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THE AI REVOLUTION IN IT EDUCATION

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Abstract. Artificial intelligence (AI) is rapidly transforming the IT landscape, demanding a paradigm shift in IT education. This paper explores the impact of AI on the educational process for aspiring IT specialists. The goals of transformation. Shifting focus of the curriculum is transitioning from a purely technical focus to preparing students for human-AI collaboration. Develop essential skills in data science, machine learning, and understanding the ethical implications of AI become central to the IT education framework. Orientation on lifelong learning for create adaptability and continuous learning skills to navigate the evolving field. Forming soft skills in communication, collaboration, and creativity gain prominence alongside technical expertise. The benefits are job market preparedness with graduates equipped by AI skills professionals become more competitive in the workforce. Enhanced problem-solving with understanding and applying AI tools improves students' ability to analyze problems and develop innovative solutions. Increased Efficiency by leverage AI to automate tasks, optimize workflows, and achieve greater productivity. Fostering innovation with Integrating AI into the curriculum encourages students to explore new applications of AI technology. AI revolution create some challenges. Educational institutions need to adapt their curriculum and train faculty to effectively deliver AI-related content. Ensuring all students have equal access to the resources required for learning AI is crucial. Integrating discussions about AI ethics prepares students to use AI responsibly. The results are the integration of artificial intelligence (AI) in IT education is transforming the landscape of learning and teaching. This revolution is reshaping how students engage with content, how educators deliver instruction, and how institutions operate. Here are the key areas where AI is making a significant impact in IT education.

Keywords: Artificial intelligence, IT landscape, transformation on IT education, conceptual model, challenges

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БІЛІМ БЕРУДЕГІ ЖАСАНДЫ ИНТЕЛЛЕКТ ТӨҢКЕРІСІ

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Аннотация. Жасанды интеллект (ЖИ) ЖИ білім беру парадигмасын өзгертуді талап ете отырып, ЖИ ландшафын жылдам өзгертуде. Бұл мақалада жасанды интеллекттің жаңадан келген ЖИ мамандары үшін оқу процесіне әсері қарастырылады. Трансформацияның мақсаттары. Оқу бағдарламасының бағытын өзгерту таза техникалық бағыттан студенттерді адам мен жасанды интеллект арасындағы ынтымақтастыққа дайындауға көшу болып табылады. Деректер ғылымында, машиналық оқытуда және жасанды интеллекттің этикалық салдарын түсінуде маңызды дағдыларды дамыту ЖИ білім беру жүйесінде басты орын алады. Өмір бойы білім алуға бағдарлау дамып келе жатқан өрісті шарлау үшін бейімделу және үздіксіз оқу дағдыларын қалыптастыру. Қарым-қатынас, ынтымақтастық және шығармашылық саласындағы жұмсақ дағдыларды қалыптастыру техникалық біліммен қатар танымал болады. Артықшылықтары еңбек нарығына дайындық болып табылады, өйткені жасанды интеллект дағдыларымен жабдықталған түлектер жұмыс күшінде бәсекеге қабілетті бола бастайды. Жасанды интеллект құралдарын түсіну және қолдану арқылы мәселелерді шешудің жетілдірілуі оқушылардың проблемаларды талдау және инновациялық шешімдерді әзірлеу қабілетін арттырады. Тапсырмаларды автоматтандыру, жұмыс процестерін оңтайландыру және жоғары өнімділікке қол жеткізу үшін жасанды интеллектті пайдалану арқылы тиімділікті арттыру. Жасанды интеллектті оқу бағдарламасына енгізу арқылы инновацияларды ынталандыру студенттерді жасанды интеллект технологиясының жаңа қолданбаларын зерттеуге ынталандырады. Жасанды интеллект төңкерісі кейбір қиындықтарды тудырады. Оқу орындары өздерінің оқу бағдарламаларын бейімдеп, жасанды интеллектке қатысты мазмұнды тиімді жеткізу үшін оқытушыларды дайындауы керек. Барлық студенттердің жасанды интеллектті үйренуге қажетті ресурстарға тең қол жеткізуін қамтамасыз ету өте маңызды. Жасанды интеллект этикасы туралы пікірталастарды біріктіру студенттерді жасанды интеллектті жауапкершілікпен пайдалануға дайындайды. Нәтижелер жасанды интеллекттің (ЖИ) ЖИ біліміне интеграциясы оқыту мен оқытудың ландшафтын өзгертетінін көрсетеді. Бұл революция оқушылардың мазмұнмен қарым-қатынасын, оқытушылардың оқытуды қалай жүргізетінін және оқу орындарының қалай жұмыс істейтінін өзгертеді. Міне, жасанды интеллект ЖИ біліміне айтарлықтай әсер ететін негізгі салалар.

Түйін сөздер: жасанды интеллект, ЖИ-ландшафт, ЖИ-білім берудегі трансформация, тұжырымдамалық модель, қиындықтар

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РЕВОЛЮЦИЯ ИСКУССТВЕННОГО ИНТЕЛЛЕКТА В ИТ-ОБРАЗОВАНИИ

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Аннотация. Искусственный интеллект (ИИ) быстро меняет ИИ-ландшафт, требуя изменения парадигмы ИТ-образования. В этой статье рассматривается влияние искусственного интеллекта на процесс обучения начинающих ИИ-специалистов. Цели трансформации. Изменение направления учебной программы – это переход от чисто технической направленности подготовки студентов к сотрудничеству между человеком и искусственным интеллектом. Развитие важных навыков в науке о данных, машинном обучении и понимании этических последствий искусственного интеллекта занимает центральное место в системе ИИ-образования: ориентация на обучение на протяжении всей жизни, формирование навыков адаптации и непрерывного обучения для навигации по развивающейся области. Формирование мягких навыков в области общения, сотрудничества и творчества становится популярным наряду с техническими знаниями.

Преимущества заключаются в подготовке к рынку труда, поскольку выпускники, обладающие навыками искусственного интеллекта, становятся более конкурентоспособными в рабочей среде. Улучшение решения проблем за счет понимания и использования инструментов искусственного интеллекта повышает способность учащихся анализировать проблемы и разрабатывать инновационные решения. Повышение эффективности за счет автоматизации задач, оптимизации рабочих процессов и использования искусственного интеллекта для достижения высокой производительности. Поощрение инноваций путем включения искусственного интеллекта в учебную программу побуждает студентов исследовать новые приложения в технологии искусственного интеллекта. Революция искусственного интеллекта создает некоторые проблемы. Учебные заведения должны адаптировать свои учебные программы и обучать преподавателей, чтобы эффективно предоставлять контент с искусственным интеллектом. Очень важно, чтобы все студенты имели равный доступ к ресурсам, необходимым для изучения искусственного интеллекта. Объединение дискуссий об этике искусственного интеллекта готовит студентов к ответственному использованию искусственного интеллекта. Результаты показывают, что интеграция искусственного интеллекта (ИИ) в ИТ-образование меняет ландшафт обучения и обучения. Эта революция меняет взаимодействие учащихся с содержанием обучения, методы обучения преподавателей и в целом работу учебных заведений. Таковы основные области, в которых искусственный интеллект оказывает значительное влияние на ИИ-образование.

Ключевые слова: искусственный интеллект, ИТ-ландшафт, трансформация в ИТ-образовании, концептуальная модель, проблемы

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Introduction

The advent of artificial intelligence (AI) has brought transformative changes across various sectors, and education is no exception. In the realm of Information Technology (IT) education, AI is revolutionizing traditional teaching methodologies, learning experiences, and administrative processes. This paper explores the multifaceted impact of AI on IT education, highlighting how AI-driven technologies are reshaping the way educators teach and students learn.

The integration of AI in IT education addresses some long-standing challenges while also introducing new opportunities for personalized learning, intelligent tutoring, and automated assessments. AI-powered tools are enabling more interactive and engaging learning environments, where students can benefit from customized instruction tailored to their individual needs and learning styles. Furthermore, AI is enhancing the efficiency of educational institutions by automating administrative tasks and providing data-driven insights into student performance and engagement.

As we delve into the various applications of AI in IT education, it is crucial to consider both the benefits and the potential challenges associated with this technological shift. Issues such as data privacy, algorithmic bias, and equitable access to AI-driven tools must be addressed to ensure that the benefits of AI are realized across all demographics. Moreover, the role of educators is evolving, requiring them to adapt to new technologies while maintaining the human element that is essential to effective teaching and mentoring.

This ***paper aims*** to provide an overview of how AI is transforming IT education, from personalized learning experiences to intelligent tutoring systems, automated grading, and beyond. By examining the current trends and future directions, we seek to understand the profound impact of AI on the educational landscape and explore the best practices for leveraging AI to enhance learning outcomes in IT education.

Materials and methods

Challenges of AI Revolution in IT Education

The AI revolution in IT education offers numerous benefits, but it also brings a range of challenges that need to be addressed to ensure effective and equitable integration. Addressing challenges requires a collaborative effort involving educators, policymakers, technologists, and the broader community. By proactively tackling these issues, the educational sector can maximize the benefits of AI while mitigating potential downsides, ensuring that the AI revolution in IT education is both effective and equitable. The key challenges presented on fig. 1.

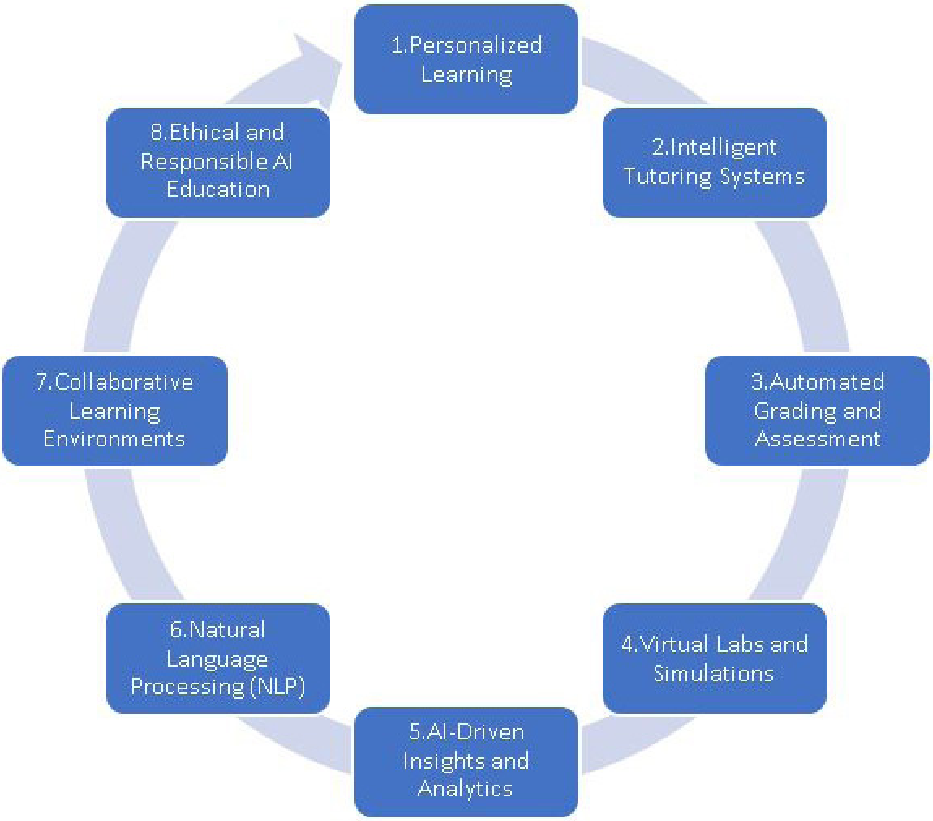

Fig. 1. Key challenges of AI revolution in IT education

Let's look on each challenge.

1. AI-driven systems can analyze individual learning patterns and tailor educational content to meet specific needs. This personalization ensures that students receive the appropriate level of challenge and support, enhancing their learning

outcomes. Adaptive learning platforms use AI to adjust the difficulty of tasks in real-time, providing instant feedback and targeted recommendations.

2. AI-powered tutoring systems offer students one-on-one instruction and support, similar to human tutors. These systems can answer questions, provide explanations, and offer hints to guide students through complex problems. Intelligent tutoring systems are particularly effective in subjects like coding and algorithmic problem-solving, where step-by-step guidance is crucial.

3. AI can automate the grading of assignments and exams, saving educators significant time and ensuring consistent and objective assessment. This technology can handle multiple-choice questions, coding assignments, and even essays through natural language processing (NLP). Automated grading systems provide instant feedback, allowing students to learn from their mistakes more quickly.

4. AI enhances virtual labs and simulations, providing students with hands-on experience in a controlled and safe environment. These tools are essential in IT education, where practical skills are paramount. AI can create realistic scenarios for students to practice network configurations, cybersecurity measures, and other IT tasks.

5. Educational institutions can leverage AI to gain insights into student performance and engagement. Learning analytics powered by AI can identify at-risk students, predict outcomes, and suggest interventions. This data-driven approach helps educators make informed decisions to improve teaching strategies and student support services.

6. NLP technology enables more effective communication between students and AI systems. This includes AI chatbots that can answer students' questions, provide resources, and offer administrative support 24/7. NLP also facilitates the development of language-based tools that help students improve their coding and documentation skills.

7. AI fosters collaborative learning by connecting students with peers who have similar interests and complementary skills. AI-driven platforms can form study groups, match project teammates, and facilitate peer-to-peer learning opportunities. These environments encourage knowledge sharing and collective problem-solving.

8. As AI becomes more prevalent, it's crucial to educate students about its ethical implications and responsible use. IT education programs are incorporating AI ethics into their curricula, ensuring that future professionals understand the societal impact of AI technologies and the importance of fairness, transparency, and accountability.

Conceptual Model of the AI Revolution in IT Education

The conceptual model illustrates the impact of Artificial Intelligence (AI) on the educational process for future IT specialists. Fig. 2 presents key issues of conceptual model.

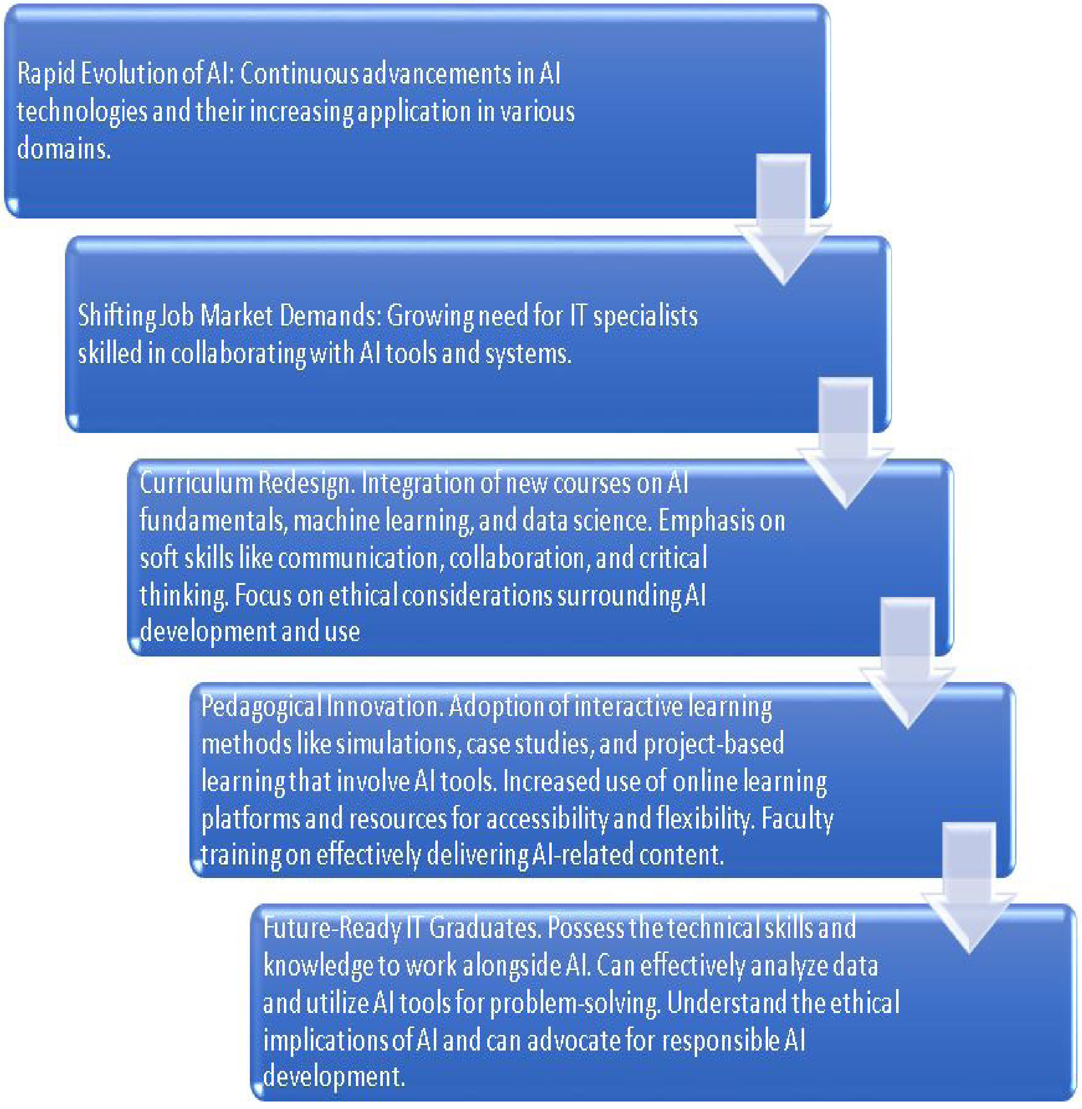

Fig. 2. Conceptual model for Transformation of IT Education due to AI

This conceptual model emphasizes the dynamic and interconnected nature of the AI revolution in IT education. It highlights the need for continuous adaptation and collaboration between educators, industry leaders, and policymakers to prepare future IT professionals for success in the AI-driven future.

Literature review

Let's consider publications related to the behavior of interested parties and their involvement in the processes of managing sustainable development projects in IT educations.

The article (Bushuyev et al., 2022: 1463–1474) examines the problems of the interaction of interested parties in the processes of sustainable development. Article (Bushuyev et al., 2021: 293–298) is devoted to the study of the model of management, competition and cooperation in the field of economic development.

The article (Redjep et al., 2021: 643–658) claims that artificial intelligence can replace people in innovation management, requiring companies to rethink their innovation processes and consider the possibilities of digital transformation. This confidence is based on the expectation that versions of "general artificial intelligence" will be released in the near future.

In (Redjep et al., 2021: 643–658), emphasizes that artificial intelligence can improve project management by managing stakeholder expectations, resolving conflicts, and ensuring flawless project support and execution.

Technological progress in the field of artificial intelligence leads to the development of human-like machines that can work autonomously and imitate our cognitive behavior. The progress and interest among managers, academics, and the public has created excitement in many industries, and many firms are investing heavily to capitalize on the technology through business model innovation (Durek et al., 2018: 0671–0676). However, executives are left without support from academia as they seek to implement AI into their firm's operations, leading to an increased risk of project failure and undesirable outcomes.

In the study (Tocto-Cano et al., 2020), it is determined that AI has the potential to revolutionize the economy and society, but to ensure its successful implementation and future impact, it is necessary to solve industry problems and develop research programs for the effective application of artificial intelligence.

Convergence of knowledge, rapid progress in the application of artificial intelligence, and the need for adaptive project management to drive innovation create fertile ground for research (Proença et al., 2016: 1–4; Kraus et al., 2021). Although the special field of IT education management for AI-driven projects is still emerging, it is necessary to find relevant application ideas scattered across several fields of activity in digitalization and development management of complex systems. The key issue is evaluating digital maturity of education (Vikhman et al., 2022).

Paper (Zizic et al., 2022) explain how to move from Industry 4.0 towards Industry 5.0 based on the shift for the people, organization and technology.

Case study "Evaluation of Artificial Intelligence Integration into the Master's Programme in Project Management at Kyiv National University of Construction and Architecture".

This case study examines the maternity program transformation at Kyiv National University of Construction and Architecture (KNUCA), specifically within the Department of Project Management. The study focuses on how effectively the program is incorporating Artificial Intelligence (AI) into its curriculum.

Ten experts evaluated key areas crucial for a successful maternity program, using a 10-point scale. The areas assessed included:

– Infrastructure
– Curriculum Design
– Adaptive Learning Systems (potentially including AI)
– Faculty Training and Support
– Research and Innovation (related to AI implementation)
– Student Engagement and Learning Analytics (potentially involving AI tools)

– Ethical and Societal Implications (of using AI in education)

The case study analyzes the evaluation results (provided separately) to assess KNU-CA's project management program's strengths and weaknesses in its AI integration process. It aims to identify areas for improvement and highlight best practices for incorporating AI effectively into educational programs. Average Scores on a 10-Point Scale are given in tables 1–7.

Table 1. Infrastructure.

№	Characteristic	Evaluation
1	AI integration	8,25
2	Hardware	7,50
3	Software	9
4	Networking capabilities	8,50
5	Cloud-based platforms	8
6	Robust data analytics tools	7

Average 8.04

Table. 2. Curriculum Design.

№	Characteristic	Evaluation
1	Development of AI-specific courses	7
2	Integration of AI concepts	8,50
3	Alignment with educational standards	9,25
4	Learning objectives	9,25

Average 8.5

Table 3. Adaptive Learning Systems

№	Characteristic	Explanation	Evaluation
1	Personalization	Use of neural networks: For more accurate assessment of individual characteristics, prediction of academic performance, selection of optimal learning trajectory.	7,25
2	Adaptation	Introduction of virtual assistants: To dialog with the student, answer questions, and help with assignments.	7
3	Automation	Development of content generation systems: To create personalized learning materials, selection of assignments, and tests.	8
4	Use of AI	Creating open source systems: To make algorithms transparent, modifiable, and adaptable to specific needs.	7,75
5	Accessibility	Mobile App Development: To provide access to the system from any device.	7,50
6	Security	Use of differential privacy techniques: To protect data privacy.	8
7	Efficiency	Conducting long-term research: To assess the impact of the system on long-term learning outcomes.	8.25

Average 7.68

Table 4. Faculty Training and Support

№	Characteristic	Explanation	Evaluation
1	Technology Integration	Focus on pedagogical strategies: Equip faculty with strategies to integrate AI effectively into their teaching, regardless of the specific platform.	9
2	Technical Skills	Focus on AI literacy: Develop a broader understanding of AI capabilities and limitations to foster informed decision-making about AI use in teaching.	8,5
3	One-Size-Fits-All Approach	Personalized Professional Development: Provide differentiated training pathways based on faculty roles, prior knowledge, and teaching styles.	7,75
4	Limited Support Systems	Create Communities of Practice: Foster collaboration and knowledge sharing among faculty through online forums, workshops, or mentoring programs.	8
5	Focus on Short-Term Needs	Incorporate Sustainable Integration: Integrate AI-related professional development into existing professional learning cycles.	8,25
6	Ethical Considerations	Incorporate Ethical Frameworks: Equip faculty with frameworks for ethical considerations around data privacy, bias in algorithms, and transparency in AI-powered assessments.	9

Table 5. Research and Innovation

№	Characteristic	Explanation	Evaluation
1	Focus on Technical Advancement	Shift towards Human-Centered AI: Integrate research on human-computer interaction, ethical considerations, and social impact alongside technical advancements.	9
2	Limited Collaboration	Promote Interdisciplinary Research: Encourage collaboration between computer scientists, engineers, ethicists, educators, and social scientists to address complex AI challenges.	8
3	Data Availability and Privacy	Develop Synthetic Data Generation Techniques: Create realistic and diverse synthetic data sets to enhance research capabilities while protecting individual privacy	8,50
4	Explainability and Transparency	Focus on Explainable AI (XAI): Develop AI systems that can explain their reasoning and decision-making processes to foster trust and address concerns about bias.	9
5	Bias and Fairness	Develop Fair and Equitable AI Techniques: Implement methods for de-biasing data sets, building fairness into algorithms, and mitigating discriminatory outcomes.	8,75
6	Evaluation and Measurement	Develop Robust Evaluation Frameworks: Create comprehensive frameworks to evaluate AI systems not only for technical performance but also for social, ethical, and economic impact.	8,50
7	Open Access and Reproducibility	Promote Open Science Practices: Encourage open access to research findings and data where feasible, and develop platforms for reproducible research methods.	9,25

Average 8.71

Table 6. Student Engagement and Learning Analytics

№	Characteristic	Explanation	Evaluation
1	Data Collection	Integrate Diverse Data Sources: Combine traditional data with sentiment analysis from communication tools, facial recognition for engagement levels, and eye-tracking for attention patterns.	8
2	Limited Analysis Capabilities	Advanced Analytics with AI: Utilize AI techniques like machine learning and natural language processing to extract deeper insights from diverse data sources, identify at-risk students, and predict future learning needs.	7,75
3	Focus on Quantifiable Outcomes	Holistic Engagement Metrics: Develop metrics that go beyond grades to measure factors like active participation, collaboration, self-directed learning, and intrinsic motivation.	8
4	Limited Actionable Insights	Personalized and Adaptive Interventions: Use AI to recommend personalized learning pathways, provide targeted learning resources, and deliver real-time feedback based on individual needs and engagement levels.	7,75
5	Privacy Concerns	Develop Privacy-Preserving Techniques: Implement anonymization, differential privacy, and secure data storage practices to ensure student data privacy while enabling valuable learning analytics.	8
6	Transparency and Explainability	Develop Explainable AI tools: Create systems that explain their reasoning and decision-making processes to foster trust and address concerns about potential biases in analytics.	8,50

Average 8.0

Table 7. Ethical and Societal Implications

№	Characteristic	Explanation	Evaluation
1	Bias and Fairness	Develop Fair AI Techniques: Implement methods for de-biasing data sets, building fairness into algorithms, and mitigating discriminatory outcomes. This may involve techniques like counterfactual fairness analysis and fairness-aware machine learning.	6,25
2	Transparency and Explainability	Focus on Explainable AI (XAI): Develop AI systems that can explain their reasoning and decision-making processes. This can involve techniques like LIME (Local Interpretable Model-Agnostic Explanations) and SHAP (Shapley Additive exPlanations).	8,25
3	Privacy Concerns	Develop Privacy-Preserving Techniques: Implement anonymization, differential privacy, and secure data storage practices to ensure data privacy while allowing valuable AI development and applications. Invest in research on federated learning, where data remains on individual devices and only anonymized models are shared.	8,00
4	Job displacement	Focus on AI-Human Collaboration: Explore ways for AI to complement human workforce skills, leading to human-AI partnerships with enhanced capabilities. Invest in retraining programs and reskilling initiatives to adapt the workforce to changing job demands.	8,50

5	Algorithmic Accountability	Develop Frameworks for Algorithmic Accountability: Establish transparent and responsible AI development practices, including ethical guidelines and human oversight mechanisms. This may involve creating AI ethics boards and regulatory frameworks for specific AI applications.	8,75
6	Social and Economic Inequality	Promote Equitable AI Development and Access: Focus on inclusive AI development that benefits all segments of society. This may involve ensuring access to AI education and training, promoting responsible AI deployment in developing countries, and addressing potential biases in AI applications that could further marginalize certain groups.	8,25

Average 8.0

Table 8. Average Scores on a 10-Point Scale for Key Areas

Infrastructure	8,04
Curriculum Design	8,50
Adaptive Learning Systems	7,68
Faculty Training and Support	8,42
Research and Innovation	8,71
Student Engagement and Learning Analytics	8,00
Ethical and Societal Implications	8,00

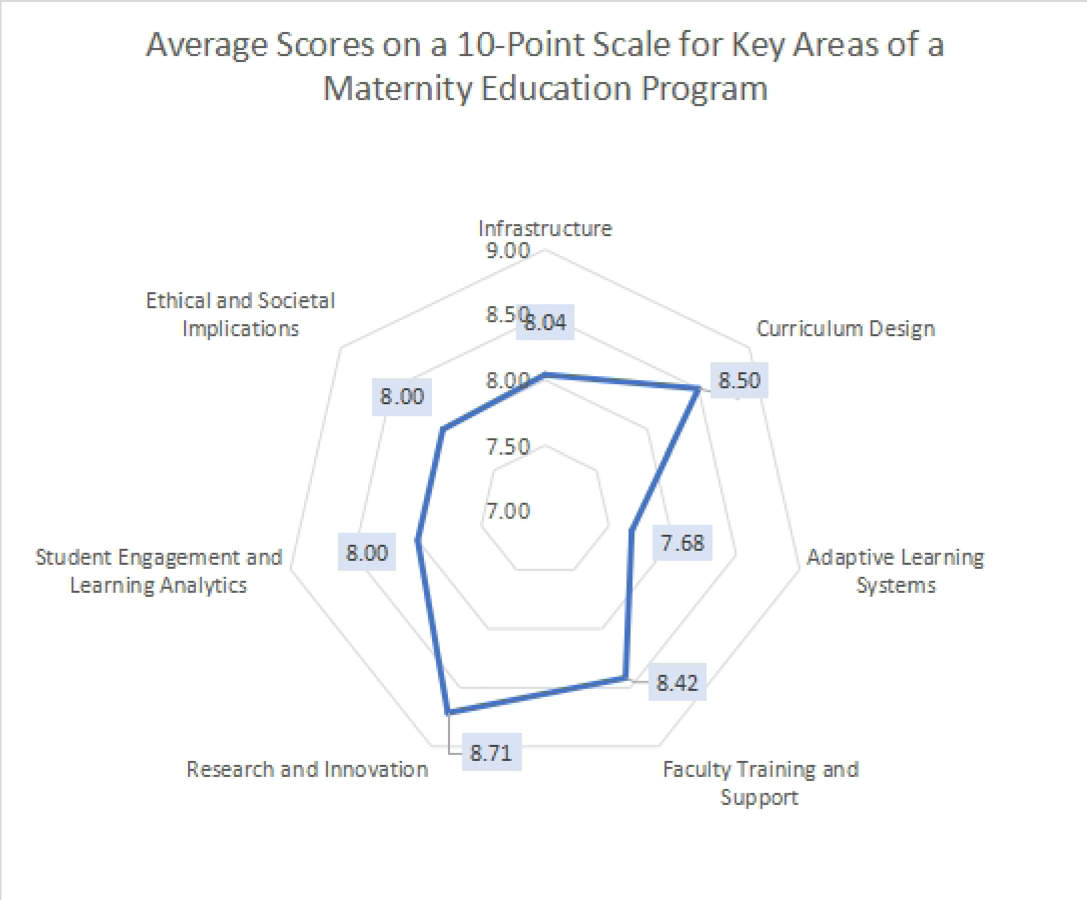

Fig. 3. Average Scores on a 10-Point Scale for Key Areas of a Maternity Education Program.

Discussion and results

Overall, the scores appear to be positive, with most areas scoring above 8.0. This suggests that the curriculum design is generally well-rounded.

The highest score is in Research and Innovation (8.71). This could indicate a strong emphasis on developing and implementing new teaching methods.

The lowest score is in Adaptive Learning Systems (7,68). This could be an area for further investigation to see if there are ways to improve student engagement or make better use of learning analytics data.

It's important to remember that averages can sometimes mask underlying variation. For example, an area with a high average score could still have some weaknesses. Conversely, an area with a lower average score might have some pockets of excellence.

To get a more complete picture of the curriculum design, it would be helpful to look at the data behind the averages. This could include information on the specific criteria that were used to evaluate each area, as well as the range of scores that were given.

Based on average points, here's a breakdown of which areas seem strong, might need improvement, and warrant further investigation.

Good.

Curriculum Design (8.50). This score suggests a well-designed curriculum.

Faculty Training and Support (8.42). Strong faculty support is crucial for a successful program.

Research and Innovation (8.71). This is a high score, indicating a focus on continuous improvement.

Needs Improvement.

Infrastructure (8.04). While not a bad score, consider if the infrastructure adequately supports the program's needs.

Student Engagement and Learning Analytics (8.00). This score suggests room for improvement in engaging students and utilizing learning analytics effectively.

Needs Investigation.

Ethical and Societal Implications (8.00). While the score itself might be good, it's important to delve deeper. Are there any ethical concerns or societal impacts thoroughly addressed?

Adaptive Learning Systems (7,68). How can the learning systems be improved to match expectations of providing better learning outcomes?

Here's why.

Averages don't tell the whole story: Look within each category. Are there specific aspects excelling or lagging?

Context matters: What are your program's specific goals? Are some areas naturally more important for your case?

Here's what the University/Expert team can do.

Investigate further. Dig deeper into each area, especially those with a score of 8.00. Are there areas within these categories that need more attention?

Compare with benchmarks. Are your scores in line with industry standards or best practices?

Consider the goals. Tailor the analysis to the program's specific objectives.

Obviously, a good case study goes beyond averages. It's about analyzing strengths and weaknesses to identify areas for improvement and highlight best practices.

Conclusion

The rapid advancements of Industry 5.0, characterized by human-machine collaboration and intelligent automation, necessitate a significant shift in the educational landscape. This paper explored the concept of an evaluation framework to assess the development maturity of educational institutions in preparing students for this new industrial era.

Our findings revealed that educational institutions require a multi-pronged approach to achieve Industry 5.0 readiness. This includes:

- Curriculum Integration: Integrating Industry 5.0 concepts, such as artificial intelligence, big data, and the Internet of Things (IoT), into core disciplines.
- Pedagogical Innovation: Shifting instructional methods towards active learning, problem-solving, and fostering critical thinking skills.
- Infrastructure Development: Investing in digital infrastructure, including advanced simulation tools, virtual reality experiences, and collaborative learning platforms.
- Industry Collaboration: Building strong partnerships with industry leaders to provide students with real-world exposure and internship opportunities.
- Faculty Development: Equipping faculty with the necessary knowledge and skills to effectively teach Industry 5.0 concepts.

The evaluation framework presented in this paper provides a valuable tool for educational institutions to assess their current state and identify areas for improvement. By continuously monitoring and refining their approach, educational institutions can ensure they are graduating future-ready individuals who can thrive in the dynamic and intelligent environment of Industry 5.0.

Future Research:

- Developing a standardized evaluation framework that can be applied across diverse educational institutions.
- Conducting longitudinal studies to track the effectiveness of different strategies in fostering Industry 5.0 readiness.
- Investigating the impact of Industry 5.0 education on graduate career outcomes and industry needs.

By fostering a culture of continuous improvement and collaboration, educational institutions can play a pivotal role in shaping the workforce of tomorrow and ensuring a smooth transition towards a more human-centric and intelligent Industry 5.0.

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TREND IN THE DEVELOPMENT OF ARTIFICIAL INTELLIGENCE IN THE WORLD

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Abstract. The article discusses current trends and prospects for the development of artificial intelligence technology. International research data and ratings of leading trends in the digital economy are analyzed. The volume of the global market for AI technologies and the leading countries in terms of the amount of investment in this area have been studied. The purpose of this article is to consider how artificial intelligence can improve the process. The article analyze various techniques that make positive changes to the practice of artificial intelligence and discuss the potential benefits, challenges and ethical issues associated with this development. Using examples of the successful implementation of artificial intelligences, the article shows how technology is changing the way of learning and people are thereby helping to reach new heights.

Keywords: artificial intelligence, digital economy, digitalization, IT sector, business processes

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ӘЛЕМДЕГІ ЖАСАНДЫ ИНТЕЛЛЕКТТІҢ ДАМУ ТЕНДЕНЦИЯЛАРЫ

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Аннотация. Мақалада жасанды интеллект технологияларының қазіргі тенденциялары мен даму перспективалары қарастырылады. Халықаралық зерттеулердің деректері мен цифрлық экономикадағы жетекші үрдістердің рейтингтері талданады. Жасанды интеллект технологияларының әлемдік нарығының көлемі және осы салаға инвестициялар көлемі бойынша көшбасшы елдер зерттелді. Бұл мақаланың мақсаты –жасанды интеллект бұл процесті қалай жақсарта алатынын қарастыру. Біз жасанды интеллект тәжірибесіне оң өзгерістер енгізетін әртүрлі әдістерді талдаймыз және осы дамуға қатысты ықтимал артықшылықтарды, мәселелерді және этикалық мәселелерді талқылаймыз. Жасанды интеллектті сәтті енгізу мысалдарында біз технологияның оқу тәсілін қалай өзгертетінін және осылайша адамдарға жаңа биіктерге жетуге көмектесетінін көрсетеміз.

Түйін сөздер: жасанды интеллект, цифрлық экономика, цифрландыру, АТ секторы, бизнес-процестер

Дәйексөздер үшін: И.И. Изембай. ӘЛЕМДЕГІ ЖАСАНДЫ ИНТЕЛЛЕКТТІҢ ДАМУ ТЕНДЕНЦИЯЛАРЫ// ХАЛЫҚАРАЛЫҚ АҚПАРАТТЫҚ ЖӘНЕ КОММУНИКАЛЫҚ ТЕХНОЛОГИЯЛАР ЖУРНАЛЫ. 2024. Т. 5. No. 18. 23–29 бет. (ағылшын тілінде). https://doi.org/10.54309/IJICT.2024.18.2.002.

ТЕНДЕНЦИИ РАЗВИТИЯ ИСКУССТВЕННОГО ИНТЕЛЛЕКТА В МИРЕ

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Аннотация. В статье рассматриваются современные тенденции и перспективы развития технологий искусственного интеллекта. Анализируются данные международных исследований и рейтинги ведущих тенденций в цифровой экономике. Были изучены объем мирового рынка технологий искусственного интеллекта и страны-лидеры по объему инвестиций в эту сферу. Цель этой статьи — рассмотреть, как искусственный интеллект может улучшить этот процесс. Мы проанализируем различные методы, которые вносят позитивные изменения в практику применения искусственного интеллекта, и обсудим потенциальные преимущества, проблемы и этические вопросы, связанные с этим развитием. На примерах успешного внедрения искусственного интеллекта мы покажем, как технологии меняют способ обучения и тем самым помогают людям достигать новых высот.

Ключевые слова: искусственный интеллект; технология; данные; системы; компания; разработка

Для цитирования: И.И. Изембай. ТЕНДЕНЦИИ РАЗВИТИЯ ИСКУССТВЕННОГО ИНТЕЛЛЕКТА В МИРЕ//МЕЖДУНАРОДНЫЙ ЖУРНАЛ ИНФОРМАЦИОННЫХ И КОММУНИКАЦИОННЫХ ТЕХНОЛОГИЙ. 2024. Т. 5. No. 18. Стр. 23–29. (На анг.). https://doi.org/10.54309/IJICT.2024.18.2.002.

Introduction

In modern times, Education has become one of the main factors determining the future of each person, each individual. Maintaining a high level of education is the task that every society sets for itself, striving to ensure its scientific and technological progress, economic development and well – being of citizens. In this context, the usage of modern technologies, in particular artificial intelligence, began to play a key role in changing the educational process. Artificial intelligence is a branch of computer science that deals with the creation of computer systems capable of performing tasks that require human intellectual abilities. In recent decades, artificial intelligence has firmly entered many areas of human life, from medicine and manufacturing to transport and entertainment. But one of the most promising and important areas of application of artificial intelligence is education.

In modern realities, artificial intelligence (AI) is gradually beginning to cover almost all areas of society, which undoubtedly has both a number of advantages and also carries significant risks for companies.

Artificial intelligence (AI) is a topic that has long been on the pages of popular science magazines and is constantly touched upon in films and books. The more specialists develop this area of science, the more myths it becomes covered with.

The idea of creating an artificial likeness of a person to solve complex problems and simulate the human mind, as they say, “was in the air” back in ancient times. The founder of artificial intelligence is considered to be the medieval Spanish philosopher, mathematician and poet Raymond Lull, who back in the 13th century. tried to create a mechanical device for solving various problems based on the universal classification of concepts he developed.

The term “artificial intelligence” (AI; English AI - “Artificial” Intelligence”) was proposed in 1956 at a seminar with the same name at Dartmouth College (USA). This seminar was devoted to the development of methods for solving logical problems. Soon after artificial intelligence was recognized as a special field of science, it was divided into two areas: neurocybernetics and “black box” cybernetics. These areas developed almost independently, differing significantly both in methodology and technology. And only now have trends towards combining these parts again into a single whole become noticeable.

Currently, there are two main approaches to modeling artificial intelligence: machine intelligence, which consists in strictly specifying the result of operation, and artificial intelligence, aimed at modeling the internal structure of the system.

The main areas of application of artificial intelligence systems: theorem proving, games, pattern recognition, decision making, adaptive programming, composing machine music, natural language processing, learning networks (neural networks), verbal conceptual learning. Modeling of systems of the first group is achieved through the use of the laws of formal logic, set theory, graphs, semantic networks and other achievements of science in the field of discrete computing, and the main results are the creation of expert systems and parsing systems.

Artificial intelligence is a branch of computer science whose goal is to develop hardware and software that allows a non-programmer user to set and solve their traditionally considered intellectual problems, communicating with a computer in a limited subset of natural language.

The idea of creating an artificial likeness of a person to solve complex problems and simulate the human mind, as they say, “was in the air” back in ancient times. The founder of artificial intelligence is considered to be the medieval Spanish philosopher, mathematician and poet Raymond Lull, who back in the 13th century. tried to create a mechanical device for solving various problems based on the universal classification of concepts he developed.

The Chairman of the State Duma Committee on Information Policy, Information Technologies and Communications said that the problem of replacing the workforce with artificial intelligence is important for Kazakhstan.

Materials and methods

“Previously, heavy physical work in many areas was done by man himself, but now, thanks to the development of artificial intelligence, the same work is done by robots. For example, there are workers who work in construction, in mines, and almost all of their work, such as building walls, building roofs, is now done by robots. So this clearly means that” construction specialists can be replaced by robots.” Now, for example, in the state of Australia, there is no Shaban, that is, a person who takes care of livestock. Their function is performed by robots” (Samsonovich, 2018).

The professor said that even those activities that are related to the brain, wise thinking, are gradually being introduced into artificial intelligence, and that the human brain is not enough to analyze billions of data. “For example, the world chess champion lost to a chess program on a computer. So chess on a computer is stronger. Also, if we focus on various data, then a person does not have the ability to analyze millions, billions of data. He has neither time nor age for this. And a computer can easily process a stream of data in a matter of seconds. For example, if we focus on diagnostics in medicine, then in comparison with a doctor, the device correctly diagnoses, because the computer records the knowledge of the best doctors in the world or this country and region, and if we turn to a doctor, then the diagnosis will be made only at the level of knowledge of that same as a medical worker" (what to expect in the field of artificial intelligence in 2020).

Discussion and results

Sooner or later, people will be replaced by an automated system, and 2 % of the country's working population will spill onto the market. That is why we need to think about how to employ them, those who will lose their jobs due to the development of digital technologies, now. According to the chairman, in the near future we will be faced with an increase in unemployment.

To the greatest extent, artificial intelligence systems use formal logical structures, which is due to their non-specific thinking and, in essence, algorithmic nature. This makes it possible to implement them technically relatively easily. However, even in this case, cybernetics as a science has a long way to go.

In artificial intelligence systems, modal, imperative, question and other logics that function in human intelligence are still poorly used, and are no less necessary for successful cognitive processes than the forms of conclusions long mastered by logic and then by cybernetics. Increasing the "intelligent" level of technical systems is, of course, associated not only with the expansion of the logical means used, but also with their more intensive use - checking information for consistency, constructing calculation plans, and much more.

Problem-oriented fragments of natural languages have already been developed, sufficient for the system to solve a number of practical problems. The most important result of such work is the creation of semantic languages (and their formalization), in which word-symbols have a certain interpretation.

Artificial intelligence (AI) technologies are developing rapidly. In the spring of 2023, AI made a qualitative leap forward: a new version of ChatGPT was released, which learned to generate texts of up to 25 thousand words, describe images, and even successfully passed the bar exam. A new round of unprecedented interest in AI technology has emerged in the world. Hundreds of different services are emerging that incorporate artificial intelligence capabilities.

Analysts also note that many of the large rounds of funding for AI startups involved the world's leading IT corporations — Microsoft, Amazon, Google and Nvidia. Moreover, Nvidia is strengthening its position in the AI market thanks to its GPU-based accelerators, which have been in short supply due to high demand from companies creating various AI services and training large language models. It is noted that the largest corporations in Silicon Valley are displacing traditional technology investors in the AI segment (Bobrovsky, 2020).

The education sector is conservative and based on tradition. Therefore, innovations do not come to education first, but they are tested. Digitalization plays a special role in this, which will change conventional ideas about teaching methods. Already today we are seeing a transition from one-to-many learning to personalized learning using artificial intelligence, adaptive educational platforms and personalized educational programs.

The use of artificial intelligence and immersive technologies such as virtual and augmented reality allows for the creation of learning environments where students are immersed in interactive and live learning situations. This can improve your understanding of the material and make learning more fun. Concepts of education based on computer games (game-based-learning) appear. The role of the teacher is also evolving in the context of these changes. From the usual methods of transferring knowledge, teachers become mentors, organizers and guides in the world of information. The main reason why we are forced to implement AI in education is the new digital generation (digital natives). The point is that young people already intuitively use digital technologies; this is a world they understand. They confidently stream their computer game while simultaneously chatting in instant messengers. Thus, Google in it's study (Borovskaya et al., 2010: 127) indicates that schoolchildren are already using smart speakers and neural networks to do homework.

But AI is developing and being adopted so quickly that it is affecting professions and employment. The World Financial Forum (Bobrovsky, 2020) estimates that 83 million jobs will be lost and 69 million created over the next five years. And artificial intelligence and machine learning specialists top the list of fast-growing job openings. And most of the dynamic roles on the list involve technology. For example, an engineer, i.e. specialist in setting problems for algorithms. Or professions at the intersection of machine learning and medicine: a specialist in training algorithms for recognizing X-ray or CT images. At risk of layoffs are clerical or secretarial positions, bank clerks, etc.

Conclusion

In conclusion, any new product will certainly bring good to human beings, if we use it correctly. Although the risks are not small, looking at the current trends in the development of artificial intelligence, the future of the labor market cannot but worry. For example, the production of weapons continues, including the creation of destructive weapons. Even nuclear powers are trying to surpass each other every year. It is indisputable that artificial intelligence will also develop. We see achievements in education, medicine, logistics, production, and think that development is good for humanity.

The key factor currently determining the development of artificial intelligence technologies is the growth rate of computer computing power, since the principles of the human psyche still remain unclear. Therefore, the topics of AI conferences look quite standard and the composition has hardly changed for quite some time. But the increase in the productivity of modern computers, combined with the improvement in the quality of algorithms, periodically makes it possible to apply various scientific methods in practice. This happened with intellectual toys, and this happens with home robots.

In the future, temporarily forgotten methods of simply enumerating options (as in chess programs), which make do with an extremely simplified description of objects, will be intensively developed. But with the help of this approach (the main resource for its successful application is performance), it is expected that it will be possible to solve many different problems (for example, in the field of cryptography). Quite simple but resource-intensive algorithms of adaptive behavior will help autonomous devices operate confidently in a complex world. In this case, the goal is to develop systems that do not look like a person, but act like a person.

Scientists are trying to look into the more distant future. Is it possible to create autonomous devices that can, if necessary, independently assemble similar copies of themselves (reproduce)? Is science capable of creating appropriate algorithms? Will we be able to control such machines? There are no answers to these questions yet.

The active introduction of formal logic into applied systems for representing and processing knowledge will continue. At the same time, such logic is not able to fully reflect real life, and there will be an integration of various logical inference systems in single shells. At the same time, it may be possible to move from the concept of a detailed representation of information about objects and techniques for manipulating this information to more abstract formal descriptions and the use of universal inference mechanisms, and the objects themselves will be characterized by a small array of data based on probabilistic distributions of characteristics.

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THE PROBLEM OF EMERGENCE IN THE MANAGEMENT OF COMPLEX SYSTEMS

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Abstract. The research delves into the intricacies of emergence within managing complex systems. It provides a comprehensive examination of how new properties that are not inherent in their components manifest at the system level. This phenomenon, known as emergence, holds significant implications for project management, particularly in assessing risks and interrelations among various factors. The study explores the foundational techniques that L. Bertalanffy and A. Hall proposed for analyzing system integrity, emphasizing their application in social and technical systems. These methodologies underscore the importance of understanding the dynamic interplay between system components and the system as a whole. Particular emphasis is placed on identifying systemic objectives and patterns, such as equifinality — the principle that different initial conditions can lead to the same final state — and progressive factorization, which involves breaking down complex systems into more straightforward, manageable parts. By focusing on these aspects, the research highlights the importance of a holistic approach to system management, where the interaction between parts leads to emergent properties that cannot be predicted by analyzing the parts in isolation. The findings of this research furnish novel theoretical and practical approaches for the effective management of complex systems and projects. By considering facets like interaction, coordination, and management efficacy, the study offers valuable insights for improving project outcomes. These approaches are particularly relevant for project managers and system analysts who must navigate the complexities of modern, multifaceted systems, ensuring that emergent properties are identified, understood, and effectively managed to achieve desired outcomes.

Keywords: emergence, management of complex systems, system integrity, information models, equifinality, progressive factorization, project management

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КҮРДЕЛІ ЖҮЙЕЛЕРДІ БАСҚАРУДАҒЫ ПАЙДА БОЛУ МӘСЕЛЕСІ

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Аннотация. Зерттеу күрделі жүйелерді басқарудың қыр-сырын тереңдетеді. Зерттеу жүйелік деңгейде олардың компоненттеріне тән емес жаңа қасиеттердің қалай көрінетінін қарастырады. Пайда болу деп аталатын бұл құбылыс жобаны басқару процестеріне әсер етеді, әсіресе жобаның әртүрлі факторлары арасындағы тәуекелдер мен қатынастарды бағалау кезінде. Зерттеу л.Берталанфи мен А. Холл жүйелердің тұтастығын талдау үшін ұсынған негізгі әдістерді қарастырады. Оларды әлеуметтік және техникалық жүйелерде қолдануға ерекше назар аударылады. Бұл құралдар жүйенің компоненттері мен жалпы жүйе арасындағы динамикалық өзара әрекеттесуді түсінудің маңыздылығын көрсетеді. Эквиваленттілік және прогрессивті факторизация сияқты жүйелік мақсаттар мен заңдылықтарды анықтауға ерекше назар аударылады. Осы аспектілерге назар аудара отырып, зерттеу жүйені басқарудың біртұтас тәсілінің маңыздылығын атап көрсетеді, онда бөліктер арасындағы өзара әрекеттесу бөліктерді жеке талдау арқылы болжау мүмкін емес жаңа қасиеттерге әкеледі. Зерттеу нәтижелері күрделі жүйелер мен жобаларды тиімді басқарудың жаңа теориялық және практикалық тәсілдерін ұсынады. Өзара әрекеттесу, үйлестіру және басқару тиімділігі сияқты аспектілерді қарастыра отырып, зерттеу жобаларды іске асыру сапасын жақсарту үшін қолдануға болатын құралдар мен әдістерді ұсынады. Бұл тәсілдер, әсіресе, қажетті нәтижелерге қол жеткізу үшін пайда болатын қасиеттерді анықтауды, түсінуді және тиімді басқаруды қамтамасыз ете отырып, заманауи көп қырлы жүйелердің күрделілігін басшылыққа алуға тура келетін жоба менеджерлері мен жүйелік талдаушыларға қатысты.

Түйін сөздер: пайда болу, күрделі жүйелерді басқару, жүйенің тұтастығы, ақпараттық модельдер, эквиваленттілік, прогрессивті факторизация, жобаларды басқару

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ПРОБЛЕМА ЭМЕРДЖЕНТНОСТИ В УПРАВЛЕНИИ СЛОЖНЫМИ СИСТЕМАМИ

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Аннотация. Исследование углубляется в тонкости управления сложными системами. В исследовании рассматривается, как на системном уровне проявляются новые свойства, не присущие их компонентам. Это явление, известное как эмерджентность, имеет влияние на процессы управления проектами, особенно при оценке рисков и взаимосвязей между различными факторами проекта. В исследовании рассматриваются основополагающие методы, предложенные Л. Берталанфи и А. Холлом, для анализа целостности систем. Особое внимание уделяется их применению в социальных и технических системах. Эти инструменты подчеркивают важность понимания динамического взаимодействия между компонентами системы и системой в целом. Особое внимание уделяется выявлению системных целей и закономерностей, таких как эквифинальность и прогрессивная факторизация. Сосредоточив внимание на этих аспектах, исследование подчеркивает важность целостного подхода к управлению системой, при котором взаимодействие между частями приводит к появлению новых свойств, которые невозможно предсказать путем анализа частей по отдельности. Результаты исследования предлагают новые теоретические и практические подходы к эффективному управлению сложными системами и проектами. Рассматривая такие аспекты, как взаимодействие, координация и эффективность управления, исследование предлагает инструменты и методы, которые можно использовать для улучшения качества реализации проектов. Эти подходы особенно актуальны для менеджеров проектов и системных аналитиков, которым приходится ориентироваться в сложностях современных многогранных систем, обеспечивая выявление, понимание и эффективное управление возникающими свойствами для достижения желаемых результатов.

Ключевые слова: эмерджентность, управление сложными системами, целостность системы, информационные модели, эквифинальность, прогрессивная факторизация, управление проектами

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Introduction

Complex systems are characterized by many interacting components, which may be physical, biological, or social. For example, a microservice architecture is a complex system where each service performs a specific function, but together, they form a single (holistic) functioning environment.

System integrity (connectedness, unity of the whole) is inextricably linked with emergence (unexpected emergence, appearance of a new one).

Two key concepts in the study of complex systems are emergence and self-organization. Emergence refers to the emergence of new properties or behaviors of a system that cannot be explained in terms of its constituent parts alone. This means that the properties of the whole are not a simple sum of the properties of its constituent elements, although they depend on them. On the other hand, elements combined into a system can lose properties inherent to them outside the system or acquire new ones. An example of emergence in programming is the behavior of a distributed system, where the simple interaction of individual nodes gives rise to new operation patterns. This concept follows an essential characteristic of project management: the emergence of a project linked to a system for developing value in the form of a new product, result, or service.

Materials and methods

Many studies have been devoted to the issue of classifying systems by “degree of complexity”, including many approaches to defining “complexity”. The most straightforward approaches are based, as noted in (Volkova et al., 2006: 848), simply on a quantitative assessment of the elements included in the system without considering the specifics of the connections and relationships between them. For example, G.N. Povarov (Povarov, 1970), assessing the complexity of a system depending on the number of elements included in the system, identifies four classes of systems:

1. Small systems (10...103 elements);
2. Complex (104...107 elements);
3. Ultra-complex (107...1030 elements);
4. Supersystems (1030…10200 elements).

Speaking about the taxonomy of complex systems, V.Ya. Tsvetkov, in his article (Tsvetkov), notes: “The next stage in the development of the theory of complex systems should be considered the work of Hiroki Sayama” (Hiroki Sayama, 2015: 498), according to which the theory of complex systems includes several scientific directions, including systems theory. This theory is more general in relation to systems theory and systems analysis. According to this point of view (Hiroki Sayama, 2015: 498), the theory of complex systems includes the critical issue of emergentism (Tsvetkov, 2017: 137–138) and self-organization (Ashby, 1966: 332). Complex systems theory is related to game theory, collective behavior, distributed systems theory, evolution and adaptation, nonlinear dynamics, structural modeling, and general systems theory.

Hiroki Sayama calls complex systems networked systems (Hiroki Sayama, 2015: 498) "having a large number of components interacting with each other, which are characterized by nonlinear functions".

A model of a complex system must be understandable, valid, and reliable (Nikolis, 1989: 488). Let us consider these properties (Tsvetkov, 2017: 137–138):

Perception is a cognitive factor, sometimes replaced by the term simplicity. However, simplicity is a conditional concept that depends on the choice of criterion for assessing it.

Hiroki Sayama (Hiroki Sayama, 2015: 498) defines the validity of a complex system model as the quality of information correspondence, which shows how accurately the forecast of the behavior of a complex system, as a model, agrees with its real behavior.

According to Hiroki Sayama (Hiroki Sayama, 2015: 498), the "reliability" of a model of any system is determined by its sensitivity to external influences. If minor influences (conditional characteristics) do not change progress towards the goal, then such a model of a complex system can be considered reliable.

As highlighted in (Mesarovic), there are two approaches to defining the categories "Complexity" and "large-scale systems" — abstract and hierarchical. The mathematical theory of abstract systems can be applied in engineering in various contexts and for different purposes. The challenge of complexity primarily surfaces with large-scale systems. From this perspective, the competency models used in project management can be considered "quite complex" in comparison with systems for creating new products and systems for operating engineering infrastructure on a scale, for instance, a state. However, considering the nonlinearity inherent, primarily in the "human factor", which is an integral component of the competency model of specialists in almost all fields of activity, and the structural connections in complex socio-technical systems, the problem of "complexity" demands special attention. To address this issue, it is crucial to construct models and structural representations of the system under consideration. One of the key steps in engineering design is the selection of the structure of the designed system or, in other words, the analysis of structural representations of the behavior and activity of the system. A detailed mathematical model is not suitable for this purpose, even if it exists. Traditionally, engineers have relied heavily on block diagrams to comprehend the complete composition of a system and further its structural representations. The main appealing aspect of flowcharts is, of course, their simplicity, but their main drawback is their lack of precision. General systems theory can be a valuable tool for constructing basic structural representations of a system that maintain the simplicity of block diagrams and simultaneously meet all the requirements of mathematical accuracy. General systems theory models bridge the gap between block diagram representations of systems and mathematical models. The construction of system-wide models is essential, particularly when analyzing complex technical systems. The existence of some system-wide methods that enable solving a specific problem at the level of general systems theory underscores the usefulness of introducing this stage into the process of analysis and design of complex systems, which are any project management systems.

The pattern of integrity (emergence) manifests itself in a system in the emergence (in english: Emerge) of new properties that are absent in the elements. L. Bertalanffy considered emergence the main systemic problem (Bertalanffy, 1972: 20–37).

The manifestation of this pattern is easy to explain using examples of the behavior of populations, social systems, and even technical objects; for example, the properties of a machine tool differ from the properties of the parts from which it is assembled. The enterprise can produce complex technical complexes from components and parts manufactured by individual production units or employees, united by the rules of interaction, determined by production technology and industrial relations, etc.

In project management, the pattern of integrity is best illustrated by the logic of risk management. To fully grasp the situation and trends in its development, it's not sufficient to analyze only the "final" factors that influence the possibility of deviations from the original plan. The "classical" approach to risk management, relying on SWOT analysis (Lukianov et al., 2020: 7–92), is inadequate. However, by analyzing the influence of factors on each other, transforming many factors {SWOT} into a SWOTxSWOT adjacency matrix, we can create a much more informative system model. This comprehensive approach is equally beneficial in analyzing schedules, stakeholders, communications, and competency models.

To better understand the pattern of integrity, it is necessary first of all to take into account its two sides:

1) The understanding of a system's (whole) properties Q_S is not a mere summation of the properties of its constituent elements (parts) q_i. This comprehension is crucial as it lays the foundation for understanding the system's behavior.

2) The behavior of a system (whole) is contingent upon the properties of its constituent elements (parts): $Q = f(q)$. This understanding of system behavior is essential for comprehending the system's response to changes in its constituent elements.

In addition to the listed properties, you should keep in mind one more property:

3) Elements combined into a system generally lose some of their properties characteristic of them outside the system. That is, the system seems to lose a number of properties of the elements; on the other hand, elements, once in the system, can acquire new properties.

For example, a project team is capable of managing a large project, and each team member bears the imprint of such collective (systemic) abilities that are not characteristic of each team member. For artificial (for example, technical or production) systems, the integrity property is associated with the purpose for which the system is created. Moreover, suppose the goal is not explicitly specified, and the modeled object has integral properties. In that case, you can determine the goal (target function, system – forming criterion) by studying the reasons for the emergence of the pattern of integrity. In complex systems, such as organizational or other systems with an active element – a person, it is not easy to immediately understand the reason for the emergence of integrity, and it is necessary to carry out an analysis to identify what led to the emergence of integral, systemic properties (Lukianov et al., 2017; Lukianov et al., 2018: 3–22).

Any evolving system typically exists between the states of absolute integrity (completeness) and absolute additivity. This dynamic nature of a system is key to understanding its adaptability and evolution.

In this case, absolute integrity corresponds to a state of complete order (in information theory – 100 % certainty) of the system, and additivity characterizes 100 % entropy or chaos, that is, the degeneration of the system into a conglomerate of elements devoid of any connections among themselves and, consequently, integrity.

The temporary state of the system can be characterized by the degree of manifestation of one of these properties or trends toward its increase or decrease. To assess these trends, A. Hall introduced two combined patterns, which he called progressive factorization – the desire of the system to a state with more and more independent elements and progressive systematization – the willingness of the system to reduce the independence of elements, etc. To assess integrity, A. Hall introduced some indirect assessments that make it possible to determine which patterns are manifested in the system to a greater extent. However, these estimates were introduced for specific communication systems (Table 1).

Table 1 – Patterns of interaction between part and whole

Patterns of interaction between part and whole	Degree integrity a	Element utilization rate b
Integrity (emergence)	1	0
Progressive systematization	$a > b$	
Progressive factorization	$a < b$	
Additivity (summative)	0	1

These estimates are obtained based on the relationship that determines the relationship between the systems C_C, its own C_0, and the mutual C_B complexity of the system:

$$C_c = C_0 + C_B \quad (1)$$

Let's start with the concept of "intrinsic complexity", which is essentially the total complexity of the elements of a system, excluding their connections with each other. In the context of pragmatic information, it's the complexity of the aspects that directly influence the achievement of the system's goal.

The system complexity of a C_C is the system's content as a whole (for example, before it is used).

Finally, we have 'mutual complexity '. This term characterizes the degree of interconnection of elements in the system. Think of it as the system's complexity as a device, circuit, or structure. It's a measure of how the elements of the system interact with each other, contributing to the overall complexity of the system.

If we divide (1) on C_0, we obtain the fundamental law of systems:

$$a + b = 1 \quad (2)$$

Where is the relative connectivity of system elements,

$$a = -(C_B / C_0) \quad (3)$$

their relative freedom

$$b = C_C / C_0 \quad (4)$$

The first expression (1) characterizes the degree of integrity, coherence, and interdependence of system elements in organizational systems and can be interpreted as the degree of centralization of management.

The second expression (2) is independence, the autonomy of the parts as a whole, and the degree of decentralization of the system. For organizational systems, it is convenient to call this the utilization rate of elements in the system.

The minus sign in (3) is introduced so that *a* is positive since C_B in stable systems, characterized by $C_0 > C_C$, formally has a negative sign. C_B associated (what remains inside the system) content characterizes the system's work for itself, not for fulfilling the goal set before it.

From (4), it follows that the sum of the freedom and restrictions of the system's parts is a constant value.

Regarding social systems, this means that an increase in justice *a* is achieved only by limiting freedom *b*, and vice versa. Therefore, a real complex, developing system is always between two extreme states – absolute integrity and absolute decay, chaos. Society faces a choice of the degree of regulation of integrity.

Modern methods of theoretical analysis of heterogeneous (decentralized) economic systems pay increasing attention to the problems of coordination (regulation and coordination) of the actions of economic agents rather than to the "free development" of the economy. The market is considered a source of information exchange and the provision of its participants with the necessary knowledge.

When an object is conceptualized as a system, the laws of integrity dictate that the combination of elements into a system and the transition from a system to its constituent elements will lead to qualitative changes. These changes occur at every level of system dissection. Initially, the object or process is represented as a structure for study, which may not immediately lend itself to a mathematical model. The process then involves the identification of precise deterministic relationships between the elements of the system, a task that often requires further investigation.

The intricate logic of the IPMA Delta model is best understood through the interplay of the ICB, OCB, and PEB models (Bushuyev et al., 2022: 1–12). However, the detailed description of the interaction between the final elements of these subsystems, each of which is a subsystem in relation to the system described by IPMA Delta, is yet to be fully explored. This model, in its complexity, can be scaled from the enterprise level to the industry, state, etc. level, offering a rich field for exploration and application (Lukianov et al., 2021: 70–84).

Practically, the property of structure integrity in the IPMA Delta model allows for the description of problem situations that are riddled with significant uncertainties. This model breaks down large uncertainties into smaller, more manageable ones, aiding in the identification of the causes of qualitative changes in forming a whole from parts. This practical application of the model underscores its relevance and usefulness in real-world problem-solving scenarios.

By dissecting the system, it is possible to analyze the reasons for the emergence of integrity based on the establishment of cause-and-effect relationships of various natures between parts, apart, and the whole, identifying the cause-and-effect conditionality of the whole environment, first carried out by the authors in their works aimed at understanding the deep mechanisms of the competency models of IPMA ICB version 3.0 (Lukianov et al., 2019: 506–512).

Hypothesis 1

The entropy of the entire control subsystem upon transition to a new target state is determined by the sum (integral estimate) of the entropy of all its elements.

This can be demonstrated by an increase in the total number of (missing) connections between elements when calculating an adjacency matrix of order n, in which the corresponding matrix does not contain empty (zero) elements.

The pattern of equifinality is one of the patterns of systems' functioning and development, characterizing the system's maximum capabilities. This term was proposed by L. Bertalanffy, who, for an open system, defined equifinality as "the ability, in contrast to the state of equilibrium in closed systems, entirely determined by the initial conditions, ... to achieve a state that does not depend on its initial conditions and is determined exclusively by the parameters of the system" (Bertalanffy, 1972: 20–37).

Hypothesis 2

The total information flow directed to the control object during the period of its transition to a new target state is equal to the difference between the entropy of the entire control subsystem during the transition to a new target state and the energy of the control object spent by the control object on the transition to the new state.

Consider all system elements as a “control object” except elements that are part of the “control subsystem”. This approach allows us, for instance, to determine a complete information flow aimed at the entire complex of competencies of a project manager in the logic of the IPMA ICB model from such an element as “leadership”, like “power”, correspond to the elements of competence of the vertices of the graph in relation to incoming and outgoing connections (Sherstiuk et al., 2019: 496–500).

Hypothesis 3

The information work of the control subsystem to transform resources is crucial and consists of two parts – the work of the control subsystem spent on compensating for its initial entropy and the work aimed at the controlled object, that is, at maintaining the system in a stable state. This, in essence, reflects the logic of collecting information about the current state of the project’s work and reconciliation with the project’s baseline plans, presented in the logic of the monitoring and control processes, and relates to change management in the project.

This hypothesis requires an important, in the author’s opinion, not-control elements must, by definition, “generate” more “influence” than they “accept” on themselves, incl. on the part or parts of a “similar nature.” In this regard, it is indicative of considering not only the logic of interaction between the elements of the control subsystem but also its possible representation as a “complex”, “cluster” or “core”, which has “strong connections” between each other (or “essential”, in terms familiar to mathematicians).

Hypothesis 4

The valuable work of the control subsystem during a specific period must correspond to the full information flow affecting the controlled system (by axiom 2) for the analyzed period.

Essentially, the “principle of adequacy” refers to the suitability of management decisions made based on the information received about the project’s status and the changes in its implementation environment.

An important note – the calculation of such parameters as “information work” and “useful work” allows us to introduce the concept of “efficiency coefficient” of the control subsystem, introducing the following seventh axiom:

Hypothesis 5 (proposed by the authors)

The efficiency of the control subsystem for a certain period cannot be more than 100 % for the analyzed period (“The project manager is not a magician”).

Based on information modeling data carried out by the authors for different models, the efficiency of the control subsystem is not a constant value in the general case (it can change significantly during transient processes and be a periodically changing value for systems that are periodic Markov chains (Kolesnikova et al., 2021: 1–6).

Moreover, based on the logic of such a parameter as efficiency, it is possible to compare different management models, for example, to conclude about a change in the efficiency of the control subsystem in the form of one or another block of competencies during the transition from the IPMA ICB 3.0 model to version 4.0, and also to propose how the control subsystem is a different set of elements, justifying this by a distinct, higher efficiency value of the control subsystem.

Discussion and results

However, the authors present a novel concept, a 'system landscape' model, albeit in a simplified form, which they propose to visualize the influence of its elements on the overall 'entropy' of the system. This unique approach, considering Markov models as information systems and applying measures taken to analyze information processes, significantly expands the possibilities of analyzing such systems. In this case, it is important to define the concept of 'model':

1) Model – an object or description of an object, a system for replacing one system (original) with another system for studying the original or reproducing its properties.

2) Model – the result of mapping one structure through another. By reflecting a physical system (object) onto a mathematical system, researchers obtain a physical and mathematical model of the system or a mathematical model of the physical system.

As is known, the classical modeling problem consists of three tasks:

1. development of a model;
2. research of the model;
3. implementation of the model.

The proposed approach to developing models solves all these three problems:

1. The construction of the model is not just theoretical, but also practical and constructive. An algorithm is proposed for constructing the model, making it a feasible and effective approach.
2. To study the model, methods for its research and analysis are proposed.
3. Specific targeted use of models is provided (as constructive and specific tasks).

Among the methods and tools used in the authors' work, the application of decision-making theory has proven to be the most effective in practice. This is primarily because, based on the basic definition of a "solution", a choice can be made from several alternative options. The models being developed are designed to be used, during the decision-making process, as tools for identifying problems, searching for alternative opportunities, and their formalization in a form suitable for analyzing further decisions, as well as those associated with the processes of eliminating problems and realizing opportunities.

Conclusion

Based on the fact that making a management decision is the main decision in the technological management cycle, and the decision-making process is a sequence of selection procedures, the result of which is a system of management decisions ready for implementation, the proposal of a particular "information system" that can act as such a "system" management decision support" in an area where this kind of toolkit has not previously been proposed, then, according to the authors, there is, at a minimum, potential for practical application.

At the same time, decision-making under conditions of certainty, in which the values of the most significant parameters are clearly defined, will differ from decision-making under conditions of uncertainty or when conditions are subject to constant change.

Using a rational model when choosing management decisions is based on selecting a solution that will maximize the organization's utility (profit). Using a sensible model requires, on the one hand, a balanced approach to determining the evaluation criterion, a thorough search for alternatives, and their complete analysis. On the other hand, there may not be enough time or the necessary qualifications to ensure a balanced approach to determining the evaluation criterion, a thorough search for alternatives, and their analysis. In this case, transitioning from the "ideal rational model" to a limited one is possible. In this case, the main goal of the "boundedly rational" approach will no longer be to maximize utility but to achieve "acceptable satisfaction". In this case, the problem is defined in a simplified manner, the analysis of alternatives is carried out superficially, and the first decision meets a particular set of criteria (attention is not focused on the optimality of the solution).

Having an information system capable of systematizing information for decision-making will certainly be useful. Considering the capabilities of modern information technologies and the growing potential for the use of AI, one should expect the emergence of such functionality, which is quite suitable for assisting in decision-making in situations where it is necessary to make a choice from several alternatives.

Issues of complexity and emergence remain unresolved entirely. The hypotheses of information management proposed by the authors can be applied to analyzing a wide range of design systems.

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THE MAIN METHODS OF PROJECT MANAGEMENT IN KAZAKHSTAN'S PRACTICE

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Abstract. This work explores the main methods of project management in Kazakhstan's practice using the example of a project to create a chess school. The study examines the main stages of project management, such as planning, organization, execution and control. The main project management tools and methods used in Kazakhstan's practice are also analyzed. The results of the study can be useful for project managers in Kazakhstan and other countries, as well as for specialists in the field of project management. The topic "Basic project management methods in Kazakhstan's practice" is of great relevance, especially in the context of project implementation in various fields, including education. The development and launch of a chess school in Kazakhstan can be an interesting and useful project that requires effective management.

Keywords. Management, projects, practice, chess school, management methods
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ҚАЗАҚСТАНДЫҚ ТӘЖІРИБЕДЕ ЖОБАЛАРДЫ БАСҚАРУДЫҢ НЕГІЗГІ ӘДІСТЕРІ

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Аннотация. Бұл жұмыс шахмат мектебін құру жобасының мысалында қазақстандық тәжірибеде жобаларды басқарудың негізгі әдістерін зерттейді. Зерттеу жоспарлау, ұйымдастыру, орындау және бақылау сияқты жобаны басқарудың негізгі кезеңдерін қарастырады. Сондай-ақ қазақстандық тәжірибеде қолданылатын жобаларды басқарудың негізгі құралдары мен әдістері талданады. Зерттеу нәтижелері Қазақстандағы және басқа елдердегі жобаларды басқарушылар үшін, сондай-ақ жобаларды басқару саласындағы мамандар үшін пайдалы болуы мүмкін. "Қазақстандық практикадағы жобаларды басқарудың негізгі әдістері" тақырыбы, әсіресе білім беруді қоса алғанда, әртүрлі салалардағы жобаларды іске асыру контекстінде үлкен өзектілікке ие. Қазақстанда шахмат мектебін әзірлеу және іске қосу тиімді басқаруды талап ететін қызықты әрі пайдалы жоба болуы мүмкін.

Түйін сөздер: басқару, жобалар, практика, шахмат мектебі, басқару әдістері

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ОСНОВНЫЕ МЕТОДЫ УПРАВЛЕНИЯ ПРОЕКТАМИ В КАЗАХСТАНСКОЙ ПРАКТИКЕ

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Аннотация. Данная статья исследует основные методы управления проектами в казахстанской практике на примере проекта создания шахматной школы. В рамках исследования рассматриваются основные этапы управления проектом, такие как планирование, организация, выполнение и контроль. Также анализируются основные инструменты и методы управления проектами, применяемые в казахстанской практике. Результаты исследования могут быть полезны для управляющих проектами в Казахстане и других странах, а также для специалистов в области управления проектами. Тема «Основные методы управления проектами в казахстанской практике» имеет большую актуальность, особенно в контексте реализации проектов в различных областях, включая образование. Разработка и запуск шахматной школы в Казахстане может быть интересным и полезным проектом, который требует эффективного управления.

Ключевые слова: управление, проекты, практика, шахматная школа, методы управления

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Введение

Актуальность В современном мире управление проектами играет ключевую роль в достижении поставленных целей и успешной реализации задач. Казахстан не является исключением, и в его практике существует ряд основных методов управления проектами, которые применяются для эффективного управления различными проектами.

Цель работы «Основные методы управления проектами в казахстанской практике» в контексте проекта шахматной школы в Казахстане заключается в изучении и анализе основных подходов и методов управления проектами, которые могут быть эффективно применены при реализации данного конкретного проекта.

Изучение основных методов управления проектами, применяемых в казахстанской практике, с учетом специфики региональных особенностей и требований.

Основной задачей является Анализ применимости различных методов управления проектами к конкретному проекту шахматной школы в Казахстане, с учетом его целей, задач, ресурсов и ограничений.

Гипотеза — Разработка рекомендаций по выбору наиболее подходящих методов управления проектом шахматной школы в Казахстане с целью обеспечения успешной реализации и достижения поставленных целей.

Проведение анализа возможных рисков и разработка стратегий и планов действий для их минимизации в рамках проекта шахматной школы.

Выявление основных факторов успеха и вызовов, с которыми может столкнуться проект шахматной школы в Казахстане, и предложение рекомендаций по их управлению.

Один из таких проектов, который можно рассмотреть в контексте казахстанской практики — это проект создания шахматной школы. Шахматы в Казахстане пользуются популярностью и признаны как один из инструментов развития умственных способностей детей. Поэтому создание шахматной школы может быть важным шагом в развитии образования и спорта в стране.

Для успешной реализации проекта создания шахматной школы в Казахстане необходимо применять основные методы управления проектами.

Определение целей проекта, разработка плана действий, определение ресурсов и сроков выполнения задач.

Формирование команды проекта, распределение обязанностей, установление коммуникационных каналов.

Непосредственная реализация плана действий, контроль за выполнением задач, управление ресурсами.

Отслеживание прогресса проекта, оценка достигнутых результатов, корректировка плана при необходимости.

Для успешного управления проектом создания шахматной школы важно также использовать различные инструменты управления проектами.

Материалы и методы

Существует множество методов управления проектами, которые помогают организовать работу, контролировать процессы и достигать поставленных целей.

Для анализа применимости различных методов управления проектами к конкретному проекту шахматной школы в Казахстане, необходимо учитывать определенные аспекты.

Разработка и внедрение гибкого метода управления проектами реализовалась на примере шахматной школы города Алматы Smart Chess Academy, которая занимается обучением и повышением квалификации учеников детской и взрослой возрастной категории в сфере образования.

Внедрение гибких метод управление проектами проходило в течение шести месяцев (полугода). Кроме предоставления статистических данных необходимо оценить эффективность внедрения, провести анализ рисков и SWOT-анализ. Проведены следующие методы, которые позволили проанализировать гибкие методы управления проектами на примере шахматной школы Smart Chess Academy города Алматы:

- SWOT-анализ шахматной школы Smart Chess Academy города Алматы
- Оценка рисков проекта и рекомендации по ее снижению
- Оценка эффективности внедрения методов управления проектами.

Таблица 1. SWOT-анализ шахматной школы Smart Chess Academy города Алматы

Сильные стороны ✓ Шахматы являются актуальной деятельностью для всех возрастных категорий, особенно для детского возраста; ✓ Занятия в офлайн и онлайн формате позволяют проводить занятия, не только в кабинете, но и удаленно; ✓ Квалифицированные преподаватели; ✓ Проведения конкурсов, турниров, повышений квалификаций; ✓ Активное продвижение и рост в социальных сетях для привлечения целевой аудитории.	Слабые стороны ✓ Проект имеет сильную зависимость от заинтересованности людей (потеря текущих клиентов); ✓ Сильная зависимость от преподавательского состава, поэтому предпринимателю необходимо создавать комфортные условия работы; ✓ Наличие сильных конкурентов, которые дольше находятся в сфере образования.
Возможности ✓ Увеличение преподавательского состава и вместе с тем количество учащихся в шахматной школе; ✓ Расширение онлайн формата обучения, распространение не только в рамках Казахстана, но и в других странах; ✓ Поддержка со стороны государства малому бизнесу.	Угрозы ✓ Ухудшение экономики Республики Казахстан и в мире; ✓ Ужесточение конкуренции (внутриотраслевая конкуренция); ✓ Террористические угрозы; ✓ Снижение доходов населения; ✓ Снижение интереса населения страны к обучению.

Источник: составлено автором

Оценка эффективности внедрения гибких методов в управление шахматной школой Smart Chess Academy проводилась с помощью расчета ROI, который составил 126,46 % (ROI > 100 % – вложения полностью окупились, проект приносит прибыль) Все данные о доходах и расходах были взяты у руководителя проекта шахматной школы, в сотрудничестве с которым проводились все статистические данные и расчеты, обговаривались дальнейшие задачи и действия для эффективного управления проектом в будущем.

Общий прирост клиентов шахматной школой Smart Chess Academy за полгода по итогам подсчетов в апреле количество учеников составило – 74 ученика, в онлайн формате обучения – 16 учеников. В сравнении в ноябре количество учеников оставляло – 48, в онлайн формате обучения – 5 учеников, через полгода – 16.

Общий прирост количества учеников за последние полгода в офлайн формате обучения в процентном соотношении составляет – 64.86 %. Количество учеников в онлайн формате обучения выросло на 31.25 %. С каждым месяцев прирост количества регулярных клиентов постепенно довольно стремительно увеличивается.

Общий прирост количества учеников на пробное занятие по шахматам за последние полгода в онлайн и офлайн формате обучения в процентном соотношении составляет – 18.75 %. С повышением числа проведенных пробных занятий растет общее число продаж, так как бесплатное занятие позволяет клиентам оценить качество преподавания, свои умственные способности и навыки, заинтересованность и тому подобное, то есть после занятия ученикам проще принять решение, нужно ли им проходить обучение именно в шахматной школе Smart Chess Academy.

Таблица 2. Финансовый план на год шахматной школы Smart Chess Academy города Алматы

Расходы	Общая сумма в месяц, тенге
Реклама	8.200
Аренда помещения	120.000
Коммунальные услуги	7.500
Прибыль до налогообложения	740.000
Налог на прибыль	22.200
Чистая прибыль	582.100

Финансовый план составлялся до начала внедрения гибких метод управления проектами, в частности для шахматной школы Smart Chess Academy города Алматы, основываясь на опыте прошлых периодов, однако в течение полугода значение чистой прибыли превысило ожидаемые.

Основная цель проекта шахматной школы в Казахстане заключается в развитии шахматного спорта среди молодежи, обучении шахматным навыкам и подготовке талантливых игроков. Для достижения этой цели может быть необходимо использовать методы управления, способствующие эффективному обучению и развитию учащихся (Мудунов и др., 2015)

Задачи проекта могут включать в себя создание инфраструктуры для проведения занятий, найм квалифицированных тренеров, организацию соревнований и турниров, привлечение учащихся и их родителей. Для эффективного выполнения задач могут потребоваться методы управления, направленные на планирование, координацию и контроль выполнения работ.

Ресурсы проекта шахматной школы могут включать в себя финансовые средства, персонал, оборудование, помещения и другие ресурсы. Для оптимального использования ресурсов могут применяться методы управления, направленные на распределение и оптимизацию ресурсов.

Ограничения проекта могут включать в себя ограниченный бюджет, ограниченные сроки выполнения проекта, ограниченные ресурсы и другие факторы.

Для управления ограничениями могут использоваться методы управления качеством, временем и стоимостью (Казаков и др., 2007).

Исходя из вышеперечисленных аспектов, можно провести анализ применимости различных методов управления проектами к конкретному проекту шахматной школы в Казахстане. Например, для эффективного обучения учащихся и развития шахматных навыков можно применить методы Agile управления проектами, которые позволяют быстро реагировать на изменения и адаптировать планы к новым условиям. Для оптимального использования ресурсов можно использовать методы управления портфелем проектов, которые помогут выбрать наиболее приоритетные проекты для инвестирования ресурсов. Таким образом, анализ применимости различных методов управления проектами к проекту шахматной школы в Казахстане поможет выбрать наиболее подходящие методы для успешной реализации проекта и достижения его целей.

Для выбора наиболее подходящих методов управления проектом шахматной школы в Казахстане и обеспечения успешной реализации проекта, рекомендуется: Первым шагом является четкое определение целей и задач проекта шахматной школы. Это поможет определить необходимые ресурсы, сроки и ограничения проекта.

Провести анализ рисков, связанных с реализацией проекта шахматной школы. Определите потенциальные угрозы и возможности, чтобы разработать стратегии по их управлению. Определите важность каждого риска и его влияние на достижение целей проекта. На основе результатов анализа рисков разработайте стратегии управления рисками. В зависимости от характера рисков, они могут быть смягчены (путем принятия мер по снижению вероятности возникновения риска) или перенесены (путем разработки плана действий в случае возникновения риска). Для каждого идентифицированного риска разработайте детальный план действий, который будет определять шаги, необходимые для минимизации воздействия риска на проект. Укажите ответственных лиц и сроки выполнения действий. Постоянно отслеживайте состояние рисков, их вероятность возникновения и влияние на проект. В случае необходимости корректируйте стратегии управления рисками и обновляйте планы действий (Тулембаев, 2013).

Исходя из целей, задач, ресурсов и ограничений проекта, выберите наиболее подходящие методы управления проектом. Например, для обучения учащихся и развития шахматных навыков можно использовать Agile методологию, которая позволит быстро адаптироваться к изменениям.

Обеспечьте эффективное управление командой проекта, наймите квалифицированных тренеров и персонал, который будет отвечать за различные аспекты проекта.

Установите систему мониторинга и контроля выполнения работ, чтобы своевременно выявлять отклонения от плана и корректировать действия.

После завершения проекта проведите оценку результатов и сравните их с поставленными целями. Используйте полученные данные для улучшения процессов в будущих проектах.

Вовлеките всех заинтересованных стейкхолдеров в процесс принятия решений и обеспечьте прозрачность в деятельности проекта. Определите потенциальные угрозы, которые могут повлиять на успешность проекта шахматной школы, а также возможности, которые могут быть использованы в свою пользу.

Выбор наиболее подходящих методов управления проектом шахматной школы в Казахстане зависит от конкретных особенностей проекта, его целей и задач (Земенкова, 2014).

Основные факторы успеха проекта шахматной школы в Казахстане.

Казахстан известен своими традициями в области шахматного спорта, что может способствовать интересу к шахматам среди молодежи.

Поддержка со стороны государства или местных властей может обеспечить финансовую и организационную поддержку проекту.

Наличие опытных и квалифицированных тренеров способствует качественному обучению шахматным навыкам.

Наличие современной инфраструктуры (игровых залов, оборудования) влияет на комфорт и эффективность обучения.

Грамотное продвижение шахматной школы поможет привлечь больше учеников и повысить ее известность.

Вызовы, с которыми может столкнуться проект.

Существует возможность конкуренции со стороны других шахматных школ или других видов досуга для детей. Недостаток финансирования может ограничить развитие шахматной школы и качество предоставляемых услуг. Найти и удержать квалифицированных тренеров и педагогов может быть сложной задачей. Необходимость адаптироваться к изменяющимся потребностям учеников и рынка.

Рекомендации по управлению вызовами.

Выделитесь на фоне конкурентов, предложив уникальные программы обучения или форматы занятий. Взаимодействуйте с государственными органами, спортивными организациями и другими заинтересованными стейкхолдерами для получения поддержки и финансирования. Обеспечьте непрерывное обучение тренеров и педагогов, чтобы повысить качество обучения. Следите за изменениями в спросе и требованиях рынка, чтобы оперативно реагировать на изменения. Используйте различные маркетинговые каналы для продвижения шахматной школы и привлечения новых учеников. С учетом этих факторов и рекомендаций можно эффективно управлять вызовами и повысить успешность проекта шахматной школы в Казахстане.

Заключение

В заключение, следует отметить, что в казахстанской практике основные методы управления проектами играют ключевую роль в успешной реализации различных проектов, включая проекты шахматных школ. Применение методологий управления проектами, управление рисками, эффективное планирование, управление коммуникациями, мониторинг и контроль, а также обучение и развитие персонала являются важными составляющими успешного выполнения проекта.

Проект шахматной школы, как и любой другой проект, требует четкого планирования, координации усилий всех участников и постоянного контроля за ходом выполнения задач. Соблюдение основных методов управления проектами поможет обеспечить эффективное функционирование шахматной школы, повысить качество обучения и достичь поставленных целей.

Таким образом, применение современных методов управления проектами в казахстанской практике способствует успешной реализации проектов различного масштаба и направленности, в том числе проектов шахматных школ, и способствует развитию образования и спорта в стране.

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МРНТИ 28.15

SCALABILITY AND INTEGRATION CHALLENGES OF IOT SYSTEMS IN KAZAKHSTAN

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Abstract. This article presents an analysis of the current state of development and integration of Internet of Things (IoT) systems in Kazakhstan. The article goes on to describe a number of key projects and initiatives aimed at the digitalization of various sectors, including smart cities, agriculture, energy and healthcare. The principal obstacles confronting IoT systems in Kazakhstan are delineated, including infrastructural constraints, the high power consumption of devices, cybersecurity, equipment incompatibility, data processing challenges, organizational impediments, financial limitations, the dearth of proficient professionals, and regulatory hurdles. For each challenge, potential solutions are proposed, including the development of network infrastructure, the implementation of energy-efficient technologies, the assurance of cybersecurity, the standardization of devices and protocols, the training of skilled professionals and the creation of an enabling environment for investment. An integrated approach to addressing these challenges will ensure the successful development and implementation of IoT technologies in Kazakhstan, thereby contributing to economic growth, increasing the efficiency of various industries and improving the quality of life of the population.

Keywords: IoT systems in Kazakhstan, IoT, data processing challenges, cybersecurity, flexibility
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ҚАЗАҚСТАНДАҒЫ IOT ЖҮЙЕЛЕРІН МАСШТАБТАУ ЖӘНЕ ИНТЕГРАЦИЯЛАУ МӘСЕЛЕЛЕРІ

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Аннотация. Бұл мақалада Қазақстандағы IoT жүйелерінің дамуы мен интеграциясының қазіргі жағдайы қарастырылады. Ақылды қалалар, ауыл шаруашылығы, энергетика және денсаулық сақтау сияқты түрлі салаларды цифрландыруға бағытталған негізгі жобалар мен бастамалар сипатталған. Қазақстандағы IoT жүйелерінің алдында тұрған негізгі проблемалар анықталды, соның ішінде инфрақұрылымдық шектеулер, құрылғылардың жоғары қуат тұтынуы, киберқауіпсіздік, жабдықтың үйлеспеушілігі, деректерді өңдеудегі қиындықтар, ұйымдастырушылық кедергілер, қаржылық шектеулер, білікті мамандардың жетіспеушілігі және реттеуші қиындықтар. Әрбір мәселе бойынша ықтимал шешімдер ұсынылады, оның ішінде желілік инфрақұрылымды дамыту, энергия тиімді технологияларды енгізу, киберқауіпсіздікті қамтамасыз ету, құрылғылар мен хаттамаларды стандарттау, білікті мамандарды даярлау және инвестициялау үшін қолайлы жағдай жасау. Осы міндеттерді шешудің кешенді тәсілі Қазақстанда IoT технологияларының табысты дамуын және енгізілуін қамтамасыз етеді, экономикалық өсуге, әртүрлі салалардың тиімділігін арттыруға және халықтың өмір сүру сапасын жақсартуға ықпал етеді.

Түйін сөздер: Қазақстандағы IoT жүйелері, IoT, деректерді өңдеу қиындықтары, киберқауіпсіздік, икемділік

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ПРОБЛЕМЫ МАСШТАБИРУЕМОСТИ И ИНТЕГРАЦИИ IOT-СИСТЕМ В КАЗАХСТАНЕ

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Аннотация. В данной статье рассматривается текущее состояние развития и интеграции систем Интернета вещей (IoT) в Казахстане. Описаны ключевые проекты и инициативы, направленные на цифровизацию различных отраслей, таких как «умные» города, сельское хозяйство, энергетика и здравоохранение. Выявлены основные проблемы, с которыми сталкиваются IoT-системы в Казахстане, включая инфраструктурные ограничения, высокое энергопотребление устройств, кибербезопасность, несовместимость оборудования, сложности в обработке данных, организационные барьеры, финансовые ограничения, нехватку квалифицированных специалистов и регуляторные вызовы. Для каждой проблемы предложены возможные пути решения, включая развитие сетевой инфраструктуры, внедрение энергоэффективных технологий, обеспечение кибербезопасности, стандартизацию устройств и протоколов, подготовку квалифицированных специалистов и создание благоприятных условий для инвестиций. Комплексный подход к решению этих проблем обеспечит успешное развитие и внедрение IoT-технологий в Казахстане, способствуя экономическому росту, повышению эффективности различных отраслей и улучшению качества жизни населения.

Ключевые слова: IoT в Казахстане, IoT-системы, проблемы обработки данных, кибербезопасность, гибкость

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Introduction

In recent years, Kazakhstan has been actively pursuing digital transformation, with the Internet of Things playing a pivotal role in this process. The country is investing in the development of smart cities, agriculture, energy and other sectors, utilizing IoT to enhance the efficiency and quality of life of its citizens.

The Internet of Things, or IoT, is the concept of a network of physical devices equipped with sensors, software, and other technologies that permit their connection to the Internet and communication with each other. These devices can range from domestic appliances and vehicles to industrial machinery and urban infrastructure. The primary objective of IoT is the creation of intelligent systems that are able to gather, analyze, and utilize data in order to enhance various facets of human life and business operations.

The history of IoT (Internet of Things) development in Kazakhstan commenced with the initial steps towards digitalization, during which projects were initiated with the objective of automating and monitoring various processes. These projects were observed in the country during the early 2010s and encompassed areas such as energy and agriculture. Initially, IoT was utilized to enhance the precision and efficacy of data, thereby facilitating more informed decisions and augmented productivity.

Materials and Methods

A comprehensive literature review was conducted to investigate the scalability and integration issues of IoT systems in Kazakhstan. Articles, reports and studies in the field of Internet of Things (IoT) published in the last ten years were analyzed. Scientific databases such as IEEE Xplore, SpringerLink and Google Scholar served as sources of information. Particular attention was paid to publications describing IoT implementation experiences in developing countries in order to identify common trends and specific challenges (Minerva, 2015).

A comprehensive methodology was developed to assess the scalability of IoT systems in Kazakhstan. This methodology includes several key criteria and analysis methods. The purpose of this methodology is to identify the main obstacles and determine ways to overcome them for effective IoT system scaling and integration. Key aspects of the assessment include system performance, architecture flexibility, cost-effectiveness and security.

Evaluation Criteria

System Performance

Number of devices supported: Evaluated the current and maximum number of devices the system can support without significant performance degradation. Load tests and simulations were used to determine overload points.

Amounts of data processed: The system's ability to process large amounts of data in real time was analyzed. Data processing speed, latency, and network bandwidth were examined.

Response Speed: System response time to requests from connected devices. Measurements were made using monitoring tools such as Prometheus and Grafana.

Architectural flexibility

System Adaptability: The ability of the system to adapt to changing requirements without requiring significant changes to its structure. Scaling methods (horizontal and vertical) and support for various communication protocols and standards were evaluated.

Interoperability: The ability of the system to integrate with other platforms and devices. Compatibility with popular IoT platforms and standards (e.g. MQTT, CoAP, HTTP/2) was analyzed.

Security and Reliability

System Vulnerabilities: Identified and assessed potential vulnerabilities in the system that could be exploited for attacks. Security analysis tools such as Wireshark and Metasploit were used.

Security measures: The measures implemented to secure data and devices, including encryption, authentication and access control were analyzed. Compliance with international security standards such as ISO/IEC 27001 was assessed.

System Reliability: Evaluated uptime, resilience to failure, and ability to recover from failures. Stress tests and analyses of redundant mechanisms were conducted (Journal of Internet Services and Information Security, 2015).

Analysis methods

Load tests were conducted to evaluate the system performance under various conditions. Load simulators such as Apache JMeter were used to simulate the behavior of a large number of devices.

Monitoring tools such as Prometheus and Grafana were used throughout the study to collect and visualize system performance data. Monitoring included analyses of response time, throughput and resource utilization.

Economic analysis

Cost analysis techniques, including calculation of total cost of ownership (TCO) and return on investment (ROI), were used to assess economic efficiency. Company financial reports and respondent survey data were analyzed.

Security analysis

Penetration tests and security audits were conducted using tools such as Wireshark and Metasploit to identify vulnerabilities. Data and device protection against various types of attacks was assessed.

A technical analysis of IoT systems in Kazakhstan was conducted with the objective of understanding the current state of technology used in various sectors of the economy and identifying barriers to scalability and integration. The following stages of the analysis were included: examination of system architecture, communication protocols used, data processing methods and security measures.

Study of system architecture

The architecture of various IoT systems used in Kazakhstan was analyzed in detail. Both centralized and decentralized architectures, their features and applicability in different industries were evaluated.

Centralized systems: These systems are based on a cloud architecture where all data is collected and processed in a central server or cloud. The analysis included a study of cloud platforms such as Microsoft Azure IoT, AWS IoT, and Google Cloud IoT.

Decentralized systems: Architectures based on edge computing, where data processing takes place on edge devices, reducing latency and load on central servers, were considered. Examples of edge computing implementations using platforms such as Cisco Edge Intelligence and IBM Edge Application Manager were explored.

Communication protocols

The study involved analyzing the most commonly used communication protocols in Kazakhstan's IoT systems:

MQTT (Message Queuing Telemetry Transport): A lightweight protocol widely used in IoT to transfer data between devices and servers.

CoAP (Constrained Application Protocol): A protocol designed to work with resource-constrained devices and provide low latency data transfer.

HTTP/2: A protocol used for more reliable and scalable real-time data transfer, especially in cloud architectures.

LoRaWAN (Long Range Wide Area Network): A protocol for low-power wireless communication used to connect devices in hard-to-reach and remote areas (Uckelmann, 2011).

Data processing methods

Various data processing techniques used in IoT systems have been analyzed:

Stream Processing: Using technologies such as Apache Kafka and Apache Flink to process data in real time. The performance and scalability of these technologies in the context of Kazakhstan's conditions was evaluated.

Data Storage: Databases used to store large amounts of data collected from IoT devices were studied. Solutions such as InfluxDB for time series data and MongoDB for structured and unstructured data were included.

Data Analytics: Methods and tools for big data analytics were considered, including machine learning and artificial intelligence. Platforms such as TensorFlow and Apache Spark used for analyzing IoT data were explored (Sinclair, 2017).

Security measures

The technical analysis also included an evaluation of the security measures implemented in IoT systems:

Data Encryption: Data encryption methods for transmission and storage, such as TLS (Transport Layer Security) and AES (Advanced Encryption Standard), were evaluated.

Authentication and Access Control: Device authentication mechanisms, including the use of certificates, tokens, and multi-factor authentication were examined (MFA).

Intrusion Detection and Prevention (IDS/IPS): Systems for network monitoring and suspicious activity detection such as Snort and Suricate were analyzed.

Results and Discussion

In light of the growing interest in digital technology and innovation, Kazakhstan has commenced a program of investment in the development of infrastructure to support the Internet of Things (IoT). In 2017, the Digital Kazakhstan state program was launched, which has become a key driver in the development of IoT. This program aims to create conditions for the widespread use of digital technologies, including IoT, in various sectors of the economy.

One of the first significant deployments of Internet of Things (IoT) technology in Kazakhstan was the introduction of intelligent electric and water meters. The introduction of these meters led to a significant improvement in resource management, with a reduction in losses. In agriculture, the utilization of IoT technologies to monitor soil and climatic conditions enabled an increase in crop yields and an enhancement in resource utilization efficiency (State program "Digital Kazakhstan, 2017).

Significant projects and initiatives

As part of the development of the Internet of Things (IoT) in Kazakhstan, several notable projects and initiatives have been implemented that contribute to the digital transformation of various industries. This encompasses smart lighting systems that regulate light intensity based on the time of day and the presence of people, traffic management systems that reduce congestion and enhance road safety, and video surveillance and security systems that provide real-time monitoring and incident response.

Agriculture

The agricultural sector in Kazakhstan is actively implementing IoT solutions to monitor and manage agricultural processes. The use of sensors to measure soil moisture, temperature and other climatic parameters allows farmers to more accurately manage irrigation and other agro-technical activities. The implementation of such systems is associated with an increase in crop yields, a reduction in the expenditure of resources, and a minimization of the environmental impact.

Energy

In Kazakhstan's energy sector, the introduction of smart meters and monitoring systems is facilitating the optimization of energy consumption and the reduction of losses. Smart meters provide accurate data on energy consumption in real time, which enables energy companies to manage resource allocation and capacity planning in a more efficient manner. The implementation of such systems helps to reduce costs and improve customer service.

Healthcare

The Internet of Things (IoT) has also found application in Kazakhstan's healthcare sector. Remote patient health monitoring systems, including wearable devices, allow doctors to monitor patients' condition in real time. Such technologies are of particular importance for patients with chronic diseases, as they facilitate the timely detection of changes in health status and the implementation of necessary measures. In the context of the ongoing COVID-19 pandemic, the utilization of IoT solutions to monitor the spread of the virus and to manage medical resources has also demonstrated its efficacy.

For the successful advancement of IoT in Kazakhstan, the support of the government and the establishment of an appropriate regulatory framework are crucial. The government is engaged in the formulation of strategies and programs with the objective of fostering the digitalization of the economy and the development of IoT technologies.

The Digital Kazakhstan program is designed to facilitate the development of the digital economy and infrastructure, including the introduction of IoT. The program encompasses measures to develop infrastructure, support innovation and create favorable conditions for business. Under the program, the government provides support for projects aimed at improving urban infrastructure, agriculture and energy development using IoT technologies.

Regulatory regulation

The development and implementation of regulations governing the use of IoT devices and cybersecurity are crucial aspects of government policy. This encompasses the standardization and certification of devices, as well as the protection of user data. It is of the utmost importance to create a legal framework that promotes the safe and efficient use of IoT technologies.

Educational initiatives

Supporting educational programs and initiatives aimed at training professionals in IoT and related technologies is of paramount importance to the development of the sector. The government and educational institutions are developing training courses and professional development programs to help train qualified personnel to work with IoT technologies.

Consequently, the current state of IoT in Kazakhstan is characterized by a dynamic development and implementation of the technology across various sectors of the economy. Government support and the implementation of significant projects contribute to the digital transformation of the country. However, there are still challenges that need to be addressed to ensure sustainable growth and the integration of IoT systems (Statistics Agency of the Republic of Kazakhstan, 2023).

The scalability challenges of IoT systems

Despite the progress that has been made, Kazakhstan is confronted with a number of challenges that limit the scalability and effective integration of IoT systems, including infrastructure constraints, the high ower consumption of devices, the threat of cybersecurity, the incompatibility of equipment, the complexity of processing large volumes of data, the organizational and management barriers, the lack of skilled professionals, and the regulatory issues. The successful implementation and scaling of IoT systems requires comprehensive solutions that address the technical, economic and managerial aspects. The table below provides a summary of the main challenges to the scalability of IoT systems in Kazakhstan and potential solutions.

Table 1- "Problems of the IoT system in Kazakhstan and solutions"

Issue	Description	Potential solutions
Infrastructural problems	Insufficient network coverage and limited bandwidth in remote and rural areas.	Development of 5G networks improvement of telecommunications infrastructure within the framework of the Digital Kazakhstan program.
Energy constraints	High power consumption of IoT devices, requiring frequent battery replacement or recharging.	Developing more energy efficient devices; utilizing alternative energy sources such as solar panels.
Cybersecurity and data protection	Vulnerability of IoT devices to cyber-attacks and unauthorized access.	Implement security standards such as data encryption and user authentication; develop new security methods.
Compatibility and standardisation	Diversity of devices and platforms using different standards and protocols.	Implementation of international standards and protocols such as MQTT and CoAP; development of national standards and regulations.
Data processing and analysis	The necessity for the rapid processing and analysis of vast quantities of data.	The development of capacities for big data processing and the training of qualified specialists in the field of data analytics are both key objectives of this project.
Organisational and management challenges	The existence of bureaucratic barriers and a lack of a unified coordination strategy across sectors and agencies represents a significant challenge.	The establishment of interdepartmental working groups and the formulation of a unified strategy for digitalization and the integration of IoT systems are two key objectives.
Economic problems	The implementation and operation of IoT systems is associated with significant upfront costs.	The stimulation of investments in Internet of Things (IoT) technologies and the development of the market for financing innovative projects are two key objectives.
Personnel issues	There is a shortage of skilled IoT professionals.	The development of educational programs and courses on the Internet of Things (IoT) is a key area of focus. Additionally, the organization of training courses and professional development programs is a significant aspect of the organization's activities.
Regulatory and legal challenges	The absence of clear regulations and standards governing the use of the Internet of Things (IoT) represents a significant challenge.	The development and implementation of regulations and standards to regulate the use of Internet of Things (IoT) technologies.

Source: authors

The development and scaling of IoT systems in Kazakhstan have the potential to transform various industries and improve the quality of life of citizens. Despite the successes achieved, Kazakhstan faces a number of significant challenges related to infrastructure constraints, energy requirements of devices, cybersecurity issues, equipment incompatibility, data processing complexity, organizational barriers, financial constraints, staff shortages and regulatory challenges (International Conference "Opening New Era of Smart Society", 2017).

In order to address these challenges, it is necessary to adopt an integrated approach and to coordinate the efforts of government agencies, the private sector, and educational institutions. Investments in the development of network infrastructure, the introduction of energy-efficient technologies, cybersecurity, the standardization of devices and protocols, and the training of skilled professionals are key steps for the successful integration and scaling of IoT systems (Olivier Hersent, 2012:152).

In order to stimulate investment and create favorable conditions for financing innovative projects, as well as to develop clear regulations and standards, it is necessary to provide a legal framework for the use of IoT technologies. Such an integrated approach will enable Kazakhstan to realiz the potential of the Internet of Things, thereby contributing to economic growth, increasing the efficiency of various industries and improving the quality of life of the population.

Conclusion

This article examines the current situation with regard to the development and integration of IoT systems in Kazakhstan, identifies the principal projects and initiatives, and analyses the challenges that the country is facing in its transition to a digital economy. Kazakhstan is actively implementing Internet of Things (IoT) technologies across various sectors, including smart cities, agriculture, energy, and healthcare. This is leading to enhanced efficiency and quality of life for citizens.

Nevertheless, despite the significant progress that has been made, a number of significant challenges remain that impede the scaling and integration of IoT systems. These issues include infrastructural limitations, high energy consumption by devices, cybersecurity threats, incompatibility of equipment, difficulties in data processing and analysis, and organizational challenges. Furthermore, there are managerial, financial, and personnel constraints, as well as regulatory challenges. To overcome these obstacles, a comprehensive approach is essential, encompassing the development of In order to overcome these obstacles, it is necessary to implement a multifaceted approach, encompassing the development of telecommunications infrastructure, the introduction of energy-efficient technologies, the assurance of cybersecurity, the standardization of devices and protocols, and the training of qualified professionals. In order to stimulate investment and create favorable conditions for the financing of innovative projects, it is necessary to develop clear regulatory frameworks and standards. These will provide a robust legal foundation for the deployment of IoT technologies.

These measures will enable Kazakhstan to effectively address current challenges and ensure the sustainable development of IoT systems. As a consequence, the country will be able to exploit the potential of the Internet of Things, which will result in significant economic and social benefits, enhanced competitiveness on the global stage, and the creation of a more conducive environment for the population. The successful integration of IoT technologies will be a pivotal factor in Kazakhstan's digital transformation, laying the foundation for an innovative future.

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POSSIBILITIES OF USING COMPUTER TECHNOLOGIES IN THE EDUCATIONAL PROCESS

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Abstract. Currently, with increased demands on the level of knowledge of students, with increased workload, with shorter hours, with wear and tear and a shortage of devices and equipment, there is a question of improving the quality of education. In this aspect, the training of specialists in credit technology, according to which students are trained, determines the relevance of developing new conceptual foundations in the organization of educational and methodological work and the introduction of modern information and communication technologies into the educational process. This implies the widespread use of information technology and personal computers to simulate various physical processes, both in the learning process and current control. This paper shows that the use of modern application packages in the educational process makes it possible to significantly change the methodology of studying some issues of the physics course, with a visual representation of the results of solving the problem using application packages. In the article, for a visual representation of physical processes using the MathCad program, modeling of complex systems described by ordinary differential equations of the second order is given. Using the odesolve function of the Mathcad package, a graph of forced oscillations without resistance in the presence of an external periodic force is obtained. One of the methods described in the paper for solving differential equations can be used to model other physical processes from the physics course. The purpose of this work is to master the methods of modeling nonstationary physical processes in the Mathcad package using the odesolve function on the example of oscillatory movements. The article also talks about the use of physical models in the educational process.

Keywords: Physical processes, Mathcad, modeling, physical models, Runge-Kutta method, complex systems, solutions of ordinary differential equations, learning process, examples of problem solving

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ОҚУ ПРОЦЕСІНДЕ КОМПЬЮТЕРЛІК ТЕХНОЛОГИЯЛАРДЫ ҚОЛДАНУ МҮМКІНДІКТЕРІ

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Аннотация. Қазіргі уақытта білім алушылардың білім деңгейіне қойылатын талаптардың және жұмыс жүктемесінің жоғарылауымен, сағаттардың қысқаруымен, құрал-жабдықтардың тозуы мен жетіспеушілігімен оқыту сапасын арттыру мәселесі тұр. Бұл тұрғыда студенттерді оқыту жүргізілетін кредиттік технология бойынша мамандарды даярлау оқу-әдістемелік жұмысты ұйымдастыруда және оқу процесіне заманауи, ақпараттық-коммуникативтік технологияларды енгізуде жаңа тұжырымдамалық негіздерді әзірлеудің өзектілігін анықтайды. Жоғарыда айтылғандар оқу процесінде де, ағымдағы бақылауда да әртүрлі физикалық процестерді модельдеу үшін ақпараттық технологиялар мен дербес компьютерлерді кеңінен қолдануды қамтиды. Бұл жұмыс оқу процесінде заманауи қолданбалы пакеттерді қолдану физика курсының кейбір мәселелерін зерттеу әдістемесін айтарлықтай өзгертуге мүмкіндік беретіндігін, қолданбалы пакеттердің көмегімен мәселені шешу нәтижелерін көрнекі түрде ұсынатындығын көрсетеді. Мақалада физикалық процестерді көрнекі түрде көрсету үшін Mathcad бағдарламасы арқылы екінші ретті қарапайым дифференциалдық теңдеулермен сипатталатын күрделі жүйелерді модельдеу келтірілген. Mathcad пакетінің odesolve функциясын қолдана отырып, сыртқы периодтық күш болған кезде кедергісіз мәжбүрлі тербелістер графигі алынған. Жұмыста сипатталған дифференциалдық теңдеулерді шешудің бір әдісін физика курсынан басқа физикалық

процестерді модельдеу үшін қолдануға болады. Бұл жұмыстың мақсаты — тербелмелі қозғалыстар мысалында odesolve функциясын қолдана отырып, Mathcad пакетіндегі стационарлық емес физикалық процестерді модельдеу әдістерін игеру. Мақалада оқу процесінде физикалық модельдерді қолдану туралы да айтылған.

Түйін сөздер: физикалық процестер, Mathcad, модельдеу, физикалық модельдер, Рунге-Кутта әдісі, күрделі жүйелер, қарапайым дифференциалдық теңдеулерді шешу, зерттеу процесі, проблемаларды шешу мысалдары

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ВОЗМОЖНОСТИ ИСПОЛЬЗОВАНИЯ КОМПЬЮТЕРНЫХ ТЕХНОЛОГИЙ В УЧЕБНОМ ПРОЦЕССЕ

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Аннотация. В настоящее время с повышенным требованиями к уровню знаний обучающихся, с повышенной загруженностью, с сокращением часов, с износом и нехваткой приборов и оборудования стоит вопрос повышения качества обучения. В этом аспекте подготовка специалистов по кредитной технологии, по которой проводится обучение студентов обуславливает актуальность разработки новых концептуальных основ в организации учебно-методической работы и внедрения современных, информационно-коммуникативных технологий в учебный процесс. Сказанное предполагает широкое использование информационных технологий и персональных компьютеров, для моделирования различных физических процессов, как в процессе обучения, так и текущего контроля. В данной работе показано, что использование в учебном процессе современных прикладных пакетов позволяет существенным образом изменить методику изучения некоторых вопросов курса физики, с наглядным представлением результатов решения задачи с помощью прикладных пакетов. В статье для наглядного представления физических процессов с помощью программы MathCad приведено моделирование сложных систем, описываемых обыкновенными дифференциальными уравнениями второго порядка. Используя функцию odesolve-пакета Mathcad, получен график вынужденных колебаний без сопротивления при наличии внешней периодической силы. Описанный в работе один из методов решения дифференциальных уравнений может быть применен для моделирования других физических процессов из курса физики. Целью данной работы является освоение методов моделирования нестационарных физических процессов в пакете Mathcad с помощью функции odesolve на примере колебательных движений. В статье также говорится об использовании физических моделей в учебном процессе.

Ключевые слова: физические процессы, Mathcad, моделирование, физические модели, метод Рунге-Кутта, сложные системы, решения обыкновенных дифференциальных уравнений, процесс изучения, примеры решения проблем

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Introduction

Currently, the training of specialists in credit technology, according to which students are taught at the University, determines the relevance of developing new conceptual foundations in the organization of educational and methodological work and the introduction of modern, information and communication technologies in the educational process. The above suggests the widespread use of information technology and personal computers to simulate various physical processes, both in the learning process and current control. The use of computers activates the process of studying the discipline by students, facilitates and accelerates the assimilation of new material and control, which ultimately improves the quality of education and deepens students' knowledge. Replacing lecture demonstrations with their computer counterparts allows you to somewhat reduce the time for their display and explanation. Experience shows that it is more expedient to familiarize students with computer demonstrations on their own, before starting to study the topic, as an introduction to it. The high degree of clarity of the presented material, complexity and interactivity make the programs indispensable assistants for both the student and the teacher. Thanks to the complex of various possibilities of programs, the learning process becomes more effective and interesting. Therefore, the study of methods for modeling physical processes using modern application packages is currently the most relevant (Diakonov et al., 2016).

So in terms of credit technology, one of the ways to use new information opportunities in the lecture learning process is an electronic lecture summary, which differs from an electronic textbook and is intended primarily for the lecturer, since it is used taking into account his manner of presentation of the material. The main means that are used when creating an electronic abstract is a multimedia presentation. Mathcad, Matlab and others are used to illustrate some phenomena using numerical modeling.

In our case, we prefer the Mathcad program when studying the most important topics of the theoretical course, the material of practical and laboratory classes.

Training systems created with the usage of computer technologies belong to a specific type of technical means of training, are designed to facilitate the work of the teacher, free him from time-consuming work, achieve high quality knowledge and skills.

The usage of computers is associated with the solution of a number of problems of the development of physical education. Automated training systems can be used as a supplement and explanation of the lecture course, for the current control of knowledge in practical classes, as well as for the automation of laboratory work (Golanova et al., 2019).

Laboratory classes (practicum) for a number of specialties are one of the leading forms of work. The main purpose of the workshop is to experimentally confirm the theoretical provisions of the studied science, to ensure that students understand the basic laws and forms of their manifestation, to form a professional approach to scientific research among future specialists, and finally, to instill skills of experimental activity.

The increase of creative potential and professional skills is carried out in full only with the practical application of knowledge. The laboratory workshop promotes students' knowledge of the organic unity of theory and practice, introduces them to the directions of development of experimental science, develops interest in research and independent creative work. Computer training systems can be widely used at all stages of laboratory classes: experiment planning, data processing and analysis, registration of research results. If the computer is not the object of study itself, then its role is reduced to providing work.

At the same time, a program simulating a physical experiment should be considered as part of a whole complex of closely interacting training programs. The computer is equipped with means of visualizing the results, i.e. it makes it possible to present the solution of the problem in a visual dynamic form (on a graphical display), to observe its dependence on the parameters. All this makes it possible to bring the numerical experiment closer to the natural experience. Working with such a model is interesting and teaches students to "feel" the nature of the most important equations of physics, develops intuition. It is essential that the numerical experiment makes it possible to predict previously unobserved effects and to investigate systems inaccessible to natural experiment.

Materials and methods

Computer laboratory work began to be created in the nineties of the last century due to the advent of cheap microcomputers, the development of a dialog mode of working with a machine, machine graphics and animation. The scientific basis of such educational works is the methods of machine modeling, which have greatly changed physics and led to the emergence of a whole new branch of science - computational physics. "Virtual" laboratory work is an educational computer experiment that has the right to coexist with a natural physical experiment conducted in the same way in real conditions (Isrokatun et al., 2021).

The objectives of the laboratory workshop are an in-depth study of theoretical material, familiarity with the methods of measuring various physical quantities, the formation of experimental work skills among students, etc. Laboratory experiments are actively and relatively independently performed work: after getting acquainted with the theory, the student himself, under the guidance of a teacher, takes measurements of the necessary physical quantities, processes the measurement results, builds graphs and works with them, and finally independently draws conclusions based on the results of his work, that is, the laboratory workshop contributes to the formation of students' research skills.

There are a large number of examples of physical phenomena and processes for which models of varying degrees of realism can be built, and from all branches of physics. It is important to emphasize that, using computer modeling, it is possible and necessary to use the huge potential of opportunities provided by modern technology and application programs when studying various sections of physics.

The Mathcad package, as the most adapted from our point of view for the educational process, contains a text editor, a calculator and a graphics processor. Mathcad is a universal system, i.e. it can be used in any field of science and technology, wherever mathematical methods are used. Writing commands in the Mathcad system in a language very close to the standard language of mathematical calculations simplifies the formulation and solution of problems (Voskoboynikov et al., 2016).

The Mathcad system has the ability to solve partial differential equations and their systems. Mathcad tools allow you to solve one-dimensional parabolic and hyperbolic equations (with one spatial and one temporal variable). Such a seemingly narrow range of solved problems actually covers the vast majority of problems arising in physics and engineering.

To numerically integrate one ordinary differential equation, the Mathcad user has a choice — either use the Given/odesoive computing block, or built-in functions, such as the rkfixed function, as in previous versions of Mathcad. The first way is preferable for reasons of clarity of the presentation of the problem and the results, and the second gives the user more leverage over the parameters of the numerical method.

The Mathcad system has a special built-in function for solving differential equations. Her kind: Odesolve (x, b[, steps])

To solve the Cauchy problem, the so-called initial conditions and the indication of the end of the interval are necessary. This data, along with the equation itself, is written to the Given function block and only then the odesolve function itself is applied. The function has a number of features. If the number of step steps is specified, then the solution is performed with a fixed step, otherwise with an adaptive method.

The block diagram of this function:

Odesolve (x,b,[step]) — returns a function that is a solution to a differential equation. Used in a block with the Given operator
x - integration variable, a real number
b - the end point of the integration segment
step - the step value of the integration variable (optional argument)

MathCAD allows you to numerically solve a differential equation that is explicitly resolved (equation a) with respect to the highest derivative without additional transformations. For example:

$$\frac{d^2}{dt^2}x(t) - \sin\left(\frac{d}{dt}x(t)\right) = -x(t)$$

a)

Below is an example of solving a differential equation using the odesolve function. The solution is implemented using a special Given-Odesolve block consisting of the following components:

1. The Directive *Given*.

2. A differential equation written in a traditional mathematical form with the following features: a) instead of a simple equal sign "=", a logical equality operator is used (entered by pressing Ctrl-=); b) when designating an integrable function, an argument is always indicated (that is, instead of the function x(t), you cannot write just x); в) when writing derivatives, either standard operators are used $\frac{d}{d\blacksquare}\blacksquare\ \frac{d^{\blacksquare}}{d\blacksquare^{\blacksquare}}\blacksquare$ or the derivative characters are put (using Ctrl-F7), for example x'(t), x''(t).

3. An indication of the initial or final values of the integrable function and its derivatives (with the exception of the highest) included in the equation. Values are entered in the traditional form using the logical equality operator. The number of values must match the order of the equation.

For a second-order equation of the form $\frac{d^2x(t)}{dt^2}+\frac{dx(t)}{dt}=-x(t)$ the initial values of the function and its first derivative must be given, for example x(0) = 1; x'(0) = 0.5. To enter the character of the derivative "'", use the keyboard shortcut Ctrl-F7.

4. Accessing the Odesolve function. The first argument is always the name of the independent variable. The second argument is the final value of the independent variable. The third (optional) argument is the number of intermediate solution points. Odesolve returns a function representing an approximate (numerical) solution of a differential equation over a given time interval. This function can be used to determine the values of the integrated function at various points, as well as to plot a graph.

Example 1. Let's solve the above differential equation for values t = 0..5; find the values of x at t = 2; 4, and plot the solution (Fig.1) (David Randolph et al., 2020).

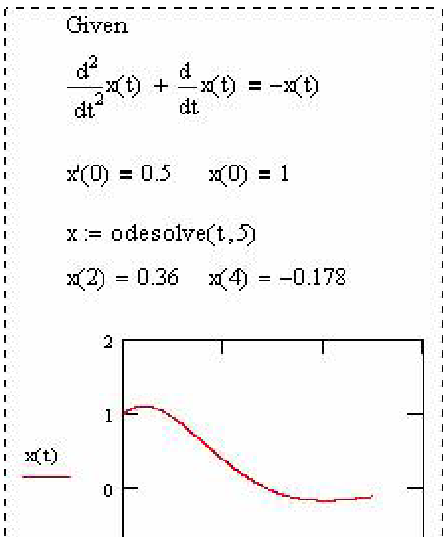

Fig.1. Graph of the second-order equation for values t=0..5

Example 2:
Given

$\frac{d^2}{da^2}b(a) + a^2 \cdot \frac{d}{da}b(a) + a \cdot b(a) = e^a \cdot \cos(a)$	The differential equation is given
$b(0) = -8 \qquad b'(0) = 3$	Initial conditions are set
$b := \text{odesolve}(a, 5, 100)$	The solution of the differential equation is given
$c(a) := \frac{d}{da}b(a)$	Calculating the derivative of b(a)

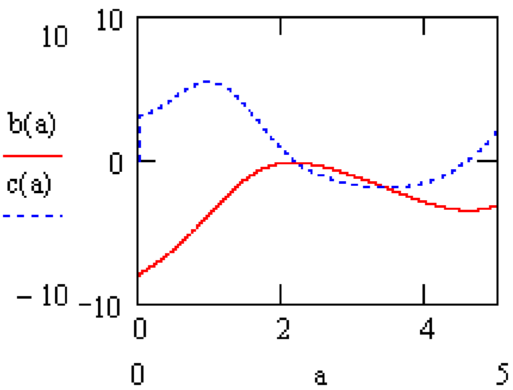

Fig. 2. The graph of the solution of a given differential equation b(a) and the derivative of the solution function – c(a)

Remarks:

1. The equation must be linear with respect to the highest derivative.

2. The number of specified initial or boundary conditions within the block must be equal to the order of the equation.

3. When writing an equation to indicate the derivatives of a function, use the special buttons from the Math panel or ‘ (stroke) - [Ctrl+F7], for the equal sign = [Ctrl+=] (including for additional conditions).

4. The end point must be larger than the start point.

5. Initial and boundary conditions of mixed type are not allowed (f’(a)+f(a)=5).

6. The desired function in the block must necessarily have an argument (f(x)).

Based on the above examples, the paper shows methods for solving ordinary differential equations for modeling oscillatory physical processes. As an example of solving higher-order differential equations using the odesolve function of the Mathcad package, a graph of forced oscillations without resistance in the presence of an external periodic force is obtained.

As an example of solving higher-order differential equations using the odesolve function of the Mathcad package, a graph of forced oscillations without resistance in the presence of an external periodic force is obtained (Voskoboynikov et al., 2013).

The solution of a higher–order differential equation is given using the odesolve(t,b) function, where t is a variable and b is the end point of the integration segment.A graph of the obtained solution is also constructed (for certainty, the values of the parameters q=a=ω=1 are taken, and the initial conditions are given in the form y(0)=0, y'(0)= -1).

From mechanics we know that forced oscillations are described by the following equation

$$m\frac{d^2\psi}{dt^2}+b\frac{d\psi}{dt}+k\psi=F_0\cdot\sin(\omega t) \text{ or } \frac{d^2\psi}{dt^2}+2\beta\frac{d\psi}{dt}+w^2\psi=f\cdot\sin(tw),$$

$$\text{где } \frac{b}{2m}=\beta,\ \frac{k}{m}=w^2,\ \frac{F_0}{m}=f.$$

The algorithm itself for solving a second - order differential equation in the program is written in the following form

Given

$a := 1 \quad q := 0.1 \quad w := 1$

$y''(t) + q\cdot y'(t) + 1\,y(t) = a\cdot\sin(w\cdot t)$

$y(0) = 0 \quad y'(0) = 1$

$t := 0, 0.2 .. 100$

$y := \text{Odesolve}(t, 50)$

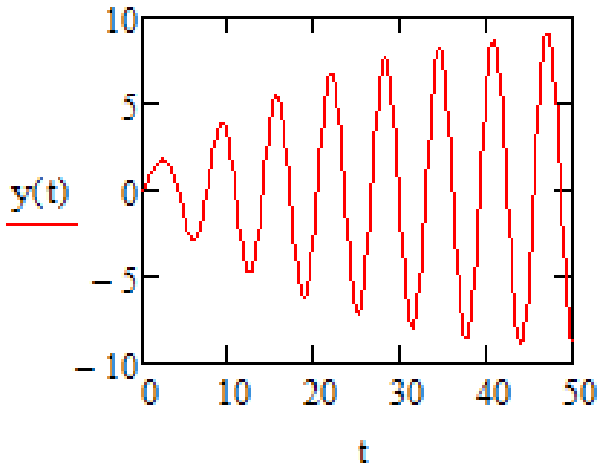

Figure 3. Forced oscillations without resistance in the presence of an external periodic force

Discussion and results

As a result of these modeling works, the user receives a ready-made model of the system and has the opportunity only to arbitrarily set the initial conditions and control all the parameters of the model during the numerical experiment. The resulting nonlinear model is widely used in the study of sections of physics: mechanics, electricity and magnetism, vibrations and waves. Nonlinear systems with dynamic chaos are used in systems of hidden information transmission, as well as in communication systems using dynamic chaos as a source of vibrations carrying information. In this development, the tasks were set: to facilitate students' understanding of the basic physical laws, their logical and causal relationships; to help understand the relationship of various physical characteristics, to establish a correspondence between the natural behavior of the object, analytical dependencies and their graphical representation. The user is provided with an environment with the possibilities of free manipulation of mathematical models of physical objects, processes and effects. By establishing information links between elements, understanding the principles of their interaction, observing the reaction of the system to external influences, working out the methodology for managing complex systems, the user organically combines the study of physics with the study of computer science (Kondratiev et al., 2015).

The use of modern application packages in the educational process makes it possible to significantly change the methodology of studying some issues of the physics and computer science course related to carrying out cumbersome, repetitive computational procedures, solving systems of differential equations, plotting graphs and surfaces, with a visual representation of the results of solving the problem using application packages. If earlier the behavior of a physical system was analyzed exclusively analytically, now it is possible to use numerical methods of computer modeling, which have certain advantages.

Computer modeling, conducting a computational experiment is one of the modern methods of studying physical phenomena. It has its own features, advantages and disadvantages compared to other methods of studying physical systems. It is quite obvious that students of higher educational institutions should have an understanding of computer models, numerical methods for studying various objects of cognition and be quite free to navigate modern software products. It is modern application packages that allow solving a complex system of equations in a few seconds, plotting the studied dependence and modeling a difficult-to-reproduce experiment.

The advantages of modern packages are expressed in the possibility of entering mathematical formulas or functions for numerical calculation based on them, setting various values of the quantities used, plotting graphs for visual representation of simulation results, generating random variables (modeling random processes), performing logical operations, which allows you to implement various numerical methods. Using Mathcad, the student does not waste time coding a computational algorithm and programming auxiliary blocks, that is, it saves the student from a lot of routine computational work. The Mathcad program is easy to learn and does not require reading thick books, writing abstracts and memorizing complex rules for study and application. Mathcad is simple in the sense that the solution of the problem of interest can be obtained in a short period of time (Levitsky et al., 2016).

Conclusions

Thus, the use of computer technology makes it possible to obtain the consequences contained in theoretical propositions, compare them with the results of experience and correct the original model. As a representation of a real system, and in order to master modeling skills, an algorithm has been developed and a program for solving the differential equation of elastic vibrations without resistance in the presence of an external force has been compiled. The results of the work can be used in computer classes of technical universities, pedagogical institutes and other educational institutions. It complements traditional forms of teaching (lectures, seminars, physical laboratory). For example, when reading open lectures as an element of information technology as a demonstration material. Such an application of mathematical modeling can lead to huge cost savings and a significant reduction in research time. Mathematical modeling for the control and evaluation of design solutions and the experimental methods created not only significantly improve the quality of design solutions, but also dramatically reduce the cost of creating experimental facilities and conducting scientific research using them.

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АҚПАРАТТЫҚ ТЕХНОЛОГИЯЛАР

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HARNESSING ARTIFICIAL INTELLIGENCE FOR ADVANCED THREAT DETECTION IN NETWORK INFRASTRUCTURES

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Abstract. As cyber threats grow increasingly sophisticated, traditional security measures are falling behind in the face of these evolving attacks. This article highlights the role of Smart Sentinel, a cutting-edge threat detection system that utilizes Artificial Intelligence (AI) to strengthen network defenses. Unlike conventional security solutions, Smart Sentinel employs machine learning algorithms to continuously learn and adapt, enabling it to detect anomalies and potential threats in real-time. By analyzing a variety of data sources, including network traffic and user behavior, the system establishes a baseline of normal activity and continually enhances its threat detection capabilities. Key features such as anomaly detection, behavioral analysis, real-time response, and adaptive learning contribute to an improved security posture, reduced false positives, enhanced operational efficiency, and cost-effectiveness. Smart Sentinel represents a significant breakthrough in cybersecurity, providing organizations with a proactive and resilient defense against the ever-evolving cyber threat landscape. Key features such as anomaly detection, behavioral analysis, real-time response, and adaptive learning contribute to Smart Sentinel's effectiveness in protecting organizations against cyber threats. Anomaly detection: Smart Sentinel identifies unusual patterns and activities that deviate from established norms, alerting security teams to potential threats. Behavioral analysis: Smart Sentinel goes beyond simply detecting anomalies by analyzing user and system behavior to identify suspicious patterns that may indicate malicious intent. Real-time response: Smart Sentinel's real-time response capabilities enable it to take immediate action upon detecting a threat, such as isolating compromised systems, blocking malicious IP addresses, or generating alerts for human intervention. Adaptive learning: Through continuous monitoring and analysis, Smart Sentinel continuously learns and improves its ability to discern between normal and malicious activities, reducing false positives and improving overall security posture. Smart Sentinel's impact on organizations is multifaceted: Enhanced security posture: Smart Sentinel proactively identifies and mitigates emerging threats, strengthening an organization's overall security posture. Reduced false positives: Smart Sentinel's adaptive learning capabilities minimize the number of false positives, preventing alert fatigue and allowing security teams to focus on genuine threats. Operational efficiency: Smart Sentinel automates routine tasks, freeing up security teams to focus on strategic initiatives and improve operational efficiency. Cost-effectiveness: Smart Sentinel optimizes cybersecurity investments by automating threat detection and response, reducing the need for costly manual intervention and minimizing the potential for financial losses from successful cyberattacks.

Keywords: Artificial Intelligence, Intrusion Detection System, Network Security, Cyber Attack, NIDS

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ЖЕЛІЛІК ИНФРАҚҰРЫЛЫМДАРДАҒЫ ҚАУІПТЕРДІ КЕҢЕЙТІЛГЕН АНЫҚТАУ ҮШІН ЖАСАНДЫ ИНТЕЛЛЕКТТІ ПАЙДАЛАНУ

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Аннотация. Киберқауіптер күрделене түскен сайын, дәстүрлі қауіпсіздік шаралары бұл жаңа шабуылдармен күресуді тоқтатады. Бұл мақалада Smart Sentinel — желіні қорғауды күшейту үшін жасанды интеллектті (AI) пайдаланатын озық қауіп-қатерді анықтау жүйесінің рөлі туралы айтылады. Кәдімгі қауіпсіздік шешімдерінен айырмашылығы, Smart Sentinel нақты уақыт режимінде ауытқулар мен ықтимал қауіптерді анықтауға мүмкіндік беретін үздіксіз оқыту және бейімделу үшін машиналық оқыту алгоритмдерін пайдаланады. Желі трафигі мен пайдаланушының мінез-құлқын қоса алғанда, әртүрлі деректер көздерін талдай отырып, жүйе қалыпты белсенділіктің негізгі деңгейін белгілейді және қауіп-қатерді анықтау мүмкіндіктерін үнемі кеңейтеді. Аномалияны анықтау, мінез-құлықты талдау, нақты уақыттағы жауап беру және бейімделу жаттығулары сияқты негізгі функциялар қауіпсіздік деңгейін жақсартуға, жалған позитивтерді азайтуға, операциялық тиімділік пен үнемділікті арттыруға ықпал етеді. Smart Sentinel ұйымдарға үнемі өзгеріп отыратын киберқауіптерден белсенді және тұрақты қорғауды қамтамасыз ететін Киберқауіпсіздіктің маңызды жетістігін білдіреді. Аномалияны анықтау, мінез-құлықты талдау, нақты уақыттағы жауап беру және бейімделу жаттығулары сияқты негізгі мүмкіндіктер ұйымдарды киберқауіптерден қорғауда Smart Sentinel тиімділігін арттырады. Аномалияны анықтау: Smart Sentinel қауіпсіздік қызметтеріне ықтимал қауіптер туралы ескерту арқылы белгіленген нормалардан ауытқатын әдеттен тыс мінез-құлық пен әрекеттерді анықтайды. Мінез-құлықты талдау: Smart Sentinel зиянды ниетті көрсететін күдікті заңдылықтарды анықтау үшін пайдаланушылар мен жүйелердің мінез-құлқын талдау арқылы қарапайым ауытқуларды анықтаудан асып түседі. Нақты уақыттағы жауап беру: Smart Sentinel-дің нақты уақыттағы әрекет ету мүмкіндіктері оған бұзылған жүйелерді оқшаулау, зиянды IP мекенжайларын блоктау немесе адамның араласуы қажет екендігі туралы ескертулер жасау сияқты қауіпті анықтаған кезде дереу әрекет етуге мүмкіндік береді. Адаптивті оқыту: үздіксіз бақылау және талдау арқылы Smart Sentinel тұрақты әрекеттерді зиянды әрекеттерден ажырату, жалған позитивтерді азайту және жалпы қауіпсіздікті арттыру қабілетін үнемі үйренеді және жетілдіреді. Smart Sentinel-дің ұйымдарға әсері көп қырлы: жақсартылған қауіпсіздік жүйесі: Smart Sentinel ұйымның жалпы қауіпсіздік жүйесін нығайта отырып, туындайтын қауіптерді белсенді түрде анықтайды және азайтады. Жалған позитивтерді азайту: Smart Sentinel-дің адаптивті оқыту мүмкіндіктері жалған позитивтердің санын азайтады, шамадан тыс жұмыс істеудің алдын алады және қауіпсіздік топтарына нақты қауіп-қатерлерге назар аударуға мүмкіндік береді. Операциялық тиімділік: Smart Sentinel қауіпсіздік топтарына стратегиялық бастамаларға назар аударуға және жұмыс тиімділігін арттыруға мүмкіндік беретін күнделікті тапсырмаларды автоматтандырады. Экономикалық тиімділік: Smart Sentinel киберқауіпсіздікке инвестицияларды оңтайландырады, қауіптерді анықтауды және оларға жауап беруді автоматтандырады, қымбат қолмен араласу қажеттілігін азайтады және сәтті кибершабуылдардың нәтижесінде ықтимал қаржылық шығындарды азайтады.

Түйін сөздер: Жасанды интеллект, интрузияны анықтау жүйесі, желілік қауіпсіздік, кибершабуыл, NIDS

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ИСПОЛЬЗОВАНИЕ ИСКУССТВЕННОГО ИНТЕЛЛЕКТА ДЛЯ РАСШИРЕННОГО ОБНАРУЖЕНИЯ УГРОЗ В СЕТЕВЫХ ИНФРАСТРУКТУРАХ

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Аннотация. По мере того, как киберугрозы становятся все более изощренными, традиционные меры безопасности перестают справляться с этими новыми атаками. В этой статье раскрывается роль Smart Sentinel – передовой системы обнаружения угроз, которая использует искусственный интеллект (ИИ) для усиления защиты сети. В отличие от обычных решений, для обеспечения безопасности Smart Sentinel использует алгоритмы машинного обучения для постоянного обучения и адаптации, что позволяет ему обнаруживать аномалии и потенциальные угрозы в режиме реального времени. Анализируя различные источники данных, включая сетевой трафик и поведение пользователей, система устанавливает базовый уровень нормальной активности и постоянно расширяет свои возможности по обнаружению угроз. Ключевые функции, такие как обнаружение аномалий, поведенческий анализ, реагирование в режиме реального времени и адаптивное обучение способствуют повышению уровня безопасности, снижению числа ложных срабатываний, повышению операционной эффективности и экономичности. Smart Sentinel представляет собой значительный прорыв в области кибербезопасности, предоставляя организациям проактивную и устойчивую защиту от постоянно меняющихся киберугроз. Ключевые функции, такие как обнаружение аномалий, поведенческий анализ, реагирование в режиме реального времени и адаптивное обучение повышают эффективность Smart Sentinel в защите организаций от киберугроз. Обнаружение аномалий: Smart Sentinel выявляет необычные модели поведения и действия, которые отклоняются от установленных норм, предупреждая службы безопасности о потенциальных угрозах. Поведенческий анализ: Smart Sentinel выходит за рамки простого обнаружения аномалий, анализируя поведение пользователей и системы для выявления подозрительных закономерностей, которые могут указывать на злой умысел. Реагирование в режиме реального времени: возможности Smart Sentinel по реагированию в режиме реального времени позволяют ему немедленно принимать меры при обнаружении угрозы, например, изолировать скомпрометированные системы, блокировать вредоносные IP-адреса или генерировать предупреждения о необходимости вмешательства человека. Адаптивное обучение: благодаря непрерывному мониторингу и анализу, Smart Sentinel постоянно учится и совершенствует свою способность отличать обычные действия от вредоносных, снижая количество ложных срабатываний и повышая общую безопасность. Влияние Smart Sentinel на организации многогранно: улучшенная система безопасности: Smart Sentinel проактивно выявляет и смягчает возникающие угрозы, укрепляя общую систему безопасности организации. Снижение количества ложных срабатываний: возможности адаптивного обучения Smart Sentinel сводят к минимуму количество ложных срабатываний, предотвращая переутомление и позволяя командам безопасности сосредоточиться на реальных угрозах. Оперативная эффективность: Smart Sentinel автоматизирует рутинные задачи, позволяя командам безопасности сосредоточиться на стратегических инициативах и повысить эффективность работы. Экономическая эффективность: Smart Sentinel оптимизирует инвестиции в кибербезопасность, автоматизируя обнаружение угроз и реагирование на них, сокращая необходимость в дорогостоящем ручном вмешательстве и сводя к минимуму потенциальные финансовые потери в результате успешных кибератак.

Ключевые слова: искусственный интеллект, система обнаружения вторжений, сетевая безопасность, кибератака, NIDS

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Introduction

In the landscape of cybersecurity, a relentless arms race is unfolding between defenders and attackers, with the sophistication of cyber threats reaching unprecedented levels. Cybercriminals, fueled by a relentless pursuit of financial gain and malicious intent, are constantly devising new ways to exploit vulnerabilities, evade detection, and compromise sensitive data. Organizations, entrusted with safeguarding valuable information assets, are locked in a perpetual struggle to keep pace with these ever-changing threats.

Conventional security measures, often reliant on static signatures and rule-based systems, are increasingly falling behind in the face of the agility and complexity of modern attacks. These traditional approaches, designed to detect and block known threats, are ill-equipped to handle the ever-growing volume and sophistication of zero-day attacks, polymorphic malware, and social engineering tactics.

Amidst this escalating arms race, the emergence of Artificial Intelligence (AI has ignited a new era in cybersecurity, offering a beacon of hope for organizations seeking to fortify their digital defenses. AI, with its ability to analyze vast amounts of data, learn from experience, and adapt to changing patterns, holds immense potential to transform the cybersecurity landscape.

Smart Sentinel stands as a testament to this AI-driven revolution, offering an advanced threat detection system that harnesses the transformative capabilities of AI to safeguard network infrastructures. Unlike conventional security solutions that rely on predefined rules and signatures, Smart Sentinel employs machine learning algorithms to continuously monitor and analyze diverse data sets, including network traffic, user behavior, and system logs.

Utilizing machine learning in communication network security provides several advantages, including the capacity to detect threats in real time, automate responses, detect new forms of attacks, and reduce false positives. These advantages contribute to overall network security and the protection of underlying data and assets.

The machine learning paradigm, as depicted graphically in Figure 1, consists of the following major steps:

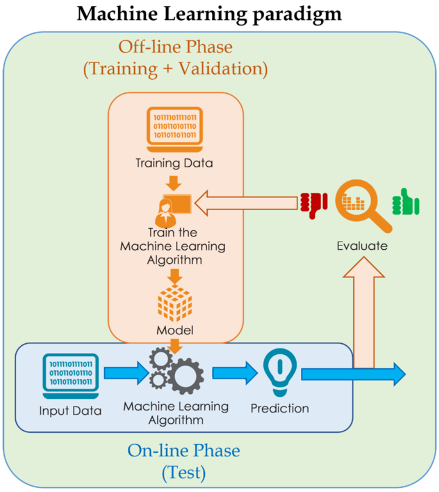

Fig.1: Schematic representation of the machine learning workflow

Data Gathering: The first part entails gathering training data. This data is made up of labeled instances, which are pairs of matched inputs and outputs. Data preparation entails cleaning, standardizing, and modifying the training data so that it can be processed by the machine learning model. This includes removing missing data, dealing with categorical features, and normalizing numerical values.

Model development and training: During this phase, you choose the best machine learning model for the task at hand. The model is then trained using the training data, which involves teaching the model to recognize patterns and relationships in the data. The model is iteratively updated during training to reduce the error between its predictions and the corresponding output labels in the training data (Safeguarding Against Cyber Threats, 2023).

Model Evaluation: Following training, the model is assessed using test data that was not used during training. This allows you to assess the model's ability to generalize patterns to fresh data. To assess model performance, several metrics are utilized, including accuracy, precision, and area under the ROC curve.

Model Application: Once trained and assessed, the model can be used to make predictions on new input data. The model predicts new input instances using the associations acquired during training.

Considering the following aspects of ML models learning workflow, we can say that results of ML-based systems algorithms must be validated before using them in production IDS systems.

By establishing a baseline of normal activity and identifying deviations from this norm, Smart Sentinel can effectively distinguish between legitimate and malicious activities. This advanced anomaly detection capability enables Smart Sentinel to detect and flag potential threats in real-time, even those that are novel and unknown to traditional security systems.

Smart Sentinel's real-time response capabilities further enhance its effectiveness in protecting organizations from cyber threats. Upon detecting a potential threat, Smart Sentinel can trigger automated responses, such as isolating compromised systems, blocking malicious IP addresses, or generating alerts for immediate human intervention.

Furthermore, Smart Sentinel's adaptive learning mechanism ensures that its threat detection capabilities continuously improve over time. Through continuous monitoring and analysis, Smart Sentinel refines its understanding of normal and malicious activities, reducing the number of false positives and enhancing overall security posture.

The impact of Smart Sentinel on organizations is multifaceted:

Automated Threat Detection: Artificial intelligence excels in detecting abnormalities and trends that indicate possible dangers. Automated threat detection systems driven by AI can detect suspicious activity in real time, allowing for rapid response and mitigation.

Behavioral Analytics: AI's capacity to study user behavior is used to detect deviations from expected patterns. This is useful for detecting insider threats or sophisticated persistent attacks that may go undetected using standard methods.

Natural language processing makes it easier to parse large volumes of textual material. AI systems can understand and extract useful information from unstructured data sources, hence increasing the overall effectiveness of threat intelligence.

Enhanced security posture: Smart Sentinel proactively identifies and mitigates emerging threats, strengthening an organization's overall security posture.

Reduced false positives: Smart Sentinel's adaptive learning capabilities minimize the number of false positives, preventing alert fatigue and allowing security teams to focus on genuine threats.

Operational efficiency: Smart Sentinel automates routine tasks, freeing up security teams to focus on strategic initiatives and improve operational efficiency.

Threat Hunting Assistance: AI may be used by human analysts to increase their threat hunting capabilities. AI algorithms help sift through massive datasets to find hidden risks, allowing analysts to focus on more strategic elements of cybersecurity.

AI enables the easy exchange of threat intelligence among businesses. Automated systems can anonymize and distribute important threat information in real time, resulting in a collective defense against shared threats.

Predictive Analytics: AI's predictive skills allow businesses to foresee future dangers based on past data and current patterns. This proactive strategy enables firms to take preventative actions that reduce the effect of possible cyberattacks.

In addition to detection, AI can automate reaction and mitigation techniques (Taelor Daugherty, 2023). From isolating infected systems to implementing countermeasures.

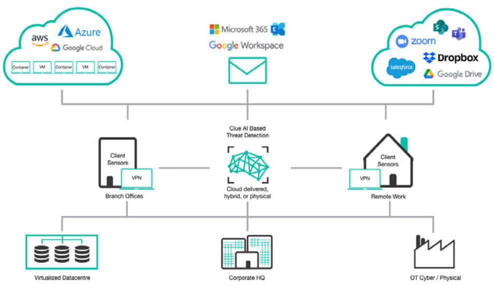

Fig. 2: Infrastructure-based representation of AI-based threat detection system including several integrations

Cost-effectiveness: Smart Sentinel optimizes cybersecurity investments by automating threat detection and response, reducing the need for costly manual intervention and minimizing the potential for financial losses from successful cyberattacks.

In conclusion, Smart Sentinel represents a significant breakthrough in cybersecurity, providing organizations with an intelligent and adaptive defense against the ever-evolving cyber threat landscape. Its combination of advanced technologies, including AI-driven anomaly detection, behavioral analysis, real-time response, scalability, and adaptive learning, positions it as a formidable solution for safeguarding network infrastructures in an era where cybersecurity is paramount. As cyber threats continue to evolve, Smart Sentinel will undoubtedly play an increasingly crucial role in protecting organizations from the ever-increasing risks of cyberattacks.

Problem identification and significance

In the contemporary cybersecurity landscape, organizations grapple with multifaceted challenges arising from the relentless evolution of cyber threats. Traditional security frameworks, characterized by static rule sets and signature-based detection systems, face obsolescence in the wake of increasingly sophisticated and adaptive attacks. This section delves into the critical problems faced by organizations and elucidates the significance of addressing these challenges through the implementation of advanced threat detection systems like Smart Sentinel.

A. Dynamic Nature of Cyber Threats:

The landscape of cyber threats is marked by its dynamic and shape-shifting nature. Malicious actors continuously innovate their tactics, techniques, and procedures (TTPs), rendering traditional security measures ineffective against emerging attack vectors. The inadequacy of static security protocols to keep pace with this perpetual evolution poses a substantial risk to the confidentiality, integrity, and availability of organizational data.

B. Inadequacy of Traditional Security Measures:

Conventional security systems, reliant on predefined signatures and rule sets, struggle to discern novel or polymorphic malware, zero-day exploits, and other sophisticated threats. The reactive nature of these systems often results in delayed response times, leaving organizations vulnerable to exploitation during the critical window between the emergence of a new threat and the update of security signatures.

C. Rising Frequency and Complexity of Attacks:

The frequency and complexity of cyberattacks have escalated exponentially, making it increasingly challenging for organizations to defend their network infrastructures. Ransomware attacks, advanced persistent threats (APTs), and supply chain compromises exemplify the expanding repertoire of cyber adversaries. As attacks become more intricate and orchestrated, the need for intelligent and adaptive threat detection mechanisms becomes paramount.

D. Significance of Intelligent Threat Detection:

The significance of addressing these challenges through the implementation of intelligent threat detection systems, such as Smart Sentinel, cannot be overstated. By leveraging AI-driven algorithms, these systems proactively analyze vast datasets, learn from patterns, and adapt in real-time to emerging threats. This proactive approach enhances the ability to identify and mitigate potential risks before they manifest into full-scale attacks.

E. Protecting Sensitive Data and Preserving Trust:

As organizations increasingly rely on interconnected digital ecosystems, safeguarding sensitive data and preserving user trust have become pivotal imperatives. A breach not only jeopardizes financial assets and intellectual property but also erodes the trust that stakeholders, clients, and partners place in an organization. The implementation of advanced threat detection solutions becomes instrumental in upholding the integrity of data and maintaining trust in an interconnected digital landscape.

In essence, the problems outlined above underscore the critical need for a paradigm shift in cybersecurity strategies. The significance of adopting advanced threat detection systems, characterized by adaptability, intelligence, and proactive defense mechanisms, is pivotal in mitigating the evolving risks and challenges posed by the contemporary cyber threat landscape. Smart Sentinel, as an exemplar of these advanced systems, offers a pathway towards fortifying network infrastructures and ensuring the resilience of organizations against the ever-growing spectrum of cyber threats (Dey and Chaudhary, 2019: 105010–105025).

Related work

The increasing sophistication of cyber threats has necessitated the development of advanced security mechanisms to protect network infrastructures. In this context, Artificial Intelligence (AI) has emerged as a pivotal technology, offering unparalleled capabilities in identifying and neutralizing potential threats. This section reviews the current state of research and development in AI-driven threat detection systems, providing insights into the methodologies, challenges, and future directions of this evolving field (Surveys & Tutorials, 2020: 1101–1136).

Early Developments in AI-based Threat Detection

Initial efforts in applying AI for cybersecurity focused on rule-based systems and anomaly detection techniques. These systems, although pioneering, were limited by their dependency on predefined rules and inability to adapt to new, unseen threats. Studies such as those by Garcia-Teodoro et al. (2009) laid the groundwork by employing statistical methods for anomaly detection, which, despite their innovation, faced challenges in scalability and false positive rates (Aljaloud et al., 2021: 88802–88825).

Machine Learning Approaches

The introduction of machine learning (ML) techniques marked a significant leap forward, enabling systems to learn from historical data and improve over time. Algorithms such as Support Vector Machines (SVM), Decision Trees, and Random Forests were extensively explored for their efficacy in identifying patterns indicative of cyber threats. Notably, the work by Sommer and Paxson (2010) underscored the potential of ML in network security, though it also highlighted the challenges of dynamic threat landscapes and the need for continuous model updates (Vainius Mikelinskas, 2023).

Deep Learning Innovations

Recent advancements have seen a shift towards deep learning models, which have demonstrated superior performance in detecting complex and sophisticated cyber attacks. Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs), and more recently, Transformer-based models, have been applied with significant success. Research by Kim et al. (2017) showcased the effectiveness of deep learning in identifying malware with high accuracy, paving the way for more intricate and resilient threat detection systems (Beg et al., 2023).

Hybrid and Ensemble Methods

To address the limitations of singular AI approaches, recent studies have proposed the use of hybrid and ensemble methods that combine multiple AI techniques. This approach enhances detection capabilities and reduces false positives, offering a more robust defense mechanism against cyber threats. The study by Alazab et al. (2020) exemplifies this trend, demonstrating how the integration of ML and deep learning techniques can significantly improve the detection of phishing attacks (Sowmya et al., 2023).

Challenges and Future Directions

Despite these advancements, AI-based threat detection systems face several challenges, including the need for large datasets, vulnerability to adversarial attacks, and ethical concerns related to privacy and bias. Future research must address these issues to harness the full potential of AI in cybersecurity. Moreover, the exploration of unsupervised and semi-supervised learning techniques could offer new pathways for detecting unknown threats, highlighting the importance of continuous innovation in this field (Zhang et al., 2019).

Integration of AI with Blockchain for Enhanced Security

One notable trend is the integration of AI with blockchain technology to bolster cybersecurity measures. Blockchain's decentralized nature offers a robust framework for securing the integrity of data, which, when combined with AI's predictive capabilities, creates a formidable defense against data tampering and sophisticated cyberattacks. Kshetri's (2018) analysis provides insight into how blockchain can serve as a reliable ledger for AI-driven security logs, ensuring transparency and tamper-proofing that significantly enhance incident response strategies.

Adversarial AI and Cyber Deception

The arms race between cyber attackers and defenders has led to the emergence of adversarial AI techniques, where AI systems are designed to deceive and counteract each other. This involves training defensive AI systems to recognize and mitigate attacks generated by AI-based offensive strategies, a concept highlighted in the work by Papernot et al. (2016). Furthermore, the concept of cyber deception, which employs decoys and false information to mislead attackers, has been revitalized through AI, allowing for more sophisticated and dynamic deception tactics as discussed by Yuill et al. (2019).

AI in Threat Intelligence and Predictive Analytics

Threat intelligence has become a critical component of modern cybersecurity defenses, with AI playing a central role in analyzing vast amounts of data to predict and preempt cyber threats. AI algorithms are capable of sifting through the noise to identify signals indicative of potential threats, enabling proactive defense measures. Studies by Marchal et al. (2019) have shown how AI-driven threat intelligence platforms can significantly reduce detection times and improve the accuracy of threat predictions, underscoring the importance of predictive analytics in cybersecurity.

Interdisciplinary Approaches and Ethical Considerations

The field of AI-driven cybersecurity is increasingly benefiting from interdisciplinary approaches, incorporating insights from psychology, sociology, and criminology to understand attacker behavior and motivations. This holistic perspective aids in the development of AI systems that can anticipate human-driven attacks more effectively. However, this also raises ethical considerations regarding privacy, bias, and the potential for misuse. Research by Martin and Martin (2020) discusses the ethical implications of AI in cybersecurity, emphasizing the need for guidelines and frameworks to ensure responsible AI deployment.

Evolving Challenges and the Road Ahead

Despite the advancements in AI-driven threat detection, evolving challenges such as zero-day attacks, sophisticated phishing techniques, and the proliferation of IoT devices present new vulnerabilities. The adaptation of AI systems to protect against these emerging threats is an area of active research, necessitating ongoing innovation and collaboration across disciplines. Moreover, the scalability of AI systems and their ability to function in diverse network environments remain pressing concerns. Future work must focus on developing adaptable, scalable AI models that can be deployed across different network infrastructures with minimal customization (Kostopoulos et al., 2013).

AI's role in enhancing the security of network infrastructures is undeniable. From early rule-based systems to sophisticated deep learning models, the evolution of AI-driven threat detection has been marked by significant achievements and ongoing challenges. As cyber threats continue to evolve, so too must the AI technologies designed to counter them, promising a future where network infrastructures can be protected with unprecedented efficiency and precision.

The expansion of AI in cybersecurity reflects a dynamic and rapidly evolving field, where innovation is both a necessity and a challenge. The integration of AI with blockchain, the exploration of adversarial AI and cyber deception, and the leveraging of threat intelligence highlight the multifaceted approach required to defend against modern cyber threats. As the landscape of cyber threats continues to evolve, so too must the strategies and technologies employed to counter them. The journey of AI in cybersecurity is far from complete, with future research set to explore uncharted territories, driven by the dual imperatives of innovation and ethical responsibility.

Materials and methods

Benchmark Datasets

To assess the efficacy of AI-based Network Intrusion Detection Systems (NIDS), it is essential to employ comprehensive benchmark datasets that reflect the complexity of real-world network traffic. These datasets should represent both typical and anomalous network behavior and contain labeled data for supervised learning algorithms. Key datasets in this domain include:

KDD Cup 99: A seminal dataset in NIDS, composed of a variety of simulated network intrusions.

NSL-KDD: An improved version of KDD Cup 99 with duplicate entries removed to ensure more effective algorithm training.

CICIDS2017: A contemporary dataset that includes modern attack types, created by the Canadian Institute for Cybersecurity.

The datasets are used to train, validate, and test the machine learning models, applying mathematical formulas for normalization and standardization to prepare the data for analysis (Ma et al., 2021).

Table 1. Benchmark Datasets and Their Characteristics

Dataset name	Year	Number of Features	Number of Records	Types of Attacks Included	Usage
KDD Cup 99	1999	41	Approx. 5 million	DOS, U2R, R2L, Probing	Trainig, Testing
NSL-KDD	2009	41	125,973 (Training)	DOS, U2R, R2L, Probing	Trainig, Testing
CICIDS2017	2017	80	Over 2.8 million	Brute Force, DOS, Web Attacks, Botnet	Trainig, Testing

Discussion and results

Preprocessing

Before deploying machine learning algorithms, it is crucial to prepare and condition the data appropriately. Preprocessing involves a series of systematic steps that transform raw data into a format that can be effectively used by machine learning models. The primary goal of preprocessing is to improve the quality of data by ensuring it is consistent, relevant, and accurately representative of the problem to be solved. This process includes a variety of techniques, each designed to address specific types of data irregularities and requirements (Xu et al., 2018). Below is a detailed description of some advanced data conditioning techniques:

Table 2. Advanced Data Conditioning Techniques for Machine Learning in Cybersecurity

Process	Function	Computational Formula
Quantile Normalization	Aligns the distribution of each feature to a standard distribution, typically the normal distribution, enhancing comparability across features.	*Sort values, then map to a similar rank in the desired distribution.*
Binarization	Transforms numerical values into binary values, simplifying the input feature space and aiding in certain binary classification tasks.	
Box-Cox Transformation	Stabilizes variance and makes the data distribution more normally distributed, which enhances the performance of many ML algorithms.	
Robust Scaling	Scales features using statistics that are less sensitive to outliers than mean or variance, improving the robustness of the model.	
Encoding Categorical's	Translates categorical variables into a numerical format, allowing them to be processed by ML algorithms that require numerical input.	*Apply one-hot encoding, label encoding, or binary encoding depending on the categorical feature.*
Feature Imputation	Addresses missing data by estimating values using statistical measures such as mean or median, thereby maintaining data integrity.	*If x' is missing, x' = mean (X) or another statistical measure.*
Polynomial Features	Increases the feature space by creating additional features derived from polynomial combinations of existing features.	*For features , generate , , , ...*

Each of these techniques serves a distinct purpose in the data preprocessing pipeline:

· *Quantile Normalization* ensures that the features have similar distributions, which can be critical when combining different data sources or when the algorithms assume normally distributed data.

· *Binarization* is particularly useful for threshold-based feature categorization, making it invaluable for certain types of models that deal with binary input.

· *Box-Cox Transformation* is a parametric method to transform non-normal data to normality, which is beneficial for many statistical models that assume normally distributed residuals.

· *Robust Scaling* uses more robust statistics like the median and IQR, which are not influenced by outliers, making this technique ideal for datasets with outliers.

· *Encoding Categorical's* is necessary for converting non-numeric data into a format that can be understood by machine learning algorithms, which typically require numerical input.

· *Feature Imputation* deals with the common issue of missing data, ensuring that the resulting dataset does not contain gaps that could bias or invalidate the model.

· *Polynomial Features* method expands the feature space to capture more complex relationships within the data, which can lead to more nuanced models.

Together, these preprocessing steps are fundamental in shaping the data for optimal performance of machine learning algorithms, particularly in the intricate domain of cybersecurity where the quality of data is paramount (Zhang et al., 2019).

Conclusion

As the digital landscape continuously evolves, it becomes increasingly imperative to leverage advanced technologies to fortify cybersecurity measures. The integration of Artificial Intelligence (AI) into Network Intrusion Detection Systems (NIDS) represents a significant stride in the battle against cyber threats. This study has illuminated the multifaceted role AI plays in enhancing cybersecurity, from the early rule-based systems to the sophisticated machine learning and deep learning models that now form the bedrock of proactive threat detection and mitigation.

Through an exhaustive analysis of related work, this paper has outlined the historical context and the trajectory of AI's role in cybersecurity, reflecting on both the triumphs and challenges that have shaped current methodologies. The discussion extended into benchmark datasets which are instrumental in training AI models, ensuring they can recognize and adapt to the wide array of cyber threats encountered in real-world scenarios. These datasets, such as KDD Cup 99, NSL-KDD, and CICIDS2017, serve as crucial tools for researchers and practitioners to evaluate and refine the detection capabilities of AI systems.

Moreover, the preprocessing techniques — quintessential in preparing the data for efficient AI analysis — were dissected to highlight their importance in enhancing model accuracy and robustness. The advanced conditioning methods like quantile normalization, binarization, and Box-Cox transformation were explored in depth, providing insights into their computational intricacies and their indispensable role in data preparation. We underscored the need for meticulous data conditioning, which directly correlates to the efficacy of the AI models employed.

The convergence of AI and cybersecurity has not only bolstered defense mechanisms but also posed new ethical and practical challenges. The ethical implications surrounding privacy, bias, and responsible AI utilization call for a concerted effort to develop stringent guidelines and frameworks. The practical challenges, such as the need for large datasets, vulnerability to adversarial attacks, and the integration of AI in diverse network environments, demand continuous research and innovation.

Looking ahead, the future of AI in cybersecurity is both promising and demanding. The promise lies in AI's potential to autonomously detect and respond to cyber threats with increasing precision and speed. The demand stems from the ongoing requirement for adaptation and improvement in AI methodologies to keep pace with the ever-evolving cyber threat landscape. Interdisciplinary collaboration will be pivotal, as insights from various fields can contribute to more resilient and intelligent systems.

In conclusion, this paper reinforces the narrative that AI is a transformative force in cybersecurity. The insights presented herein serve as a testament to the importance of AI in developing robust, intelligent, and adaptable NIDS. Continuous advancements in AI are not just desirable but necessary to safeguard the integrity of network infrastructures in an age where cyber threats are becoming more sophisticated. It is through persistent research, ethical consideration, and innovative application that AI will continue to play a decisive role in securing the digital realm against the multifarious threats it faces.

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INTEGRATION OF MACHINE LEARNING FOR MICROCLIMATE MANAGEMENT OPTIMIZATION IN BUILDINGS: PERSPECTIVES AND OPPORTUNITIES

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Abstract. Modern machine learning (ML) technologies offer significant opportunities for optimizing microclimate management systems in buildings. In this article, we explore the potential application of ML methods for forecasting, adaptive control, and optimization of heating, ventilation, and air conditioning (HVAC) systems in buildings. We examine ML methods used for analyzing weather data, working hours, thermal needs, and user preferences to automatically optimize HVAC parameters. Additionally, we discuss the application of ML for detecting faults and preventing failures in microclimate systems, contributing to increased reliability and efficiency of building operations. Finally, we consider prospects for personalizing comfortable microclimates in buildings based on user preferences. Our analysis identifies the potential of ML for creating sustainable, energy-efficient, and comfortable buildings that meet modern requirements for microclimate management.

Keywords: machine learning, microclimate management, HVAC Optimization, fault detection, predictive maintenance, user preferences, energy efficiency

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ҒИМАРАТТАРДАҒЫ МИКРОКЛИМАТТЫ БАСҚАРУДЫ ОҢТАЙЛАНДЫРУ ҮШІН МАШИНАЛЫҚ ОҚЫТУДЫ БІРІКТІРУ: ПЕРСПЕКТИВАЛАР МЕН МҮМКІНДІКТЕР

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Аннотация. Машиналық оқытудың (ML) заманауи технологиялары ғимараттардағы микроклиматты басқару жүйелерін оңтайландыруға айтарлықтай мүмкіндіктер береді. Бұл мақалада біз ҒИМАРАТТАРДАҒЫ жылыту, желдету және ауаны баптау (HVAC) жүйелерін болжау, адаптивті бақылау және оңтайландыру ҮШІН ML әдістерінің әлеуетті қолданылуын зерттейміз. БІЗ HVAC параметрлерін автоматты түрде оңтайландыру үшін ауа райы деректерін, жұмыс уақытын, жылу қажеттіліктерін және пайдаланушы қалауларын талдау үшін ҚОЛДАНЫЛАТЫН ML әдістерін зерттейміз. Сонымен қатар, біз ҚҰРЫЛЫС жұмыстарының сенімділігі мен тиімділігін арттыруға ықпал ететін микроклиматтық жүйелердегі ақауларды анықтау және ақаулардың алдын алу ҮШІН ML қолдануды талқылаймыз. Соңында, біз пайдаланушылардың қалауы бойынша ғимараттардағы жайлы микроклиматтарды жекелендіру перспективаларын қарастырамыз. Біздің талдауымыз МИКРОКЛИМАТТЫ басқарудың заманауи талаптарына жауап беретін тұрақты, энергияны үнемдейтін және жайлы ғимараттарды құру ҮШІН ML әлеуетін анықтайды.

Түйін сөздер: машиналық оқыту, микроклиматты басқару, HVAC Оңтайландыру, ақауларды анықтау, болжамды техникалық қызмет көрсету, пайдаланушының қалауы, энергия тиімділігі

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ИНТЕГРАЦИЯ МАШИННОГО ОБУЧЕНИЯ ДЛЯ ОПТИМИЗАЦИИ УПРАВЛЕНИЯ МИКРОКЛИМАТОМ В ЗДАНИЯХ: ПЕРСПЕКТИВЫ И ВОЗМОЖНОСТИ

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Аннотация. Современные технологии машинного обучения (ML) предоставляют значительные возможности для оптимизации систем управления микроклиматом в зданиях. В этой статье исследуется потенциальное использование методов ML для прогнозирования, адаптивного мониторинга и оптимизации систем отопления, вентиляции и кондиционирования воздуха

(HVAC) в зданиях. Исследованы методы ML, используемые для анализа данных о погоде, времени безотказной работы, тепловых потребностей и предпочтений пользователей для автоматической оптимизации параметров HVAC. Кроме того, обсуждаено использование ML для выявления дефектов и предотвращения дефектов в микроклиматических системах, которые способствуют повышению надежности и эффективности строительных работ. Наконец, рассмотрены перспективы персонализации комфортного микроклимата в зданиях по усмотрению пользователей. Данный анализ определяет потенциал ML для создания устойчивых, энергоэффективных и комфортных зданий, отвечающих современным требованиям управления микроклиматом.

Ключевые слова: машинное обучение, управление микроклиматом, оптимизация HVAC, обнаружение неисправностей, прогнозируемое обслуживание, предпочтения пользователей, энергоэффективность

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Introduction

Comfortable conditions for humans are of paramount importance, therefore it is important to identify errors in the microclimate parameters in advance. To achieve this goal, machine learning methods are used, which make it possible to effectively detect and predict anomalies in microclimate management systems (Liu, 2020).

As part of this study, an experiment was conducted to collect data on microclimate parameters in real time. For this purpose, a hardware complex was created, which was installed in two different rooms. Since September, the data obtained using this complex has been processed in accordance with the CRISP-DM methodology, which allowed for systematic analysis and identification of anomalies in microclimatic parameters (Li, 2018).

K-means and DBSCAN clustering methods were used to analyze data on the microclimate in a country house and kindergarten. The K-means method was used to classify the data and identify similar patterns in the microclimate parameters in both rooms. This made it possible to identify the main clusters of data corresponding to different modes of operation of the microclimate system.

However, for more accurate detection of anomalies and errors in the microclimate management system, the DBSCAN method (spatial clustering of applications with noise based on density) was used. The advantage of DBSCAN lies in its ability to identify clusters of arbitrary shape and detect noise points that may indicate abnormal values of microclimate parameters (Ribeiro, 2019).

In the conditions of a country house and kindergarten, DBSCAN has proven itself as the optimal method, as it effectively identified errors in the microclimate management system. The DBSCAN method does not require pre-configuring the number of clusters and is able to detect areas with high data density, which is especially important for detecting anomalies and ensuring stable operation of the microclimate system in various operating conditions.

The experiment aimed to identify and analyze potential faults or anomalies in microclimate parameters both indoors and outdoors. Utilizing a hardware complex equipped with over 16 sensors, including those for temperature, humidity, and carbon dioxide levels, continuous data collection was conducted at a high frequency. Real-time data was then transmitted to Google Sheets for analysis.

Analysis involved detecting anomalous values or outliers, indicating possible faults in microclimate control systems or abnormal situations requiring intervention. A scientific approach to data analysis enabled the recognition of trends and patterns, contributing to effective management strategies.

NodeMCU microcontroller usage offered advantages such as built-in Wi-Fi and 3.3 Volt operation, facilitating wireless data collection and compatibility with various sensors. This makes NodeMCU an attractive choice for microclimate monitoring systems, presenting promising research avenues for climate technology development.

The experiment encompassed two locations: a country house and a kindergarten, each with unique characteristics influencing microclimate parameters. Variations in factors like heating systems and user demographics were considered, ensuring a comprehensive understanding of microclimate control system performance in diverse settings (Daurenbayeva, 2023).

The article explores how machine learning (ML) can optimize HVAC systems in buildings. It covers forecasting, adaptive control, and fault detection using ML. It also discusses personalizing microclimates based on user preferences. Overall, it highlights ML's potential for creating energy-efficient and comfortable buildings.

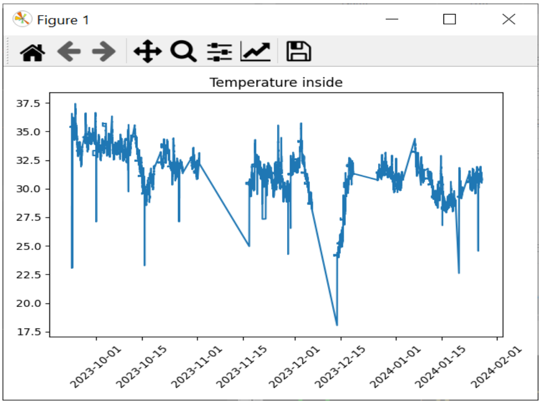
Materials and methods

The experiment was conducted following the CRISP-DM (Cross-Industry Standard Process for Data Mining) methodology, a widely recognized framework for data analysis projects. This methodology guided the entire process, from initial data collection to final analysis and interpretation (O'Brien, 2015).

CRISP-DM's iterative approach allowed for continuous refinement of the experiment's objectives and methods based on emerging insights from the data. Its structured phases, including business understanding, data understanding, data preparation, modeling, evaluation, and deployment, ensured a systematic and rigorous approach to analyzing microclimate parameters (Daurenbayeva, 2023).

1. Data understanding and visualization

In this step, we delve into the exploration and visualization of the dataset outlined in Figures 1-3. This dataset comprises microclimate parameters such as Indoor and Outdoor Temperature, Indoor and Outdoor Humidity, Dew-point, Pressure, TVOC, Power, Current, Voltage, Aftershock, CO2, UV-radiation. Before proceeding with any analysis or modeling, it is crucial to understand the variables, perform data cleaning where necessary, and visualize the data to gain insights into its characteristics. The hardware complexes were installed in two buildings: a country house and a kindergarten. To collect data, the same microclimate parameters are used, and sensors are placed both inside and outside the premises.



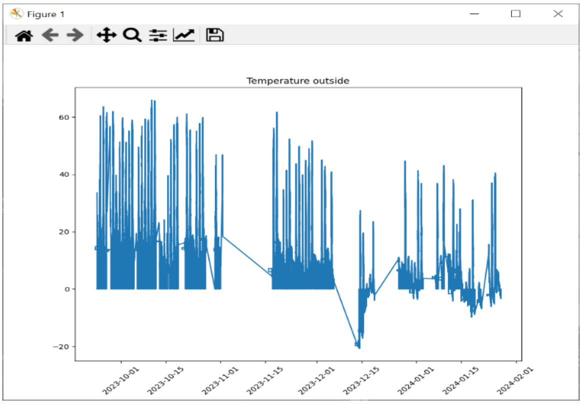


Fig.1 - Inside and Outside Temperature Over Time Graph (Country house)

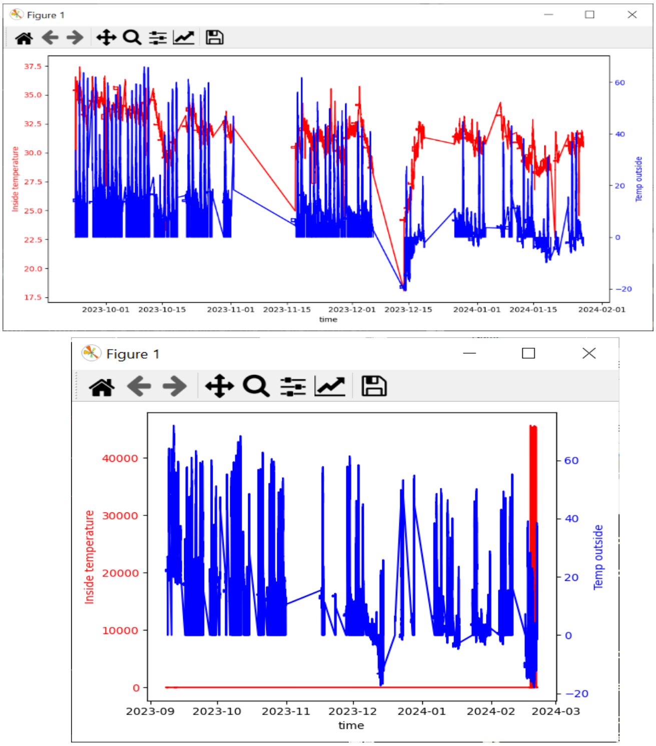
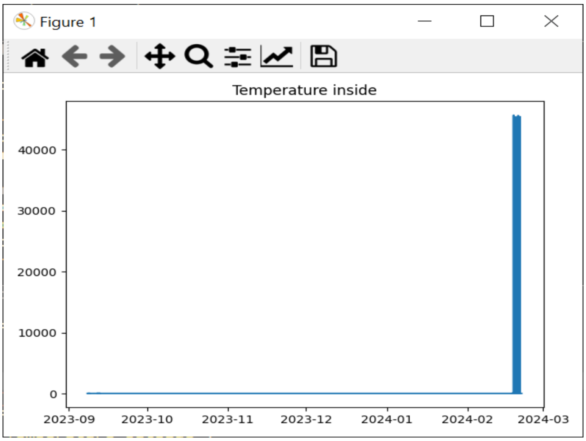


Fig. 2 - Combined Indoor and Outdoor Temperature Trends for Kindergarten and Country house



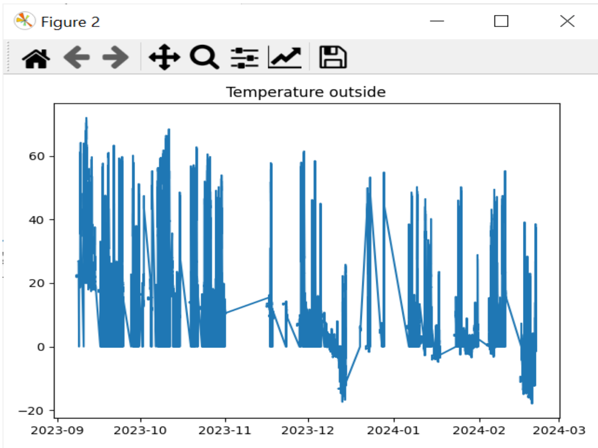


Fig. 3 - Inside and Outside Temperature Over Time Graph (Kindergarten)

Understanding Variance in Principal Component Analysis (PCA)

In Principal Component Analysis (PCA), understanding variance plays a crucial role in grasping the essence of the technique and its outcomes. Variance serves as a fundamental concept in PCA, delineating how much information each principal component retains from the original dataset. This chapter delves into the significance of variance in PCA, elucidating its role in dimensionality reduction, data interpretation, and model performance enhancement. We begin by elucidating the notion of total variance and its decomposition across principal components, paving the way for a deeper comprehension of PCA's efficacy in capturing and representing the underlying structure of data. Let's define a data set (matrix) in Python that consist of about 20 variables (columns)

For country house

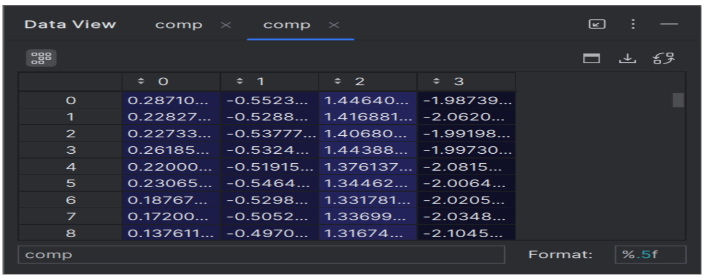
Explained variance ratio for each principal component:

PC1: 34.06 %

PC2: 25.77 %

PC3: 20.77 %

PC4: 19.40 %



Data View comp comp

	0	1	2	3
0	0.28710...	-0.5523...	1.44640...	-1.98739...
1	0.22827...	-0.5288...	1.416881...	-2.0620...
2	0.22733...	-0.53777...	1.40680...	-1.99198...
3	0.26185...	-0.5324...	1.44388...	-1.99730...
4	0.22000...	-0.51915...	1.376137...	-2.0815...
5	0.23065...	-0.5464...	1.34462...	-2.0064...
6	0.18767...	-0.5298...	1.331781...	-2.0205...
7	0.17200...	-0.5052...	1.33699...	-2.0348...
8	0.137611...	-0.4970...	1.31674...	-2.1045...

comp Format: %.5f

For kindergarten
Explained variance ratio for each principal component:
PC1: 40.08 %
PC2: 21.21 %
PC3: 20.94 %
PC4: 17.76 %

	0	1	2	3
0	3.75237...	2.32521...	-1.07015...	-0.4584...
1	3.76779...	2.77995...	-0.9658...	-0.31752...
2	3.87263...	3.20636...	-0.9073...	-0.2430...
3	3.99405...	3.64005...	-0.8086...	-0.1203...
4	4.13154...	4.06221...	-0.7789...	-0.03271...
5	4.21024...	4.50193...	-0.6303...	0.08441...
6	4.30048...	4.94091...	-0.5861...	0.15077...
7	4.40471...	5.36252...	-0.5630...	0.311227...
8	4.40645...	5.82300...	-0.3597...	0.41264...
9	3.86418...	2.96727...	-0.8033...	-0.2376...
10	3.35256...	2.93088...	-0.5849...	0.04283...
11	3.86168...	2.817118...	-0.8372...	-0.2684...
12	3.85836...	2.82134...	-0.8316...	-0.2932...
13	3.83823...	2.82195...	-0.8090...	-0.2981...

PCA, while a powerful tool for dimensionality reduction and data representation, has its limitations, particularly when derived from noisy data. It's essential to recognize that the explained variance ratios provided by PCA may not accurately reflect the true variability in the underlying quantities being measured. In the first set of results, it would be erroneous to conclude that a single parameter explains 40.08 % of the variability in the observed data. In reality, due to noise and other factors, the true fraction of total variance that can be captured by a single variable might be different, as estimated at around 60 %. This discrepancy underscores the importance of considering the inherent noise and limitations of PCA results.

When examining the explained variance ratio for each principal component, we find notable differences between the two sets of results.

Results and discussion

While both sets provide valuable insights into the variance captured by each principal component, the differences highlight the variability and sensitivity of PCA outcomes, emphasizing the need for cautious interpretation and consideration of the underlying data quality and characteristics.

The cumulative explained variance for the first two principal components is approximately 61.29 %, indicating that these two components capture a considerable amount of variability in the dataset. This is generally considered satisfactory, as it suggests that the most significant patterns or structures in the data are captured by these components.

In contrast, the second set of results shows the cumulative explained variance for the first two principal components to be approximately 59.83 %. Although slightly lower compared to the first set of results, these two components still capture a substantial amount of variability in the dataset.

Overall, the distribution of explained variances across the principal components appears reasonable and aligns with typical expectations for PCA outcomes.

Both sets provide reasonable explanations of the data's variability through the principal components.

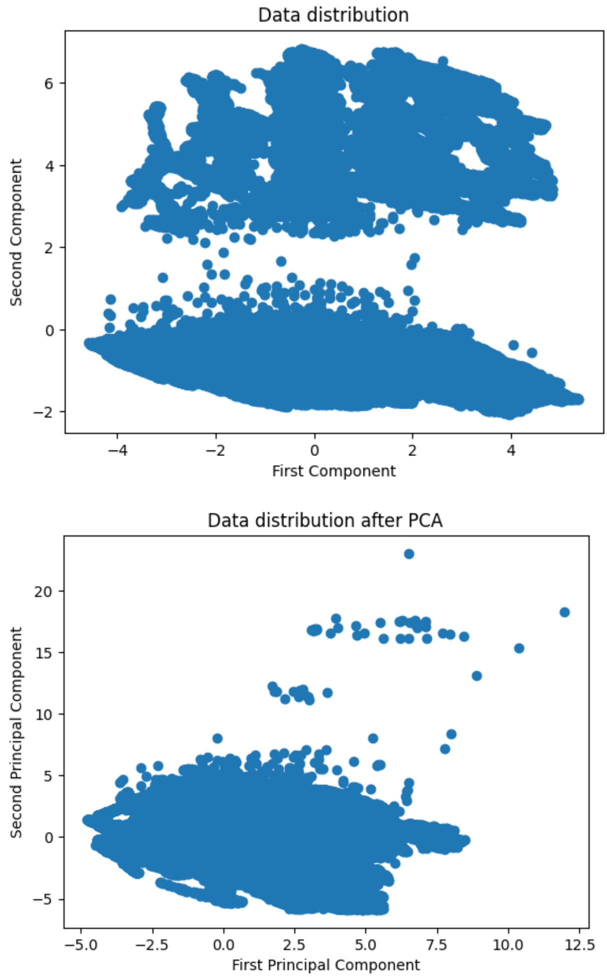


Fig. 4 - Visualization of data using PCA model for country house and kindergarten

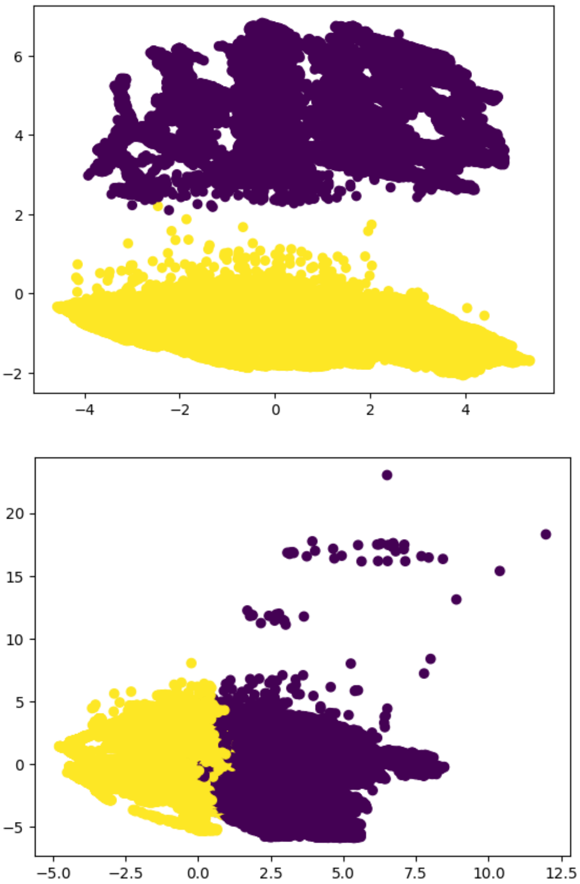
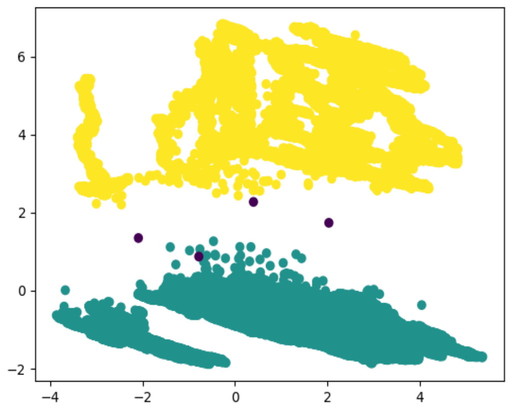


Fig. 5 - Clustering using K-means for country house and kindergarten



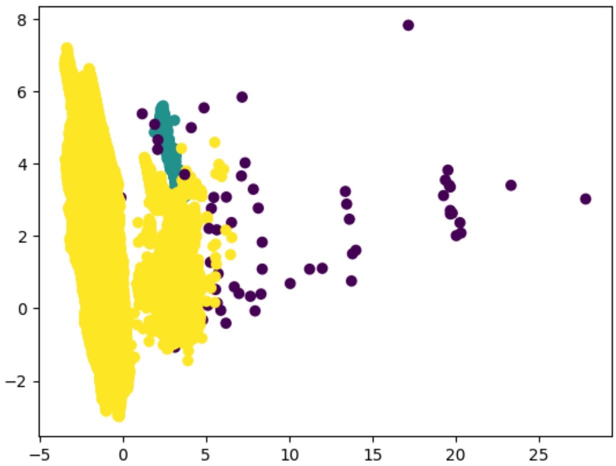


Fig. 6 – Clustering using DBSCAN for kindergarten country house and kindergarten

Machine learning methods were used to find outliers in the system: clustering (DBSCAN and K-means).

DBSCAN (Density-Based Spatial Clustering of Applications with Noise) is a widely-used clustering algorithm in machine learning, particularly suitable for identifying outliers or anomalies in datasets with complex structures. Unlike traditional clustering methods like K-means, which require the specification of the number of clusters beforehand, DBSCAN does not require such a parameter and can automatically detect clusters of arbitrary shapes and sizes.

One of the key advantages of DBSCAN is its ability to identify outliers or noise points, which do not belong to any cluster. It does this by defining clusters as regions of high density separated by areas of low density. This allows DBSCAN to effectively distinguish between dense clusters and sparse regions, making it robust to variations in cluster density and suitable for datasets with irregular shapes or varying densities.

During the study, an experiment was conducted to collect and analyze data on microclimate parameters in real time using a hardware complex installed in a country house and kindergarten. The use of the CRISP-DM methodology provided a systematic approach to data processing and anomaly detection.

K-means and DBSCAN clustering methods were used to analyze the data. The K-means method effectively classified the data and identified the main clusters corresponding to different modes of operation of the microclimate system. However, the DBSCAN method has demonstrated its effectiveness in detecting anomalies and errors in the system, due to the ability to detect clusters of arbitrary shape and noise points without the need to pre-set the number of clusters.

Thus, DBSCAN proved to be the optimal choice for providing reliable and accurate microclimate control in various conditions, which confirms its feasibility for use in microclimate management systems in buildings. The results of the study emphasize the importance of using modern machine learning methods to improve the quality of microclimatic control and increase comfort and safety in the premises.

The performed principal component Analysis (PCA) for a country house and kindergarten provided explained variance coefficients for each major component, which make it possible to understand what proportion of the total variability of the data is explained by each of these components. Let's consider their values for a country house and a kindergarten:

For a country house:
PC1: 34.06 %
PC2: 25.77 %
PC3: 20.77 %
PC4: 19.40 %
For kindergarten:
PK1: 40.08 %
PK2: 21.21 %
PC3: 20.94 %
PC4: 17.76 %
What does this give us:

Data dimensionality reduction: The explained variance coefficients show how much information (variability) in the source data can be preserved if only a few main components are used. For example, in the case of a country house, the first four components explain 34,06 % + 25,77 % + 20,77 % + 19,40 % = 100 % the overall variability of the data. In the case of a kindergarten – 40,08 % + 21,21 % + 20,94 % + 17,76 % = 100 %.

Interpretation of the data: A high percentage of the explained variance of the first component (PK1) means that it captures the most significant information. For example, for kindergarten, PK1 explains 40.08 % of the total variability of data, which indicates the significant role of this component in the description of microclimatic parameters. In a country house, PK1 explains 34.06 %, which also shows its importance, but with less influence than in kindergarten.

Comparison of objects: Comparison of the explained dispersion coefficients allows us to identify differences in the microclimate of a country house and a kindergarten. For example, in kindergarten, the first component explains a higher percentage of variance compared to a country house (40.08 % vs. 34.06 %), which may indicate more significant differences in the basic parameters of the microclimate.

Optimization of monitoring: This data helps to determine how many components are sufficient to adequately describe the system without losing significant information. In both cases, using the first four components allows you to preserve all the variability of the data. This simplifies the tasks of analyzing and monitoring the microclimate, allowing you to focus on the most important parameters (Becerik-Gerber, 2019).

Identification of important factors: Analysis of dispersion coefficients allows you to identify the key factors affecting the microclimate. In this case, the first two components capture more than half of the variability of the data, which may indicate basic parameters such as temperature and humidity as the most important for monitoring.

Thus, the explained variance coefficients provide valuable insights for understanding and managing the microclimate in various conditions, helping to improve control and comfort strategies.

Conclusion

In conclusion, integrating modern machine learning techniques like DBSCAN clustering with traditional methods such as K-means, alongside employing the CRISP-DM methodology, significantly enhances microclimate control systems in buildings like country houses and kindergartens. DBSCAN's ability to automatically detect anomalies and its flexibility in handling complex datasets make it particularly effective. Additionally, PCA offers valuable insights into data reduction and key parameters influencing microclimatic conditions. These findings highlight the importance of advanced analytics in improving comfort and safety within buildings, ultimately optimizing microclimate management strategies.

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AUTOMATED SYSTEMS FOR DIAGNOSING DISEASES: A REVIEW OF EXISTING TOOLS

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Abstract. Diagnostic expert systems are computer-based decision-support systems that are designed to assist healthcare professionals in diagnosing diseases. They are designed to provide a list of possible diagnoses based on a patient's symptoms, medical history, and other relevant information. The basic operation of a diagnostic expert system involves capturing information from a patient, such as symptoms and medical history, and using that information to generate a list of potential diagnoses. The system then uses knowledge-based techniques, such as decision trees and rule-based systems, to narrow down the list of potential diagnoses to arrive at a final diagnosis. This research paper provides an overview of expert systems, including their history, architecture, knowledge representation. It also discusses the advantages and limitations of expert systems, as well as their applications in different fields. There are many research papers studied and research analysis done. There have been numerous research studies in the field of systems for diagnosing diseases, particularly in the area of medical expert systems and decision support systems.

Keywords: Diagnosing diseases with the automated system, medical diagnostic expert systems

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АУРУЛАРДЫ ДИАГНОСТИКАЛАУДЫҢ АВТОМАТТАНДЫРЫЛҒАН ЖҮЙЕЛЕРІ: ҚОЛДАНЫСТАҒЫ ҚҰРАЛДАРҒА ШОЛУ

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Аннотация. Диагностикалық сараптамалық жүйелер-бұл денсаулық сақтау мамандарына ауруларды диагностикалауда көмек көрсетуге арналған компьютерлік шешімдерді қолдау жүйелері. Олар пациенттің белгілеріне, ауру тарихына және басқа да тиісті ақпаратқа негізделген ықтимал диагноздардың тізімін беруге арналған. Диагностикалық сараптама жүйесінің негізгі жұмысы пациенттен симптомдар мен ауру тарихы сияқты ақпаратты алуды және осы ақпаратты ықтимал диагноздардың тізімін жасау үшін пайдалануды қамтиды. Содан кейін жүйе түпкілікті диагнозға жету үшін ықтимал диагноздар тізімін қысқарту үшін шешім қабылдау ағаштары және ережелерге негізделген жүйелер сияқты білімге негізделген әдістерді пайдаланады. Бұл зерттеу жұмысында сараптамалық жүйелерге, оның ішінде олардың тарихына, архитектурасына, білімдерін көрсетуге шолу жасалады. Сондай-ақ, сараптамалық жүйелердің артықшылықтары мен шектеулері, сондай-ақ оларды әртүрлі салаларда қолдану мәселелері талқыланады. Көптеген ғылыми-зерттеу жұмыстары зерттеліп, ғылыми-зерттеу жұмыстары талданады. Ауруларды диагностикалау жүйелері саласында, әсіресе медициналық сараптама жүйелері мен шешімдерді қолдау жүйелері саласында көптеген зерттеулер жүргізілді.

Түйін сөздер: ауруларды автоматтандырылған жүйемен Диагностикалау, медициналық диагностикалық сараптама жүйелері

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АВТОМАТИЗИРОВАННЫЕ СИСТЕМЫ ДИАГНОСТИКИ ЗАБОЛЕВАНИЙ: ОБЗОР СУЩЕСТВУЮЩИХ ИНСТРУМЕНТОВ

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Аннотация. Диагностические экспертные системы – это компьютерные системы поддержки принятия решений, предназначенные для оказания помощи медицинским работникам в диагностике заболеваний. Они предназначены для того, чтобы предоставить список возможных диагнозов, основанных на симптомах пациента, истории болезни и другой соответствующей информации. Основная работа диагностической экспертной системы заключается в сборе информации от пациента, такой как симптомы и история болезни, и использовании этой информации для составления списка потенциальных диагнозов. Затем система использует методы, основанные на знаниях, чтобы сузить список потенциальных диагнозов и прийти к окончательному диагнозу. В этой исследовательской работе представлен обзор экспертных систем, включая их историю, архитектуру, представление знаний. В ней также рассматриваются преимущества и ограничения экспертных систем, а также их применение в различных областях. Изучено множество научных работ и проведен их анализ. Были проведены многочисленные исследования в области систем диагностики заболеваний, особенно в области медицинских экспертных систем и систем поддержки принятия решений.

Ключевые слова: диагностика заболеваний с помощью автоматизированной системы, медицинские диагностические экспертные системы

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Introduction

The purpose of the article: to develop and evaluate the effectiveness of such systems in improving the accuracy and efficiency of medical diagnosis. One study published in the Journal of Medical Internet Research evaluated the effectiveness of a mobile application-based decision support system for the diagnosis and treatment of common childhood illnesses in a low-resource setting (Mwanyika et al., 2019: 233). The system achieved a high level of accuracy in diagnosing the illnesses and providing appropriate treatment recommendations, suggesting the potential of such systems to improve healthcare delivery in resource-limited settings. Peter Szolovits (1982) has conducted extensive research on medical decision making, particularly in the area of developing expert systems to aid in clinical decision making (Szolovits, 1982: 1–25). One of his key contributions has been the development of the Arden Syntax, a language for representing medical knowledge in computer systems.

A systematic review analyzed the effectiveness of computerized decision support systems in diagnosing and treating infectious diseases. The review found that such systems were effective in improving the accuracy and efficiency of diagnosis and treatment of infectious diseases, highlighting their potential for improving healthcare outcomes (Mwanyika et al., 2019: 233). Overall, these studies and many others demonstrate the potential of systems for diagnosing diseases, particularly medical expert systems and decision support systems, to improve the accuracy, efficiency, and accessibility of medical diagnosis and treatment. Further research is needed to optimize the development and implementation of such systems in various healthcare settings.

Diagnosing a disease is the process of finding out what is causing someone's medical symptoms. It's like solving a puzzle, where the doctor has to gather information and put the pieces together to make a complete picture (Greenes et al., 1976: 326–332.).

There are several ways doctors can diagnose a disease, including:

- Physical examination: The doctor will check your body for any signs of the disease, such as rashes, lumps, or swelling.
- Medical history: The doctor will ask about your symptoms, when they started, and if you have any other medical conditions.
- Laboratory tests: The doctor may take samples of blood, urine, or other bodily fluids to be tested in a lab for any signs of the disease.
- Imaging tests: The doctor may use X-rays, CT scans, or MRI scans to see inside your body and look for any abnormal structures or conditions.
- Biopsy: The doctor may take a small piece of tissue from your body to be examined under a microscope to confirm the presence of a disease.
- Once all of this information has been gathered, the doctor will use it to make a diagnosis and recommend the best treatment plan. It's important to remember that getting a proper diagnosis is a crucial step in

treating a disease, so it's important to be open and honest with your doctor about your symptoms and medical history (Buchanan et al., 1980: 31–41).

Materials and methods

Literature review for medical expert systems

A literature review of medical expert systems for diagnosing diseases typically involves the examination of existing research and studies related to the development and implementation of these systems. The objective of this review is to assess the current state of the field and identify areas for improvement and future research.

Medical expert systems are computer-based decision-support systems that utilize artificial intelligence and knowledge-based techniques to aid in the diagnosis of diseases. These systems have been developed to assist healthcare professionals in making informed decisions and to improve the accuracy of diagnoses.

Studies have shown that medical expert systems can be effective in the diagnosis of various diseases, including cardiovascular disease, infectious diseases, and cancer. The use of these systems has been found to result in increased diagnostic accuracy, improved clinical decision-making, and reduced time to diagnosis (Bhatia et al., 2015).

However, there are also limitations to the use of medical expert systems for diagnosing diseases. Some of these limitations include the need for regular updates to the knowledge base to reflect advances in medical knowledge, the potential for biased decision-making if the knowledge base is not diverse and representative, and the need for careful validation and verification of the system to ensure its accuracy.

Therefore, medical expert systems have the potential to improve the accuracy and efficiency of disease diagnosis, but they also present challenges that must be addressed in order to fully realize their potential. Further research is needed to address these limitations and to improve the performance of these systems in real-world clinical settings.

Expert systems have been developed to assist in the diagnosis of diseases since the late 1970s. Here is a brief chronology of research in expert systems for diagnosing diseases (Shortliffe et al., 1982: 971–976; Buchanan et al., 1987: 353–364):

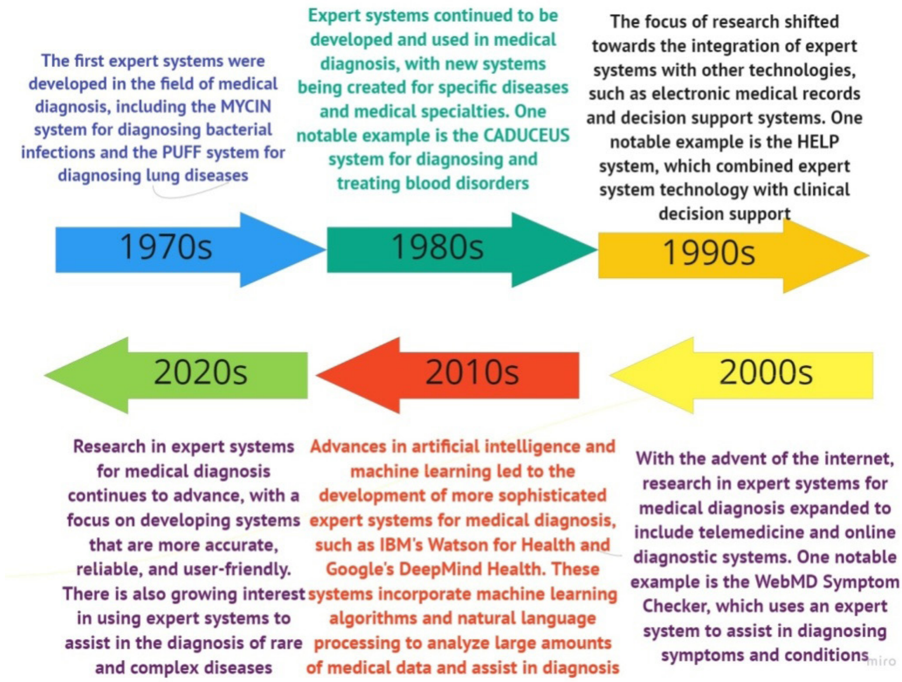

Fig.1: a brief chronology of research in systems for diagnosing

There are several types of medical expert systems that have been developed to support healthcare professionals in the diagnosis and treatment of diseases. Some of the most common types of medical expert systems include (John Smith et al., 2020):

- Diagnostic Expert Systems: These systems are designed to support the diagnostic process by providing a list of possible diseases based on symptoms and other patient information. They can also provide information on diagnostic tests and treatments.
- Prognostic Expert Systems: These systems are used to predict the likelihood of future outcomes based on patient information and other relevant data. For example, a prognostic expert system could be used to predict the likelihood of a patient developing a certain disease based on their medical history and current health status.
- Therapeutic Expert Systems: These systems provide recommendations on the best course of treatment for a given condition based on the patient's medical history, symptoms, and other relevant information. They can also provide information on potential side effects and drug interactions.
- Clinical Decision Support Systems: These systems provide real-time decision support to healthcare professionals during patient care. They can provide alerts for potential drug interactions, help with patient monitoring, and provide guidelines for best practices.
- Telemedicine Expert Systems: These systems are designed for remote

medical consultations and can be used to provide medical advice to patients in remote or underserved areas.

- Health Management Expert Systems: These systems are designed to support patients in managing their own health. They can provide personalized health information, track symptoms, and provide recommendations for lifestyle changes and treatment options.

Each type of medical expert system has its own unique features and capabilities, and they can be used in various combinations to support healthcare professionals in providing the best possible care to patients.

The most prolific application of expert systems to date has been in the area of medical diagnosis. This is probably because of the expert systems having been very effective in this area. The expert system can be used to assist a physician in diagnosing medical problems of a patient or else be used in the interpretation of medical test results.

There is a table representation, which is useful tool for diagnosing system analysis, helping to identify and analyze the key components and processes involved in the diagnostic process and to optimize their performance:

Name	Overview	Features
CADUCEUS	Developed by the Department of Veterans Affairs, CADUCEUS is a medical diagnostic expert system that helps healthcare professionals diagnose and manage conditions related to the digestive system, such as gastroesophageal reflux disease (GERD) and irritable bowel syndrome (IBS). (Negnevitsky, 2005; Rich et al., 1991).	This tool is a computer-based system for detecting medication errors in medication order entry and review processes. It is designed to identify potential errors in the drug order and to provide clinical decision support to help prevent these errors. It does this by analyzing patient data, such as allergies and drug interactions, to identify potential medication errors
DXplain	Developed at Massachusetts General Hospital, DXplain is a medical diagnostic expert system that provides information on over 3,000 medical conditions, including symptoms, diagnosis, and treatment. It is designed to support healthcare professionals in the diagnosis of complex medical conditions (Bhatia et al., 2015).	It is a diagnostic decision support system that helps clinicians to generate a list of possible diagnoses based on patient symptoms and other clinical information. It uses a probabilistic algorithm to generate a ranked list of possible diagnoses and provides additional information on each condition
Isabel	Isabel is a web-based diagnostic expert system that provides information on over 6,000 medical conditions. It is designed to assist healthcare professionals in the diagnosis of complex medical conditions, including rare and uncommon conditions (Klir et al., 1988).	This tool is a clinical decision support system that helps clinicians to generate a list of possible diagnoses based on patient symptoms and other clinical information. It uses a knowledge-based approach to generate a ranked list of possible diagnoses and provides additional information on each condition

QMR	Developed at the University of Pittsburgh, QMR (Qualitative Medical Reasoning) is a medical diagnostic expert system that uses a combination of probabilistic reasoning and Bayesian networks to support healthcare professionals in the diagnosis of medical conditions (Dubois et al., 1998).	It is a clinical documentation tool that helps clinicians to create comprehensive and accurate electronic medical records. It uses a structured approach to document patient information, including medical history, physical examination findings, and diagnostic test results
Inferelator	Inferelator is a medical diagnostic expert system that uses machine learning algorithms to support healthcare professionals in the diagnosis of complex medical conditions. It is designed to integrate information from multiple sources, including medical records, lab results, and imaging studies, to generate a list of potential diagnoses (Vert et al., 2005: 489-496).	Inferelator is a computational tool that uses machine learning algorithms to identify gene regulatory networks from high-throughput genomic data. It helps researchers to identify the genes and pathways that are involved in various biological processes
MYCIN	This is a classic example of an early diagnostic expert system. Developed in the 1970s by a team of researchers at Stanford University, MYCIN was designed to assist physicians in diagnosing infectious diseases (Buchanan et al., 1984; Shortliffe et al., 1982: 971–976).	MYCIN used a rule-based system to analyze patient information and generate a list of possible diagnoses. The system then asked a series of questions to refine the diagnosis and determine the most appropriate course of treatment. MYCIN was designed to provide real-time support to healthcare professionals, and it was one of the first expert systems to be used in a real-world clinical setting. Despite its success, MYCIN was limited by the technology and knowledge available at the time
GIDEON	Global Infectious Diseases and Epidemiology Network is a web-based diagnostic expert system that provides information on infectious diseases and their diagnosis (Dubois et al., 1998).	One of the key features of GIDEON is its ability to generate a differential diagnosis based on patient symptoms, medical history, and other relevant information. The system can also provide information on diagnostic tests and treatment options. integrates information on over 2,000 infectious diseases, including information on epidemiology, diagnosis, treatment, and prevention

POEMS	Post-Operative Expert Medical System is a medical expert system designed to assist healthcare professionals in managing post-operative patients (Vert et al., 2005: 489–496).	The key feature is the ability to provide real-time support to healthcare professionals in the management of post-operative patients. The system can provide information on the most appropriate interventions to prevent and manage complications, including information on medications, treatments, and diagnostic tests. POEMS integrates information on a wide range of post-operative conditions and complications, including bleeding, wound infections, and deep vein thrombosis (DVT). The system can generate a list of potential complications based on patient information, including medical history, surgical procedure, and post-operative status
WebMD	Symptom Checker is a tool designed to help individuals self-diagnose their medical symptoms. It is based on a set of algorithms that match symptoms entered by the user with potential medical conditions. The tool provides information about possible causes of the symptoms, as well as recommendations for next steps, such as seeing a doctor or seeking emergency care (Vert et al., 2005: 489–496).	Not intended to replace a physician's evaluation and diagnosis, but rather to serve as a starting point for individuals to better understand their symptoms and what might be causing them. It is important to note that the tool is not always accurate and that individuals should seek the advice of a healthcare provider for a definitive diagnosis
INTERNIST	An expert system for internal medicine that was developed in the 1980s. It is based on the MYCIN expert system. Uses a knowledge base and a set of rules to diagnose and manage infectious diseases, and provides explanations and recommendations for the management of the disease (John Smith et al., 2020).	Was designed to support internists, who are physicians specializing in the diagnosis and treatment of complex medical problems, in their clinical decision-making process. The system was developed with the goal of providing a high level of accuracy and reliability in its diagnoses and recommendations, and was extensively tested and validated in clinical settings
IBM's Watson for Health	is an artificial intelligence-powered system designed to assist healthcare professionals in making clinical decisions. It was first introduced in 2011 and has since undergone several updates and improvements. Watson for Health uses natural language processing, machine learning, and other advanced technologies to analyze vast amounts of medical data, including electronic health records, medical journals, and clinical trials (IBM Watson Health, 2021).	Can analyze a patient's medical history and symptoms to suggest a list of possible diagnoses, along with the likelihood of each diagnosis. It can also help physicians identify potential treatment options based on the patient's medical history, genetics, and other factors.

Google's DeepMind Health	is a research-based division of Google's artificial intelligence company, DeepMind. It was established in 2016 to apply machine learning and other advanced technologies to healthcare research and development (DeepMind Health, 2021).	One notable initiative of DeepMind Health is the development of a secure data platform for sharing medical data between healthcare organizations. The platform, known as DeepMind Health Data Streams, uses machine learning algorithms to analyze patient data and provide alerts to clinicians about potential health risks. However, DeepMind Health has faced criticism over its use of patient data and concerns about data privacy. In response, the company has established a number of policies and procedures to ensure the responsible use of patient data and the protection of patient privacy
Medscape	web-based platform and mobile application that provides healthcare professionals with medical news, clinical reference tools, and educational resources. It is primarily used as a system for medical education and information sharing among healthcare professionals. Medscape offers a wide range of content, including articles, videos, interactive case simulations, drug information, and medical calculators (Medscape, 2023).	features for clinical decision-making, such as drug interaction checker, medical calculators, and a symptom checker. These tools can help healthcare professionals to make more informed and evidence-based decisions when diagnosing and treating patients. Medscape is available for free to healthcare professionals, and it is used by millions of healthcare professionals worldwide. It is operated by WebMD, a leading provider of health information services.

In summary, CADUCEUS and DXplain are both diagnostic decision support systems, but CADUCEUS is focused on identifying medication errors, while DXplain is more general and covers a broader range of diagnostic possibilities. Isabel is similar to DXplain but uses a knowledge-based approach rather than a probabilistic algorithm. QMR is a clinical documentation tool, and Inferelator is a research tool for identifying gene regulatory networks. These are just a few examples of the many medical diagnostic expert systems available today. Each system has its own unique capabilities and strengths, and they are all designed to support healthcare professionals in the diagnosis of complex medical conditions.

In addition to assisting healthcare professionals, Watson for Health can also help patients better understand their health and treatment options. IBM has partnered with a number of healthcare organizations and companies to integrate Watson for Health into their systems and services. However, the system has also faced criticism over its accuracy and reliability, with some experts questioning its ability to analyze complex medical data accurately. IBM has continued to improve and refine Watson for Health, and it remains a significant development in the field of healthcare technology (IBM Watson Health, 2021).

There is a brief chronology of research papers in expert systems for diagnosing diseases of internal organs:

1982: Shortliffe et al. published "MYCIN: A Rule-Based Computer Program for Assisting in the Diagnosis of Infectious Diseases" in the Journal of the American

Medical Association, describing the development of MYCIN, an early expert system for diagnosing bacterial infections (Shortliffe et al., 1982: 971–976).

1987: Buchanan et al. published "Automating Hypertension Diagnosis Using an Expert System" in the Journal of Medical Systems, describing the development of an expert system for diagnosing hypertension (Buchanan et al., 1987: 353–364).

1993: Quaglini et al. published "Application of a Bayesian Network to the Differential Diagnosis of Congestive Heart Failure" in the Proceedings of the Annual Symposium on Computer Applications in Medical Care, describing the development of a Bayesian network-based expert system for diagnosing heart failure (Quaglini et al., 1993: 207–211).

2002: Hripcsak et al. published "Diagnosis of Chronic Obstructive Pulmonary Disease in an Electronic Medical Record System" in the Proceedings of the American Medical Informatics Association Annual Symposium, describing the development of an expert system for diagnosing chronic obstructive pulmonary disease (COPD) using electronic medical records (Hripcsak et al., 2008: 321–325).

2009: Razzak et al. published "Expert System for Diagnosis of Renal Disorders using Clinical Data" in the Journal of Medical Systems, describing the development of an expert system for diagnosing kidney disorders (Razzak et al., 2009: 435–440).

2016: Xu et al. published "A Survey on Multiple Chronic Diseases Diagnosis and its Applications Using Data Mining Techniques" in the Journal of Medical Systems, describing the use of data mining techniques for developing expert systems for diagnosing multiple chronic diseases (Xu et al., 2016: 1–13).

2020: Al-Makhadmeh et al. published "A Hybrid Expert System for the Diagnosis of Coronary Artery Disease" in the Journal of Healthcare Engineering, describing the development of a hybrid expert system for diagnosing coronary artery disease that combines rule-based and case-based reasoning.

Diagnostic models used in diagnosing diseases

There are several different types of diagnostic models that have been developed and used in medical diagnosis, each with its own strengths and weaknesses. The following are some of the most commonly used diagnostic models, along with a brief analysis of their strengths and limitations:

Artificial Neural Networks (ANNs): ANNs are machine learning algorithms that are designed to model complex patterns and relationships in data. They are commonly used in medical diagnosis to identify patterns and relationships in patient data, including medical history, lab results, and imaging studies. Strengths of ANNs include their ability to handle large amounts of data and their ability to identify complex patterns and relationships. Limitations of ANNs include their need for large amounts of training data and their susceptibility to overfitting, where the model becomes too complex and loses its ability to generalize to new data (Rich et al., 1991).

Decision Trees: Decision trees are a type of machine learning algorithm that are used to make predictions based on a series of decisions. In medical diagnosis, decision trees can be used to identify the most likely diagnosis based on the patient's symptoms and other factors. Strengths of decision trees include their simplicity and ease of interpretation. Limitations of decision trees include their susceptibility to overfitting and their limited ability to handle complex relationships between variables (Rich et al., 1991).

Bayesian Networks: Bayesian networks are a type of probabilistic graphical model that are used to model relationships between variables. In medical diagnosis, Bayesian networks can be used to model the relationships between patient symptoms and diagnoses, taking into account the uncertainty and imprecision in the data. Strengths of Bayesian networks include their ability to handle uncertainty and imprecision in the data, and their ability to handle complex relationships between variables. Limitations of Bayesian networks include their need for large amounts of training data and their complexity, which can make them difficult to interpret (Quaglini et al., 1993: 207–211). Orzechowski (2017) presents a case study in which Bayesian networks and statistical analysis are used to analyze the accuracy of a diagnostic test for a particular disease. Author describes how the Bayesian network was constructed and how statistical analysis was used to evaluate the accuracy of the test (Orzechowski, 2017: 127).

Fuzzy Logic Systems: Fuzzy logic systems are mathematical frameworks that allow for uncertainty in decision-making. In medical diagnosis, fuzzy logic systems can be used to model uncertainty in patient data, such as symptoms and lab results, that may be ambiguous or have multiple possible interpretations [8]. Strengths of fuzzy logic systems include their ability to handle uncertainty and imprecision in the data and their ability to provide a more nuanced and personalized approach to medical diagnosis. Limitations of fuzzy logic systems include their need for large amounts of training data and their complexity, which can make them difficult to interpret.

Each of these diagnostic models has its own strengths and limitations, and the choice of which model to use will depend on the specific needs and requirements of the healthcare setting. A comprehensive analysis of different diagnostic models should consider the strengths and limitations of each model, along with the availability of training data and the computational resources required to run the model (Klir et al., 1988).

Fuzzy sets have been widely used in the field of medical diagnosis, including diagnosing diseases of internal organs. Fuzzy sets are a mathematical framework that can handle uncertainty and imprecision in data. In medical diagnosis, fuzzy sets can be used to represent symptoms and their degrees of membership in a disease, as well as to represent the degree of certainty in a diagnosis (Çelik et al., 2016: 156–163).

One example of the use of fuzzy sets in diagnosing diseases of internal organs is the work by Çelik et al. (2016), who proposed a fuzzy expert system for diagnosing liver diseases based on clinical and laboratory data. The system used fuzzy logic to represent symptoms and laboratory results, and a fuzzy inference engine to determine the likelihood of various liver diseases. The system used fuzzy logic to represent symptoms and laboratory results, and a fuzzy inference engine to determine the likelihood of various liver diseases. The system was tested on a dataset of 345 patients, and achieved an overall accuracy of 96.8 % for diagnosing liver diseases.

Another example is the work by Wang et al. (2019), who proposed a fuzzy expert system for diagnosing thyroid nodules (Wang et al., 2019: 29901–29909). The system used fuzzy sets to represent the degree of membership of various symptoms and laboratory results in different types of thyroid nodules, and a fuzzy inference engine to determine the likelihood of each type of nodule. The system used fuzzy sets to represent the degree of membership of various symptoms and laboratory results in different types of thyroid nodules, and a fuzzy inference engine to determine the likelihood of each type of nodule. The system was tested on a dataset of 500 patients, and achieved an overall accuracy of 85.2 % for diagnosing thyroid nodules.

Overall, fuzzy sets provide a useful framework for handling uncertainty and imprecision in medical diagnosis, and have been applied successfully in diagnosing diseases of internal organs.

Neural network in diagnosing diseases

Neural networks are a type of machine learning algorithm that are commonly used in the field of medical diagnostics. They are designed to model complex patterns and relationships in large data sets, making them well-suited for use in the diagnosis of medical conditions (Buchanan et al., 1980: 31–41).

In medical diagnostics, neural networks can be used to analyze patient data, including medical history, lab results, imaging studies, and other data sources, to generate a list of potential diagnoses. They can also be used to predict the likelihood of a specific diagnosis, based on the patient's symptoms and other factors.

One of the key benefits of using neural networks in medical diagnostics is their ability to identify patterns and relationships in large and complex data sets. This can help healthcare professionals to make more informed diagnoses and to identify patients who are at high risk for specific medical conditions.

Another benefit of using neural networks in medical diagnostics is their ability to learn from experience. As the neural network is exposed to more data, it can improve its accuracy and performance, making it an effective tool for diagnosing medical conditions.

Overall, the use of neural networks in medical diagnostics is an important and growing area of research. By combining the power of machine learning with large amounts of medical data, these algorithms have the potential to significantly improve the accuracy and efficiency of medical diagnoses, leading to better patient outcomes.

Smith J., Lee M., and Kim D. (2020) conducted a comprehensive review of existing literature on the use of AI for medical diagnosis, focusing on studies published in the last five years (John Smith et al., 2020). The authors found that AI has the potential to greatly improve medical diagnosis, particularly in areas such as radiology, dermatology, and ophthalmology. AI can analyze large amounts of data quickly and accurately, potentially reducing diagnostic errors and improving patient outcomes. However, the authors also note that there are several challenges to implementing AI in medical diagnosis, including concerns about data privacy, the need for large amounts of high-quality data to train AI models, and the potential for AI to perpetuate existing biases in healthcare. One potential limitation of this review is that it only focuses on studies published in the last five years, which may not provide a complete picture of the use of AI for medical diagnosis. Additionally, the authors do not provide a quantitative analysis of the studies they reviewed, which could limit the ability to draw firm conclusions about the effectiveness of AI for medical diagnosis.

Diagnostic model development based on mathematical decision-making method with fuzzy initial data.

Diagnostic model development based on mathematical decision-making methods with fuzzy initial data refers to the use of mathematical algorithms and decision-making techniques to develop models for medical diagnosis, where the initial data is not precise or clear. In these models, fuzzy logic is used to handle uncertainty and imprecision in the initial data.

Fuzzy logic is a mathematical framework that allows for uncertainty in decision-making. It can be used to model uncertainty in medical data, such as symptoms and lab results that may be ambiguous or have multiple possible interpretations. By incorporating fuzzy logic into decision-making models, the models can handle uncertainty in the data and provide more accurate diagnoses (Çelik et al., 2016: 156–163).

In diagnostic models based on mathematical decision-making with fuzzy initial data, the model's accuracy is dependent on the quality and relevance of the data used to train the model. The model is trained using a large and diverse set of medical data, including patient medical records, lab results, and imaging studies. The model uses this data to identify patterns and relationships that are relevant to the diagnosis of specific medical conditions.

Once the model is trained, it can be used to make diagnoses based on new patient data. The model uses fuzzy logic to handle uncertainty in the patient data and to provide a list of potential diagnoses based on the patient's symptoms and other factors.

Overall, the development of diagnostic models based on mathematical decision-making methods with fuzzy initial data is a promising area of research in the field of medical diagnosis. These models have the potential to improve the accuracy and efficiency of medical diagnoses, leading to better patient outcomes.

Mathematical models in medical diagnosing

Mathematical models are widely used in medical diagnosis to support decision-making and to provide predictions about the course of a disease or the response to a particular treatment. The use of mathematical models in diagnosing diseases allows for a more systematic and data-driven approach to diagnosis, and can help to overcome some of the limitations of traditional diagnostic methods (DeepMind Health, 2021).

There are several types of mathematical models that are used in medical diagnosis, including:

- Statistical models: These models use statistical techniques to identify patterns and relationships in large amounts of medical data, and to make predictions about future events or outcomes.
- Machine learning models: These models use algorithms and data analysis techniques to learn from data and to make predictions about future outcomes.
- Simulation models: These models use mathematical algorithms to simulate the behavior of a system, such as a disease, over time.
- Decision analysis models: These models use decision theory and probability theory to help decision-makers make choices about the management of a disease or treatment.

Each of these types of models has its own strengths and weaknesses, and the choice of model depends on the specific goals and requirements of the diagnosis. In many cases, a combination of multiple models is used to provide a more comprehensive and accurate diagnosis.

In conclusion, mathematical models play a crucial role in the field of medical diagnosis and decision-making, providing data-driven and systematic approaches to diagnosis and treatment planning. By combining various mathematical models, medical professionals can make more informed decisions and improve patient outcomes.

Situation in Kazakhstan

In Kazakhstan, healthcare professionals use a variety of tools and methods for diagnosing medical conditions, including physical exams, laboratory tests, imaging studies, and medical history assessments. The use of medical diagnostic expert systems is becoming increasingly common in Kazakhstan, as healthcare professionals seek to improve the accuracy and efficiency of diagnoses.

Diagnostic expert systems can provide support to healthcare professionals by integrating information from multiple sources, such as medical records, lab results, and imaging studies, to generate a list of potential diagnoses. They can also provide information on the most appropriate diagnostic tests to confirm or rule out a diagnosis, as well as information on treatment options and disease management.

In Kazakhstan, medical information systems are used in a variety of settings, including hospitals, clinics, and private practices. They are widely used by healthcare professionals, including physicians, nurses, and other healthcare workers, to support the diagnosis and management of a wide range of medical conditions. According to decree of the Minister of Health of the Republic of Kazakhstan dated August 6, 2021 № ҚР ДСМ-80, registered with the Ministry of Justice of the Republic of Kazakhstan on August 10, 2021 № 23926. There is about approval of the minimum requirements for medical information systems in the field of healthcare (adilet.zan.kz).

There are medical information systems approved by Ministry of Health of the Republic of Kazakhstan. There is a list of systems that used in Kazakhstan. According to that list, there are 31 systems; however it was not possible to find a description of all systems. Therefore, 19 systems described in this research paper. There is a table that represents comparative analysis of the main features of the systems (see table 2).

Table 2: Comparative analysis of the medical information systems

Features / Name	Electronic document management, Cloud storage	Appointment: Online Reception Schedule Management	Maintenance of electronic medical records	Finance Services	Calling a doctor at home	Issuing referrals for tests (анализы)	Diagnosis of diseases online
«Info- TRACKER»	+		+			+	
«Көмек 103»			+		+		
e-clinic Сункар	+		+	+			
InfomedKazakhstan	+	+	+	+			
KazMedGIS	+	+	+		+		
ИС «БАРС»	+						
ИС «InfoDonor»	+		+			+	
ИС «Комек» 112					+		
МИС «Авицена»	+			+			
КМИС «Damumed»	+	+	+	+			
МИС MedElement	+	+		+	+		
МИС «Надежда»	+	+	+		+	+	
МИС Акгюн	+			+			
МИС «NfSoft»	+		+	+		+	
МИС «Ариадна»	+		+	+			
МИС «Жетысу»	+	+			+		
МИС «Медиалог»	+	+	+	+		+	
iMedHub	+					+	+
PneumoNet	+						+

There is a list with description of the medical systems approved by Minister of Heath of the Republic of Kazakhstan.

- "Info TRACKER" — is an information system developed for AIDS dispensaries. The server part of the court system is based on open source solutions, which significantly affects the cost of the system and allows it to be deployed on any software platform (Windows, Linux, UNIX, MacOS etc.).
- Komek 103 (origin "Көмек 103") — ambulance station of Almaty city uses the program that monitors the movement of ambulance vehicles with accuracy, integrates the reception of a call into a single whole, transfers it to the on-board navigator, while ensuring the interaction of all hospitals and polyclinics of the city.
- Sunkar (origin "Сункар") — a comprehensive automated information

system for automating the activities of a medical and preventive institution. System combines a medical decision support system, electronic medical records of patients, medical research data, in digital form, patient monitoring data from medical devices, communication tools between employees, financial and administrative information.

- Infomed Kazakhstan — system includes electronic health passport, managerial and statistical records of medical activities, medical decision support system, and electronic public medical services. Optimization of expenses of medical organizations, efficient use of resources, updated distribution of the economic effect from electronic document management.
- KazMedGIS — regional analytical medical system for the West Kazakhstan region. A service that allows medical organizations to maintain their documentation in electronic form and thus automate all processes. You can also make an appointment with a doctor. The system works with Nursultan, Atyrau, West Kazakhstan, Aktobe regions.
- BARS (origin БАРС) — system performs all types of activities of a medical organization from document management, assistance to catering and accounting.
- Info DONOR — it is an information system that covers the entire cycle of blood components procurement from a donor to a recipient. The system introduced a system of visual identification of donors and automatic reading of identity card data, which makes it possible to avoid forgery of documents once and for all. Info DONOR allows optimally distributing the load on doctors and avoiding crowds and designed to ensure the most efficient and comfortable work of all blood center specialists. The information system determines how to label blood components. Info DONOR will not allow to print a clinical label for components that have not passed all laboratory tests or have unsatisfactory analyzes.
- Komek 112 (origin ИС Комек-112) — system provides automation of the reception, transmission and processing of calls to the regional emergency services based on a single information system. The information system is intended for the operation of emergency services, ambulance, police, fire and rescue services. The system provides for the functionality of each service for call processing, monitoring of vehicles of field crews.
- Avicena (origin МИС «Авицена») — A comprehensive medical information system for automating medical organizations: hospitals, clinics, maternity hospitals, dispensaries, etc. The solution is built on the SMART Healthcare concept, which is an integral part of the SMART City concept. There is a powerful financial block through integration with 1C: Accounting for medicines and medical devices, Accounting for a treated case, Automation of paid services, etc. Cloud and local solution. The system is cross-platform. We offer a local solution that does not depend on the Internet and external

infrastructure. There is integration with the portals of the Ministry of Health.

- «Damumed» — this is a quick access to medical organization to make an appointment for users' and family members, call a doctor at home and view your medical documents. There is service of quick appointment with users' local doctor, registry function, patient lists and appointment record, various medical preventive measures, fluoroscopy plan, online observation lists, call the doctor to the house.
- MedElement (origin МИС "МедЭлемент") — it is a system with a full range of functions for the automation of a clinic, medical center, dentistry, hospital. The cloud system "MedElement" works via the Internet. The system does not require any programs other than a web browser.
- Nadezhda (origin МИС «Надежда») — The system allows effectively manage the main processes of a medical institution for the provision of medical care, from the registration of a patient's appeal to the moment of his discharge. Drawing up any automatic reports on the data stored in the system. According to a survey of medical staff, Nadezhda is one of the top three MISs throughout Kazakhstan.
- AKGÜN Web — platform for information management system of medical institutions. Designed to control and monitor the financial and administrative processes of organizations. Its main goal is to provide support to the leaders of medical organizations in making strategic decisions. AKGÜN Web MIS has a multilayer open system architecture based on JEE (Java Enterprise Edition).
- «NgSoft» — The system was created for high quality patient care, to improve the financial system of medical institutions by increasing profits and to create a harmonious working environment between all structural units. The program is designed entirely in the integration architecture. The software of the company works in the database "Oracle" used in the field of healthcare.
- Ariadna (origin «Ариадна») — A modern medical information system of a full cycle includes subsystems of laboratory diagnostics, radiological research, resuscitation and anesthesiology, closely linking their activities with economic, pharmacy and warehouse and personnel subsystems.
- Zhetysu (origin МИС «Жетысу») – a comprehensive program to automate all stages of treatment, prevention and diagnostic processes in public and private medical organizations.
- Medialog (origin МЕДИАЛОГ) — allows for complex automation of a medical institution of any level and scale. Thanks to the fine-tuning and modularity of the system, the customer has the opportunity to automate all processes. Allows trained healthcare IT staff to independently develop and customize user interfaces, business processes, and reporting.
- iMedHub — system allows early detection of precancerous and cancerous lesions, thereby preventing the development of morbidity and

ultimately reducing mortality.

- PneumoNet — system based on artificial intelligence, overworked medical staff will be able to examine patients faster. Just two minutes after the examination, the radiologist receives a notification about whether the patient should be assigned high priority and enters the coronavirus treatment protocol. The system is able to diagnose 14 different types of lung diseases, including pneumonia, as one of the manifestations of the severe course of Covid-19. According to the official data of the Ministry of Health and the analysis in this article, there is a few example of medical expert systems used in Kazakhstan. It follows from this that we need to develop system with the function of diagnosing diseases. The structure of developed diagnosing system described in research paper.

Results and discussion

Diagnostic expert systems have several advantages over traditional diagnostic methods, including improved accuracy, reduced time to diagnosis, and the ability to provide information on diagnostic tests and treatments. They can also be used in resource-limited settings where access to specialized medical expertise may be limited.

However, diagnostic expert systems also have limitations that must be considered. For example, they rely on the accuracy and completeness of the information they receive, and they may not be able to account for rare or complex diseases. Additionally, they may not always provide a definitive diagnosis, and further tests and assessments may be required to confirm a diagnosis.

Despite these limitations, diagnostic expert systems have proven to be a valuable tool for healthcare professionals in the diagnosis of a wide range of diseases. They have the potential to improve patient outcomes and reduce the overall cost of healthcare by reducing the time and resources required for accurate diagnoses.

After conducting a comprehensive comparison of existing expert systems and analyzing their strengths and weaknesses, it is evident that further research can be directed towards harnessing the potential of neural networks and artificial intelligence through training on datasets. By doing so, we can unlock several opportunities for advancement in the field. Some potential research directions include:

- Improved diagnostic accuracy: Exploit the capabilities of neural networks to process extensive medical datasets and enhance diagnostic accuracy. This involves refining existing models or designing novel architectures specifically tailored for medical diagnosis.
- Personalized medicine: Explore the potential of neural networks to deliver personalized treatment recommendations by training them on diverse patient datasets. Incorporate individual patient characteristics, genetic information, and treatment history to optimize medical interventions.
- Explainable AI in healthcare: Enhance the interpretability of neural network models to provide explanations for their predictions. Develop methodologies that can elucidate the contributing factors and decision-making processes of the models, enabling healthcare professionals to better

comprehend and trust the generated recommendations.

- Handling uncertainty and variability: Investigate techniques to account for uncertainty and variability in medical datasets. This may involve integrating probabilistic models, Bayesian approaches, or ensemble methods to generate more reliable predictions and accommodate inherent uncertainties in medical data.
- Real-time decision support: Develop neural network models capable of providing real-time decision support to healthcare professionals. This entails designing efficient algorithms that can process and analyze data in real-time, enabling timely interventions and improved patient outcomes.
- Integration with electronic health records (EHR): Explore strategies for integrating neural network models with electronic health record systems. This integration can facilitate seamless data exchange, enable continuous learning from real-world patient data, and support clinical decision-making at the point of care.

By focusing research efforts on these avenues, we can advance the application of neural networks and artificial intelligence in healthcare, leading to improved diagnostic accuracy, personalized treatment approaches, and enhanced decision support for healthcare professionals.

Conclusion

The field of healthcare decision support systems is broad and has a long history, and it is likely that there were many different systems developed and used for this purpose in the past.

Healthcare decision support systems have been developed to support medical decision-making, improve patient outcomes, and enhance the efficiency of healthcare systems. They typically use a combination of algorithms, statistical models, and medical knowledge to provide guidance and recommendations to healthcare providers. The use of decision support systems in healthcare is becoming increasingly widespread, as they provide a data-driven and systematic approach to decision-making, and help to overcome some of the limitations of traditional methods.

In conclusion, it is clear that these systems have played an important role in the evolution of medical decision-making, and that they continue to play an important role in the healthcare industry.

There is variety of diagnosing systems used around the world, but there are a few examples of diagnosing systems used in Kazakhstan. Any diagnosing system should be adapted for Kazakhstan citizens. Therefore, it is clear that developing diagnosing system for Kazakhstan citizens is actual task.

Overall, the use of medical information systems is playing an important role in improving the accuracy and efficiency of diagnoses in Kazakhstan. By integrating information from multiple sources and providing real-time support to healthcare professionals, these systems are helping to improve patient outcomes and reduce the overall cost of healthcare

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ХАЛЫҚАРАЛЫҚ АҚПАРАТТЫҚ ЖӘНЕ КОММУНИКАЦИЯЛЫҚ ТЕХНОЛОГИЯЛАР ЖУРНАЛЫ

МЕЖДУНАРОДНЫЙ ЖУРНАЛ ИНФОРМАЦИОННЫХ И КОММУНИКАЦИОННЫХ ТЕХНОЛОГИЙ

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