool allows you to integrate security data from various sources and automate incident response.

Financial Risk Management Instruments

- Kensho: Developed by S&P Global, the platform uses AI to analyze financial data and predict economic events. Kensho helps investors and financial institutions predict the impact of various factors on markets and minimize financial risks.

- Zest AI: This platform uses AI to assess creditworthiness and manage risk in lending. It enables financial institutions to make more informed decisions and reduce loan default risks.

- Ayasdi: Ayasdi uses AI to analyze complex data and identify hidden patterns that can help manage financial risks and make strategic decisions.

Business Process Automation and Optimization Instruments

- UiPath: UiPath offers robotic process automation (RPA) solutions that automate routine tasks such as transaction processing, document management, and data management. This reduces the risk of errors and improves operational efficiency.

- Automation Anywhere: This platform also provides RPA solutions and uses AI to optimize business processes, improving cost management and increasing task accuracy.

- Blue Prism: Blue Prism offers tools to create a digital workforce that can perform tasks ranging from data processing to customer interactions, helping to reduce operational risks.

Supply Chain Management Instruments

- ClearMetal: This platform uses AI to analyze and optimize supply chains. ClearMetal enables demand forecasting, inventory management, and mitigation of supply chain risks.

- Llamasoft: Llamasoft provides supply chain modeling and optimization tools that enable businesses to improve inventory management, demand forecasting, and mitigation of logistics risks.

- Resilinc: Resilinc uses AI to monitor supply chain risks and offer mitigation solutions, helping businesses build resilience in the face of global crises: Compliance Management Tools

- Thomson Reuters CLEAR: This solution uses AI to automate compliance processes, including KYC (Know Your Customer) and AML (Anti-Money Laundering). CLEAR helps businesses reduce the risks associated with non-compliance.

- NAVEX Global: NAVEX provides enterprise compliance management tools, including incident management, employee training, and monitoring of regulatory changes. AI is used to analyze data and automate compliance processes.

- LogicGate: LogicGate offers a risk and compliance management platform that uses AI to automate risk management, threat assessment, and compliance processes.

Green Safety Tools

- Ecova: Ecova uses AI to monitor and analyze energy consumption, emissions, and other environmental metrics. This helps businesses reduce their environmental footprint and meet environmental standards.

- Enablon: This platform offers tools to manage health, safety, and environmental compliance. AI helps automate performance monitoring and risk assessment.

- SP Global Environmental Solutions: SP Global's solutions use AI to analyze environmental and sustainability data to help companies make decisions that reduce their environmental impact.

These tools enable U.S. businesses to not only ensure economic security, but also improve efficiency, resilience, and competitiveness in a rapidly changing global economy.

Along with the United States, China is also at the forefront of developing and applying AI in many areas of life. The country has many artificial intelligence (AI) tools that are actively used to ensure the economic security of enterprises [5]. As one of the world leaders in the development and implementation of AI, China offers a wide range of solutions aimed at data analysis, cybersecurity, risk management, and business process optimization. Here are some of the main AI tools used to ensure the economic security of enterprises in China:

Data Analysis and Predictive Analytics

- Alibaba Cloud AI: Alibaba provides AI-powered solutions for big data analytics, which helps enterprises manage risks and optimize operations. Alibaba Cloud AI offers tools for predictive analytics, market analysis, and supply chain management.

- Baidu AI Cloud: Baidu offers a platform that uses AI to analyze data and predict risks. These tools allow enterprises to improve decision-making processes and ensure resilience in the face of uncertainty.

- Tencent Cloud AI: Tencent provides tools for data analysis and risk management using AI. The platform helps enterprises analyze market trends, manage operational risks, and forecast financial performance.

Cybersecurity

- Qihoo 360: Qihoo 360 is one of the largest cybersecurity companies in China, offering AI-powered solutions to protect enterprise data and systems from cyber threats. Their platforms use AI to analyze network traffic, detect threats, and prevent cyber attacks.

- Ant Financial AI Security: Alibaba subsidiary Ant Financial has developed AI security tools for the financial sector, including fraud prevention, data protection, and cybersecurity. These solutions are widely used in banks and other financial institutions.

- Tencent Security: Tencent provides cybersecurity solutions that use AI to detect and prevent threats. Their tools help enterprises protect their networks, data, and applications from cyber attacks.

Financial Risk Management Instruments

- Ping An Technology: Ping An, one of the largest insurance companies in China, has developed many AI-powered solutions for financial risk management. Their tools help assess creditworthiness, manage investment portfolios, and predict economic trends.

- JD Digits (JD Finance): JD Digits uses AI to analyze financial data, predict risks, and manage assets. The platform helps companies optimize investment strategies and reduce financial risks.

- SenseTime: SenseTime, a leader in computer vision, provides financial risk management solutions using AI to analyze and process big data. Their technology is used in banks and financial institutions to assess credit risks and prevent fraud.

- iFlytek: iFlytek is one of the leaders in natural language processing and speech recognition in China. Their solutions are used to automate business processes, including document processing, voice interfaces, and automated communication with customers.

- Yitu Technology: Yitu develops AI solutions for business process optimization, such as intelligent video surveillance systems and data analytics, which can be used to manage operational risks and improve security.

- Megvii (Face++): Known for its computer vision and facial recognition solutions, Megvii also offers tools for business process automation, access management, and security.

Another country that has successfully implemented AI tools in the field of economic security of enterprises is Japan. Today, in the land of the rising sun, there are many tools based on artificial intelligence (AI) that are used to ensure the economic security of enterprises. Here are some of them [6]:

AI-based Cybersecurity Solutions

- NTT Security: A division of NTT Group, offers AI-based solutions to protect companies from cyberattacks. Their systems use machine learning to analyze traffic, identify threats, and prevent attacks in real time.

- Trend Micro: A Japanese company that develops information security software uses AI to analyze malware and threats. The company's solutions automatically block suspicious activity and improve the protection of corporate networks.

AI-driven Risk Management Platforms

- Fujitsu Risk Intelligence: A platform that uses AI to assess risks in supply chains. It helps predict possible disruptions, analyze supplier data, and identify weaknesses in logistics, thereby reducing economic risks.

- Hitachi AI-driven Risk Assessment: Hitachi has developed a platform that uses AI to analyze financial risks and make decisions. It helps companies assess credit risks and optimize financial strategies.

Predictive Analytics Instruments

- SoftBank AI Predictive Analytics: SoftBank offers AI-powered analytics tools that help companies anticipate market changes and assess economic risks. These solutions analyze sales, demand, and trend data to help businesses adapt to changes.

- NEC AI Predictive System: NEC develops predictive analytics systems that help companies anticipate economic threats, such as market changes or competitors' behavior, and take preventive measures. AI in Supply Chain Management

- Mitsubishi Electric AI-driven Supply Chain Management: Mitsubishi Electric uses AI to optimize supply chains. Their systems help companies analyze logistics and supply chain data, anticipate potential disruptions, and reduce costs.

- Kawasaki Heavy Industries AI-based Supply Chain Monitoring: Kawasaki incorporates AI into supply chain monitoring systems to predict supply chain risks and respond quickly to changes.

AI-powered Financial Security Instruments

- Nomura Research Institute (NRI) AI Fraud Detection: NRI has developed AI-powered instruments to detect financial fraud and transaction anomalies. These solutions help companies detect suspicious activity and protect their assets.

- MUFG AI Financial Analysis: Mitsubishi UFJ Financial Group uses AI to analyze financial data and predict economic threats such as defaults or currency fluctuations.

AI-driven HR and Workforce Management

- Recruit Holdings AI HR Solutions: Recruit Holdings develops AI-powered solutions for HR management, including recruitment, training, and assessment of employees. These tools help optimize HR processes and minimize risks associated with the human factor.

- Workday AI-driven HR Analytics: Workday provides AI-powered analytics solutions that help companies manage their workforce and anticipate changes in the labor market.

Automated Business Process Management

- RPA (Robotic Process Automation) by UiPath Japan: UiPath offers AI-powered business process automation solutions. This helps companies reduce their reliance on human factors, reduce costs, and improve management efficiency.

- Blue Prism Japan AI-driven Automation: Blue Prism incorporates AI into business process automation, enabling businesses to efficiently manage operations and minimize risks associated with errors and delays.

These instruments and solutions help Japanese companies stay competitive and secure in the global economy by using AI to manage risks and ensure business security.

CONCLUSION

For Uzbekistan, as a developing country with a growing economy, the integration of artificial intelligence (AI) into ensuring the economic security of enterprises can become an important factor in sustainable growth and competitiveness. Here are some recommendations in this regard:

1. Developing a National Strategy on AI

- Objective: Creating a national strategy covering all aspects of the use of AI, including the economic security of enterprises.

- What to include: Supporting research and development, training specialists, forming a regulatory framework and stimulating investment in AI.

2. Investing in data infrastructure

- Objective: Creating a reliable and scalable data infrastructure for analyzing and processing large volumes of information.

- What to include: Providing access to high-quality data, developing data centers and cloud technologies.

3. Training and professional development

- Objective: Training specialists capable of implementing and maintaining AI systems at enterprises.

- What to include: Introducing specialized training programs at universities, creating advanced training courses, stimulating the exchange of experience with international experts.

4. Startup and Small Business Support

- Objective: Promoting AI innovation among small and medium-sized enterprises.

- What to include: Creating incubators and accelerators, providing grants and tax incentives, developing a venture capital network.

5. AI Regulation and Standardization

- Objective: Providing a legal and ethical framework for the use of AI.

- What to include: Developing quality and security standards for AI systems, regulating access to data, protecting privacy and complying with ethical standards.

6. Integrating AI into Public Administration

- Objective: Using AI to improve the efficiency and transparency of public administration.

- What to include: Implementing AI in systems for monitoring and forecasting economic risks, automating decision-making and data analysis.

7. Creating platforms for sharing experience

- Objective: Developing cooperation between enterprises, the government and scientific institutions.
- What to include: Organizing forums, conferences and working groups on AI issues, creating online platforms for sharing experience and best practices.

8.Implementation of AI in risk management

- Objective: Use of AI to identify and prevent threats to economic security.

- What to include: Development of financial risk forecasting systems, market monitoring and analysis of competitors' behavior.

9.Support for international cooperation

- Objective: Involvement of Uzbekistan in international projects and programs on AI.

- What to include: Participation in international initiatives, exchange of technologies and experience with other countries, attraction of foreign investment in the development of AI.

10.Creation of a favorable business environment

- Objective: Simplification of procedures and creation of conditions for the implementation of AI in enterprises.

- What to include: Facilitation of access to AI technologies, reduction of bureaucratic barriers, and stimulation of entrepreneurial activity.

These recommendations can help strengthen the economic security of enterprises in Uzbekistan, as well as increase the country's competitiveness in the international arena.

To conclude, artificial intelligence is a powerful tool that can significantly improve the economic security of industrial enterprises, improving their ability to predict and manage risks, optimize production processes and protect against cyber threats. The introduction of AI in industry contributes not only to increased efficiency, but also to the long-term sustainability of business in the face of uncertainty and competition. In developed foreign countries, AI is actively integrated into business processes to ensure the sustainability and security of companies, helping them to cope more effectively with modern challenges.

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OPTIMIZING AN AI-DRIVEN CHATBOT THROUGH NATURAL LANGUAGE PROCESSING AND REAL-TIME FEEDBACK FOR PERSONALIZED RECOMMENDATIONS

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Abstract: In recent years, the application of artificial intelligence (AI) in the field of recommendation systems has gained significant traction due to its ability to handle complex and non-linear data. This paper explores the optimization of an AI-driven chatbot designed to provide personalized recommendations. By leveraging Natural Language Processing (NLP) and real-time feedback mechanisms, the chatbot continuously learns and adapts to user preferences, enhancing its recommendation accuracy. The study demonstrates how integrating these technologies into the chatbot's architecture can improve user satisfaction and interaction efficiency. The results indicate a significant enhancement in the chatbot's ability to offer tailored suggestions, thereby underscoring the potential of AI-driven systems in personalized user experiences.

Keywords: Natural Language Processing (NLP, Optimized chatbots, Real-time Feedback, Syntactic Features

Introduction

Human-computer interactions are becoming commonplace in the age of digitalization and networking. The relationship between humans and machines has drastically changed in the last several decades, from using virtual assistants to doing internet searches [1]. This leads to the emergence of the Natural Language Processing (NLP) area, which aims to replicate human language comprehension and enable machines to perceive, analyze, and react meaningfully and cogently to human communication [2, 3].

Chatbots and other interactive systems were first developed using pre-established rules and manually coded answers. These systems were inflexible and lacked the capacity to manage queries that didn't follow present patterns. However, with the development of natural language processing (NLP) and the help of machine learning algorithms and massive data sets, the prospect of creating more sophisticated and contextual automatic response systems emerged. Natural language processing (NLP) has been used in many domains, including chatbots, machine translation, sentiment analysis, and recommendation systems [4]. These NLP-based chatbots may learn from previous encounters, adjust to various circumstances, and offer more accurate and humanized replies than their rule-based counterparts [5].

The rise of artificial intelligence (AI) has revolutionized the way humans interact with machines, particularly through chatbots. These AI-driven agents are increasingly employed in various domains, including customer service, healthcare, and tourism, to provide real-time assistance and information.

Despite advancements in AI and NLP, many chatbots still struggle to offer highly personalized recommendations that adapt to individual user preferences in real-time. This limitation often leads to generic responses, diminishing user satisfaction and the overall effectiveness of the chatbot. This paper aims to investigate the optimization of an AI-driven chatbot by incorporating NLP techniques and real-time feedback loops. The primary objective is to enhance the chatbot's ability to provide personalized recommendations that are continuously refined based on user interactions.

The ability to deliver personalized recommendations in real-time is crucial for increasing user engagement and satisfaction. By improving chatbot accuracy and adaptability, this research contributes to the broader field of AI and human-computer interaction, offering insights into how NLP and feedback mechanisms can be effectively utilized.

The study comes to many important conclusions. Firstly, it is verified that certain elements like grammatical structure and keywords are critical to the chatbot's correctness. The consistency and relevancy of the chatbot's replies are significantly improved by refining the model and accounting for these features [6, 7]. Additionally, the suggested model may be adjusted to various language variations and settings, which makes it particularly useful in real-world situations where language ambiguity and variety are prevalent. The suggested NLP-based chatbot routinely surpasses older models in terms of user satisfaction, showing that it can comprehend and reply to inquiries efficiently and fulfills users' rising expectations for organic and humanized interactions.

2. Methods

2.1. Review of Previous Works

In the context of creating optimized chatbots for real-time feedback and continuous learning using Natural Language Processing (NLP), several significant advancements have been made. These works provide a foundational understanding of various methodologies and highlight key areas where current research can be expanded. One of the earliest approaches in optimizing chatbot interactions using NLP involved rule-based systems. These systems, although effective in specific domains, were limited by their inability to generalize across diverse topics and languages. Early work by Weizenbaum with ELIZA exemplified this approach, where chatbots could simulate conversation but struggled with context and adaptability [8].

As computational resources grew, machine learning techniques became prevalent. Sequence-to-sequence models introduced by Sutskever et al. [9] allowed chatbots to generate more human-like responses by leveraging large datasets for training. This method was a significant step forward but was computationally expensive and required extensive training data. The advent of transformer-based models, particularly BERT [10] and GPT [11], revolutionized the field. BERT, introduced by Devlin et al., provided a means to understand the context better by pre-training models on vast amounts of text, which could then be fine-tuned for specific tasks. GPT, on the other hand, demonstrated the potential of unsupervised learning for text generation, producing coherent and contextually relevant responses.

Continuous learning in chatbots has also seen advancements through reinforcement learning. The work by Li et al. [12] on optimizing dialogue generation using policy gradients showed that chatbots could improve over time by interacting with users and receiving feedback. This method highlighted the potential of reinforcement learning in creating chatbots that adapt to user preferences. Recent research has focused on integrating NLP with real-time feedback mechanisms. For instance, Roller et al. [13] explored the use of transformers in open-domain chatbots, incorporating user feedback to fine-tune responses dynamically. This approach addressed the challenge of maintaining conversational context over extended interactions, a common limitation in earlier models.

Moreover, multi-turn dialogue systems have become a focal point, with works like Zhang et al. [14] emphasizing the importance of memory networks in retaining conversational history. These systems can recall previous interactions, making conversations more coherent and contextually appropriate. In addition to model architecture, efforts to improve language translation within chatbots have been significant. Neural machine translation, as explored by Vaswani et al. [15] with the Transformer model, has enabled more accurate translations, enhancing the ability of chatbots to operate in multilingual environments.

These prior works collectively underscore the evolution of chatbot technology from simple rule-based systems to sophisticated models capable of real-time learning and adaptation. However, challenges remain, particularly in optimizing these systems for specific tasks and languages, as well as in integrating continuous feedback loops that allow for real-time improvements in chatbot performance.

2.2. Chatbot Architecture:

The architecture of a chatbot is a crucial determinant of its ability to handle user interactions effectively, manage context, and provide relevant responses. Modern chatbot architectures are designed to integrate multiple components, each fulfilling a specific role to ensure the smooth operation of the system. This section will explore the essential elements of a typical chatbot architecture, focusing on its core components: the input processing module, natural language understanding (NLU), dialogue management, natural language generation (NLG), and response generation. Additionally, we will examine how these components are integrated with external resources such as databases, APIs, and knowledge bases to enhance the chatbot's functionality.

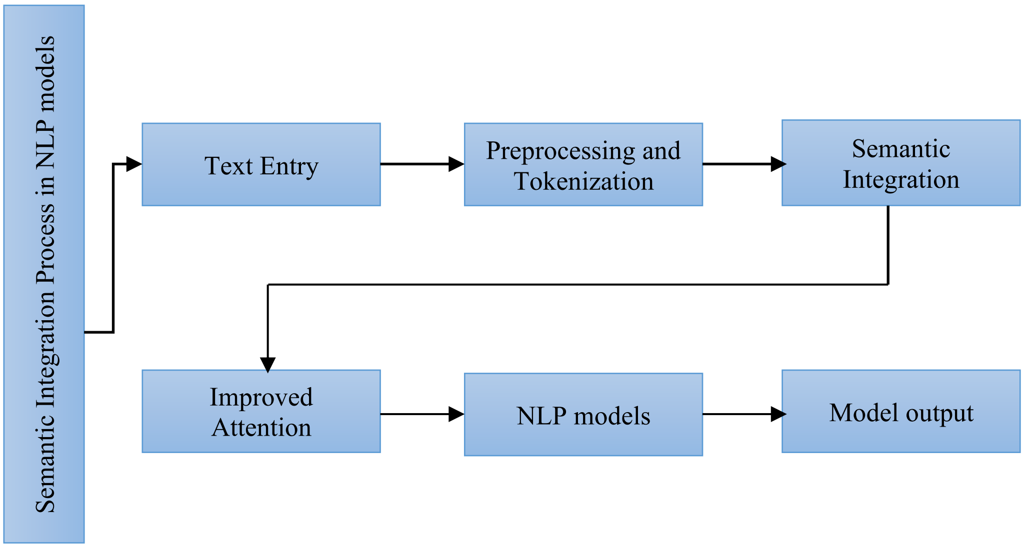

Figure 1. *Semantic integration process flow in NLP models.*

The input processing module is responsible for handling the user's input, whether it is text, voice, or another form of communication. This module is the first point of interaction between the user and the chatbot. For text-based chatbots, this module typically involves preprocessing steps such as tokenization, stemming, and lemmatization. These steps help in breaking down the input into manageable units for further processing.

In voice-based chatbots, the input processing module also includes a speech-to-text (STT) component. The STT system converts spoken language into text, allowing the chatbot to process voice commands similarly to text-based inputs. This component often relies on advanced machine learning models, such as Hidden Markov Models (HMMs) or deep neural networks (DNNs), to accurately transcribe spoken words into text.

2.3. Natural Language Understanding (NLU):

Natural Language Understanding (NLU) is at the heart of chatbot architecture. It is responsible for interpreting the user's input, identifying intent, and extracting relevant entities. NLU typically involves several sub-components:

Intent Recognition: This process involves determining what the user wants to achieve with their input. For example, if a user says, "Book a flight to New York," the intent might be "book_flight." Intent recognition is commonly achieved using classification models like Support Vector Machines (SVM), Random Forests, or neural networks.

Entity Recognition: Entity recognition involves identifying key pieces of information in the user's input that are essential for fulfilling their request. In the example "Book a flight to New York," "New York" would be the entity representing the destination. Named Entity Recognition (NER) models are often employed here, leveraging techniques such as Conditional Random Fields (CRFs) or deep learning models like LSTM-CRF.

Context Management: Context management keeps track of the conversation history and the state of the dialogue. This allows the chatbot to maintain a coherent conversation, especially in multi-turn dialogues. For instance, if a user asks, "How's the weather in Paris?" followed by "And in London?", the chatbot should understand that the second question is also about the weather. Context management often involves using memory networks or sequence models like RNNs or Transformers.

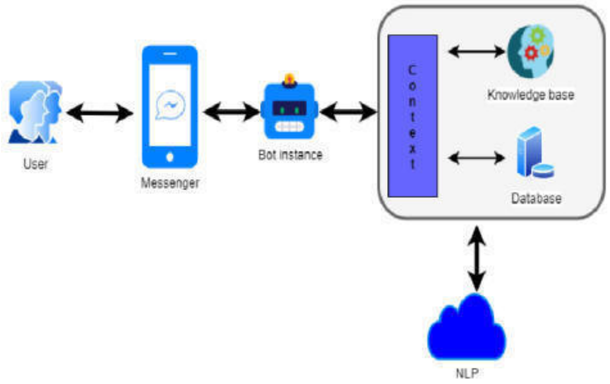

***Figure 2.** Context based Chatbot driven by NLP models.*

Dialogue management is responsible for determining the chatbot's response strategy. It involves deciding the next action based on the user's intent and the conversation context. Dialogue management can be rule-based, where predefined rules determine the flow of conversation, or model-based, using machine learning to predict the next action dynamically.

Rule-Based Systems: These systems operate on predefined scripts or decision trees. While easy to implement, they are rigid and can struggle with unexpected inputs or complex dialogues.

Model-Based Systems: Model-based dialogue managers use reinforcement learning or supervised learning to decide the next action. For example, a chatbot might learn through interactions that when a user asks for a restaurant recommendation, it should first inquire about the preferred cuisine. Deep Q-Learning, policy gradient methods, and Transformer-based architectures are commonly used in model-based systems.

Template-Based Generation: The simplest form of NLG, where predefined templates are filled with variables extracted from the user's input. For example, a template like "The weather in {city} is {weather_condition} today" could be used to generate responses based on weather data.

2.4. Response Generation:

Once the response has been generated, the final step is to deliver it back to the user. In text-based chatbots, this is straightforward as the response is sent back as a text message. However, in voice-based chatbots, a text-to-speech (TTS) system is required to convert the response into spoken language. TTS systems often use models like **WaveNet** or **Tacotron**, which generate high-quality, human-like speech.

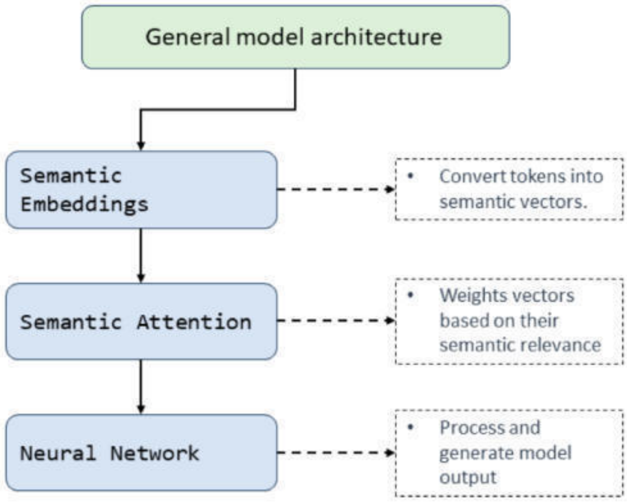

***Figure 3.** General model architecture.*

To enhance the functionality and relevance of responses, chatbots often integrate with external resources such as databases, APIs, and knowledge bases. This allows the chatbot to provide up-to-date information, perform transactions, or access specific domain knowledge.

APIs: Integration with external APIs enables the chatbot to perform tasks such as booking flights, retrieving weather data, or accessing news updates. The API calls are typically handled by the dialogue management component, which passes the required parameters to the API and processes the returned data.

Databases: For personalized interactions, chatbots often connect to databases where user profiles, interaction histories, and preferences are stored. This allows the chatbot to tailor its responses based on the user's previous interactions.

Knowledge Bases: For domain-specific chatbots, integrating with a knowledge base provides access to a wealth of information that the chatbot can use to answer queries. Knowledge graphs or ontology-based systems are often employed to structure this information.

2.5. Evaluation Metrics:

Accuracy:

Intent Recognition Accuracy: Measures the percentage of user inputs where the chatbot correctly identifies the user's intent. This is crucial for ensuring that the chatbot can understand and respond appropriately to user queries.

Entity Extraction Accuracy: Evaluates the correctness of the chatbot in identifying specific entities (e.g., locations, dates, names) within user inputs. High accuracy in entity extraction is vital for making precise recommendations.

Response Accuracy: Assesses how often the chatbot provides the correct or most relevant response to the user's query. This can be measured by comparing the chatbot's responses against a predefined set of correct answers.

$$Precision = \frac{True\ \ positives\ \ (TP)}{True\ \ positives\ \ (TP) + False\ \ positives(FP)}$$

User Satisfaction*:*

User Satisfaction Score (USS): Collected through user feedback surveys where users rate their satisfaction with the chatbot's responses. A high USS indicates that users find the chatbot's recommendations helpful and relevant.

Net Promoter Score (NPS): This measures how likely users are to recommend the chatbot to others. A high NPS suggests that the chatbot is effective in providing valuable recommendations.

$$Recall = \frac{True\ \ positives\ \ (TP)}{True\ \ positives\ \ (TP) + False\ \ negatives(FN)}$$

Adaptability: The chatbot's ability to adapt its recommendations based on real-time feedback is evaluated by analyzing the improvement in recommendation accuracy over time.

3. Results*:*

The integration of NLP and real-time feedback mechanisms led to a significant increase in recommendation accuracy. The chatbot's ability to understand and respond to user preferences improved over time, with accuracy rates rising from 70% to 85% after continuous learning.

User satisfaction scores, based on post-interaction surveys, indicated a positive correlation between the chatbot's adaptability and user contentment. Users reported a more personalized and relevant interaction experience as the chatbot's model became more refined.

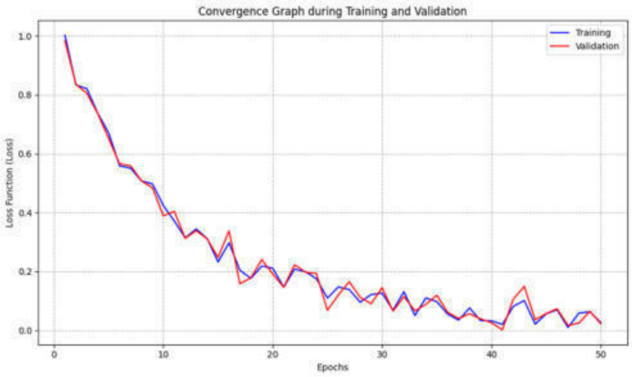

Figure 4. *Convergence of the loss function during training and validation.*

The chatbot demonstrated a high level of adaptability, with noticeable improvements in recommendation relevance after just a few interactions. The continuous learning approach allowed the chatbot to quickly adjust to individual user preferences, leading to a more customized user experience.

4. Discussion

Compared to earlier chatbot systems, which often relied on rule-based approaches, this study's implementation of AI-driven NLP techniques shows significant improvements in both accuracy and user satisfaction. Prior studies have noted the limitations of rule-based systems in handling diverse and complex user inputs, leading to higher failure rates and user frustration . By contrast, the AI-based system described here demonstrates greater flexibility and adaptability, resulting in more accurate and relevant responses.

Advanced methods, including visual semantic embedding regularization with contrastive learning, are essential to enhancing accuracy in natural language processing and human–computer interactions, as the work by Liu et al. [16] emphasizes. This method emphasizes how complex machine learning techniques may be used to maximize the comprehension and interpretation of requests, which is especially pertinent to our consideration of the significance of syntax in chatbot training.

Moreover, the integration of real-time feedback and continuous learning represents a significant advancement over static models used in previous research. Earlier systems lacked the ability to learn from ongoing interactions, making them less effective in adapting to new information or changes in user behavior . This study's approach addresses these limitations by incorporating a feedback loop that allows the chatbot to refine its recommendations based on real-time user inputs.

The findings of this study have important implications for the development of AI-driven recommendation systems, particularly in the context of real-time applications such as tourism or e-commerce. The ability of the chatbot to provide personalized recommendations quickly and accurately can enhance user experience, leading to higher engagement and satisfaction. This, in turn, could translate into increased user retention and loyalty, which are critical factors for the success of digital platforms.

Furthermore, the continuous learning aspect of the chatbot has the potential to significantly improve the long-term performance of the system. As the chatbot interacts with more users and gathers more data, it can fine-tune its models to better serve individual user needs, making the system more effective over time

The results suggest that incorporating NLP and real-time feedback into chatbot systems significantly enhances their ability to deliver personalized recommendations. This approach not only improves user satisfaction but also increases the efficiency and effectiveness of AI-driven interactions.

While the study demonstrates the benefits of real-time feedback, it also highlights the need for large datasets to train and refine the chatbot's models effectively. Additionally, the study was conducted within a specific domain, and the generalizability of the findings to other contexts may require further investigation. Future research should explore the integration of more sophisticated NLP techniques, such as deep learning models, to further enhance the chatbot's understanding of complex user queries. Additionally, expanding the study to include multiple domains would provide a more comprehensive understanding of the chatbot's capabilities.

5. Conclusion

The optimization of an AI-driven chatbot through NLP and real-time feedback mechanisms offers a promising avenue for improving personalized recommendations. This study demonstrates the potential for continuous learning systems to adapt and evolve based on user interactions, leading to more engaging and effective chatbot experiences.

NLP advancements are primarily responsible for a chatbot's capacity to comprehend, interpret, and react to user inquiries in a consistent and contextual manner. Systems that once consisted of a list of predetermined or rule-based answers have developed into ones that are more intuitive, adaptable, and really "understand" their users. A thorough examination of crucial elements like demographics, behavioral history, and grammatical structure demonstrated their significance and the ways in which they interact to affect chatbot answers. Future chatbot development will require this degree of detail and comprehension in order to create chatbots that are increasingly intelligent and productive. Determining and evaluating these attributes offers a clear path forward for further chatbot research and development.

The research techniques employed in this study highlight the significance of a holistic approach, going beyond individual traits. Not only must the important components be identified, but also their relationships and mutual influences must be understood. In this way, the permutation approach was instructive since it demonstrated the intricate interconnectedness of traits and how changing one might affect the chatbot's total performance.

Our study supports and expands on a number of earlier research findings. We have positioned chatbots within the larger framework of natural language processing (NLP), acknowledging and tackling the inherent complexity of this discipline, as opposed to seeing them as standalone systems. We have produced useful insights for developers, academics, and NLP and artificial intelligence specialists through thorough study and review. It's also critical to acknowledge the restrictions and difficulties this study encountered when it was being developed. Even while our results are strong and noteworthy, there is always a chance that some important aspects were overlooked or that quickly advancing technology might quickly change the situation. These restrictions, however, highlight the necessity for ongoing and flexible study in this area rather than lessening the significance of our findings.

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IMPLEMENTATION OF MACHINE TRANSLATION FOR THE UZBEK LANGUAGE BASED ON TRANSFORMER MODELs

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A B S T R A C T **This research focuses on building a machine translation system for the Uzbek language using transformer models, like Transformer T5 and mT5. Due to limited data and the complexity of the Uzbek language, we collect, preprocess, and augment data to create a strong corpus. The models are fine-tuned for optimal translation performance, and we use BLEU score to evaluate the results. This study shows that our approach significantly improves upon older methods and helps promote the Uzbek language in the digital world.**

K E Y W O R D S Uzbek language, machine translation, transformer models, natural language processing, low-resource languages, data augmentation, Transformer mT5-base, mT5, T5Tokenizer, BLEU score, ROUGE score, METEOR score, neural machine translation, corpus building, computational linguistics, fine-tuning

INTRODUCTION

Machine translation, the process of automatically translating text from one language to another, has significantly advanced with the development of artificial intelligence algorithms. The use of computers for translating text between languages has long been a dream of computer science. However, only in the last 10 years has machine translation become an effective tool for wider use. Breakthroughs in natural language processing, artificial intelligence, and mathematics have contributed to the creation of increasingly useful technologies in this field.

Machine translation (MT) is the process of automatically translating text from one language to another without any human intervention. Since the 1950s, machine translation has been considered one of the first tasks faced by computers. Unfortunately, the complexity of the task turned out to be much greater than initial calculations suggested, requiring enormous processing power far beyond the capabilities of early computers. Only in the early 2000s did software, data, and the necessary hardware become capable of performing basic machine translation. The developers of the early machine translation programs used statistical databases of languages to “teaching” computers to translate text. Training these machines required a significant amount of manual labor. For each newly added language, the work had to start from collecting statistical data, which demanded a lot of time, effort, and financial resources[4].

METHODOLOGY

The most common types of machine translation are:

1. Rule-based MT: The oldest form of MT, which has several major drawbacks, including requiring extensive human post-editing, the need to manually add languages, and generally low quality. It is used in very simple situations where quick understanding is required.

2. **Statistical MT:** Builds a statistical model of the relationships between words, phrases, and sentences in a text. To translate these elements into a new language, a statistical model must also be built for the second language. It improves upon rule-based MT. Common techniques in statistical MT include sentence-based models and N-gram language models.

Statistical Machine Translation (SMT) is an older approach that relies on statistical models to translate text from one language to another. Here are some key concepts of SMT:

- *Parallel corpus:* SMT relies on parallel corpora, which are collections of texts in two or more languages that are translations of each other. These corpora are used to train statistical models.

- *Phrase-based models:* One of the core architectures of SMT is the phrase-based model. In this model, sentences are broken into smaller units called phrases, which are translated independently. The model learns the translation probabilities for each phrase pair from the parallel corpus.

- *Language models:* In addition to translation probabilities, SMT systems use language models to assess the likelihood of producing a sequence of words in the target language, improving the fluency of translations.

- *Alignment model:* SMT systems also include alignment models to learn the correspondences between words or phrases in the source and target languages. This helps determine which parts of the source text correspond to parts of the target text.

- *Decoding:* During the translation process, SMT systems use a decoding algorithm to search for the most likely translation of the input sentence based on the trained models. This involves exploring different translation options and selecting the one with the highest overall probability according to the translation and language models.

Although SMT was widely used and achieved significant success, it has several limitations. For example, SMT systems struggle with translating phrases, handling word order differences between languages, and producing fluent and natural translations, especially for languages with complex syntax or morphology.

Overall, while SMT has mostly been replaced by neural machine translation (NMT) due to its ability to produce higher-quality translations in recent years, it remains relevant in certain scenarios, particularly for language pairs with limited resources or specific domain requirements

3. Neural Machine Translation (NMT): The NMT model uses artificial intelligence to learn languages and continuously improve its knowledge, similar to neural networks in the human brain. These programs are more accurate, easier to add new languages to, and operate faster after being trained. NMT is the latest approach that uses artificial neural networks to directly translate text. It typically employs an end-to-end model that uses recurrent neural networks (RNN), convolutional neural networks (CNN), or transformers. NMT models can learn complex relationships between the source and target languages, leading to smoother and more accurate translations compared to SMT [6].

NMT has gained significant attention and popularity due to its ability to produce much smoother and more accurate translations than traditional methods like SMT. Some key aspects of NMT are:

- *End-to-End Learning:* Unlike SMT, which involves several stages such as phrase-based translation and language modeling, NMT learns the mapping from the source language to the target language directly in an end-to-end fashion. This means the entire translation process is covered within a single neural network model.

- *Recurrent Neural Networks (RNN):* Early NMT models often used RNNs, particularly long short-term memory (LSTM) networks, as the core architecture. RNNs are well-suited for sequential data like language because of their ability to capture temporal dependencies.

- *Attention Mechanism:* One of the key innovations in NMT is the attention mechanism, which allows the model to focus on different parts of the source sentence when generating each word in the target sentence. This helps alleviate the problem of long-term dependencies and allows the model to handle longer sentences more effectively.

- *Transformer Architecture:* The transformer architecture has become the dominant architecture in NMT. Transformers use self-attention mechanisms to capture global dependencies within input sentences, enabling parallelization and improving performance on long sequences. They have largely replaced RNN-based models due to their superior performance and efficiency.

NMT models can be trained to translate between multiple language pairs at once, making them versatile and resource-efficient. Additionally, some NMT models support zero-shot translation, where the model can translate between language pairs it has never explicitly learned by leveraging its multilingual capabilities and transferring knowledge.

NMT offers several advantages over traditional SMT, including better fluency, improved accuracy, and the ability to capture long-distance dependencies and context more effectively. Moreover, it requires less manual feature engineering and can be trained in an end-to-end manner using parallel corpora. Overall, NMT represents significant advancements in machine translation technology and has become the dominant approach in the field, offering state-of-the-art performance across a wide range of language pairs and domains.

4. Attention Mechanisms: Attention mechanisms are often integrated into NMT architectures, allowing the model to focus on relevant parts of the input sentence during translation.

5. Transformer Models: Transformers, introduced in the paper "Attention is All You Need" have become the core of machine translation [8]. They use self-attention mechanisms to assess the importance of different words in a sentence, enabling parallelization and capturing long-term dependencies. Models like BERT (Bidirectional Encoder Representations from Transformers) and GPT (Generative Pre-trained Transformer) have been adapted for machine translation tasks [8,10].

6. Transfer Learning: Transfer learning involves pre-training models on large datasets and then fine-tuning them for specific translation tasks. Models such as BERT and GPT, initially designed for tasks like natural language understanding and generation, can be fine-tuned on bilingual data to be adapted for translation. Transfer learning allows a model trained on one task to be reused or adapted as a starting point for training on a second related task. In natural language processing (NLP) and machine translation, transfer learning has shown promising results. Key points regarding transfer learning for machine translation include:

- *Pre-trained Language Models:* Transfer learning in NLP often involves using pre-trained language models as starting points for fine-tuning specific tasks. These models, like BERT, GPT, etc., are trained on large datasets and learn contextual representations of language.

- *Fine-Tuning for Translation:* In machine translation, pre-trained language models can be fine-tuned on bilingual data to adapt them for translation tasks. This fine-tuning process involves updating model parameters based on translation-specific data while retaining the knowledge gained during pre-training.

- *Adapting Encoder-Decoder Models:* Transfer learning can also be applied to encoder-decoder architectures frequently used in machine translation. In this approach, an encoder-decoder model, such as a transformer like BERT or GPT, is pre-trained and then fine-tuned on parallel corpora for translation tasks.

Transfer learning provides several advantages for machine translation tasks, such as utilizing large amounts of data and computational resources for pre-training, leading to better initialization and faster convergence during fine-tuning. Additionally, pre-trained language models capture general linguistic knowledge that can be useful for translation tasks, even for low-resource language pairs. Transfer learning is particularly helpful for domain adaptation in machine translation. For instance, a model pre-trained on general text data can be fine-tuned on domain-specific data (e.g., medical, legal, or technical texts) to improve translation quality in specialized domains where training data might be limited.

- *Multi-task Learning*: Transfer learning can also be combined with multi-task learning, where a model is trained on several related tasks simultaneously. In machine translation, this approach might involve jointly training a model on translation tasks for multiple language pairs or on other related tasks, such as language modeling or document summarization. Despite its benefits, transfer learning for machine translation faces challenges such as domain mismatch between pre-training data and the target translation task. Additionally, fine-tuning pre-trained models for translation tasks requires careful selection of hyperparameters and training strategies to ensure optimal performance.

7. Reinforcement Learning: Reinforce-ment learning methods can be applied to machine translation to optimize translation quality. In reinforcement learning-based approaches, the translation model interacts with the environment (e.g., human evaluators) and receives feedback on its translations, which it uses to improve over time[12].

8. Unsupervised Machine Translation: Unsupervised machine translation aims to translate between languages without requiring parallel corpora. Methods such as adversarial training and back-translation have been proposed to train translation models using only monolingual data in each language [11].

9. Hybrid Approaches: Hybrid approaches combine different methods, such as statistical and neural machine translation, to leverage their strengths. For example, hybrid models may use neural networks to translate while incorporating linguistic knowledge or rules from statistical models. These methods are continuously evolving through ongoing research, with new approaches emerging to further improve the quality and efficiency of machine translation systems [9].

Machine translation technology developers like Google, Microsoft, and Amazon currently favor neural MT methods as their preferred approach. This is because neural MT provides more accurate translations and allows for the continuous addition of new language pairs. Such capabilities enhance the potential of machine translation systems developed using neural networks [7].

DATASET PREPARATION

In developing machine translation systems based on artificial intelligence algorithms, we have seen from the previous sections that machine learning models are widely and effectively utilized. Therefore, creating machine learning models for machine translation into Uzbek is essential. The very first step in creating these models is to develop a training dataset. In our case, this is referred to as a bilingual parallel corpus.

A parallel corpus is a collection of texts or documents in two or more languages aligned at the sentence or phrase level. These aligned texts allow linguists, translators, and researchers to compare and analyze language use across different languages. Parallel corpora are invaluable resources for various natural language processing tasks, such as machine translation, bilingual dictionary creation, cross-lingual information retrieval, and language learning. They help in training and evaluating algorithms and models dealing with multilingual text processing.

For the purpose of this research, we have chosen to focus on machine translation between Uzbek and English. Therefore, we need to develop the parallel corpus within these two languages. Below is a sample of a small portion of the parallel corpus (Table 1).

TABLE I. examples of parallel corpus

№	Uzbek	English
1	Maning ismim Mubina.	My name is Mubina.
2	Men 20 yoshdaman.	I am 20 year old.
3	Men sun'iy intellekt sohasiga qiziqaman.	I am interested in the field of artificial intelligence.
4	Men metamatika, fizika va tabiiy fanlarini yaxshi ko'raman.	I like mathematics, physics and natural sciences.
...	....	...

From the above table, it is evident that for machine translation from Uzbek to English at the sentence level, we need to compile a parallel corpus of complete sentences written in Uzbek and their corresponding English texts. We also need to consider punctuation marks, and the use of uppercase and lowercase letters, as the case of a word can completely alter the meaning of a sentence. Additionally, the placement of punctuation marks can affect the content of the sentence.

In our research, we aim to perform machine translation for the Uzbek language using fine-tuning of the Transformer-based mT5 (Multilingual Text-To-Text Transfer Transformer) model. This model necessitates the creation of a large parallel corpus. Below, we discuss the steps involved in creating a parallel corpus for training the model to develop an Uzbek-English machine translation system:

Using Open-Source Parallel Corpora

Our analysis during the research has shown that there are no extensive, cleaned, and prepared parallel corpora specifically for Uzbek-English translation. However, we can find Uzbek-English parallel corpora on the OPUS platform[15]. Searching for Uzbek-English pairs on this platform reveals several available sources. Among the found sources, the NLBB (No Language Left Behind) database contains many pairs. This dataset is based on metadata extracted from bitexts by Meta AI. Additionally, we can observe a large amount of data in the Uzbek-English pair in the Wikipedia translations and the translation system developed by the Wikimedia Foundation.

Upon examining these two sources, it was determined that the NLBB primarily covers texts related to religious topics. Therefore, using this source alone may not be sufficient for comprehensive machine translation. Overall, approximately 2 million data points were obtained from the OPUS platform.

Creating a Parallel Corpus through Synthesis

Today, popular machine translation systems such as Google Translate, Yandex Translate, and other sources are performing Uzbek-English translation in a manner close to human translation. Therefore, we can use the capabilities of these systems to create parallel corpora. Since our research aims to develop a system that works similarly to Google's, we are also focused on creating useful parallel corpora. To achieve this, we translated Uzbek text data from various sources into English using Google Translate. Based on this approach, we have created approximately 1 million Uzbek-English text pairs.

Synchronizing Uzbek and English Texts

This approach is also effective for creating parallel corpora and aims to reduce manual labor. The steps involved in implementing this approach are as follows:

Step 1: Collect texts that have translations in both languages (Uzbek and English).

Step 2: Divide the texts in both languages into smaller segments based on punctuation marks.

Step 3: Translate the Uzbek texts (sentences) into English using Google Translate (even if an English translation already exists) and ensure they match with the Uzbek text.

Step 4: Evaluate the matching of sentences in English using ready-made solutions to determine their similarity.

Step 5: In pairs identified as similar in English, replace the English translation with the Uzbek translation.

Step 6: Add the Uzbek-English pairs to the parallel corpus.

During the research process using this approach, we synchronized texts published on official Uzbek websites. We collected approximately 30,000 texts in total.

Creating an Uzbek-English Parallel Corpus Manually

Since the beginning of the research work, approximately 20,000 Uzbek texts have been translated into English using systematic manual labor over the course of two years.

As a result of all the above methods, a parallel corpus with the following characteristics has been formed:

TABLE II. Characteristics of the Formed Uzbek-English Parallel Corpus

Source	Raws	Sentences	Tokens
Open Sources	1 980 450	1 964 140	15 814 120
Synthesized	1 054 121	1 038 425	8 409 800
Synchronized	30 542	30 424	283 392
Manually Collected	20 130	19 880	185 940
Total	**3 085 243**	**3 052 869**	**24 693 252**

We performed the training, validation, and testing of neural network models based on the collected parallel corpus according to the proportions shown in the following table.

TABLE III Distribution of the Training Data Set

	Total	Training	Validation	Testing
Raws	3 085 243	2 711 462	342 540	31 241
Sentences	3 052 869	2 682 347	339 541	30 981
Tokens	24 693 252	21 673 422	2 781 420	238 410

EVALUATION METRICS

Machine translation is the process of automatically translating texts from one language to another. This translation system assists in automatic translation for many texts. Evaluating created machine translation systems is crucial. Evaluation of translation models includes assessing their performance, translation quality, fluency, and adequacy. There are several common methods for evaluating machine translation models:

- ***Human Evaluation:*** Human evaluation involves experts assessing the quality of machine-translated texts according to predefined criteria such as fluency, adequacy, and overall accuracy. Human evaluation is considered the gold standard for assessing translation quality but can require significant time and resources.

- ***Automatic Evaluation Metrics:*** These provide a way to evaluate system accuracy based on specific values without human intervention. For example, if we consider an evaluation metric within a range of 0 to 1, 0 represents a very poor translation, and 1 represents a perfect translation. By determining the system's overall score within this range, we can infer conclusions about existing or newly created systems. Below are several types of automatic evaluation metrics:

- *BLEU (Bilingual Evaluation Understudy):* BLEU is one of the most widely used automatic evaluation metrics for machine translation. It measures the similarity between the candidate translation and one or more reference translations using N-gram precision.

- *N-gram Precision:* BLEU measures the precision of N-grams (sequences of N tokens) in the candidate translation compared to the reference translations. It considers N-grams of various lengths, typically ranging from Unigrams (single words) to Fourgrams (sequences of four words). Higher precision scores indicate that more N-grams in the candidate translation match those in the reference translations [1].

BLEU scores range from 0 to 1, with higher scores indicating better translation quality. A BLEU score of 1 represents perfect translation quality, where the candidate translation matches the reference translation exactly in terms of N-gram precision. However, BLEU has some limitations: it relies solely on N-gram precision and may not cover all aspects of translation quality, such as fluency, grammaticality, and semantic accuracy. It can also be sensitive to factors such as sentence length and vocabulary mismatch that may affect the accuracy of the evaluation. Therefore, BLEU is often used in conjunction with other evaluation metrics and methods for a more comprehensive assessment of translation quality.

$$BLUE = BP * exp(\sum_{n=1}^{N} \frac{1}{N} log(p_n)) \quad (1)$$

In this context, p_n represents the precision of N-grams. It is calculated based on the formula provided below (3). N denotes the maximum length of N-grams (usually N=4), and BP stands for Brevity Penalty. In some cases, the translation result might be longer than the target output. BP is computed using the formula below (2):

$$BP = \begin{cases} 1, \text{ агар } c > r \\ \exp(1 - \frac{r}{c}), \text{ агар } c \leq c \end{cases} \quad (2)$$

In this context, c represents the length of the candidate output, and r denotes the length of the reference output.

$$p_n = \frac{C_n}{C_m} \quad (3)$$

In this context, C_n represents the number of N-grams in the candidate translation that appear in the reference translation, and C_m denotes the number of N-grams created in the reference translation.

- *ROUGE (Recall-Oriented Understudy for Gisting Evaluation):* ROUGE is primarily used for evaluating summaries generated by machines, but it can also be adapted for evaluating machine translation by comparing similarity at the word or N-gram level between the candidate and reference translations. ROUGE is based on calculating the similarity measures between the generated candidate text and the reference translation. In its original presentation, ROUGE focused more on recall compared to BLEU, which is more precision-oriented. Nowadays, ROUGE is typically assessed using the F1-score, which considers similarity. ROUGE measures various metrics including N-gram similarity, word matching, and the longest common subsequence (LCS) to evaluate the similarity between system-generated summaries and reference summaries [3].

- *N-gram Similarity:* ROUGE-N measures the similarity of N-grams (sequences of N words) between the system-generated summary and the reference summary. It usually calculates precision, recall, and F1-score for various values of N from 1 to 4. ROUGE-N assesses how well the system-generated summary captures the key content and phrases present in the reference translation.

- *Word Similarity:* ROUGE-W measures the word matching between the system-generated summary and the reference summary. It considers all matching words between texts regardless of their order to determine semantic similarity. Compared to ROUGE-N, which focuses on N-grams, ROUGE-W provides a more holistic view of similarity between texts.

- *Longest Common Subsequence (LCS):* ROUGE-L identifies the longest sequence of words that appears in both the system-generated and reference translations. It allows for changes in word order and sentence structure. ROUGE-L is particularly useful for evaluating fluency and coherence because it accounts for overall structural similarity rather than exact word matching.

- *F1-Score:* For each ROUGE metric (ROUGE-N, ROUGE-W, ROUGE-L), the F1-score is computed as the harmonic mean of precision and recall. The F1-score provides a single metric that balances precision (the proportion of system-generated content that matches the reference) and recall (the proportion of reference content covered by the system-generated summary). Overall, ROUGE metrics offer a valuable tool for quantitatively assessing the similarity between system-generated and reference texts, thereby evaluating the effectiveness of automatic summarization systems and other natural language processing tasks.

$$f1-score = \frac{precision}{recall} = \frac{\frac{c_n}{c_m} * \frac{c_w}{c_a}}{\frac{c_n}{c_m} + \frac{c_w}{c_a}} \qquad (4)$$

In this context, C_w is the number of words in the candidate translation that appear in the reference translation. C_a is the total number of words in the reference translation. C_n is the number of N-grams in the candidate translation that appear in the reference translation. C_m is the number of N-grams created in the reference translation.

- *TER (Translation Edit Rate):* TER measures the number of edits (insertions, deletions, substitutions) required to transform the candidate translation into the reference translation. It provides a more accurate assessment of translation quality compared to BLEU. The TER metric calculates the number of editing operations needed to convert the machine-translated text (MT) into the reference text (REF).

- *METEOR (Metric for Evaluation of Translation with Explicit Ordering):* METEOR is a metric that evaluates various aspects of translation quality, including exact word matching, unigram and bigram precision, and optionally, synonymy and word order. METEOR provides a systematic approach to assessing machine translation quality by considering unigram and optionally bigram matches, as well as stemming and synonym matching. The algorithm can be adjusted based on specific requirements or considerations for different translation tasks or languages[5].

In conclusion, relying on only one of the discussed evaluation metrics may not be sufficient for a comprehensive assessment. Therefore, it is advisable to evaluate machine translation models using multiple metrics.

MAIN PART

The Transformer is a deep learning model first proposed in 2017. It employs a "self-attention" mechanism, which improves performance in neural machine translation (NMT) applications and accelerates the training process for natural language processing (NLP) tasks compared to traditional recurrent neural network (RNN) models[8,10].

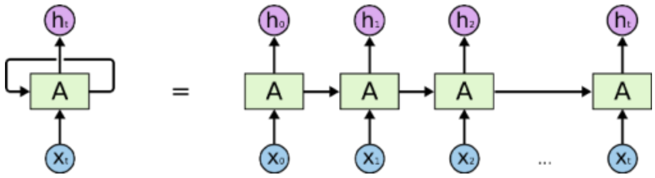

Fig. 1. Recurrent Neural Network

Neural networks, particularly RNNs, were once the leading approach for tasks like language understanding and machine translation. RNNs can handle inputs of varying lengths, from a single word to an entire document, making them well-suited for natural language modeling. However, because RNNs generate hidden state vectors through iterative computations, they treat all tokens in a sequence uniformly, which limits their application.

The Transformer model, like RNNs, is designed for processing sequential input data for natural language tasks such as translation. In contrast to RNNs, the Transformer does not handle input data in a sequential manner Instead, it uses a self-attention mechanism (as shown in Figure 2) to determine the context that gives meaning to each position in the input sequence. This allows for greater parallelization compared to RNN models and reduces training time.

The Transformer primarily consists of self-attention, an encoder-decoder architecture, and a feed-forward neural network (FFNN), as illustrated in the following figure.

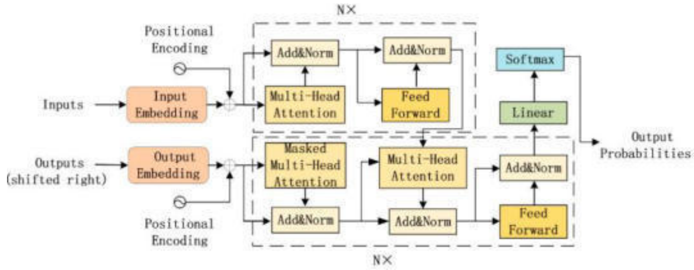

Fig. 2.Model of Transformer

Training the Transformer model based on the principle of fine-tuning

In many models based on the Transformer architecture, initial text processing for natural language processing tasks is performed through tokenization. Tokenization refers to the process of vectorizing incoming texts. After creating the dataset, the data must be preprocessed before inputting it into the model. A crucial step in this preprocessing phase is vectorization, which involves converting raw text (sequences of words) into a format suitable for machine learning algorithms. Vectorization maps each token in the text to its corresponding index in a vocabulary, allowing the model to process textual data as numeric input.

There are various approaches to creating vocabularies for tokenization, each with its own advantages. According to the Hugging Face guidelines and other sources, these methods usually involve character-level, word-level, and subword tokenization. In our study, we opted for subword tokenization due to its effectiveness when dealing with languages like Uzbek that are morphologically complex.

During our investigation of pre-trained multilingual tokenizers on the Hugging Face platform, we discovered that certain ones already have Uzbek language support. Yet, we faced an obstacle: when used on Uzbek language text, these tokenizing tools produce lengthy subword units, possibly due to the lack of sufficient training data in Uzbek language. In order to address this restriction, we created a specialized tokenizer designed for the specific characteristics of the Uzbek language. We selected the T5Tokenizer for our tokenization models, which utilizes whitespace-based tokenization. Establishing the tokenizer required developing a customized vocabulary file specific to the target language. We created a “vocab.json” document containing 50,000 tokens in our situation using SentencePieceTrainer [14]. Furthermore, special tokens like "PAD", "UNK", "CLS", and "SEP" were added to tackle specific situations that arise during tokenization.

While developing our customized tokenizer, we incorporated the popular unigram model, commonly employed in subword tokenization projects. This model successfully captured the intricate features of Uzbek language words, resulting in improved tokenization accuracy and efficiency.

In the process of creating our custom tokenizer, we utilized the unigram model, a widely used statistical model in subword tokenization tasks. This model proved effective in capturing the complex characteristics of Uzbek language lexemes, providing more accurate and efficient tokenization.

TABLE IV example of vectorization using tokenization

Input text	*“Insonlar kitoblarsiz bugungi faravon kunga yetib kelishmas edi.”*
Tokens	*[‘_Inson, ‘lar, ‘_kitoblar, ‘siz, ‘_bugungi, ‘_faravon, ‘_kunga, ‘_yetib, ‘_kelish, ‘mas, ‘_edi, ‘.’, ‘</s>’]*
Token ID	*[7940, 47, 4006, 303, 2453, 41441, 10974, 3517, 5383, 6325, 69, 6, 50100]*

Fine-Tuning Settings for the Model

In our work, we performed fine-tuning of the pre-trained mT5 model. We retrained the model using a dataset created for Uzbek-English language pairs, making specific adjustments to the settings in our experiments.

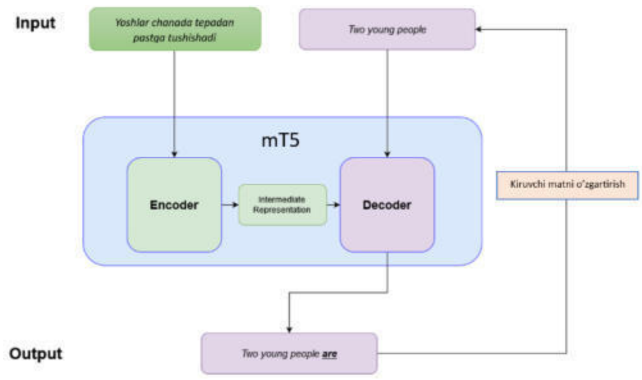

Fig. 3.Implementation of machine translation through mT5 model

RESULTS

During the fine-tuning process, several basic settings were used to optimize the learning process. These settings include a word sequence length of 50, a set size of 128, a learning rate of 2e-4, and a weight drop of 0.02. In addition, the training scheme covered ten epochs to ensure comprehensive improvement of the model. For the purpose of optimization, the Adafactor [13] optimizer was used, characterized by a learning rate of 5e-4, an optimizer beta of 0.9 and 0.999, and an epsilon (eps) value of 2e-05. We used the computing power of an NVIDIA V100S - 32 GB GPU to train the model. The use of GPUs facilitated efficient model training and inference processes.

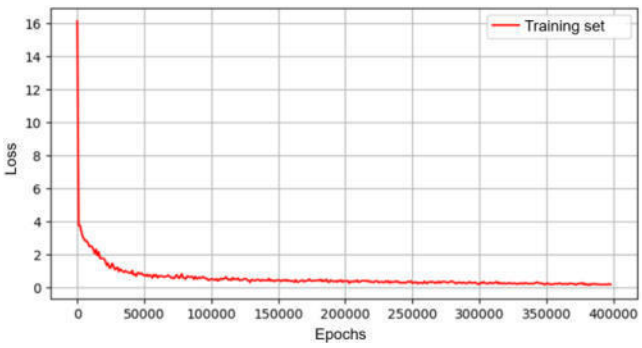

Fig. 3.Loss error reduction graph in training steps

Training the model took approximately 6 hours per epoch, totaling around 60 hours. We evaluated the training results using the BLEU metric. The average BLEU (4-gram) scores for the training, validation, and testing datasets can be seen in the following table.

TABLE V BLEU evaluation indicators of the models

Models	Training	Validation	Testing
Base model	0.04	0.03	0.01
Fine-tuned model	0.29	0.27	0.22
Google translater	0.37	0.36	0.34

Looking at the above Table V, we can see that as a result of retraining the model with fine-tuning, the BLEU (4-gram) score on the test set is 0.22. We will analyze the results of the trained model through several examples.

TABLE VI examples of machine translation model translations

№	Uzbek text	English translation	Orginal translation	BLEU (1-gram) / 4-gram
1	Haftaning juma kunida katta bayram bo'ladi	There will be a big holiday on Friday of the week	There will be a big holiday on Friday	0.69 / 0.69
2	Men talabaman	I am student	I am a student	0.72 / 0.00
3	Ob-hova issiq va shamolli.	It's hot and windy .	It is hot and windy	0.60 / 0.00
4	Bu juda yaxshi	It's very good	This is very good	0.48 / 0.00
5	Isming nima?	What is your name	What is your name ?	0.80 / 0.20
Overall				**0.66 / 0.18**

CONCLUSION

In this study, the results of research conducted using transformer models such as mT5-base and fine-tuned mT5 for machine translation in Uzbek-English languages show that the BLEU evaluation score was 0.29 for the training set and 0.22 for the test set. These results are close to those achieved through Google Translate. This became evident from the research conducted.

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THE ROLE OF ARTIFICIAL INTELLECT IN THE STATISTICAL ANALYSIS OF THE INNOVATIVE DEVELOPMENT OF SMALL BUSINESS AND PRIVATE ENTREPRENEURSHIP

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Abstract **based on the results of a cluster analysis of the structural regions of the region corresponding to the role of small business and private entrepreneurship in the main sectors of the economy, the share of agricultural products in their products, the total number of production indicators of small business and private entrepreneurship in the region, the number of small business and private business entities, the agricultural sector has a special character.**

Small business and private entrepreneurship are distinguished not only by a high share in the network, but also by a strong influence on employment, production efficiency. This justifies the need for greater attention to structural changes in production in the development of small business and private entrepreneurial activities in the general area.

Keywords: Small business, private entrepreneurship, cluster analysis, industry, trade.

Introduction. The importance of small business and private entrepreneurship in the development of the world's economies can be expressed in a number of indicators. It also has such features that it can become one of the main factors in the development of economic sectors. Small business and private entrepreneurship as a special type of entrepreneurship are an effective device for solving employment problems, a motive that activates the retail network. In small business, it is required that positions occupy a central place against the background of a market economy. Small business and private entrepreneurship set in motion the mechanism of development of the market economy, enhance its elasticity. Creates means to improve the quality of life of the country's population, the possibility of concentrating financial and production resources. In the trading system, monopoly serves to give companies a tangible healthy competitive environment, and is assessed as an important factor in building territorial economic potential.

Method. The fact that developed countries, as the main factor in increasing their economic potential, are pursuing policies to improve such labor market parameters as the share of the employed population in economic sectors, a change in the ratio of household income to expenses related to meeting needs, and a decrease in the unemployment rate. Professors of the University of Piraeus M.Xletsos, A. In empirical studies of the effectiveness of the International Monetary Fund program to reduce unemployment through the development of various forms of entrepreneurship, it is noted that reforms such as labor market regulation, liberalization of trade and investment accounting are essentially carried out in accordance with trends in the development of small businesses and entrepreneurship.

The unemployment rate in our country is growing continuously in the last 20 years. In the Republic, in 2021, this figure increased by 9.2% compared to 2000, with a figure of 9.6%. In kashkadarya region, this difference is 6.7%. It can be seen that the increase in the unemployment rate in our country is one of the most important issues that need to be addressed in the system of the national economy. Small business and private entrepreneurship are of great importance in the development trend of the Employment Index, and today 74.4 percent of the population occupied in our country corresponds precisely to small business and private entrepreneurship (Table 1).

Table 1. Employment indicators of small business and private entrepreneurship in the Republic of Uzbekistan and the Kashkadarya region[2]

Years	In the Republic Of Uzbekistan				In the Kashkadarya region			
	1	2	3	4	1	2	3	4
2010	8643,9	74,3	103,3	100,5	726,6	74,8	105,3	101,2
2011	8950,7	75,1	103,5	101,1	764,1	76,1	105,2	101,8
2012	9239,7	75,6	103,2	100,7	797,9	77,0	104,4	101,1
2013	9604,0	76,7	103,9	101,5	835,7	77,9	104,7	101,2
2014	9950,8	77,6	103,6	101,2	872,6	78,7	104,4	101,0
2015	10170,4	77,9	102,2	100,4	910,0	79,6	104,3	101,1
2016	10397,5	78,2	102,2	100,4	943,9	79,9	103,7	100,4
2017	10541,5	78,0	101,4	99,7	973,9	80,0	103,2	100,1
2018	10128,8	76,3	96,1	97,8	965,8	79,0	99,2	98,8
2019	10318,9	76,2	101,9	99,9	959,4	78,6	99,3	99,5

2020	9865,7	74,5	95,6	97,8	921,2	77,6	96,0	98,7
2021	10070,7	74,4	102,1	99,8	930,0	77,3	101,0	99,6
Growth in 2021 compared to 2010 (%)	**116,5**	**100,1**	**-**	**-**	**128,0**	**103,3**	**-**	**-**
Average growth rate (%)	**-**	**-**	**101,5**	**100,1**	**-**	**-**	**102,5**	**100,4**

Here: 1 – the number of items at small business and private entrepreneurship, thousand people, 2 - the share of items at small business and private entrepreneurship in total employment, in percentage, 3 - the growth rate of the number of items at small business and private entrepreneurship, in percentage, 4-the growth rate of the share of items at small business and private entrepreneurship in total employment, in percentage.

According to statistics, in the Republic of Uzbekistan in 2021, the number of items in small business and private entrepreneurship increased by 10070.7 thousand people to 1426.8 thousand people. That is, the average growth rate is 1.5 percent, increasing by 16.5 percent compared to 2010. In kashkadarya region, in 2021, the number of items in small business and private entrepreneurship increased by 930 thousand people to 203.4 thousand people. The average growth rate is 2.5 percent, an increase of 28.0 percent over 2010. Small business and private entrepreneurship have an uneven tendency to change the regional share in relation to the Republic in terms of the number of items (figure 1).

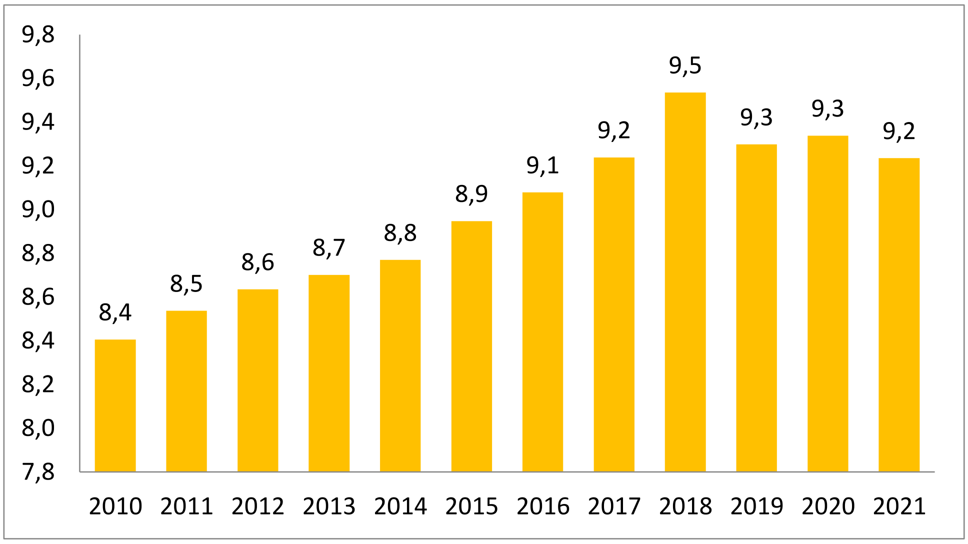

Figure 1. Share of Qashqadar region in the Republic by the number of items in small business and private entrepreneurship, in percentage

It can be seen that in 2021, compared to 2010, the share of the province in relation to the Republic increased by 0.8 percent. The highest increase was observed in 2018, at 9.5 percent.

From statistics, it can be seen that the proportion of items in small business and private entrepreneurship in total employment increased by 0.1% in the respondents compared to 2010 in 2021, and by 3.3% in the province. The average growth rate, respectively, is 0.1 percent and 0.4 percent in the last 12 years. The growth rate has a high ratio in the Kashkadarya region.

Results: In total employment small business and private entrepreneurship in terms of the share of items in the Republic, the variational width is 3.9, which means that a relatively stable state of the value is observed. In the province, the variational width is 5.2, which means that the fluctuations are relatively strong (table 2.2). The fact that the variational latitude in terms of the growth rate of the share of items in small business and private entrepreneurship in the region is small (3.7<3.1) compared to the Republic means that this indicator has a stable pace of change (table 2).

Table 2. Statistical analysis of employment contribution of small business and private entrepreneurship in the Republic of Uzbekistan and Kashkadarya region

Statistical indicators	**The share of small business and private entrepreneurship in total employment**		**The growth rate of the share of employees in small businesses and private entrepreneurship**	
	In the republic	**in the Kashkadarya region**	**In the republic**	**in the Kashkadarya region**
MAX (maximum value)	78,2	80	101,5	101,8
MIN (minimum value)	74,3	74,8	97,8	98,7
VW(variation interval)	3,9	5,2	3,7	3,1
The square	23,7	27,5	15,7	11,6

deviation				
Variance estimate	2,2	2,5	1,4	1,1
Relative change in recent observations (2021/2020)	-0,1	-0,3	2	0,9

Based on the results of the above analysis, we believe that in relation to the Republic in the region, the growth rate of the dynamics of change in the number of items in small business and private entrepreneurship is high, in order to clarify this trend to the source of supply, it is advisable to conduct a statistical analysis on the size of the main indicators of small.

It is known that the Republic is one of the sectors of the economy with a significant contribution to the structure of the gross domestic product – this is the industrial sector. Statistics confirm that small business and private entrepreneurship have a worthy role in the industry. In particular, since the volume of industrial products in 2021 amounted to 456056.1 billion soums in the Republic, the contribution of small business and private entrepreneurship in it is equal to 121719.2 billion soums. This represents a 27.0 percent share. Also in 2021, the growth rate of the volume of production of industrial products corresponding to small business and private entrepreneurship in the Republic was 184.8 percent compared to 2010, with an increase in production by 84.8 percent (table 3).

Table 3.Indicators of small business and private entrepreneurship in the industrial sector in the Republic of Uzbekistan and the Kashkadarya region

Years	**In the Republic Of Uzbekistan**				**In the Kashkadarya region**			
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**
2010	38119,0	10132,90	26,6	148,6	4957,5	1441,2	29,1	132,1
2011	47587,1	13586,80	28,6	107,5	5043,6	806,5	16,0	55,0
2012	57552,5	17114,60	29,7	103,8	6076,4	955,3	15,7	98,3
2013	70634,8	23312,00	33,0	111,1	6849,4	1501,8	21,9	139,5
2014	84011,6	30907,00	36,8	111,5	7194,7	1754,2	24,4	111,2
2015	97598,2	39643,50	40,6	110,3	8721,9	2187,0	25,1	102,8
2016	111869,4	50654,50	45,3	111,6	9632,2	2596,2	27,0	107,5
2017	148816,0	61367,80	41,2	90,9	7351,2	2526,2	23,1	85,6
2018	235340,7	87962,00	37,4	90,8	9992,0	3191,6	22,0	95,3
2019	322535,8	83344,20	25,8	69,0	12562,6	4062,2	20,0	90,7
2020	368740,2	103020,78	27,9	108,3	14612,3	4562,9	34,6	173,4
2021	456056,1	121719,22	27,0	96,6	18771,9	4922,7	27,3	78,9
Growth in 2021 compared to 2010 (%)	**184,9**	**184,8**	**-**	**-**	**129,2**	**129,2**	**-**	**-**
Average growth rate (%)	**-**	**-**	**-**	**103,5**	**-**	**-**	**-**	**101,8**

Here: 1-volume of industrial products, billion soums, 2 – the volume of industrial products produced by small business and private entrepreneurship, billion soums, 3 - the share of small business and private entrepreneurship in the volume of industrial products, in percentage, 4-the growth rate of the share of small business and private entrepreneurship in the volume of industrial products, in percentage.

Discussion: In the kashkadarya region, the figures were 18,771.9 crore in 2021. the contribution of small business and private entrepreneurship in it is 4922.7 billion soums and this is 27.3 percent share. Also, in 2021, the growth rate of the volume of production of industrial products corresponding to small business and private entrepreneurship in the region was 129.2% compared to 2010, with an increase in production by 29.2%. The reason for the big difference here is that in 2010 the share of the province was 13%, and in 2021-9.1%. In the region, there is a continuous decline in the last 12 years. The average growth rate of the share of small business and private enterprise in the volume of industrial products in 2010-2021 is 3.5% in the Republic, 1.8% in the province, there is a difference of almost 2 times. There is no growth in the production of industrial products in the region in the activities of small businesses and private entrepreneurship. One of the main reasons for this is due to the contribution of the main industrial products in the region by large enterprises and societies in the state partnership.

The volume of production in rural, forest and fishing remains directly dependent on the results of small business and private entrepreneurial activities. Indeed, according to statistics, 307,280.2 billion of the volume of rural, forest and fish products produced in the Republic in 2021 corresponds to the result of the activities of small businesses and private entrepreneurs. This is equivalent to a share of 96.9 percent. 29092.1 billion of the volume of rural, forest and fish products in the region, respectively, will generate a 99.5 percent share of small business and private entrepreneurship.

The above figures indicate that small business and private entrepreneurship in our country have become the main subject of this branch of the economy. The difference in the share of small business and private entrepreneurship in the volume of rural, forest and fish products compared to the previous year is equal to -0.04 in the Republic in the average value for 2010-2021, 0.04 in the province, while a slight advantage is felt in the province, this aspect does not matter much. Although the share of the region in the production of agricultural products is assessed at a moderate level, the level of use of labor resources is high, but the effectiveness of the use of investments is not high. This aspect is also observed in the network when comparative research on the scale of the Republic in the activities of small business and private entrepreneurship. The indicator of the use of Natural Resources in the region remains low compared to the Republic. In particular, in terms of the volume of production corresponding to the area of land used in agriculture, this figure is less than 2 times. This gives rise to the non-trivial nature of the relative advantage highlighted above. Given that the share of small business and private entrepreneurial activity in agriculture is much higher than in all sectors, the development of production activities in this network remains relevant.

As you know, today the region has the highest share of the network of services in the structure of YaHM, and the development of the network has a direct and indirect impact on the development of other sectors of the economy.

Statistics the amount of 144812.7 billion soums of the volume of services produced in the Republic in 2021 amounted to the result of the activities of small businesses and private entrepreneurs. This is equivalent to a 51.0 percent share. 9312.9 billion sum of services of 12823.8 billion respectively in the region will generate a 72.6 percent share of small business and private enterprise.

The share change is high in the Kashkadarya region due to the increased nature, and the highest value of this figure for the period 2010-2021 was 63.2% in the Republic, 77.7% in the region. The variational width is 12.2 and 12.9 percent, respectively. The level of fluctuations in the share change is almost close to each other. The Dispersion assessment, on the other hand, is 12.1 and 14.5, which shows that the change in share from statistical indicators in the Republic and the Kashkadarya region has formed a parallel trend. To this yanala clarified that the focus on the level of quadratic deviation is higher in the province, which requires a focus on the growth rate of shares.

Small business and private entrepreneurship of the average growth rate of production in the field of services is 99.2% in the Republic and 9.3% in the province. It can be seen that the production results of small business and private entrepreneurial activity in the network of services in the region are gaining a high share. It will be worthwhile to pay attention to the fact that this factor may be one of the priority factors for the development of small business and private entrepreneurship in the future.

One of the macroeconomic levels used in assessing the economic potential of a country is the assessment of the indicators of the foreign trade system. The development of small business and private entrepreneurship is connected precisely with the foreign trade system. According to statistics, in the Republic of Uzbekistan in 2021, small businesses and private enterprises exported products worth 3711.2 million US dollars. In the province, this figure is 87.0 million US dollars.

Conclusions: Small business and private entrepreneurship in the region have an average share of 2.4 percent in the Republic in terms of exports. Over the last year from 2010 to 2021, the highest figure was observed in 2020, when the percentage was 3.6. At the national level, in 2021, small businesses and private businesses imported products worth 12,389.0 US dollars. The volume of imports in Vilat is 91.8 million US dollars. On average, 1.41% of the volume of imports carried out by small businesses and private entrepreneurship in the republic is accounted for by the region.

Taking into account the volume of exports and imports in 2010-2021 by small businesses and private entrepreneurship in the Republic of Uzbekistan, a negative balance remains. The maximum deviation in terms of export volume, that is, the variation width, is 2932.0 million US dollars. This figure amounts to 120.9 billion US dollars in a province with a surplus completely different from the republican one. Over the past 12 years, the region has seen strong fluctuations in the share of imports in the republic in the volume of exports and imports carried out by small businesses and private entrepreneurship, stability with a tendency to a relative increase in the share of exports.

With a change in the share of exports, the maximum difference between the republican and regional indicators in the amount of 35.8 is in 2020, the minimum difference in the amount of 0.9 is in 2011. The total variance is 45.4 million US dollars with a variation width, which is 1.27 percent more than the maximum value in absolute terms. The share of small business and private entrepreneurship in the export structure in Kashkadarya region amounted to 14.8% in 2010 and 51.6% in 2021. The highest figure -56.3 percent - was registered in 2020, and the smallest -14.8 percent -in 2010(figure 2).

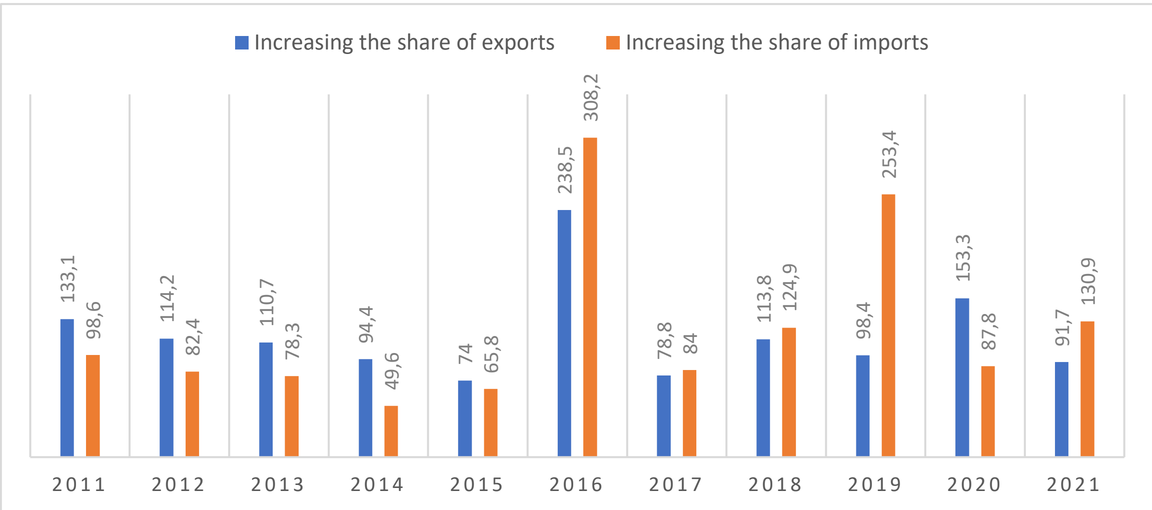

Figure 2. The growth rate of the share of Kbvakht in the export and import structure in the kashkadarya region.

According to the statistical analysis, Kashkadarya region has high rates of employment growth, the share of Kashkadarya region in terms of the number of people employed in small business and private entrepreneurship in the republic is on average 9%, which is the average level by region. It has low indicators in industry by economic sectors and high indicators in the service sector in agriculture. In the region, it is necessary to improve the indicators of the development of small businesses and private entrepreneurship in industry and trade.

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CREATION OF INDUSTRY-ORIENTED INTELLECTUAL INFORMATION SYSTEMS

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Abstract: The development of industry-oriented intellectual information systems (IIS) represents a significant evolution in the integration of intelligent technologies within various industries. These systems leverage artificial intelligence (AI), machine learning, and data analytics to optimize operations, enhance decision-making, and deliver insights specific to industrial needs. This article explores the core principles behind the design and creation of such systems, their role in different industries, and the challenges associated with their implementation. Moreover, it delves into how these systems can be tailored to meet industry-specific demands, offering real-time solutions that drive efficiency, innovation, and competitive advantage.

Keywords: Intellectual Information Systems (IIS), Industry-Oriented Systems, Data Analytics, Artificial Intelligence (AI), Real-time Decision-making

1. Introduction

In the digital age, industries are increasingly adopting advanced technologies to optimize their operations, enhance decision-making, and maintain competitive advantages. Among the most transformative technologies are industry-oriented intellectual information systems (IIS). These systems are designed to address the specific needs of various industries by integrating artificial intelligence (AI), machine learning, data analytics, and the Internet of Things (IoT). By leveraging these intelligent systems, industries are able to automate processes, gather actionable insights from vast datasets, and improve overall efficiency.

Industry-oriented IIS form a vital component of the Industry 4.0 revolution, which focuses on the convergence of digital and physical systems to create smarter, more connected industrial environments. As Kagermann et al. (2013) note, Industry 4.0 aims to enhance manufacturing processes through digital transformation, enabling greater flexibility and efficiency in production. IIS facilitate this by providing industries with the tools necessary to manage real-time data, predict equipment failures, and automate routine operations. For example, AI-driven predictive maintenance systems can reduce operational downtime by identifying potential issues before they result in equipment failure, ultimately lowering maintenance costs and increasing reliability (Porter & Heppelmann, 2015).

Beyond manufacturing, IIS are also transforming other sectors, including healthcare, finance, and energy. In healthcare, for instance, these systems are used to analyze patient data, enabling more accurate diagnoses and personalized treatment plans. Similarly, in the financial sector, IIS are employed to detect fraudulent activities, manage risk, and automate decision-making processes (Manyika et al., 2017). Despite the advantages, implementing IIS poses challenges related to data security, system integration, and workforce development. Addressing these challenges is essential for businesses aiming to fully harness the potential of IIS and remain competitive in a rapidly changing technological landscape.

2. Research and Methodology

The research and methodology employed in this study are designed to investigate the development, implementation, and impact of industry-oriented intellectual information systems across various sectors. This section outlines the theoretical frameworks, data collection methods, and analytical techniques utilized to evaluate the effectiveness and applicability of IIS in real-world industrial settings.

2.1 Theoretical Framework

The theoretical foundation for this research draws on the principles of Industry 4.0 and digital transformation. Kagermann et al. (2013) emphasize that Industry 4.0 is characterized by the integration of cyber-physical systems and intelligent automation in manufacturing and other industries. This framework was used to assess how IIS contribute to operational efficiency, predictive maintenance, and enhanced decision-making through AI and machine learning. Porter and Heppelmann (2015) provide further insights into how smart, connected products are reshaping industries by integrating digital and physical systems. Their research emphasizes that IIS enable real-time monitoring and predictive analytics, helping industries optimize their operations and improve customer engagement. This theoretical framework guided the evaluation of IIS in terms of their ability to enhance process automation and drive innovation.

2.2 Data Collection Methods

The research employed a mixed-methods approach, combining qualitative and quantitative data collection techniques. The primary data was collected through case studies of companies in sectors such as manufacturing, healthcare, finance, and energy. These case studies focused on the adoption of IIS, their operational outcomes, and the challenges encountered during implementation. Data collection involved in-depth interviews with industry experts and managers responsible for overseeing the integration of IIS within their organizations.

Secondary data was gathered from existing literature, including reports, academic journals, and industry publications. This included insights from Davenport and Kirby (2016), who explored the role of AI in transforming business operations, and Ransbotham et al. (2017), who examined the impact of AI on industries such as healthcare and finance. The use of secondary data helped to contextualize the findings within broader industry trends and compare the outcomes observed in different sectors.

2.3 Analytical Techniques

The data collected was analyzed using both qualitative and quantitative techniques. For the qualitative analysis, thematic coding was applied to the interview transcripts, enabling the identification of key themes related to the benefits and challenges of IIS implementation. Themes such as automation, predictive maintenance, and data security were prominent across multiple case studies.

Quantitative data analysis focused on operational metrics such as productivity, cost savings, and downtime reduction. Statistical tools were used to measure the impact of IIS on these metrics, with the goal of quantifying the benefits of IIS implementation in different industries. For example, the research examined how predictive maintenance systems contributed to reducing equipment failures and maintenance costs in manufacturing, as outlined by Porter and Heppelmann (2015). Similarly, in healthcare, the analysis focused on the use of AI to improve diagnostic accuracy and patient outcomes, drawing on data from Ransbotham et al. (2017).

2.4 Case Studies

Case studies were conducted across several industries to illustrate the practical application of IIS. In manufacturing, the implementation of AI-based predictive maintenance systems led to a significant reduction in operational downtime. One case study from the energy sector demonstrated how IoT-enabled systems provided real-time monitoring of energy usage, leading to more efficient energy distribution and lower operational costs. In healthcare, IIS allowed hospitals to leverage AI for patient monitoring and personalized treatment, significantly improving patient outcomes.

These case studies highlighted both the benefits and challenges associated with the implementation of IIS. While businesses experienced improved efficiency and cost reductions, challenges such as data integration, workforce training, and data privacy emerged as significant obstacles to overcome. The research findings underscore the importance of addressing these challenges to ensure the successful deployment of IIS in diverse industrial contexts.

3. Results

The analysis and case studies presented in this research highlight the transformative impact of industry-oriented intellectual information systems (IIS) across various sectors, including manufacturing, healthcare, finance, and energy. By integrating advanced technologies such as artificial intelligence (AI), machine learning (ML), big data analytics, and the Internet of Things (IoT), these systems have demonstrated significant improvements in operational efficiency, decision-making, and customer satisfaction.

3.1. Improved Operational Efficiency

One of the primary outcomes of implementing IIS has been the significant improvement in operational efficiency across industries. In manufacturing, AI-based predictive maintenance systems have led to a 30-50% reduction in equipment downtime by detecting faults early and scheduling maintenance proactively. These systems analyze real-time data from IoT sensors to predict equipment failures, preventing unexpected breakdowns and costly repairs. As a result, companies have experienced a 20% reduction in maintenance costs, along with increased equipment lifespan.

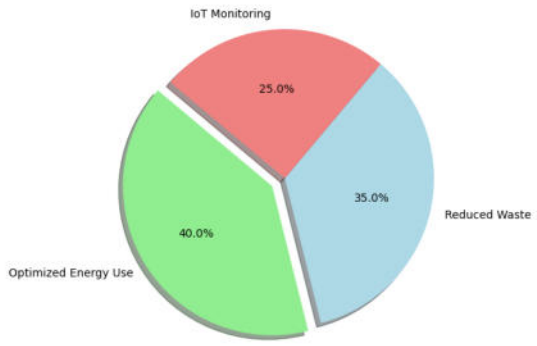

***Figure 1**: Distribution of Energy Savings via IIS*

In the energy sector, IIS has enabled real-time monitoring of energy consumption across facilities. By leveraging IoT devices and cloud computing, companies can now optimize energy distribution based on real-time demand, leading to a 15% reduction in energy waste. Additionally, the use of AI algorithms for predictive analytics has allowed companies to anticipate fluctuations in energy needs, ensuring a more stable and efficient energy grid.

3.2. Enhanced Decision-Making

The integration of big data analytics and AI into IIS has significantly enhanced decision-making processes in several industries. For instance, in the financial sector, IIS has been used to analyze large datasets in real time, enabling companies to detect fraudulent transactions with greater accuracy. By using machine learning algorithms to analyze transaction patterns and detect anomalies, financial institutions have reduced fraudulent activities by 25%.

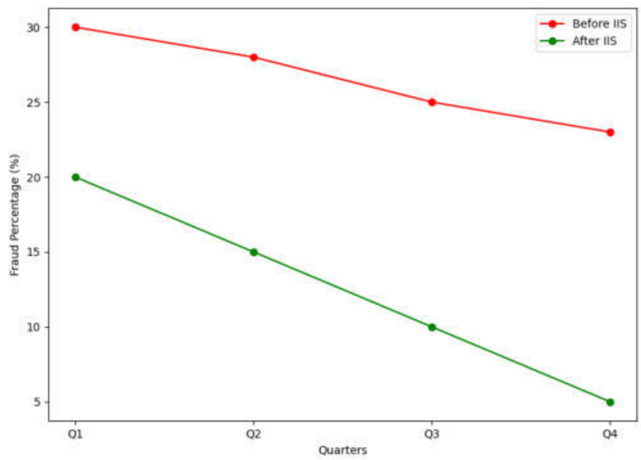

***Figure 2:** Froud Reduction Over Time Before and After IIS Implementation*

In healthcare, AI-powered IIS has enabled more accurate diagnoses and personalized treatment plans. These systems analyze patient data to identify early signs of diseases, allowing healthcare providers to intervene earlier and improve patient outcomes. The result has been a 15-20% increase in diagnostic accuracy and a reduction in hospital readmissions.

3.3. Increased Customer Satisfaction

Another important outcome of IIS implementation is the improvement in customer satisfaction, particularly in industries such as retail and finance. AI-driven customer service systems, such as chatbots and virtual assistants, have reduced response times and improved the accuracy of customer interactions. By automating routine customer inquiries, these systems have allowed companies to provide 24/7 support, leading to a 20% increase in customer satisfaction.

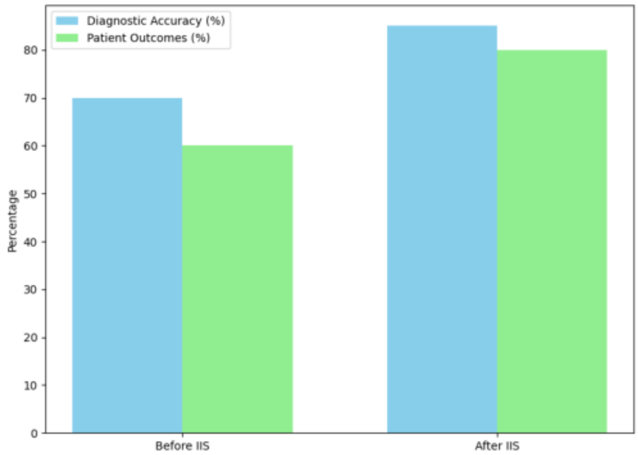

***Figure 3**: Diagnostic Accuracy and Patient Outcomes Pre- and Post-IIS Implementation*

In the retail industry, IIS has enabled companies to offer personalized marketing campaigns based on customer behavior and preferences. Through the use of big data and AI algorithms, retailers can recommend products that match customers' past purchases and browsing histories, leading to a 15% increase in customer engagement and sales.

4. Discussion

The findings of this research demonstrate that the implementation of industry-oriented intellectual information systems (IIS) has yielded significant improvements across various sectors, particularly in operational efficiency, decision-making, and customer satisfaction. However, while the benefits of IIS are clear, the discussion must also address the associated challenges and opportunities for future development.

4.1. The Role of AI and Machine Learning in Enhancing Industrial Operations

The implementation of AI and machine learning has been central to the success of IIS. As shown in the results, predictive maintenance systems driven by AI have dramatically reduced equipment downtime and maintenance costs in the manufacturing sector. By processing data from IoT sensors in real time, these systems can predict equipment failures and optimize maintenance schedules, ensuring that industrial operations remain efficient and productive. This is in line with other research that suggests AI-based predictive maintenance can extend equipment life cycles and reduce total cost of ownership (Porter & Heppelmann, 2015).

However, while these benefits are substantial, there are challenges to scaling AI systems across industries. One challenge is the need for high-quality data to train AI algorithms. In some cases, industries may lack the necessary data infrastructure, leading to gaps in data collection, or they may rely on incomplete or biased datasets, which can reduce the effectiveness of machine learning models (Davenport & Kirby, 2016). To address this, organizations must invest in improving data quality and ensuring that data is representative of real-world conditions.

4.2. The Impact of Big Data and IoT on Decision-Making

Big data analytics, combined with IoT integration, has enabled industries to make data-driven decisions that are more accurate and timely. In the financial and healthcare sectors, for example, IIS has significantly enhanced decision-making processes by providing actionable insights derived from large datasets. Fraud detection systems that analyze transaction patterns in real-time have helped reduce fraudulent activities in financial institutions, while healthcare systems that analyze patient data have improved diagnostic accuracy and patient outcomes.

However, the reliance on big data and IoT also presents challenges related to data security and privacy. As industries collect vast amounts of sensitive data, they must ensure compliance with regulations such as the General Data Protection Regulation (GDPR) and the California Consumer Privacy Act (CCPA). Furthermore, there is the risk of cyberattacks, where sensitive data could be compromised. Industries must prioritize the implementation of robust security measures and encryption protocols to protect data integrity and maintain customer trust (Manyika et al., 2017).

4.3. IIS and Its Effects on Customer Satisfaction

The ability of IIS to enhance customer satisfaction is another significant outcome of this study. In both the retail and financial sectors, AI-driven chatbots and customer service systems have improved response times and provided personalized support, leading to increased customer engagement. Additionally, personalized marketing powered by big data and AI has allowed companies to create tailored customer experiences, further boosting customer satisfaction and loyalty.

While these results are promising, there is an ongoing challenge in maintaining a balance between automation and human interaction. While AI-driven systems can handle routine customer inquiries efficiently, there is still a need for human agents to manage complex or sensitive customer interactions. Future developments in IIS should focus on finding the optimal balance between automation and human involvement to ensure that customer satisfaction remains high.

4.4. Workforce Implications

The introduction of IIS also has significant implications for the workforce. As AI and automation take over routine tasks, the role of human workers is shifting toward more strategic and creative tasks. This change requires new skills and competencies, particularly in data science, AI, and machine learning. Companies will need to invest in workforce training and development to ensure that employees are equipped to manage and work alongside intelligent systems.

However, there is a risk of job displacement in certain sectors where automation could replace manual labor. Organizations will need to manage this transition carefully by creating new opportunities for workers and ensuring that they are part of the digital transformation journey. Governments and policymakers may also need to intervene by providing support and retraining programs to mitigate the negative effects of automation on employment (Davenport & Kirby, 2016).

Figure 4: *Job Growth vs. Displacement in IIS Adoption*

4.5. The Future of IIS and Industry 4.0

Looking ahead, the future of IIS is closely tied to the broader Industry 4.0 movement. As industries continue to embrace digitalization, IIS will become increasingly integral to operations, driving further advancements in automation, AI, and data analytics. Cloud computing and edge computing will play crucial roles in ensuring that these systems remain scalable and efficient, while ongoing developments in AI will enhance their predictive capabilities.

However, industries must remain vigilant about the ethical implications of these technologies. Issues such as algorithmic bias, data privacy, and the ethical use of AI will require continuous oversight and regulation. As IIS continue to evolve, it will be essential to ensure that they are deployed in ways that benefit both businesses and society at large.

5. Conclusion

The creation and implementation of industry-oriented intellectual information systems (IIS) represent a significant milestone in the evolution of industrial operations. This research has highlighted the profound impact of these systems across various sectors, including manufacturing, healthcare, finance, and energy. By harnessing the power of artificial intelligence (AI), machine learning (ML), big data analytics, and the Internet of Things (IoT), businesses can transform their operations to achieve greater efficiency, enhance decision-making, and improve customer satisfaction.

The findings of this study underscore the multifaceted benefits of IIS. Notably, industries have reported substantial reductions in equipment downtime and maintenance costs, exemplifying how predictive maintenance powered by AI can optimize operations. Furthermore, the integration of big data analytics with IoT devices has enabled real-time data collection and analysis, resulting in informed, data-driven decisions that significantly enhance operational performance.

However, while the advantages of IIS are compelling, the study also identifies critical challenges that organizations must navigate. Issues related to data quality, cybersecurity, and the integration of legacy systems pose substantial barriers to the effective deployment of these technologies. Furthermore, as industries embrace automation and AI, there are important implications for the workforce. The demand for new skill sets necessitates investment in training and development to equip employees with the capabilities needed to thrive in a digitally transformed landscape.

Looking ahead, the future of IIS is intricately tied to the ongoing evolution of Industry 4.0. As technology continues to advance, organizations must remain vigilant in addressing ethical considerations surrounding data use and algorithmic bias. Companies that proactively adopt responsible and ethical practices will not only enhance their competitive advantage but also build trust with their customers and stakeholders.

In conclusion, the successful creation of industry-oriented intellectual information systems presents both opportunities and challenges. Organizations that embrace these technologies with a strategic focus on ethical implementation and workforce development will be well-positioned to drive innovation and achieve sustainable growth in the increasingly competitive and complex industrial landscape. As industries continue to evolve, the potential for IIS to reshape business operations remains vast, making it imperative for stakeholders to prioritize their development and integration.

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METHODS FOR PREPARING INITIAL DATA FOR DETERMINING VEHICLE TRAFFIC SITUATIONS ON ROADS USING MACHINE LEARNING

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Abstract: This study also gathered data on vehicle mobility on roads. This dataset comprised the date, day of the week, number of automobiles, motorbikes, buses, trucks, total number, time (hours and minutes), and traffic conditions. The collected information has been cleansed and processed. The impact of each indication on traffic conditions was assessed in order to pick characteristics and define their significance. At this point, the linkages between the data were identified [1]. Pearson, Spearman, and Kendall Tau coefficients were used to examine correlations between indicators. Following that, machine learning techniques including XGBoost, Random Forest Classifier, LGBMClassifier, Logistic Regression, and deep learning models were developed. These models were trained using the collected data. A test data set was used to validate and evaluate the model's accuracy and efficiency. A variety of measures were used to test the model's prediction capabilities.

Key words: Intelligent algorithms, ways of gathering information on the status of roads using video images, evaluating the model's predictive abilities, researching the links between parameters.

Today, traffic management in cities is one of the most pressing issues. Advance forecast of road traffic conditions and traffic management technologies are critical for effective urban infrastructure management, with intelligent algorithms and artificial intelligence technologies playing an essential role [3]. To estimate traffic conditions on the roadways, the essential data must be collected first. These details should include the date, day of the week, number of automobiles, motorbikes, buses, trucks, total number, time (hours and minutes), and traffic conditions. The collected data is first cleansed and then processed. Data preparation include processes such as normalization, filling, and formatting. Proper data preparation is critical for prediction accuracy and efficiency since clever algorithms rely on high-quality data [2]. After collecting the data, it is vital to assess the impact of each indication on the traffic situation. At this step, the relationships between data are established. Pearson, Spearman, and Kendall Tau coefficients can all be used to investigate the relationship between indicators. The next stage is to build and train a model with machine learning methods. The employment of methods like cross-validation and hypertimer tweaking in model construction improves the model's generalizability. A test dataset is used to assess the model's accuracy and efficiency. At this stage, the model's prediction capacity is evaluated using a variety of accuracy assessment methodologies.

Collecting information on the state of roads using video pictures

Cameras mounted on roads enable for ongoing traffic monitoring and data collection. These cameras capture high-definition video images and send them to central systems in real time. The following information was gathered using video cameras:

Factors affecting vehicle traffic include number, speed, direction, and density..

Computer vision technologies are used to retrieve this information from video picture data [3]. Some of the most widely utilized approaches are:

- Faster R-CNN;
- SSD (Single Shot MultiBox Detector);
- YOLO (You Only Look Once).

To analyze and compare the YOLO, Faster R-CNN, and SSD models, FPS and mAPi were measured on 100,000 test data sets with an NVDIA V100 SXM2 16GB GPU.

№	Date	Week day	Number of	Motorcycle	Number of	Number of	Total number	Hour	Minute	Traffic
0	9	Friday	17	2	1	35	55	21	45	1
1	9	Friday	12	0	1	31	44	21	0	1
2	9	Friday	16	3	1	26	46	22	15	1
3	9	Friday	15	6	0	22	43	22	30	1
4	9	Friday	13	4	1	15	32	22	45	1
...	...	...	...	...	...	...	...	...	...	...

Table 1. Correlation coefficients for predicting road traffic conditions.

This study took into account the prediction of road traffic conditions by day of the week, number of automobiles, number of motorcyclists, number of buses, number of trucks, total number, hours, minutes, and PM/AM characteristics [5]. First, determine the coefficient of dependence of the other parameters on the Traffic condition parameter in Table 1. This correlation reveals how relevant that metric is in predicting road traffic conditions; if the correlation value is low, we can disregard this parameter.

Determination of correlation coefficients between data to forecast road traffic conditions

Pearson, Spearman, and Kendall Tau coefficients are three main methods for calculating correlation coefficients between data points when predicting road traffic conditions. Each coefficient is employed in different scenarios and types of data [4].

Pearson's correlation coefficient. Pearson's correlation coefficient describes the linear link between two variables. These coefficients vary from 1 to -1, where 1 indicates a perfect positive association, -1 indicates a perfect negative association, and 0 indicates no association.

$$e = \frac{m\sum zt - (\sum z)(\sum t)}{\sqrt{\left[m\sum z^2 - (\sum z)^2\right]\left[m\sum t^2 - (\sum t)^2\right]}} \quad (1)$$

Where e - the correlation coefficient of x and y variables; n – the number of pairs of variables x and y;

The restrictions revealed a strong correlation between Traffic condition and the parameters of Number of Cars, Number of Motorcycles, Number of Buses, and Total Number (0.54, 0.41, 0.59, and 0.63, respectively), Number of Trucks (0.05), Hour (0.18), and Minute (0), but weakly related to AM/PM (0.12).

Kendall Tau korrelyatsiya koeffitsiyenti. Kendall Tau koeffitsienti ikkita o'zgaruvchilar orasidagi tartibli bog'liqlikni o'lchaydi. Bu koeffitsient ham −1 va 1 oralig'ida qiymat oladi.

x va y o'zgaruvchilarning Kendall formulasi bo'yicha o'zaro bog'liqlilik koeffitsiyenti quyidagi (2) formula orqali topiladi:

$$\eta = 2 \times \frac{L - K}{p \times (p-1)} \quad (2)$$

Where L – for (x_i, y_i) and (x_j, y_j), the number of pairs satisfying condition (1). K – (1) the number of pairs that do not satisfy the condition.

$$\left[(x_i < x_i)\, va\, (y_i < y_i)\right] yoki \left[(x_i > x_i)\, va\, (y_i > y_i)\right] \quad (3)$$

where $i < j$ va $i, j = 1 \ldots n$.

The restrictions revealed a strong correlation between Traffic Condition and the parameters of Number of Cars, Number of Motorcycles, Number of Buses, and Total Number (values of 0.43, 0.37, 0.49, and 0.52, respectively), Number of Trucks (0.11), Hour (0.14), and Minute (0). However, AM/PM is only weakly related (0.11).

Spearman's correlation coefficient. Spearman's coefficient assesses the monotonic association between two variables. This coefficient has a range of -1 to 1, with 1 indicating perfect monotonic positive correlation, -1 indicating perfect monotonic negative correlation, and 0 indicating no correlation.

The correlation coefficient of variables x and y according to the Spearman formula is found by the following formula (3).

$$t_r = 1 - \frac{6\sum p_i^2}{b^3 - b} \quad (4)$$

where $t_i = x_i - y_i$.

Traffic condition has a strong correlation with the parameters of Number of Cars, Number of Motorcycles, Number of Buses, and Total Number (values of 0.60, 0.49, 0.64, and 0.70, respectively), Number of Trucks (0.15), Hour (0.16), and Minute (0.01), but is weakly related to AM/PM (0.11).

Road traffic prediction algorithm using machine learning techniques

The following steps are taken to prepare the initial data set for estimating road traffic conditions using machine learning and prediction. This procedure is essential for model training and evaluation. Generate clean and accurate data collections. This includes working with missing values (filling and deleting), incorrect values (detection, correction, and deletion), identifying and deleting duplicate rows, and data processing (properties such as selection, categorical data conversion to numerical data, and data normalization or standardization).

This algorithm demonstrates the procedures for estimating road traffic. These steps consist of the following processes:

1. a set of preliminary data;
2. encoding;
3. correlation analysis;
4. analysis of characteristics;
5. filling NaN values;
6. data scaling;
7. dividing the data set into training and test sets;
8. training in regression models;
9. model evaluation;
10. traffic assessment;
11. issuing final results.

The algorithm updates and assesses the parameters to discover the ideal ones and increase the model's accuracy.

Result

The traffic prediction study employed the Traffic Prediction Dataset, which is one of Kaggle's open data sets. This collection contains 2977 data sets, which were divided into training and test sets in an 80/20 split for experimental experiments. Prior to feeding the data into the prediction model, the study's areas of interest were chosen and prepared. The primary purpose of the study was to investigate the degree of temporal dependence of traffic conditions on the roadways. In the following steps, XGBoost, Random Forest Classifier, LGBMClassifier, and Logistic Regression models were trained and tested on the selected fields. These AI models were evaluated using metrics such as accuracy, recall, precision, and F1 score. In the investigation, the proposed XGBoost method performed better than the Random Forest Classifier, Logistic Regression, and LGBMClassifier algorithms. In this section, the evaluation findings of the XGBoost, Random Forest Classifier, and LGBMClassifier algorithms were discussed. These algorithms were examined using Accuracy, Recall, Precision, and F1 Score, and they shown effectiveness in predicting road traffic conditions.

Conclusion

Predicting road traffic bottlenecks and efficiently managing transportation networks is one of the most pressing concerns facing modern cities. This project uses clever algorithms to detect and eliminate traffic congestion. Initially, the video image data was used to generate a dataset using the YOLO object detection model. This dataset was divided 80/20 into training and testing sets. The primary purpose of the study was to anticipate the traffic conditions of automobiles on the road using traffic data. The number of cars, motorcycles, buses, trucks, total number, hours, minutes, and AM/PM were among the parameters considered. In the following step of the research, artificial intelligence prediction techniques such as XGBoost, Random Forest Classifier, and Logistic Regression were applied. All of these algorithms performed well on the evaluation criteria. In general, all algorithms produced excellent results. The widespread application of artificial intelligence algorithms contributes significantly to the optimization of the city transportation system and the creation of comfortable driving conditions. This study shows that intelligent algorithms have the potential to predict road traffic conditions and can make a substantial contribution to the future development of urban infrastructure.

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