Zaporizhzhia National University

# INNOVATIVE APPROACHES TO THE USE OF ARTIFICIAL INTELLIGENCE IN COUNTERING DISINFORMATION: EU EXPERIENCE AND PROSPECTS FOR UKRAINE

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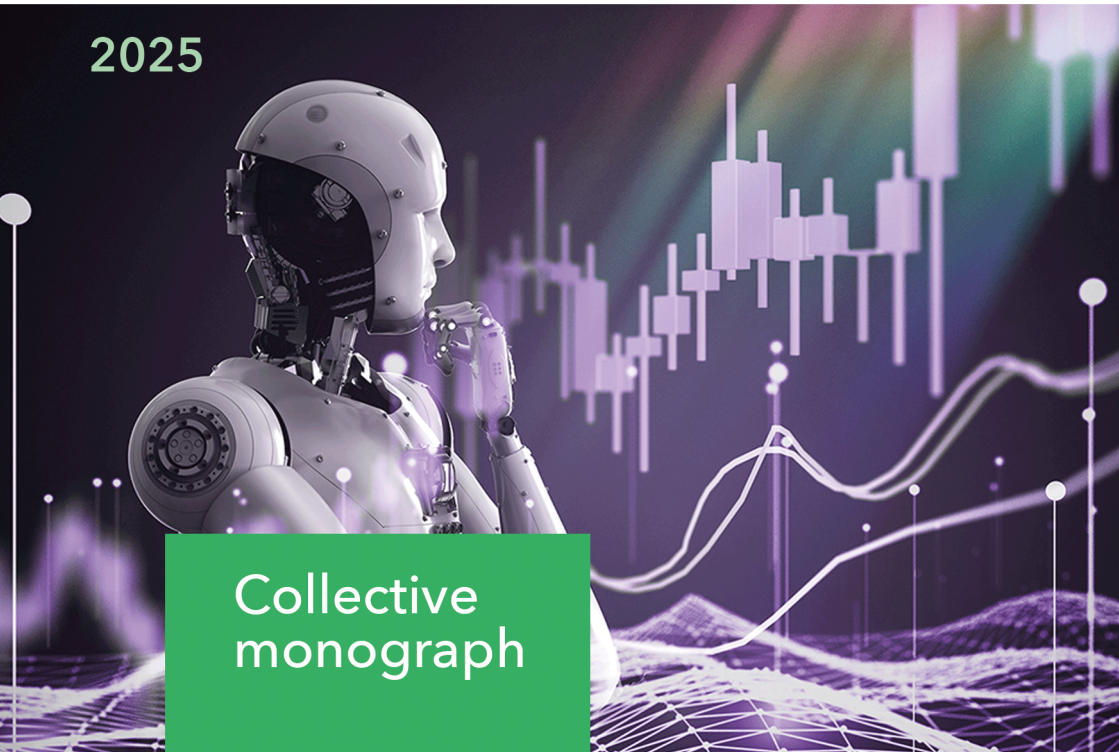

Collective monograph

MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
ZAPORIZHZHIA NATIONAL UNIVERSITY


Запорізький
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# INNOVATIVE APPROACHES TO THE USE OF ARTIFICIAL INTELLIGENCE IN COUNTERING DISINFORMATION: EU EXPERIENCE AND PROSPECTS FOR UKRAINE

Collective monograph

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In570 **Innovative** approaches to the use of Artificial Intelligence in countering disinformation: EU experience and prospects for Ukraine : collective monograph / edited by O. H. Cherep, J. V. Kaliuzhna, S. V. Markova. Riga, Latvia : Baltija Publishing, 2025. 218 p.

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The collective monograph is devoted to a comprehensive analysis of artificial intelligence as a tool for the development of socio-economic security in the context of digitalization, labor market transformation and the need to adapt to the challenges of wartime. It explores the definition, history of development and main areas of application of artificial intelligence, as well as its potential in ensuring information resilience and effective management of big data. Special attention is paid to the experience of EU countries in countering disinformation and the possibilities of implementing similar solutions in the Ukrainian context.

The monograph is based on the results of research within the framework of the project of basic scientific research, applied scientific research, scientific and technical (experimental) developments on the topic № 2/25 "Artificial intelligence as a tool to counter disinformation during the war and post-war economic recovery in Ukraine" (state registration number 0125U000996) (01.01.2025–31.12.2027).

The collective monograph is intended for scholars, teachers, students of higher education institutions, graduate students, doctoral students, practitioners, representatives of state authorities and local self-government, business, university administrative staff, representatives of civil society, the public and all interested persons.

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# CONTENT

# PREFACE

In today's world, the rapid development of digital technologies is driving fundamental changes in all spheres of society. Artificial intelligence, as one of the most powerful technologies of the 21st century, plays a key role in transforming the global environment, influencing not only scientific and technological progress but also economic stability, social security, and the information space. In light of current challenges related to military aggression, cybersecurity threats, the spread of fake news, and manipulative technologies, the issue of implementing artificial intelligence in the system of countering disinformation is gaining particular importance.

Under martial law, Ukraine is compelled to seek innovative solutions capable of ensuring not only effective defense on the front lines but also information resilience in the rear. In this context, the use of artificial intelligence technologies opens up new prospects. This involves not only technical tools for automating data processing or enhancing analytical capabilities, but also the creation of a comprehensive digital ecosystem that enables the detection, analysis, and neutralization of destructive information influences in real time.

The monograph "Innovative Approaches to the Use of Artificial Intelligence in Countering Disinformation: EU Experience and Prospects for Ukraine" aims to comprehensively explore both the theoretical and methodological foundations and practical tools for applying AI in the current conditions of digital transformation. The chapters presented in the volume examine the definition, historical development stages, and key areas of artificial intelligence application. The study analyzes the impact of digitalization on the socio-economic security of European countries and Ukraine, business

adaptation to martial law using AI, and provides a SWOT analysis of digitalization of small and medium-sized enterprises in Ukraine. It also considers the prospects of digital solutions in post-war economic recovery, improving the efficiency of big data processing, the impact of AI on the labor market, and the transformation of professional spheres during wartime.

Special attention is given to the European experience in combating disinformation and the potential for adapting these approaches within the Ukrainian information space. The monograph highlights the potential of artificial intelligence as a strategic resource for shaping a new information policy, building digital security, and fostering societal resilience to external threats.

The collective monograph offers theoretical and methodological generalizations, conclusions, and practical recommendations that will be useful for researchers, teachers, students of higher education institutions, PhD Students, doctoral students, practitioners, representatives of state authorities and local governments, business, university administrative staff, representatives of civil society, the public, and all interested parties.

The collective monograph is based on the results of research within the framework of the project of basic scientific research, applied scientific research, scientific and technical (experimental) developments on the topic No. 2/25 “Artificial intelligence as a tool to counter disinformation during the war and post-war economic recovery in Ukraine” (state registration number 0125U000996) (01.01.2025–31.12.2027).

# CHAPTER 1.
# ARTIFICIAL INTELLIGENCE: DEFINITION, HISTORY OF DEVELOPMENT, USING

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## 1.1. ARTIFICIAL INTELLIGENCE: DEFINITION, HISTORY, USES

**Introduction.** In recent years, the problem of the development and use of technologies based on artificial intelligence has become more relevant. Artificial intelligence is developing rapidly and is becoming increasingly widespread in human activity, as a result of using advantages in business and everyday life of people. Although artificial intelligence began to attract special attention in the early 1920s, the history of artificial intelligence, according to J. McDonald, can be traced back to the development of computers after World War II, when at the Dartmouth Conference in 1956, researchers from various fields came together to study "thinking machines." This is considered to be

the beginning of the development of AI as a separate field of study. The term "artificial intelligence" was first used at the Dartmouth Conference (McDonald, 2024).

**Presentation of the main research material.** Artificial intelligence gained particular attention from scientists and the public after the IBM Deep Blue supercomputer defeated Garry Kasparov in 1997 and the IBM Watson computer in 2011 on the American game show Jeopardy. These events demonstrated that computers could work with large amounts of data and artificial intelligence software and outperform humans at complex tasks.

The next step was the development of artificial intelligence systems by large companies to perform tasks that humans cannot perform due to the complexity and scale of the data. Programs use artificial intelligence in scientific research, disease diagnosis, drug research, vaccine and medical product development and preclinical studies, in creativity and digital media.

In recent years, the creative technologies of artificial intelligence have improved significantly. For example, in 2023, a museum in The Hague exhibited in its gallery the painting "Girl with Shining Earrings", made by artificial intelligence. German artist Boris Eldagsen won the 2023 Sony World Photography Award for his image entitled "Pseudnomnesia: Electrician", but refused the prize, providing information that the image was created by artificial intelligence. Also in 2023, artificial intelligence began to be used to create musical works. The Grammys announced that music created with the help of artificial intelligence will be eligible for participation in the competition and for awards. According to Stuart Russell and Peter Norvig, the origins of artificial intelligence lie in the study of such areas of knowledge as philosophy, mathematics, economics, neuroscience, psychology, computer engineering, control theory and cybernetics, and linguistics (Russell & Norvig, pp. 5–16).

The stages of the history of artificial intelligence are shown in Table 1.

Table 1

**Stages in the history of artificial intelligence development**

| Development period | Scientists/ organizations | Characteristics of the period |
|---|---|---|
| **1** | **2** | **3** |
| 1943–1955 The birth of artificial intelligence | | |
| 1943 | Warren McCulloch, Walter Pitts | Proposed a model of artificial neurons, which is built on knowledge of the basic physiology and function of neurons in the brain; formal analysis of propositional logic by Russell and Whitehead; Turing's theory of computation |
| 1949 | Donald Gebb | Proposed a simple update rule for changing the strength of connections between neurons (Hebbian rule) |
| 1949 | Edmund Callis Berkeley | Publishes the book "Giant Brains, or Thinking Machines" |
| 1950 | Marvin Minsky, Dean Edmonds | The first neural network computer SNARC was created |
| 1950 | Alan Turing | Published the work "Computer Science and Intelligence", which proposed a machine intelligence test called "Imitation Game" |
| 1952 | Arthur Samuel | Developed a checkers program for the IBM701 (the first attempt at evolutionary computing) |
| 1954 | Belmont Farley, Wesley Clark | The first artificial neural network was launched |
| 1955 | John McCarthy | Held a seminar at Dartmouth on the topic of "artificial intelligence", where the term was first used |

Table 1 (continued)

| 1 | 2 | 3 |
|---|---|---|
| 1955–1956 | Alain Newell, Clifford Shaw, Herbert Simon | Created a theorem proving program Logic Theorist |
| 1956 Birth of artificial intelligence | | |
| 1956 | Marvin Minsky, Claude Shannon, Nathaniel Rochester | They worked on how to enable machines to use language, to use abstractions based on this, which are aimed at solving the stated problems; AI was proposed to be separated into a separate field |
| 1957 | Frank Rosenblatt | Beginning of research into artificial neural networks (perceptrons), introduction of the connectionist approach (study of the creation and change of connections between neurons in learning) |
| 1958 | John McCarthy | LISP (List Processing) is created, the first programming language for research in the field of artificial intelligence |
| 1959 | Arthur Samuel | The term “machine learning” was introduced |
| 1959 | John Holland | The first doctoral dissertation in computer science was defended, which proposed a multiprocessor computer |
| 1961 | General Motors in New Jersey | Unimate industrial robot created for assembly line operation |
| 1965 | Edward Feigenbaum, Joshua Lederberg | The first expert system (DENDRAL – chemical analysis system) was created – a form of AI programmed to reproduce the decision-making ability of human experts |

Table 1 (continued)

| 1 | 2 | 3 |
|---|---|---|
| 1966 | Joseph Weitzenbaum | The first ELIZA chatbot was created to simulate a therapist |
| 1966 | Kenneth Colby | Parry program created |
| 1970 | Marvin Minsky, Seymour Papert | It is proposed to focus artificial intelligence research on developing programs in microworlds |
| 1972 | Terry Vinograd | The SHRDLU program was written to control the arm of a robot working on a flat surface with game blocks scattered on it |
| 1972 | Stanford University | Created the MYCIN expert system for diagnosing and treating blood infections |
| 1979 | AAAI (Association for the Advancement of Artificial Intelligence) | American Association for Artificial Intelligence created |
| 1980-present Artificial Intelligence becomes an industry (development boom) | | |
| 1980 | AAAI | The first artificial intelligence conference was held at Stanford |
| 1980 | Digital Equipment Corporation | Developed the first successful commercial expert system R1 (XCON – eXpert CONfigurer), which helped configure orders for new computer systems |
| 1981 | Government of Japan | $850 million allocated for the Fifth Generation Computer project |

Table 1 (continued)

| 1 | 2 | 3 |
|---|---|---|
| 1984 | Microelectronics and Computer Technology Corporation | The CYC project has been launched – an experiment in the field of symbolic artificial intelligence |
| 1985 | AAAI conference | AARON drawing program demonstrated |
| 1988 | AI group DEC DuPont | 40 expert systems deployed 100 used and 500 expert systems developed |
| 1986 – present The return of neural networks | | |
| 1986 | David Ramelhart, James McClelland | The back-propagation learning algorithm was rethought, a network of 920 neurons was trained to form the past tense of English verbs |
| 1987 | Alex Weibel | Developed a time-delayed neural network (TDNN) |
| 1988 | Wei Zhang | Applied trained CNN |
| 1989 | Jan Lecoun | LeNet was created to recognize postal codes at the post office |
| 1991 | Wei Zhang, Akira Hasegawa, Kazuyoshi Ito, Yoshiki Ichioka | CNN has been used to segment medical image objects and diagnose breast cancer |
| 1998 | Jan Lecoun | A neural network has been created that recognizes handwritten numbers on checks |
| 1986 | Michael Jordan | Networks were created in which RNNs were used to study cognitive psychology |
| 1990 | Jeffrey Elman | |
| 1991 | Jürgen Schmidhuber | Proposed neural sequencer |

Table 1 (continued)

| 1 | 2 | 3 |
|---|---|---|
| 1985–1995 | Terry Sejnowski, Peter Dayan, Geoffrey Hinton | Architectures and methods for unsupervised learning of deep generative models have been developed |
| 2009–2012 | Dena Siresan, Uli Meyer, Jonathan Muskie and others | CNN DanNet achieved performance three times that of traditional methods |
| 2016 | Ian Goodfellow, Joshua Bengio, Aaron Courville | Deep learning (a type of machine learning that gives computers the ability to learn based on existing experience) has been proposed |
| 2018 | Alibaba Language Processing AI | High-quality machine translation services offered |
| 2014–2022 | Tero Karras, Wu Zang, Hu Freeman, Tenenbaum, H. Ye, L. Liang, G. I. Lee, B. H. Huang, Gregory A. Bryant | Generative modeling has been developed – image generation using GAN (generative adversarial network) |

*Source: summarized and arranged by the authors from (McDonald, 2024; Turing, 1950; Salecha, 2016; Tableau; Wikipedia; Aggarwal, 2021; Copeland, 2025)*

Thus, it can be concluded that an important characteristic of artificial intelligence is that it is a multifunctional technology. Artificial intelligence has a wide scope of application. It can be applied in many different ways to many different scenarios (McDonald, 2024, p. 7).

Another approach is to view the history of AI as a series of nested or derived concepts that have emerged over more than 70 years. The following concepts are considered: artificial intelligence, machine learning, deep learning, and generative AI (Fig. 1).

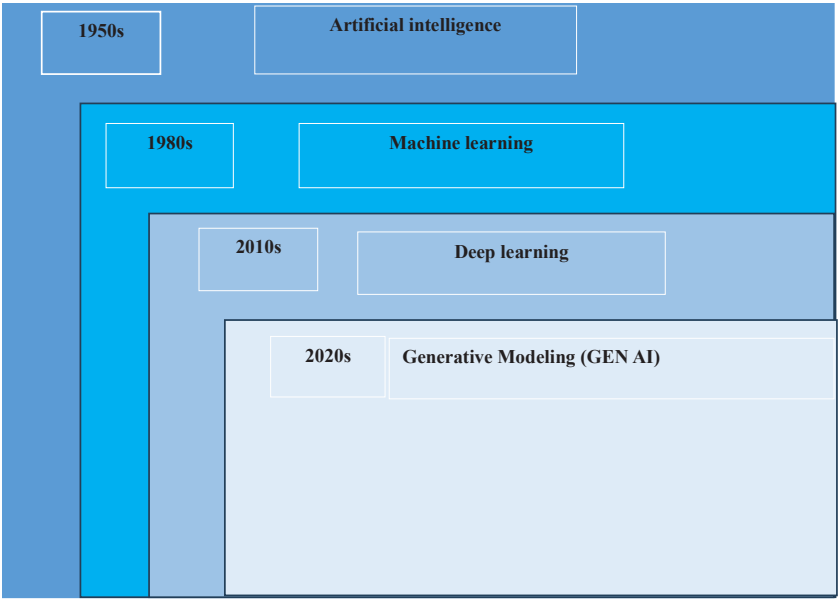


Fig. 1. Concepts of artificial intelligence development

*Source: Stryker. 2025*

There is no single definition of artificial intelligence in the scientific literature. To understand the concept of artificial intelligence, it is useful to define the difference between human intelligence and artificial intelligence.

Intellect – intellectus from Latin – knowledge, understanding, perception.

Ostrovska G. Y. gives the following definition of intelligence. Intelligence as an ability is usually realized taking into account other abilities (cognition, learning, logical thinking,

systematization, etc.); intelligence has the ability to develop; any activity requires a certain level of intellectual abilities of the individual (Ostrovska, 2021, p. 185).

There are many definitions of artificial intelligence in the scientific literature. The approach proposed in the paper (Russell & Norvig, p. 2) is noteworthy. The authors propose, using eight definitions of artificial intelligence as an example, to consider its definition from the perspective of four approaches. The definition of artificial intelligence is arranged along two dimensions: the definitions on the top relate to thought processes and reasoning, while those on the bottom relate to behavior. In addition, the definitions on the left measure success in terms of the accuracy of human performance, and on the right – in terms of success, compared to an ideal indicator of efficiency (rationality). The approach proposed by the author is shown in Fig. 2.

| **Thinking like a human** | **Rational thinking** |
|---|---|
| "The exciting new effort to make computers think... machines with intelligence, in the full and literal sense." (Haugelan, 1985).<br>"[The automation of] activities that we associate with human thinking, such as decision-making, problem-solving, learning..." (Bellman, 1978) | "The study of mental abilities using computational models." (Czarniak and McDermott, 1985).<br>"The study of computations that enable perception, reasoning, and action" (Winston, 1992) |
| **Act humanely** | **Act rationally** |
| "The art of creating machines that perform functions that require intelligence, when they are performed by people." (Kurzweil, 1990).<br>"Studying how to make computers do things that that people are currently doing better" (Rich and Knight, 1991) | "Computational intelligence is the study of the design of intelligent agents." (Poole et al., 1998).<br>"Artificial intelligence... deals with intelligent behavior in artifacts" (Nilsson, 1998) |

Fig. 2. Definitions of artificial intelligence, organized into four categories

A summary of views on the definition of artificial intelligence, based on the results of the analysis conducted by the authors, is given in Table 2.

Table 2

**Approaches to defining artificial intelligence**

| Author, source | Definition |
|---|---|
| 1 | 2 |
| J. McDonald (McDonald, 2024, p. 7) | Artificial intelligence is the ability of computers or other machines to exhibit intelligent behavior |
| John McCarthy (Jose Moya, 2024) | Artificial intelligence is the science and technology of creating intelligent machines, especially intelligent computer programs |
| O. A. Baranov (Baranov, 2023, p. 46) | Artificial intelligence is a certain set of methods, means, tools and technologies, primarily computer ones, that imitate (model) cognitive functions that have criteria, characteristics and indicators equivalent to the criteria, characteristics and indicators of the corresponding human cognitive functions |
| Paul Scharre, Michael K. Horowitz, Robert O. Work (Scharre, et al., 2018, p. 4) | Artificial intelligence is a field of research dedicated to creating intelligent machines. Intelligence measures a system's ability to determine the best course of action to achieve its goals in a wide range of environments |
| US Department of Defense (Summary, 2018) | Artificial intelligence is the ability of machines to perform tasks that typically require human intelligence, such as "recognizing patterns, learning from experience, drawing conclusions, and making predictions" |
| Cole Stryker (Stryker, 2025) | Artificial intelligence is a technology that allows computers and machines to mimic human learning, understanding, problem-solving, decision-making, creativity, and autonomy |
| Brian Jack Copeland (Copeland, 2025) | Artificial intelligence is the ability of a digital computer or computer-controlled robot to perform tasks typically associated with intelligent beings |

Table 2 (continued)

| 1 | 2 |
|---|---|
| Ogirko I. V. and others. (Ogirko I. V. et al., 2022, p. 203) | Artificial intelligence is a scientific direction within which the tasks of hardware or software modeling of those types of human activity that are traditionally considered intellectual are posed and solved |
| Shcherbak N. M., Utkina M. S. (Shcherbak, Utkina, 2021, p. 215) | Artificial intelligence is a computer program based on algorithms for analyzing relevant data and algorithms for making autonomous decisions based on them, in the process of achieving which it can learn from experience and improve its own efficiency through data analysis, in order to achieve the set goals |
| Ben Coppin (Coppin, 2004 p. 4) | Artificial intelligence is the ability of machines to adapt to new situations, cope with emerging situations, solve problems, answer questions, develop plans, and perform various other functions that require a certain level of intelligence, which is usually manifested in humans |
| Blay Whitby (Whitby, 2008 p. 1) | Artificial intelligence is the study of the intelligent behavior of humans, animals, and machines, and the attempt to translate such behavior into an artifact such as computers and computer-related technologies |
| Gary Pence (Pence, 2022) | Artificial intelligence is the use of computer algorithms that think, work, and react like humans |
| Herrod R. A., Papas B. C. (Herrod, & Papas, 1989) | Artificial intelligence is transforming various industries, providing new solutions, increasing efficiency, and reducing costs |
| Shiza Malik, Khalid Muhammad, Yasir Wahed (Malik et al., 2024) | Artificial intelligence refers to the development of computer systems that can perform tasks that typically require human intelligence, such as learning, problem-solving, perception, decision-making, and language understanding |

*Source: summarized by the authors*

Researchers mainly include the ability to control motor activity, plan, count, verbal perception, verbal flexibility, the ability to identify and analyze, and memory as signs of intelligence (Shcherbak, Utkina, 2021, p. 215).

In contrast, research in the field of artificial intelligence has mainly focused on the following components of intelligence: learning, reasoning, problem solving, perception, and language use (Copeland, 2025).

Artificial intelligence is created with the aim of reproducing and copying the cognitive functions of the human brain. The basis for creating artificial intelligence is considered to be the imitation of the cognitive functions of the human brain by completely copying the architecture and completely copying human thought processes in order to achieve certain results (Shcherbak, Utkina, 2021, p. 215).

The use of artificial intelligence has expanded significantly. Artificial intelligence has found application in market analysis and the study of its development trends, the production of machinery and equipment, intralogistics, in production processes, the construction of supply chains, in architecture and construction, trade optimization, demand research, etc.

Artificial intelligence systems learn and act like humans, and in some cases, outperform humans. Artificial intelligence systems can analyze vast amounts of data, solve complex problems, make decisions, and perform creative tasks.

Copeland B. J. (Copeland, 2025) notes that a good expert system can often outperform any single human expert. Today, there are a large number of commercial expert systems, including programs for medical diagnostics, chemical analysis, credit authorization, financial management, corporate planning, financial document routing, oil and mineral exploration, genetic engineering, automobile design and production, camera lens design, computer system design, and airline scheduling.

Let’s consider some possible areas of use of artificial intelligence.

***Using artificial intelligence in education.*** In schools, most learning takes place in social settings. Teachers play a major role in planning, shaping, and managing the learning sequence.

Intelligent learning systems emerged with the advent of desktop computers, offering curricula that provided immediate feedback and adapted learning paths based on student responses. These systems demonstrated the potential benefits of personalized learning, making the introduction of technology in education increasingly attractive.

Artificial intelligence is used in various fields of education and in educational institutions. The use of artificial intelligence in education has had a significant impact, including increasing efficiency, global learning, individual / personalized learning. Artificial intelligence in education has introduced more intelligent content and provided increased efficiency and effectiveness in educational management (Timms, 2016).

Intelligent learning systems emerged with the advent of desktop computers. They began to offer educational programs that provided rapid feedback, generated answers, and derived grades based on students' or schoolchildren's responses.

Artificial intelligence systems have demonstrated the potential benefits of personalized learning, making the implementation of technology in education increasingly attractive.

Artificial intelligence offers innovative solutions in the field of personalized learning, adaptive learning platforms, intelligent learning systems, automated assessment and feedback, and administration of the learning process.

As AI advances, new ways to use it in education are emerging. One way to use AI could be to observe students working in small groups to determine when the group is "in sync" or "out of focus."

To further implement AI in education, researchers should focus on the need to recognize the social role of technology in learning. Educational cobots, if well designed, will play a leading social role in the classroom as teacher assistants (Timms, 2016).

The trend of digitalization of education involves the active use of artificial intelligence in the educational environment, which makes it possible to use modeling in the educational process, tools for generalizing information, its dissemination and assimilation.

Methodically balanced use of artificial intelligence tools and open science cloud services can significantly diversify and improve the visualization of educational material, given that the role of distance and blended learning has increased in Ukraine due to stabilization or emergency power outages (Mar'enko, Kovalenko, 2023).

***Using artificial intelligence in libraries.*** Artificial intelligence is widely used in library services, transforming them with the help of modern information technologies.

Currently, the most common way that library visitors encounter AI is through search engines, which use AI to detect spam, improve the accuracy of query rankings, customize query responses based on previous user activity, develop natural language answers to questions, and search for images. AI makes the search engine process more accurate and less dependent on human attention (Pence, 2022).

The main obstacle to the widespread adoption of AI in library activities is the limited budget. However, even with limited library budgets, there are free resources that allow libraries to introduce users to advanced AI-based search methods. Machine learning is being used to create a new class of literature search programs called literature mapping tools, such as ResearchRabbit, Connected Papers, and others (Tay, 2021).

Artificial intelligence can be used to create literature maps, to show connections between similar works. Applications can also suggest additional articles of possible interest and allow for literature tracking to recommend related articles as they are published.

Libraries now offer many more types of resources than books, magazines, newspapers, etc. The list of resources is expanding to include films, tapes, databases, e-books, digital image collections,

musical works, and digitized audio files. Library users are increasingly accessing library resources from external locations (Tynan, 2019).

In industry, the use of artificial intelligence is ensured through robotization and automation of processes, which optimizes production processes, costs, minimizes inventory. Provides equipment diagnostics for emergency conditions, reduces downtime, and finds optimal solutions in the design, organization, and management of processes.

***The use of artificial intelligence in industry.*** Artificial intelligence is revolutionizing various industries, including food processing, drug development, e-commerce, and chemical industries, by offering intelligent solutions. This leads to reduced energy consumption, increased cost efficiency, reduced operational risks, and improved performance indicators (Malik, at all, 2024).

Artificial intelligence is seen as an element of the fourth industrial revolution, which has an impact on improving life and allows for the automation of processes.

According to a survey conducted by MIT Technology Review Insights, as of 2020, manufacturing is the second largest industry for the adoption of artificial intelligence.

Today's industries face global competition, unpredictable changes in the external environment and customer needs, as well as ever-growing environmental problems.

These challenges are forcing manufacturers to shift their focus to improving and implementing effective communication products so that they are available to consumers within a specified timeframe with less cost (Ahmed at all, 2022). The best possible solution lies in artificial intelligence, which maximizes its beneficial effects and minimizes the risks and threats associated with the application of artificial intelligence in industries.

Overall, AI is transforming industries by providing innovative solutions that improve productivity, efficiency, and customer service. AI helps researchers, managers, and developers evaluate, analyze,

integrate, and deploy the most robust AI technologies in their respective industries (Peres, 2020).

Artificial intelligence allows you to optimize processes, increase productivity and provide increased security. Artificial intelligence solves problems of confidentiality, data, regulatory compliance, and quality control.

In the near future, one of the challenges will be the integration of artificial intelligence into global industries.

According to (Malik, 2024), this will help researchers find alternative solutions to gather sufficient knowledge and information, as well as decision-making authority for future investments and developing a big picture related to AI-based applications for sustainable development of industries.

Artificial intelligence helps manage and optimize business processes in industry, develop new products, and scale operational processes.

Arkady Sendler (Sendler, 2023) identifies seven ways in which artificial intelligence is changing manufacturing: predictive maintenance, quality assurance, defect inspection, warehouse automation, assembly line integration and optimization, AI-based product development and design, and the use of robotics.

***The use of artificial intelligence in pharmacology and the healthcare sector.*** Artificial intelligence is widely used in drug discovery and development programs.

In pharmacology, artificial intelligence has begun to be used to search for new possible combinations of components and compounds that would have a targeted therapeutic effect by processing large amounts of information.

The development of artificial intelligence has found application as an important tool for more efficient and accurate drug development.

According to scientists, it usually takes more than 10 years to develop a new drug. In addition, it is an expensive process. According to biotechnologists, artificial intelligence can significantly

speed up this process and make it cheaper, since artificial intelligence predicts the possible effects of potential compounds on the human body and automatically filters out ineffective ones.

Artificial intelligence simplifies the drug development process by eliminating large clinical trials through the use of simulation and modeling alternatives that allow scientists to study molecules comprehensively (Hamid Yeganeh, 2019). It allows for the production of industrial drugs with improved quality control, end-product characterization, fixed and variable operating conditions according to defined conditions (Lee, Yoon, 2021, p. 271).

The most significant issues associated with the widespread use of artificial intelligence and digital devices in pharmacology include issues of privacy, cybersecurity, data integrity, data ownership, the problem of data exchange between different organizational units, issues of medical ethics, liability for medical errors, and risks of system failures (Yoon, & Lee, 2021; Abomhara, & Køien, 2015).

The development of artificial intelligence and its use in healthcare has made it possible to consider patient health as the result of taking into account the influence of many factors, namely: healthy nutrition, physical activity, management of emotional and psychological state, disease prevention, diagnosis and treatment of diseases.

In addition, online services allow the population to conduct their own health research. Digital devices are used to supplement the skills of medical personnel.

The development of new technological applications using artificial intelligence creates the need for retraining of medical personnel. Artificial intelligence allows for innovation in the field of healthcare and pharmacology.

Artificial intelligence occupies a special place in the provision of home medical care, conducting operations, organizing the work of family doctors, organizing document flow and storing information.

Artificial intelligence in pharmacology allows you to automate processes that were previously performed manually.

***Using artificial intelligence in marketing.*** Artificial intelligence has found wide application in marketing. With the help of artificial intelligence, customer service is developing. Artificial intelligence is necessary for a deep analysis of each client and the study of his tastes. Own knowledge of consumers and their consumer preferences ensures the effectiveness of a marketing strategy using artificial intelligence.

Artificial intelligence allows for the customization of customer service and the optimization of supply chains. Scientific articles identify understanding customer needs, improving operational efficiency, and stimulating innovation as priorities when implementing artificial intelligence.

This is because in these areas, artificial intelligence dominates human capabilities in terms of analysis and execution time. It is noted that one of the most significant advantages of artificial intelligence is its ability to quickly and efficiently analyze large amounts of data, which, of course, would take a lot of time for a person, while artificial intelligence ultimately allows companies to provide services and products personalized for each client individually (Khabibulin, 2024).

To optimize marketing activities, artificial intelligence can perform demand forecasting, as it operates on large databases, allowing it to better understand customer needs, optimize inventory and supply chains. Artificial intelligence plays a crucial role in product development, allowing companies to anticipate trends and possible changes in consumer preferences. According to research by B. Marr (Marr, 2022), companies that invest in product development based on artificial intelligence benefit from faster production cycles and the creation of more targeted products.

Artificial intelligence has defined significant changes in the way we communicate with customers, the methods and techniques that companies use to achieve their goals, and the acquisition of competencies necessary for marketers to perform their functional duties.

In marketing activities, artificial intelligence is used to implement content marketing, send emails, support customers using chatbots, perform predictive analysis and behavioral analysis to create effective segmentation of the target group, which allows for high-quality prediction of consumer behavior and determination of pricing policy (Nazmuz, 2022).

Of particular interest is the determination of the impact of artificial intelligence on advertising. This issue is being studied by practitioners and scholars at both the micro and macro levels. The use of artificial intelligence in advertising determines target segments and the best appeal option.

In addition, artificial intelligence is used in the formulation of marketing strategy. Thus, the article (Mahabub Basha, 2023, p. 999) notes that before the introduction of artificial intelligence in marketing, the main focus in strategy planning was on increasing marketing resources and expanding the product range. After the introduction of artificial intelligence, marketing managers focused on business analytics, which made it possible to better understand marketing, sales and operations trends. Thus, predictive models were created based on data to predict future strategies.

The main problems of integrating artificial intelligence into marketing are technical compatibility in the integration process, staff training, technical capabilities, database formation, and consideration of the ethical consequences of using artificial intelligence when collecting personal information.

***Using artificial intelligence in research.***

The European Union recommends that universities, national sponsors and states promote artificial intelligence research:

– include artificial intelligence for research – strengthening fundamental research in the field of artificial intelligence and increasing its use in interdisciplinary research;

– developing and strengthening skills in using artificial intelligence in research and encouraging talent;

– optimization of the creation and use of computing infrastructure and data, which is determined by the importance of data exchange capabilities;

– ensuring the availability and access to resilient computing infrastructures (The Guild, 2024).

The use of artificial intelligence for research involves the development of interdisciplinary tools that encompass big data, machine learning, statistics, mathematics, computer science, language technology, logic, and computer vision.

The development of the use of artificial intelligence in research in the social sciences and humanities, and the arts also plays a significant role in improving our understanding of processes.

However, the issue of responsible use of artificial intelligence and its compliance with human rights remains relevant.

Scientists emphasize the need to develop artificial intelligence to deepen knowledge to promote multilingualism and multiculturalism, increasing investment in mono-, inter-, and transdisciplinary research.

To ensure the openness of AI models, code (in the sense of open source) and data used, it is crucial for their verification, adoption in academic communities and acceptance. This also requires responsibility on the part of the producers. This implies the presence of clear documentation (Chinimilli, & Sadasivuni, 2024).

Increasingly, research is incorporating the results obtained by artificial intelligence. However, scientists' opinions on the use of artificial intelligence differ. There are those who advocate the use of artificial intelligence and predict that the development of its potential will improve the evidence base of research.

Another group of scholars is concerned about the growing use of artificial intelligence, focusing on the risks that accompany this process and possible problems with academic integrity.

The use of artificial intelligence in Ukraine is developing at a rapid pace. Over the past ten years, the number of AI/ML specialists has increased 5 times and is 5,200 professionals as of January 2024.

At the same time, 36% of all AI/ML specialists are young people aged 21–25.

The most common professions (63% of all specialists in the industry) among specialists are Data Scientists and ML Engineers.

Ukraine currently ranks second in the number of AI companies among Central and Eastern European countries. At the end of 2023, there were 243 AI companies in Ukraine, a number that has grown 2.5 times over the past decade (Government Portal, 2024).

**Conclusions.** The use of artificial intelligence, despite its significant positive aspects, is also characterized by certain disadvantages. Artificial intelligence in society requires "guardrails" for its proper use, which can range from formal regulations to codes of conduct and recommendations for best practices (McDonald, 2024, p. 6).

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## 1.2. USE OF AI IN MANAGING INNOVATIVE ECONOMIC DEVELOPMENT: WORLD EXPERIENCE

**Introduction.** In recent decades, the greatest development has been achieved by countries focused on structural transformations and the development of high technologies. The innovative development of such countries contributes to increasing competitiveness, creating new technologies, goods and improving the business environment, which allows reducing the consumption of natural resources and anthropogenic impact. Ukraine needs to move to an innovative development model that will reduce economic dependence and promote social and environmental changes. To do this, it is necessary to implement the experience of economically developed countries in innovation management and increase export potential, ensuring stable economic growth and a place in the EU [1, p. 150].

Therefore, domestic and foreign scientists focus on the feasibility and necessity of using artificial intelligence to ensure economic development, namely: Andrushkiv B. M., Cherep A. V. [2; 13], Golovkova L. S., Kyrych N. B. [2], Cherep O. G. [2; 3], Dashko I. M. [3; 13], Mykhailichenko L. V. [3], Derba V. S. [4], Hryshko V., Zinchenko I. [5], Zhang M., Chen Y. [6], Kuchmiyova T. S. [7], Muzychenko T. O., Skorba O. A., Shevchuk A. A. [8], Masoud R., Basahel S. [9], La Torre D., Colapinto C., Durosini I., Triberti S. [10], Singh N.,

Chouhan S. S. [11], Chernyshova O. O., Domashenko S. V., Domashenko D. G. [12], Ogrenych Yu. O. [13], Yavorska O. H. [14].

**Presentation of the main research material.** The basis of effective innovative development of the economy is a management system that includes coordination of interests of producers, consumers and the state. This system is implemented through the formation of innovation policy, which changes depending on the stages of development of the country's economy. L. Fedulova [15] identifies the following main types of innovation development policy, in particular, the policy of "technological push", which involves the determination of priority areas of development of science and technology by the state with a large participation in financing and implementation of programs; the policy of "market orientation", where the role of the state is reduced, stimulating the innovation process through tax breaks and promoting market initiative; the policy of "social orientation", which provides social control over the consequences of scientific and technological progress and involves public participation in determining development directions; a comprehensive policy of innovation development, which covers changes in the economic structure and requires new forms of organization and regulation.

The use of artificial intelligence (AI) as a key tool for ensuring development and change to ensure increased competitiveness involves a focus on skills and competencies and the use of innovative technologies. The transition from human to machine decision-making will ensure the selection of the most optimal innovation processes that are aimed at innovative development. Multiple goals are the prevailing reality of organizational life, so the use of AI is aimed at taking into account complex decision-making situations that include several, and often conflicting goals and priorities.

The leap in the use of AI allows for innovative development on the basis of modeling and computational capacity to solve problems and involves choosing from a large number of conflicting

criteria – the most optimal. The use of AI ranges from budget allocation to planning, as well as in many areas, from marketing and quality control to production and personnel management.

Financing innovative development includes both active state intervention in creating demand for innovations and decentralized regulation, in which the state supports those innovative directions that appear at the request of society [16].

As the authors of the article "Development of Artificial Intelligence: Advantages and Disadvantages" note, in the process of planning financing for innovative development, artificial intelligence can be used to analyze loan applications and identify the creditworthiness of borrowers, quickly assess data on the borrower's income and expenses, as well as analyze credit histories, which allows you to reduce the time required to make a decision on issuing a loan and reduce risks for the bank. In the field of finance, artificial intelligence can be used to create investment portfolios, analyze market data and predict its movement in order to make effective investments.

A mixed mechanism for regulating innovative development is often used in countries with a significant share of the public sector in the economy. In such a strategy, the state actively intervenes in the activities of enterprises and sectors of the economy, trying to achieve a high level of competitiveness. This approach is characteristic of Sweden, and to some extent also of Ukraine.

The main component of the system for stimulating innovative development is the financing and creation of a system for disseminating innovations within the framework of the general scientific and technical policy of industrial countries, which is aimed at ensuring the implementation of the results of scientific research and development into production and the further application of innovations in the real economy [17, p. 51]. Analysis of the experience of innovative development of the economies of industrial countries [18; 19] allows us to conclude that the structure of innovative development management in developed countries

is similar. In particular, the most typical is the structure of innovative development management of the national economy of the USA, a country that belongs to the top 10 most developed innovative economies in the world.

The process of innovative development of the economy in the USA is typical of the Euro-Atlantic model and includes all stages of the innovation cycle – from the emergence of a global innovative idea to its implementation in the production process. This allowed the USA to take a leading position in the market of high-tech products (space, weapons), where the share of US products is 39% [1, p. 152]. Among the government agencies regulating innovation development, the Department of Commerce plays an important role, which is engaged in determining global innovation trends, patenting, standardization and collecting statistical information on innovation processes, as well as funding promising innovation research. In addition, federal agencies such as the Department of Health and Human Services and the Department of Defense also have an impact on commercialization and innovation in their respective areas.

Small and medium-sized enterprises play an important role in the development of the US innovation economy. The main federal initiatives to support innovation development are the Small Business Innovation Research (SBIR) Program, the Small Business Support Program, and the Technology Transfer Program (STTR), which support innovative small and medium-sized enterprises. Thus, in 2015, these programs allocated almost $2 billion to small businesses with fewer than 500 employees [20].

The US Congress has the authority to implement innovations through legislative initiatives, granting permits and financing, organizing hearings, and overseeing the commercialization of innovations. The most important are the Committee on Innovation and the Committee on Small Business, as well as the Senate Committee on Commerce, Science, and Transportation.

Another element of innovation development management is the US judicial system, which resolves legal issues related to innovations, patents, and intellectual property.

Due to the favorable highly competitive business environment, the role of the state in the USA is mainly reduced to guaranteeing loans and tax breaks for innovative enterprises. State funding of innovative research is about 10% for industrial research and 17% for basic research, according to analytical data from the National Science Foundation (NSF) [21, p. 49].

At the regional level, innovative economic development is actively supported by state governments, which are closer to the specific needs of industries that form regional economies.

Non-governmental organizations also play an important role in shaping the innovative economy at the meso- and macro-levels. In addition, universities in the USA actively influence innovative development through research commissioned by industrial corporations. Therefore, most innovative ideas in the USA are implemented by the private sector, in particular through financing scientific research and development.

The main characteristic of the American model of management of innovative economic development at the meso- and micro-levels is that decisions on the implementation of innovative ideas are made by the top management of corporations. They determine the directions of innovation development, ways of their integration into the production process, the characteristics of products resulting from innovations, as well as methods and ways of their distribution. This approach makes it possible to quickly adjust research directions in case of incorrect decisions, in order to achieve the desired results. The advantage of this model is the accelerated entry of innovative products into the market, the conquest of new markets and the establishment of close feedback with consumers, which allows for rapid changes or improvements to the product. Examples of this are the successes of Microsoft, Tesla and Apple,

whose innovation management has made them among the most powerful in the world.

However, this approach also has disadvantages, including the risk of making wrong decisions due to insufficient qualifications of individual managers and the limited financial and scientific potential of corporations to solve problems. As a result, innovative products may have a short life cycle or quality deficiencies. This may lead to the withdrawal of innovative products from the market for further development, which, in turn, leads to additional financial losses and harms the image of corporations. In Germany, like the USA, state intervention in the innovative development of the economy is limited to financing global innovations, the implementation of which is deferred in time. Support for operational innovations consists in providing tax breaks to innovative enterprises and grant funding for research in the field of environmental and social innovations that do not bring a quick economic effect, but solve important issues, such as environmental protection and improving the quality of life.

Management of innovative development at the meso- and micro-levels in Germany has its own specific features, due to the cultural characteristics of society, which are expressed in resistance to risks and the desire for stability. German corporations have historically been leaders in innovation in the field of technology and quality, but due to fear of risks and loss of image, they cannot always respond quickly to new innovative ideas, as Americans do, which slows down their innovative development. The advantage of the German model is high-quality innovative products that have a longer service life, but they may be late to the market and face competition.

In Germany, decisions on the implementation of innovations are agreed upon by the owners of corporations, which takes more time, and even after the decision is made, the process of developing innovations can be slowed down by a lack of finance. However, small and medium-sized enterprises have the opportunity to respond faster to changes and successfully implement innovative ideas. Such

companies should constantly stimulate innovations, monitoring new ideas from the very beginning.

The innovation development system in Sweden is an example of successful state intervention. In Sweden, most innovation programs are developed in universities and private companies and are financed by manufacturing corporations and the state budget. However, the largest funding for innovations in the country is carried out by big business through industrial research institutes. Sweden actively finances innovations at the level of 1% of GDP and involves big business, which finances up to 3% of GDP.

Japan has a different model of innovation management, in which the government actively supports innovations through various ministries, as well as through a system of research centers and universities. Japan ranks 13th in the world ranking of innovative economies and has a developed system of public funding of innovations through competitions and specialized agencies. The main part of financing of innovation processes is carried out by large businesses, such as Toyota, Softbank, and Hitachi, which finance up to 98% of their scientific and technological research [22].

**Conclusions.** Thus, the management of innovative development of national economies has different approaches depending on the country. In Ukraine, due to the absence of large corporations, innovative development at this stage depends mainly on state support, which causes a number of problems, such as a weak legislative framework, high interest rates on loans and corruption.

We also believe that the problematic issues of forming a team whose members have technical knowledge, experience of teamwork, personal characteristics, communication skills, leadership and motivation for personal innovative development, taking into account the use of artificial intelligence in order to ensure a high level of competitiveness of the state economy, are important.

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## 1.3. ARTIFICIAL INTELLIGENCE AS A PRACTICAL TOOL FOR HUMAN DEVELOPMENT

**Introduction.** The impact of artificial intelligence (AI) as a practical tool for the development of humanity in various spheres of life is studied, including healthcare, education, finance, industry, and logistics. The advantages of using AI are described, which contribute to increasing efficiency, optimizing processes, and creating new opportunities for development. Examples of successful implementation of AI are considered, including automation of disease diagnostics, forecasting disease outbreaks, personalized learning, and detecting financial fraud. Ethical and social challenges associated with the use of AI are identified, including issues of data security, algorithm transparency, and the threat of unemployment due to automation. Recommendations for the responsible use of AI are proposed, including the creation of ethical standards, protecting data confidentiality, retraining employees, and ensuring the transparency of decisions made by AI. Prospects for further research are related to improving the regulatory framework and the impact of AI on social processes.

Artificial intelligence (AI) is one of the most powerful and controversial technologies of our time, with the potential to radically change human activity and social processes. In the context of the digital transformation of the economy,

AI plays an important role in increasing business efficiency, automating routine operations, reducing costs and improving decision-making processes. However, the implementation of AI is accompanied by a number of problems, including ethical dilemmas, employment challenges, security and control issues, as well as the uneven distribution of technological benefits.

**Presentation of the main research material.** Artificial Intelligence (AI) has become a key tool that contributes to the development of humanity, introducing innovations and increasing efficiency in various areas of life (Fig. 1):

– healthcare. AI helps diagnose diseases by analyzing medical images and patient data, which contributes to early detection of diseases and increased accuracy of treatment;

– finance. In banking, AI is used to detect fraudulent transactions, analyze market trends, and automate customer service;

– education. Intelligent adaptive learning systems adapt to the individual needs of students, providing a personalized approach to education;

– industry. AI-based robotic systems optimize production processes, increasing productivity and reducing costs;

– Transport. The development of autonomous vehicles and the optimization of logistics routes contribute to increasing the safety and efficiency of transportation;

– business. AI allows you to automate routine tasks such as order processing, inventory management and accounting, which reduces the cost of time and resources. The ability to quickly analyze large databases and volumes of information helps to detect hidden errors, which eases the workload on staff.

At the same time, the issue of regulating and responsible use of AI remains relevant to avoid abuse and negative consequences for society. The challenge lies in the need to develop a comprehensive approach that will allow for the integration of AI without harming fundamental human values.

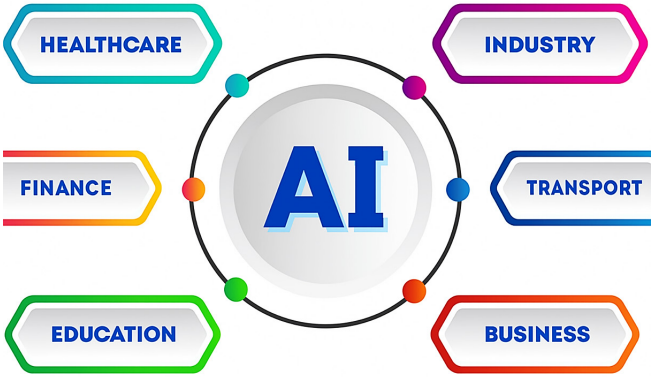


Fig. 1. Areas of application of AI (compiled by the authors)

Today, the key challenges are:

– Job losses. Automation could lead to mass unemployment, especially among workers engaged in manual labor and simple administrative tasks.

– Data privacy and security. The development of AI requires the use of large amounts of data, which creates privacy risks and ethical issues.

– Ethical issues: How can we ensure that AI algorithms act in accordance with moral norms and do not discriminate?

– Control and accountability. Autonomous systems can operate independently of human control, which increases the risk of unintended consequences.

Thus, the need for comprehensive theoretical and practical research into the impact of AI, its potential threats, and benefits is urgent and critical for the development of modern society.

The issue of artificial intelligence as a practical tool for human development is widely discussed in academic circles. A review of research reveals a number of key aspects: the economic impact of AI, its role in creating new jobs, reducing costs and increasing the efficiency of business processes. At the same time, there are

concerns about ethical implications and the risks of losing control over the technology.

Artificial intelligence is one of the most relevant topics of modern scientific research, covering various aspects of its impact on society, economy and culture. According to a study by the McKinsey Global Institute [1], the implementation of AI could add from 2.6 to 4.4 trillion dollars annually to the global economy, increasing productivity in various sectors.

In the field of education, research highlights the importance of ethical use of AI, particularly with regard to academic integrity and student data privacy [2].

The use of AI in the educational process requires the development of clear ethical norms and standards to ensure the responsible use of technology.

Meanwhile, a study conducted in Ukraine analyzes the impact of AI on the national and international economy, predicting a 14% increase in global GDP by 2030 due to the implementation of AI [3]. This highlights the significant potential of AI in stimulating economic development.

However, alongside the positive predictions, there are concerns about the ethical aspects of AI use. A study published on the Zenodo platform examines the impact of AI on the ethical aspects of scientific research in Ukrainian educational institutions, highlighting the need to develop ethical guidelines to ensure the responsible use of AI.

The aim of the article is to study the impact of artificial intelligence as a practical tool for the development of humanity in various spheres of life. The article aims to analyze both positive and potentially negative aspects of the implementation of AI, with an emphasis on its role in increasing efficiency, automating processes, and influencing social and economic structures.

The main objectives of the study are:

– assess the current state and trends in the development of artificial intelligence;

– identify key areas of AI use, including economics, education, medicine, and other industries;

– analyze the ethical and social challenges associated with the use of AI;

– develop recommendations for the responsible and effective implementation of AI in social processes;

– to identify prospects for further research and development of a regulatory framework to regulate the use of AI.

Despite the great contribution of AI to the development of humanity, ethical and social challenges associated with the use of AI have gained considerable relevance in modern society. The large-scale implementation of this technology creates new opportunities, but also raises a number of issues that require discussion and resolution. The main problems are privacy and data security. Since AI systems analyze huge amounts of information, including confidential data, there is a need to ensure reliable protection and compliance with confidentiality standards.

Another challenge is the ethical dilemmas associated with algorithmic decision-making. The opacity of algorithms and the difficulty of understanding them create risks of discrimination, as AI can make decisions that unknowingly reproduce social biases or injustices. Therefore, mechanisms need to be developed to ensure transparency and accountability of AI systems.

The automation of work through AI also creates social consequences, including the threat of unemployment for workers whose jobs may be automated. This requires the introduction of retraining programs and support for workers who may be affected by such changes.

There are also concerns about the autonomy of AI systems, which can operate independently of human control. This increases the risk of creating unpredictable situations that could have serious consequences for society. In particular, the question of who will be responsible for the decisions made by artificial intelligence is important.

Thus, the development of AI requires not only technical improvements, but also the development of ethical norms and social mechanisms that would ensure the responsible use of the technology. Addressing these challenges is critical for AI to work for the benefit of society, respecting fundamental human rights and freedoms.

Artificial intelligence is one of the most important technological advances of our time, with the potential to transform almost every aspect of human activity. Its applications have been found in various areas of life: from healthcare and education to industry and transportation.

AI is significantly transforming the healthcare sector, offering innovative solutions for diagnostics, treatment, and management of medical processes [4]. Let's consider specific examples of AI applications and the problems it helps solve:

– Disease diagnosis. AI algorithms analyze medical images, such as X-rays, MRIs, and CT scans, to detect abnormalities. For example, AI-based systems can detect signs of breast cancer in mammograms with accuracy that exceeds the capabilities of the human eye. This contributes to early detection of diseases and increased treatment effectiveness.

– Disease outbreak prediction. AI analyzes large amounts of data from various sources, including social media and medical records, to predict infectious disease outbreaks. This allows health authorities to take proactive measures to prevent epidemics.

– Automation of administrative processes. Implementing AI in administrative tasks, such as processing medical records and managing appointment schedules, reduces the burden on medical staff and minimizes the likelihood of errors.

– Drug development. AI accelerates the process of developing new drugs by analyzing large amounts of scientific data and predicting the effectiveness of potential drugs. This reduces the time and cost of bringing new drugs to market.

– Telemedicine and remote monitoring. AI supports the development of telemedicine, enabling remote monitoring

of patients and real-time medical consultations. This is especially important for patients in remote regions.

It is also important to consider the impact of AI on economic processes. Its application allows businesses to significantly increase efficiency, reduce costs, and create new opportunities for development, while solving complex economic problems.

In the manufacturing sector, one of the most prominent examples of AI in manufacturing is General Motors (GM). GM's production lines used to suffer from high levels of defects, which resulted in significant financial losses. The introduction of machine learning systems made it possible to analyze data in real time, detect anomalies, and prevent defects from occurring. GM uses AI to monitor the condition of its factory equipment. The system collects 165 million images every day, the analysis of which allows it to predict possible malfunctions before they occur. This ensures smooth operation of production lines and reduces repair costs and downtime.

AI is also being used extensively in retail. Walmart has used demand forecasting algorithms that analyze large amounts of data about sales, weather, holiday periods, and other factors to optimize inventory. It is estimated to reduce inventory costs by up to 10%, saving the company more than $1 billion annually.

Artificial intelligence is making a significant contribution to improving efficiency in the financial industry. For example, JPMorgan Chase has created a Contract Intelligence (COiN) platform that automatically analyzes and processes legal documents. This solution allows processing 12,000 contracts in a matter of seconds, instead of the 360,000 hours that employees previously spent. The implementation of COiN has helped the bank significantly reduce operating costs, increase efficiency, and optimize the use of human resources.

Artificial intelligence plays a key role in increasing efficiency and optimizing processes in the logistics industry. DHL is actively implementing AI to optimize delivery routes and manage supply

chains. According to a DHL report, AI allows analyzing large amounts of data, including traffic information, weather conditions and other factors that affect the delivery of goods. This helps reduce fuel costs and shorten delivery times, increasing the company's competitiveness in the market.

Artificial intelligence (AI) plays a key role in combating fraud in financial transactions, ensuring effective detection and prevention of illegal activities [5]. By analyzing large volumes of data and detecting anomalies, AI is able to respond quickly to potential threats.

US Treasury Department. The department has been implementing AI-based systems to detect fraudulent schemes and improper payments. In the past year, these technologies have helped prevent more than $1 billion in losses, demonstrating their high effectiveness in protecting government finances.

Barclays Bank: Uses AI to monitor payment transactions in real time, allowing it to detect and prevent potential fraud. This approach not only protects customers but also strengthens their trust in the bank's security measures.

JPMorgan Chase has implemented AI algorithms to detect fraudulent credit card transactions. These systems analyze transaction information in real time, allowing them to quickly identify suspicious transactions and prevent financial losses.

AI is being actively implemented in the educational sector, helping to solve a number of problems and increase the efficiency of the educational process:

– Personalized learning. AI-powered platforms like Century Tech analyze individual student needs and tailor learning materials to their strengths and weaknesses, leading to increased student engagement and improved learning outcomes.

– Automated grading. AI systems like Grammarly help teachers automatically check students' written work, identifying grammatical and stylistic errors. This significantly reduces grading time and ensures objectivity in grading.

– Virtual tutors. Platforms like Duolingo use AI to teach foreign languages, adapting tasks to the user's level of knowledge and providing instant feedback. This promotes effective learning and increases motivation to learn.

– Student performance analysis. Universities are implementing AI-based systems to track students' academic progress, allowing them to identify potential problems early and provide needed support. This helps reduce student dropout rates and increase overall performance.

The results of the study show that artificial intelligence is one of the most important technological achievements of our time, capable of significantly influencing various aspects of human activity, including healthcare, education, economics and logistics [6]. It was found that its application provides increased efficiency of processes, reduced costs and created new opportunities for development.

The responsible implementation of artificial intelligence (AI) in social processes requires a comprehensive approach that includes ethical, social and economic aspects. To ensure the harmonious development of technologies and protect the interests of society, the following recommendations should be followed (Table 1):

– Establishing ethical standards and regulations. Developing clear regulations governing the use of AI is critical to protecting human rights and upholding ethical principles.

– Data privacy protection. Ensuring reliable protection of personal information using encryption and other modern technologies.

– Retraining of workers. Development of retraining programs for people whose professions can be automated to avoid social tension.

– Algorithmic transparency. Increasing the transparency of decisions made by AI, especially in critical areas such as healthcare or finance.

– Raising public awareness. Implementing educational programs to familiarize the public with the work of AI and the basics of data security.

Table 1

**Recommendations for implementing AI in social processes (developed by the authors)**

| Recommendation | Description | Expected result |
|---|---|---|
| Creating ethical standards | Developing clear regulations and ethical principles for the use of AI | Protection of human rights and compliance with ethical standards |
| Data privacy protection | Use of encryption and information protection technologies | Maintaining privacy and data security |
| Retraining and social support | Implementation of employee retraining and support programs | Reducing socio-economic impacts |
| Transparency of algorithms | Developing algorithms that can be explained and tested | Building trust and preventing discrimination |
| Raising citizen awareness | Implementation of educational programs to familiarize with the principles of AI | Raising awareness and protecting citizens' rights |

Implementing these recommendations will ensure that the benefits of AI are maximized while minimizing risks and ensuring that the technologies work for the benefit of society.

Creating a clear and effective regulatory framework is a key aspect of the responsible implementation of AI [7]. Modern regulations should take into account the specifics of new technologies and ensure a balance between the development of innovations and the protection of citizens' interests (Table 2).

Main directions for further research:

– the impact of AI on the labor market and social sphere. Research is needed on how automation of work processes will affect employment and what skills will be needed in the future. This will help develop strategies for retraining workers and supporting those who may lose their jobs due to the introduction of AI;

Table 2

**Prospects for further research and regulatory regulation**

| Research / regulation area | Description | Expected result |
|---|---|---|
| Impact on the labor market | Researching the impact of automation on employment and identifying the skills needed | Creating retraining and support programs |
| Data security | Developing new methods for data protection and ensuring regulatory compliance | Increasing security and maintaining privacy |
| Ethical standards and algorithm transparency | Creating ethical standards for developers and ensuring transparency of AI solutions | Preventing discrimination and ensuring fairness |
| Global collaboration | Collaboration with international organizations to create global regulatory standards | International regulatory consistency |
| Control mechanisms | Implementing mechanisms for monitoring AI performance and accountability | Reducing risks and ensuring responsible use |

– data security and privacy protection. Research into methods for protecting large amounts of data used by AI should continue to ensure privacy and information security. Particular attention should be paid to the development of encryption technologies and ensuring regulatory compliance;

– ethical aspects and algorithmic transparency. The need for research that would help create ethical standards for AI developers and users is extremely important. Approaches to ensuring algorithmic transparency need to be developed to prevent discrimination and bias in the decisions made by AI;

– Analyzing the impact of AI on society. It is important to study the social consequences of AI implementation, including the impact

on education, healthcare, and the economy. This will allow us to understand how technologies are changing social processes and how they can be used to improve the quality of life.

**Conclusions.** Summarizing the above, it can be argued that artificial intelligence is a powerful tool that significantly affects various areas of human activity. Its application allows you to optimize processes, increase work efficiency, reduce costs and create new opportunities for development. In the field of healthcare, AI contributes to improving diagnostics and treatment, and in the economy it helps to increase productivity and reduce company costs. In the field of education, artificial intelligence personalizes learning and automates assessment, which improves the quality of the educational process. The implementation of AI in logistics and finance demonstrates cost reduction and effective detection of fraudulent actions. The practical value of the research results lies in the development of recommendations for the responsible and effective implementation of artificial intelligence in various industries, which will ensure sustainable growth and increased competitiveness.

The practical value of the study lies in providing recommendations for the responsible and effective implementation of AI in social processes. The proposed measures, in particular the development of ethical standards and ensuring the transparency of algorithms, are aimed at ensuring a balance between using the benefits of AI and protecting public interests. Prospects for further research are related to improving the regulatory framework, developing new methods for regulating the technology, and studying its socio-economic impact on society.

This emphasizes the need for a comprehensive approach to the implementation of AI, which will take into account both technological and ethical aspects, contributing to the sustainable development of humanity and improving the quality of life.

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# CHAPTER 2.
# THE IMPACT OF DIGITALIZATION ON THE SOCIO-ECONOMIC SECURITY OF EUROPEAN COUNTRIES AND UKRAINE

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## 2.1. THE IMPACT OF DIGITALIZATION ON THE SOCIO-ECONOMIC SECURITY OF EUROPEAN COUNTRIES AND UKRAINE

**Introduction.** Digitalization is an important factor in modern social and economic development, as its impact is visible in all spheres of life – from business and education to public administration. The introduction of digital technologies contributes to increased productivity, optimization of business processes, development of e-government and improvement of the quality of life of the population. At the same time, digital transformation is radically changing the labor market, methods of communication and mechanisms of doing business, which significantly affects the socio-economic security of states. It, in turn, covers both economic

indicators, namely employment, income level, competitiveness of the economy, and social factors – accessibility of education, medicine, social protection. Successful digitalization contributes to increasing socio-economic security through automation of processes, development of digital services and creation of new opportunities for citizens and businesses, which were studied by scientists: Brown T., Mann B., Ryder N., Subbia M., Kaplan J., Dhariwal P. [1], Khalid M., and Yusaf M. M. [2], Prakash D. [3], Garcia K. [4], Jordan M. I., and Mitchell T. M. [5], Oleinikova L. G., Savenko D. M., Kolisnyk K. A. [6], Cherep A. V. [7–10], Cherep O. G. [7; 9], Gelman V. M., Loseva E. S. [7], Dashko I. M. [8; 9], Ogrenych Yu. O. [8–10], Oleinikova L. G., Vasylenko D. O. [10].

At the same time, digital transformation carries certain risks, including the growth of cyber threats, increasing digital inequality and dependence on global technology corporations. European countries are leaders in the implementation of digital technologies, implementing comprehensive digitalization strategies to increase competitiveness and security. Ukraine is not lagging behind them, but on the contrary is actively implementing digital reforms, in particular in the areas of e-government, banking technologies and e-commerce. However, on the path to digital transformation, the country faces certain problems, including: uneven access to digital technologies, low level of cybersecurity and insufficient readiness of the labor market for changes.

**Presentation of the main research material.** Due to the ambiguity of interpretations and a wide range of contexts, the concept of “digitalization” still remains a subject of ambiguous understanding and application, especially in the legal sphere and the activities of executive authorities in Ukraine. This situation often arises due to confusion with the concepts of “digitization” and “digitalization”, which are often used as synonyms for digitalization, although they have significant differences. In particular, digitization

and digitalization involve the conversion of analog data into digital format, while digitalization covers a much wider range of changes, including the transformation of business processes and the modernization of society through the use of digital technologies. An additional problem is the perception of digitalization exclusively through the prism of technology or the reduction of its essence to the simple conversion of paper documents into digital form. Such a superficial understanding leads to a narrow approach that ignores key aspects of digital transformation – changes in management, organizational culture, business development strategy, communications and other important areas.

In this context, it is important to pay attention to the research of K. V. Nychiporenko and M. V. Aleksandrova, who, analyzing the benefits of digitalization, also focus on its risks, such as digital inequality and discrimination, which are significant deterrent and preventive factors. As well as the presentation of the perception of digitalization through such trivial things as "leadership", "trust", "a person of the new generation", etc., similar to the imposition of elements of indoctrination – "uncritical perception by social subjects of ideas proposed from the outside, the purposeful implementation of certain political ideas to form a certain public consciousness" [12]. Thus, digitalization is a complex and multifaceted process that goes far beyond the implementation of technologies, it covers not only technical aspects, but also significant social, economic and legal changes. This is not just the integration of innovative solutions, but a profound transformation that affects the structure and principles of functioning of state institutions, the economy, and society as a whole. Its role cannot be ignored, as it shapes the country's position in the global economic space. The COVID-19 pandemic and military operations in Ukraine have become particularly significant catalysts for digital transformation, accelerating the introduction of digital solutions into all aspects of life. In the era of globalization, the digital economy is becoming increasingly important for

the development of states. It is important to realize that it is not a separate industry, but an integrated digital environment that changes traditional economic models. The boundary between the classical and digital economies is gradually blurring, which makes it difficult to distinguish them. Digitalization is the driver of modern social development, contributing to the modernization of all spheres of activity, in particular the labor market and economic processes. Investments in digital technologies demonstrate significantly higher profitability compared to traditional areas. The rapid development of information technologies is fundamentally changing the way people live, gradually introducing digital solutions into all spheres of activity. Government institutions, the business environment, and citizens are actively using technologies such as artificial intelligence, robotics, cyber systems, big data, blockchain, paperless technologies, cloud computing, 3D printing, unmanned systems, biometrics, and quantum technologies. Digitization of economic processes brings significant benefits, including:

For society:

– increasing economic and social effects from the use of digital technologies;
– improving the quality of life of citizens;
– increasing labor productivity;
– creating new profitable business models;
– effective monitoring of economic processes.

For businesses:

– minimizing the involvement of intermediaries or the possibility of selling directly to consumers;
– reduction of operating costs;
– improving business communications;
– quick feedback from customers;
– creating new products and services that meet market demands.

For consumers and employees:

– reducing the cost of goods and services by optimizing logistics and production processes;

– global availability of goods and services regardless of geographical location;

– personalization of offers that better meet customer needs.

Despite its numerous advantages, digitalization is also accompanied by certain threats, including:

a) cyber risks:the risk of unauthorized access, cyberterrorism, personal data leakage;

b) social challenges: automation can lead to job losses and increased unemployment;

c) privacy issues: digital control and monitoring of the population;

d) technical threats: Internet connection instability, which may affect access to digital services.

Despite certain shortcomings, the digital economy contributes to the reduction of social barriers and creates equal opportunities for all. Remote employment eliminates gender discrimination, since the productivity of an employee is assessed not by secondary characteristics, but by his skills and work results. In particular, the opportunity to work online opens up new prospects for women, housewives, and other social groups who previously had limited access to quality jobs. In addition, digitalization provides ample opportunities for distance learning, development of professional skills, access to the global labor market and information. This allows people to effectively realize their own potential and improve their financial situation.

The practical implementation of electronic technologies in the sphere of public administration in Ukraine started in 2016 with the approval of the Concept of the Development of the Electronic Services System. Its main goal was to determine strategic directions, mechanisms and time frames for creating an effective system of electronic services that would meet the needs of individuals and legal entities. The main principles of this system included accessibility, transparency, security, absence of corruption risks, cost minimization and efficiency. According to the plans, by 2020, it was planned to fully

ensure the electronic provision of services in all spheres of public life, the implementation of integrated and cross-border electronic services. However, due to a number of factors, in particular the lack of political will, some of the planned initiatives were never fully implemented. The key tool for the implementation of electronic services was e-government (electronic governance), the conceptual basis of which was formed by the theories of the information society that became widespread in the second half of the 20th century.

The use of electronic governance mechanisms can significantly improve the quality of service to citizens and businesses, make the activities of state bodies more open, transparent and efficient. It is important to understand that e-government is not just a modern management tool, but a new approach to public administration, which involves the automation of administrative processes, digital interaction between authorities, business and citizens, as well as the performance of its functions by the state using digital technologies. According to the Concept of the Development of Electronic Governance, this system has become one of the priority areas of public administration reform. It was assumed that its development would be transformative and even revolutionary in nature, aimed at:

– optimization of e-government functionalities;

– reducing costs for government agencies through digitalization of processes;

– introduction of innovative methodologies and technologies to improve the efficiency of public administration.

To achieve these goals, a set of strategic measures was identified, including the modernization of public services and the digital integration of interaction between the state, citizens and business. Particular attention was paid to digitalization in the field of social protection of the population, which provided for:

1. Creation of a single state register of the social sphereand unifying existing disparate databases for more efficient management of social benefits.

2. Implementation of electronic sick leave, which allows you to reduce bureaucratic procedures and increase convenience for citizens.

3. Automation of data verification when assigning social benefits and benefits, which minimizes possible abuses and increases the speed of processing applications.

4. Introduction of electronic employment contracts, which simplifies the employment process and promotes transparency in labor relations.

One of the key tools for implementing the Strategy should be the information system – the Unified Information System of the Social Sphere (hereinafter referred to as the EISSS).

This is a joint project of the Ministry of Social Policy and the Ministry of Digital Economy, an expansion and continuation of the updated project "E-Social", which was created taking into account the latest information and management technologies, unified modern standards of quality of service to citizens, with the possibility of making effective organizational and structural decisions. The EISSS is being created on the technological basis of information systems and registers of the social sphere that are already in operation, in particular the Register of Insured Persons of the Pension Fund (RZO), with full integration with the Unified State Web Portal of Electronic Services "Diya" [13]. With the help of the EISSS, the digitalization of the social sphere will cause global changes in the organization, management and provision of social services. The main innovation will be the creation of a unified social register, which will be formed on the basis of the register of insured persons.

This integrated system will accumulate data on all citizens receiving social support, as well as provide complete and up-to-date information on all payments made and benefits assigned. An important step will be to merge data from disparate social registries into a single digital ecosystem. This will ensure the automation and centralization of social processes, eliminating

duplication of administrative procedures and the need for numerous local social security offices. Digitalization of the social sphere is beneficial for both citizens and the state. For citizens personally, it means a convenient and accessible service, the ability to receive a service (payment) in a few minutes without leaving home, which will also help overcome corruption. For the state, digitalization will allow for the optimization of expenditures, in particular by streamlining payments, transparent control over them, as well as reducing administrative costs and bureaucracy, along with a complete transition to electronic document management.

Developed countries of the world in the conditions of the modern economy pay considerable attention to digital transformation. In particular, in 2010, the European Union countries launched the strategic initiative Digital Order, which defined key measures to achieve the set goals by 2020. One of the main components of this initiative was the formation of the Digital Single Market.

To assess the level of technological development and implementation of digital innovations in EU countries, a special indicator is used – the DESI Index. This index includes five main sub-indices: development of digital infrastructure, level of digital skills of the population, activity of Internet use, integration of digital technologies into the business environment and development of e-government.

A component of the DESI index is the digital capital indicator, which is based on five key parameters grouped into two main categories. One of them analyzes the basic digital skills of the population, while the other assesses the level of preparation of graduates of educational institutions for work in the digital environment. According to the results of this index for 2020, the leaders of the European Union in the field of digital technologies were countries such as the Netherlands, Belgium, Luxembourg, Denmark, Finland, Sweden, Ireland, the United Kingdom, Austria and Estonia (Fig. 1).

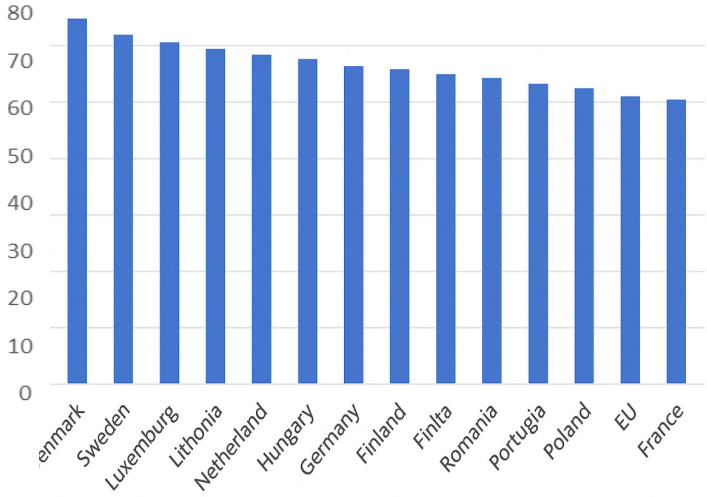


Fig. 1. Score indicator of the rating level of communication accessibility in EU countries in 2020

According to the 2020 DESI Report, the coverage of households in the European Union with next-generation networks increased from 83% to 86%. The share of households with access to fixed broadband networks also increased from 15% to 26%. Almost the entire EU population (96%) is covered by the 4G network, while the level of 5G coverage remains relatively low at around 25%. The countries with the highest level of digital readiness have strong information and communication capabilities. Among them are Finland, Germany, Hungary and Italy. The leaders in terms of digital accessibility are Denmark, Sweden and Luxembourg, where DESI index indicators are in the range of 65–68 points. On average, the average level of digital accessibility in EU countries is 50 points, while the lowest indicators are observed in Bulgaria, Cyprus and Greece.

Actively modernizing the educational process, the European Union countries are forming a strategy for the development of education,

implementing the results of scientific research, taking into account innovative digitalization programs. It is the implementation of digital innovative technologies that allows for the implementation of many European grants that support Ukrainian educators during the Russian-Ukrainian war. The formation of the Digital Education Action Plan for 2021–2027 allows for the implementation of domestic initiatives, taking into account European experience.

This Plan:

– Forms a long-term vision for high-quality, accessible and inclusive digital education in Europe.

– Analyzes the challenges and opportunities that have arisen as a result of the COVID-19 pandemic, when technology has played a major role in enabling continuous learning.

– Emphasizes the need for enhanced cooperation between EU countries in the field of digital education and emphasizes the importance of intersectoral interaction for the effective implementation of digital solutions in the educational process.

– It provides a wide range of opportunities, including improving the quality of digital teaching, supporting the digitalization of pedagogical methods and learning approaches, and providing the necessary infrastructure for inclusive and sustainable distance learning.

This document builds on the previous 2018–2020 plan, which was developed to support distance learning during the pandemic. It was then that the first steps were identified to adapt educational institutions and national education systems to rapid digital change.

The new plan has two strategic priorities: 1) promoting the development of a highly effective digital education ecosystem; 2) enhancing digital skills and competencies for the digital transformation of education.

Priority 1: Promoting the development of a high-performance digital education ecosystem includes:

– infrastructure, connectivity and digital equipment;

– effective planning and development of digital potential, along with modern organizational capabilities;
– digitally competent and confident teachers and educational staff;
– high-quality educational content, user-friendly tools, and secure platforms that adhere to digital privacy rules and ethical standards.

Priority 2: Improving digital skills and competencies for digital transformation involves:
– basic digital skills and competencies from an early age;
– digital literacy, including combating disinformation;
– computer education;
– good knowledge and understanding of artificial intelligence (AI) technologies;
– advanced digital skills, increase in IT specialists;
– ensuring equal participation of girls and young women in digital research and careers (European Commission, 2021) [15].

Currently, digitalization has not yet had a significant impact on improving the operational efficiency and overall profitability of most enterprises in Ukrainian sectors of the economy. The only exceptions are such industries as trade, where e-commerce is actively developing, administrative services thanks to the introduction of e-government, and information technologies, where the development and integration digital technologies are an integral part of the evolutionary process. However, digitalization in these industries causes contradictory results, which concern both the use of Ukraine's competitive advantages in the international economic space and ensuring stable socio-economic development. It is important to note that the main growth is observed mainly in the extractive industry, much smaller – in the manufacturing industry, and even less pronounced – in mechanical engineering.

It is important to note that there is a slowdown in production volumes over the 10 months of 2021. However, there is an increase in services provided in terms of the volume of exports of IT services, the volume of taxes paid by the IT sector

to the budget, and the volume of investments attracted to the IT sector (Table 1) [16].

Table 1

**Volumes of IT sector activity in Ukraine for 2016–2020 [16]**

| Indicators | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|
| Volume of IT services exports, million USD | 1,975 | 2,485 | 3,204 | 4,173 | 5,026 |
| The amount of taxes paid by the IT sector to the budget, UAH million | 7,117 | 9,642 | 13,048 | 16,697 | 1,155 |
| The volume of investments attracted to the IT sector, million USD | 80 | 265 | 345 | 544 | 571 |

Within the framework of the EU4Digital program, which supports the harmonization of digital markets among the Eastern partners, several pilot initiatives are being implemented in Ukraine, such as eDelivery, eCustom, eCommerce, which will become available to all Ukrainian companies in the near future. These initiatives will contribute to the acceleration of digital transformations in the country's economy. The Ministry of Infrastructure of Ukraine is working on issues related to e-commerce, and the National Commission for Regulation of Communications and Informatization provides standards for postal services. Both international standards (UPU) and national ones are being implemented in Ukraine. We believe that the introduction of a data exchange system based on digital technologies into the activities of domestic businesses allows for beneficial relationships with foreign partners, in particular European ones, which will avoid traditional problems associated with paper red tape, delays and risks of loss or leakage of confidential information when it is transmitted by mail. The eDelivery pilot project, for example, was tested on the Ukraine-Poland route, where a Ukrainian exporter sends an electronic invoice through a national access point,

and it then arrives at a Polish company through a Polish access point in the Peppol network. The eCustom pilot project has also been launched, which is aimed at combating shadow customs schemes, where, for example, an empty truck can leave one country and not reach another country or arrive with goods. Thanks to electronic data exchange, customs authorities will be able to quickly detect and block such violations. The eCommerce initiative aims to increase trade volumes between countries using digital platforms. Companies will be able to sell their goods on the markets of the EU and other countries, placing the necessary information on generally accepted trading platforms. A special feature is the work of postal operators, who must deliver shipments from Ukraine to the EU within 24 hours from the moment of acceptance. Of course, these factors positively characterize the processes of digitalization in Ukraine. However, the success of these initiatives largely depends not on existing support, but rather on overcoming it, in particular regarding the institutional environment and legislative support. The digital development of Ukraine is significantly slowed down due to imperfect management of the national economy, the inconsistency of current legislation with the requirements of digital changes, the lack of appropriate legal institutions and procedures for regulating relations and protecting rights in conditions of rapid socio-economic transformations. This is especially noticeable when analyzing the path that Ukraine is taking to building a developed information society.

Cyber threats in the financial sector cover a wide range of dangers that can cause significant financial losses and damage the reputation of financial institutions among customers. The list of main cyber threats:

– Phishing is the process of providing customers with false information aimed at soliciting reliable information about confidential payment card data.

– There are also processes of distributing programs that are aimed at damaging the computer systems of banks and other financial institutions in order to obtain reliable information about their activities.

– DDoS attacks are attempts by attackers to overload a financial institution's website by using hacked servers, making the site inaccessible due to excessive load on the servers.

– Intelligence involves collecting confidential data about financial institutions and their customers in order to further implement cyberattacks using previously obtained information.

– Information interception is carried out using spyware that monitors and receives data transmitted over the network.

– Skimming involves installing special devices on ATMs or payment terminals that allow criminals to steal information entered by users, including credit card numbers or PIN codes.

– There is also cyber espionage, which is aimed at obtaining confidential information about the activities of financial and non-financial institutions through illegal means.

– Fraud also has a fairly wide range of uses of digital technologies to obtain reliable information about the activities of individuals and legal entities in order to use this information for further criminal use.

However, this list is not exhaustive, as the development of new technologies and the emergence of social challenges force cybercriminals to create new ways of fraud. Despite the complexity of methods for penetrating organizational networks, a significant proportion of security incidents arise from internal threats, in particular from current or dismissed employees, as well as from unintentional errors of personnel. According to research, insider attacks are 48% more difficult to detect and prevent than external cyberattacks. Another common type of cybercrime is cryptocrime. More and more financial services include cryptocurrency transactions, which attracts crypto enthusiasts, but such services are not without significant risks, as their systems usually do not have adequate protection and have not undergone extensive testing [17].

Encryption, which is used in the development of new forms of cyber threats, complicates the process of their detection and analysis. The globalization of information systems creates a threat

from external actors that can negatively affect the information security of the country, which requires the development of effective international protection strategies. Ensuring the security of large volumes of data and their processing in real time is a serious challenge for government agencies, as this requires effective cybersecurity without losing productivity and speed. The constant development of cyber threats, such as adaptive attacks that change according to protection tools, makes it difficult to predict and detect new forms of cybercrime. One of the main elements of this is assessing the effectiveness of antivirus programs that help detect and neutralize malicious programs that threaten the security of systems. Intrusion detection methods are powerful tools for identifying anomalies and abnormal actions in public management systems. Research in this area includes the development of new algorithms and technologies for rapid threat detection and prevention. Multi-layered protection strategies that combine hardware and software solutions are attracting the attention of researchers. Based on the analysis of security in public administration systems, the following recommendations can be offered for data protection and preservation:

1. Raising awareness and training staff – introducing mandatory cybersecurity courses for all employees, which will include regular training, seminars, and online learning.
2. Developing a password policy – establishing strict requirements for password length, complexity, and regular password changes.
3. Systems security audit – conducting regular checks and monitoring network activity to identify anomalies and malfunctions, and eliminate vulnerabilities.
4. Encryption of confidential information – implementing encryption to protect data during transmission and storage, including files and network connections.
5. Protection against unauthorized devices – setting restrictions on access of non-core devices to the network to avoid possible threats from vulnerable connected devices.

6. Using modern antivirus solutions – active use of the latest antivirus programs to effectively detect and block malware.

7. Creating backups – regular backups of important information to restore data in the event of loss or attack.

8. Monitoring and threat detection – setting up monitoring and threat detection systems for rapid response to cyber threats.

International business practice shows that, on the one hand, the use of the above-mentioned technical capabilities of digital platforms is quite widespread, and on the other hand, there are deep intra-country, inter-state and inter-regional differentiations in the ability of economic entities to use them. Let's look at the numbers: in the United States of America, the share of jobs requiring employees with advanced "digital skills" increased from 4.8% in 2002 to 23% in 2016; employment in professions with an average level of "digital intensity" – from 39.5 to 47.5%, against the background of a simultaneous decrease in the share of jobs with a low level of use of digital technologies – from 55.7 to 29.5%, respectively. Today, more than 32 million people in the United States work in "high-digital jobs," 66 million in mid-digital jobs, and 41 million in "low-digital jobs" that require only basic digital skills [19]. According to the results of 2020, the top ten countries in the world in terms of network readiness (out of 134 countries) were: Sweden (with an index of 82.75), Denmark (82.19), Singapore (81.39), the Netherlands (81.37), Switzerland (80.41), Finland (80.16), Norway (79.39), the United States (78.91), Germany (77.48), and the United Kingdom (76.27). However, in the context of economic asymmetries both within and between countries, digital technologies can only exacerbate these inequalities, causing an even greater gap between rich and poor countries. This conclusion is supported by estimates from experts from the Boston Consulting Group, who note that the richest 20% of citizens in high-income countries should spend only a month's salary on the purchase of a basic laptop. At the same time, in middle-income countries, these same 20% of citizens spend six months of their salary,

and in low-income countries – as much as eight months for the same purposes. This confirms the traditional approach to the analysis of the global digital divide, which was formed in the theoretical context of global economic development in the early 2000s. The main idea of this theory is that there is a significant asymmetry between countries that have information resources and those that do not have these resources [19].

Despite the significant difficulties in determining the scale of the digital economy, due to the lack of a single generally accepted definition and the lack of accurate statistical data on its structural components, the system of indicators and metrics for assessing the digital divide remains quite variable, depending on the level of this gap under study. The degree of access of economic entities to the Internet and information and communication technologies is assessed by quantitative parameters, namely, the audience coverage of broadband and mobile Internet (daily, weekly, monthly), the number of subscribers, the speed of the Internet connection and the cost of access to it, the number of households with the Internet, the level of penetration of mobile radiotelephone communication, the average speed of the Internet connection, the types and number of devices for accessing the Internet, etc. The existing deficit of digital skills and literacy is the main factor contributing to the deepening of the digital divide between countries. According to a study by the Boston Consulting Group, more than 60% of the population in low- and middle-income countries lack basic computer skills, such as using copy and paste functions in documents, sending emails with attachments, and transferring files between computers and other devices. At the same time, in high-income countries, almost 60% of youth and adults lack the next level of standard digital skills, such as using basic formulas in spreadsheets, connecting new devices, creating electronic presentations, installing new software, and so on.

The level of the digital divide in the AI component can also be judged by the indicators of patenting innovations in this area:

from the time of the emergence of AI in the 1950s to 2018, about 417 thousand applications for the commercial application of its technologies were filed in the world. At the same time, there are clearly pronounced asymmetries in the structure of patenting of AI methods, in which more than 30% of the total patent portfolio falls on machine learning. At the same time, the most dynamic growth in patent applications over the specified period was recorded in the deep learning segment – 175%, the use of neural networks – 46%; and among the functional applications of AI, the most common today are video analytics (almost half of all patents in the AI sphere), the robotics segment and the development of control methods. In the country distribution of practical use of patent proposals in the field of artificial intelligence, the first place belongs to the USA (39%), followed by the European Union – 19%, China – 19%, India and the Republic of Korea – 6% each, Japan – 4% [19]. The rapid development of digital transformation processes in economic activity stimulates an active response of national governments of different countries, which are increasingly aware of its critical importance for ensuring high competitive positions in the global market. These processes also contribute to optimizing the use of assets by enterprises and business structures, as well as stimulating innovations in national economies and increasing labor efficiency in society. This is confirmed by the fact that recently 32 OECD countries and 6 partners of this group have developed and are actively implementing national digital strategies, programs and projects that fully comply with the digital agenda for Europe, the European Digital Single Market Strategy and the EU Action Plan on e-Government.

**Conclusions.** Digitalization has a significant impact on the socio-economic security of both European countries and Ukraine. Thanks to the development of digital technologies, new opportunities for economic growth, improved governance and integration with global markets are emerging. However, this process is not without risks, in particular, cybersecurity threats, deepening digital inequality and job

losses in traditional sectors of the economy. In Europe, digitalization is an important component of the economic development strategy, where national digital strategies contribute to increasing the competitiveness and stability of economies. Ukraine, in turn, must actively implement such strategies, develop digital infrastructure and maintain equal access to digital technologies for all segments of the population. Digitalization also improves the efficiency of public administration, but requires significant investments in the development of digital skills of the population and increasing cyber protection. Therefore, to ensure the stability of socio-economic security, it is necessary to take a comprehensive approach to managing digital transformations, taking into account both their opportunities and risks. Overall, digitalization is an important factor in ensuring socio-economic security, but it requires proper regulation and adaptation to the specific needs of each country.

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## 2.2. ADAPTING BUSINESS UNDER MARTIAL LAW WITH THE USE OF ARTIFICIAL INTELLIGENCE TECHNOLOGIES

**Introduction.** Adaptation of businesses to war conditions using artificial intelligence is becoming extremely relevant in the modern world, as war creates numerous difficulties for enterprises. Damage to infrastructure, limited access to resources, reduction of the workforce – all this threatens the stability and efficiency of business processes. Artificial intelligence, capable of quickly processing large amounts of data and making automated decisions, allows companies to adapt to these conditions. Therefore, scientists in their studies focused on the feasibility and necessity of digitalization in the context of globalization and the use of AI: Alekseeva O. V., Mazur K. V., Kryvogubets V. A. [1], Andros S. V. [2], Harry Bauman, Shahrokh Niku, Francisco J. [3], Hrybinenko O. M. [4], Guralyuk A. G., Kononenko A. G. [5], Guseva O. Yu., Legominova S. V. [6], David Eder, Christoph Buck [7], Oleinikova L. G. [8; 12], Savenko D. M., Kolisnyk K. A. [8], Cherep A. V. [9–12], Cherep O. G. [9; 11], Gelman V. M.,

Loseva E. S. [9], Dashko I. M. [10; 11], Ogrenych Yu. O. [10–12], Vasylenko D. O. [12].

In particular, AI can optimize logistics, predict changes in demand for products and services, and automate key processes, which helps maintain operational efficiency even during crisis situations. Integrating AI into risk management is another important aspect of business adaptation in wartime. AI systems can make predictions and analyze external factors, such as changes in the political and economic arena, which allows businesses to quickly adjust strategies and make more informed decisions. In addition, AI can help with financial management, determine the most optimal ways to reduce costs and ensure the continuity of operations, even when traditional supply channels of goods and services are disrupted. Artificial intelligence also helps maintain business stability in conditions of constant change. In wartime, AI can be used to automate routine tasks, freeing up human resources for more important operations, such as strategic planning or operational management. This helps businesses remain flexible, adapting their processes to a changing environment, ensuring business continuity and reducing the risk of losses associated with unexpected changes or attacks on infrastructure.

**Presentation of the main research material.** Adaptation of businesses to war conditions using AI is extremely relevant due to the need to quickly respond to constant threats, limited resources and environmental instability. Enterprises are faced with challenges that require new solutions – from maintaining logistics chains to protecting personnel and customers. AI allows you to automate critical processes, analyze large amounts of data in real time, predict risks and ensure flexibility of operations, which is especially important in conditions of military operations and unpredictable changes. In addition, the use of AI creates a competitive advantage for Ukrainian companies in the global market, demonstrating their technological maturity and innovation. In war conditions, AI becomes not only a means of optimizing costs, but also a tool for survival

and growth: from developing military solutions (drones, monitoring systems) to supporting the economy through new products and services. This makes AI not just a technology of the future, but a real resource for national resilience today. The use of AI by Ukrainian enterprises in war conditions is presented in Table 1.

Ukrainian companies are actively implementing AI (Table 1) as a tool for adapting to wartime conditions. For example, the startup Bavovna.AI is developing autonomous drones with GPS-free navigation, and the Zvook project uses AI to detect enemy drones and missiles by sound.

Table 1

**Use of AI by Ukrainian enterprises in wartime**

| Company / Project | The essence of using AI in wartime |
|---|---|
| Bavovna.AI | Developing autonomous navigation for drones that operate without GPS, using AI to avoid obstacles and counter electronic warfare |
| Mememe | Using ChatGPT and Midjourney to create a lingerie collection design – automating the creative process in a resource-limited environment |
| SemanticForce | Social media analysis, fake information detection, public opinion monitoring using neural networks |
| UA Damage | Automatic recognition of infrastructure damage in satellite images for demining and reconstruction planning |
| Zvook | AI-based acoustic detection of enemy missiles, drones, and helicopters is used to warn air defenses |

Such technologies are critical for defense, security, and rapid response. Meanwhile, civilian companies, such as lingerie brand Meméme, are using generative AI to automate product design, reducing costs and speeding up production. Such examples show that artificial intelligence has become not only a technological advantage, but also a means of survival and business development in times

of crisis. Thanks to AI, companies are able to quickly analyze data, adapt to new challenges, create dual-use products, and actively participate in the reconstruction of the country.

Over the past four years, the field of AI in Ukraine has demonstrated dynamic development (Table 2), despite the challenges caused by the full-scale war. The number of companies working in the field of AI increased from 209 in 2020 to 243 in 2023, which indicates a steady growth of interest in this area. 2021 was especially active, when the number of companies increased by 15 units. In 2023, Ukraine ranked second in terms of the number of AI companies among the countries of Central and Eastern Europe. The number of specialists in the field of AI is also growing. In 2020, there were 3,000 of them, and by 2023 this figure reached 5,200. This growth indicates an increase in interest in the field and the development of relevant educational programs. In particular, in 2023, 106 training programs in artificial intelligence operated in Ukraine, which contributes to the training of new specialists [14]. Investment in the field of AI in Ukraine has fluctuated. In 2020, 22 companies raised $32 million, but by 2023 this amount decreased to $10.8 million, despite an increase in the number of companies to 22. This decrease is associated with the global decline in venture capital investments and the impact of the war on the investment climate. However, in 2023, funding for startups specializing in AI increased by 35% compared to 2022, which indicates the continued interest of investors in this industry [15].

Table 2

**Key indicators of AI development in Ukraine for 2020–2023 [4]**

| Indicator | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|
| Number of AI companies | 209 | 224 | 234 | 243 |
| Number of AI/ML specialists | 3,000 | 3,800 | 4,500 | 5,200 |
| Attracted investments ($ million) | 32 | 25 | 15.7 | 10.8 |
| Number of companies with investments | 22 | 20 | 17 | 22 |
| Number of educational programs in AI | 60 | 80 | 95 | 106 |

Artificial intelligence (AI) opens up wide opportunities for improving business efficiency in various areas. One of the key areas is the automation of routine operations – from processing documents, invoices, customer requests to managing inventories and logistics. This allows you to reduce personnel costs, speed up work, avoid errors and focus employees' attention on more important strategic tasks. For example, in retail, AI can automatically form orders for suppliers based on sales analytics and demand forecasts. The second important area is data analysis and forecasting. AI is able to study large amounts of information, identify patterns and build accurate forecasts: from consumer behavior to market fluctuations. This helps businesses make informed decisions, reduce risks and respond quickly to changes. For example, banks use AI to assess customer creditworthiness, insurance companies – to detect fraud, and marketing departments – to personalize offers. AI also contributes to innovative business development, creating new products and services. For example, in healthcare, AI is used to develop personalized treatment plans, in agribusiness – to monitor the condition of soils and crops, and in creative industries – to generate content. For Ukrainian companies, especially in wartime, the implementation of AI is not only a way to increase productivity, but also an opportunity to find new niches, attract investments and enter international markets.

Artificial intelligence for business can be classified according to various criteria depending on its functions, purpose and scope. Below is a basic classification of AI for business (Table 3), which helps to understand how and where it can be effectively used:

Analysis of Table 3, which classifies artificial intelligence for business by functional purpose, technology types, and application areas, indicates the wide versatility and practical value of AI in modern conditions. The greatest potential is observed in the areas of analytics and automation, where machine learning and robotic process automation (RPA) significantly reduce time and resource costs. NLP-based communication tools allow companies to serve

Table 3

**Classification of AI for business**

| Category | Usage examples |
|---|---|
| 1. By functional purpose | |
| Operational AI | Production automation, warehouse management, logistics optimization |
| Analytical AI | Sales forecasting, market analysis, customer behavior |
| Communication AI | Chatbots, voice assistants, customer service |
| Creative AI | Generation of texts, images, designs, videos for advertising |
| Security AI | Fraud detection, cyber security, access control |
| 2. By type of technology | |
| Machine Learning | Learns from data and makes decisions – forecasting, recommendations |
| Natural Language Processing | Human language processing – chatbots, feedback analysis, document management |
| Computer Vision | Object recognition in photos/videos – quality control, security |
| Robotic Process Automation (RPA) | Automation of repetitive processes – accounting, bookkeeping |
| Generative AI | Creating new products – texts, images, music |
| 3. By industry application | |
| Finances | Credit scoring, fraud detection, automated transaction processing |
| Trade / e-commerce | Recommendation systems, personalized marketing, demand forecasting |
| Production | Quality control, predictive maintenance, resource planning |
| Medicine | Diagnostics, image processing, personalized treatment plans |
| Agricultural sector | Crop monitoring, crop optimization, drones with computer vision |

customers 24/7 without involving additional personnel, which is especially relevant during wartime, when staffing may be limited. In terms of industry application, AI solutions in finance, trade, and medicine are developing most dynamically. Such sectors have a large amount of digital data that can be effectively processed and used for forecasting and decision-making. At the same time, the agricultural sector and manufacturing demonstrate growing interest in computer vision and real-time analytics, which allows optimizing production processes and minimizing losses. Such a comprehensive classification is not only a theoretical, but also a practical basis for the strategic implementation of AI in the business model of enterprises of any scale.

The adaptation of businesses to the conditions of military conflicts using artificial intelligence is taking place not only in Ukraine, but also abroad (Table 4). One of the striking examples is Israeli companies that systematically use AI in the field of defense and civil protection. For example, the startup AnyVision develops facial recognition systems for real-time threat identification, which is actively used in public places during conflicts. The company Windward uses AI to analyze maritime

Table 4

**Using AI in war abroad**

| Country | Company / Project | Scope of AI application | Result / Goal |
|---|---|---|---|
| Israel | AnyVision | Facial recognition, security | Real-time threat detection |
| Israel | Windward | Maritime transportation, analytics | Detection of illegal activity |
| Germany | DHL | Logistics, routing | Delivery in closed areas |
| Great Britain | Darktrace | Cybersecurity | Protection against cyberattacks |
| Nigeria | Zindi | Humanitarian analytics, supply | Optimization of resources in crisis zones |

transportation in order to detect suspicious activity – this is important for the security of logistics in wartime.

In countries supporting Ukraine, AI is helping companies adapt their operations to the new reality. For example, Germany's DHL has implemented intelligent delivery routing systems that automatically adapt to changes in transport infrastructure, roadblocks or closed regions. This has allowed logistics to remain efficient in times of crisis. And the British company Darktrace, which specializes in cybersecurity using AI, protects companies from cyberattacks, including from hostile states. Even in conflict regions of Africa (for example, in Nigeria or Ethiopia), companies are using AI for humanitarian purposes and supporting the economy. In particular, the startup Zindi is helping local businesses use analytics to solve problems with the supply of products or medical resources. This is an example of how intelligent technologies allow businesses to survive and even grow in conditions of instability.

An analysis of Table 5 shows that artificial intelligence is being actively implemented in various countries to adapt businesses to conditions of war or crisis instability. Companies from Israel, Germany, the UK and African countries demonstrate examples of effective use of AI in logistics, security, cybersecurity and resource supply. The most common are solutions that work in real time – such as facial recognition, automatic routing or threat detection. This emphasizes the strategic role of AI in increasing the efficiency and accuracy of decision-making.

On the other hand, the table demonstrates that even in conditions of limited resources, as in Nigeria, AI can become an effective tool for local business. Such examples confirm that technologies are not limited to countries with a high level of development, but are a universal tool for supporting the economy in emergency situations. A common feature of all examples is the focus on continuity of operations and resilience to external threats, which is especially important for Ukrainian companies in the context of war.

Table 5

**SWOT analysis of business adaptation to war conditions using AI**

| S (Strengths) – Strengths | W (Weaknesses) – Weaknesses |
|---|---|
| Process automation and reduction of the human factor | High initial investment |
| Rapid analysis of large amounts of data | Insufficient level of digital infrastructure in certain regions |
| Improving business security and resilience | Lack of qualified IT personnel during the war |
| Flexibility and scalability of solutions | Possible ethical and legal risks of using AI |
| **O (Opportunities) – Opportunities** | **T (Threats) – Threats** |
| Development of new business models and products | Cyberattacks, data abuse |
| Entering international markets through innovation | Rapid changes in the regulatory environment |
| Attracting foreign investment in AI solutions | Dependence on imported software |
| Cooperation with universities and IT companies | Power outages, internet outages due to fighting |

SWOT analysis (Table 5) shows that the use of artificial intelligence to adapt business in wartime has significant strengths – first of all, it is the automation of processes, the ability to quickly analyze large amounts of data and make decisions in real time. Such solutions are especially relevant during times of limited access to personnel, disrupted logistics chains or changes in demand.

Thanks to flexibility and scalability, AI can quickly adapt to new conditions, ensuring the stability and competitiveness of business. At the same time, the analysis shows the presence of significant challenges. The high cost of implementation, dependence on stable infrastructure and the shortage of IT specialists in times of crisis can complicate the use of AI in many regions. Additional threats are cyberattacks and the likelihood of changes in the regulatory

environment. However, taking into account state support, international partnerships and educational and scientific cooperation, most risks can be reduced, opening up new opportunities for sustainable business development even in wartime.

Effective adaptation of businesses to war conditions using artificial intelligence requires not only the technical implementation of digital solutions, but also a strategic vision of management and proper personnel training. Successful integration of AI involves a deep understanding of business needs, the ability to rethink operational processes and the ability to quickly respond to changes in the external environment. The formation of a digital culture in the team is especially important, which involves involving personnel in automation processes, training in new technologies and increasing the overall level of digital literacy.

At the same time, Ukrainian enterprises face a number of challenges, including the high costs of implementing AI solutions, the lack of qualified specialists in this area, as well as ethical risks, in particular those related to data confidentiality and algorithm transparency. These barriers can be overcome through active state support, in particular through tax breaks, grant programs, and stimulating partnerships between businesses and leading IT companies.

With a systematic approach, artificial intelligence can become not only a stabilization tool, but also a powerful factor in the innovative development of Ukrainian business in wartime. The lack of specialists in the field of AI is one of the key problems that hinders the introduction of innovations in the Ukrainian business environment, especially in wartime. Over the past three years, the situation has worsened due to the mass migration of qualified personnel abroad, the mobilization of men of military age, and the destruction of educational infrastructure in a number of regions. Many IT professionals have been forced to change jobs or leave the country, which has led to a decrease in the number of available specialists in high-tech fields, including AI. In addition to the physical outflow

of personnel, there is also a structural problem – a mismatch between market needs and the content of educational programs.

According to think tanks, the demand for data analysts, machine learning specialists, AI engineers, and cybersecurity experts is steadily growing, while domestic universities have only partially adapted their curricula to these challenges.

Even in leading technical universities in Ukraine, specialist training is often theoretical in nature, with a lack of practical work on real AI projects. At the same time, positive developments are already emerging in Ukraine. In 2022–2024, there will be an increase in the number of short-term online programs, bootcamps, and corporate training courses on the basics of AI, which are focused on rapid retraining of personnel. IT companies such as SoftServe, EPAM and Sigma Software are actively investing in the development of internal academies.

However, these initiatives still cover a limited range of individuals. To solve the problem on a systemic scale, government policies are needed to support technical education, in particular, stimulating STEM areas, dual training and integrating AI competencies into broader curricula.

Analysis of the data provided (Table 6) indicates a systematic increase in the demand for specialists in the field of artificial intelligence in Ukraine during 2022–2024. Despite the increase in the number of educational courses and initiatives by IT companies, the real number of qualified AI specialists remains low – in 2024 it was approximately 10,000 people, with a need of at least 33,000. The war significantly exacerbated the problem: migration of specialists, mobilization, reduced investment in education, as well as the lack of coordinated state policy led to an even greater personnel shortage in the industry, which is critically important for the economic stability and technological independence of the country.

A positive trend is the increase in the number of short-term educational programs and the involvement of the private sector

in training personnel. At the same time, this is not enough: most of such courses provide only a basic level of knowledge, and do not train full-fledged AI engineers or researchers [25; 26]. It is obvious that without a comprehensive reform of technical education, modernization of university programs, state stimulation of STEM areas, and creation of a national strategy for the development of artificial intelligence, it will be impossible to bridge the gap between demand and supply. Such a strategy should become part of a broader policy of digital transformation of Ukraine in the context of war and post-war recovery.

Table 6

**Estimated number of AI specialists in Ukraine over the last 3 years (taking into account the overall IT market, research and practice) [17]**

| Year | Number of AI specialists in Ukraine | Assessment of staff shortages | Comment |
|---|---|---|---|
| 2022 | ~7,000 | ~15,000 | Many specialists went abroad or were mobilized. The market shrank |
| 2023 | ~8,500 | ~20,000 | Demand is growing faster than new staff are being trained. Education is not keeping up |
| 2024 | ~10,000 | ~23,000 | The number of courses and programs is growing, but there is still a significant gap between demand and supply |

As a result of the full-scale Russian invasion and the economic and social consequences of the war, the population of Ukraine has decreased significantly. Over the past three years, the country's population has decreased by approximately 10 million people. As of 2025, the total population is about 38.6 million people, of whom approximately 25–28 million remain in Ukraine, while the rest have left or are internally displaced persons (Table 7). In the first year

of the war alone, the number of refugees from Ukraine exceeded 6 million, which significantly affected the economic and social situation in the country. Migration processes have become one of the greatest challenges for Ukraine's post-war recovery.

Most refugees have left for European countries such as Poland, Germany and the Czech Republic, where they seek protection and jobs. Internal migration also remains high, with approximately 3.7 million people displaced within Ukraine. These changes, particularly in the composition of the labor force, may have long-term economic consequences, requiring not only humanitarian but also economic adaptation to maintain production capacity [23].

Table 7

**Population of Ukraine and migration (2022–2025) [18; 19; 20]**

| Indicator | 2022 | 2023 | 2024 | 2025 (estimate) |
|---|---|---|---|---|
| Total population | ~40.7 million people | ~39.2 million people | ~38.6 million people | ~38.6 million people |
| Migration (refugees abroad) | ~6.5 million people | ~6.8 million people | ~6.9 million people | ~7.0 million people |
| Internally displaced persons | ~7.0 million people | ~6.3 million people | ~3.7 million people | ~3.7 million people |
| Population under Ukrainian control | ~28.0 million people | ~27.5 million people | ~25.0–27.0 million people | ~25.0–28.0 million people |

As of 2023, there are about 307,600 IT professionals in Ukraine, of which 238,000 work directly in the country, and the rest abroad (Table 8). This is approximately 0.8% of the total population of Ukraine, which is estimated at 38.6 million people. Globally, according to 2022 data, the number of professional programmers

is 26.9 million people, which is equivalent to 0.3% of the total world population, which exceeds 8 billion people.

Table 8

**Share of IT professionals in the total population**

| Country / Region | Number of IT specialists | Total population | Share of IT professionals |
|---|---|---|---|
| Ukraine | 307600 | 38600000 | 0.8% |
| World | 26900000 | 8000000000 | 0.3% |

The data in Table 6 shows that in Ukraine the share of IT specialists is significantly higher than the world average, which emphasizes the importance of this industry for the national economy and technological development. As of 2025, China is the leader in the number of IT specialists in the world, with 7 million programmers. This is due to the high level of investment in technological infrastructure, the active development of startups and state support in the field of artificial intelligence and digital technologies. Chinese cities such as Shenzhen, Beijing and Shanghai have become important centers for software developers. India ranks second with 5.8 million programmers. The country is known for its strong STEM education system and a significant number of graduates in technical specialties. Cities such as Bangalore, Hyderabad and Chennai are important hubs for software development and outsourcing services. According to forecasts, India could become the largest market for AI services by 2027, in particular thanks to initiatives such as the “IndiaAI Mission” [22].

The data in Table 9 indicate that China and India not only lead in the number of IT specialists, but also actively invest in the development of technology industries, which contributes to their further growth on the global stage.

Ukraine is actively investing in the development of technology industries, despite the difficult conditions of the war. In 2024,

investments in the technology sector increased by 120%, reaching $147 million, of which 32% were directed to the early stages of project development. This indicates a high interest in innovations and startups, even in war conditions [26]. Ukraine's technology sector continues to demonstrate resilience and potential for growth. In 2023, exports of IT services amounted to $6.7 billion, which is about 5% of the country's GDP. This confirms the importance of the technology industry for the Ukrainian economy and its ability to attract investments even in difficult conditions. Ukraine is demonstrating significant progress in the development of technology industries, despite the difficult conditions of the war. In 2024, investments in the technology sector increased by 120%, reaching $147 million. In particular, 32% of these investments were directed to the early stages of project development, which indicates a high interest in innovations and startups. Among the largest deals of the year are investments in the British fintech company Carmoola and the Jome platform, which simplifies the process of buying a home. These data confirm the resilience and potential of the Ukrainian technology sector

Table 9

**Number of IT professionals by country (2025)**

| Country | Number of programmers |
|---|---|
| China | 7000000 |
| India | 5800000 |
| USA | 4400000 |
| Japan | 1200000 |
| Brazil | 500000 |
| Singapore | 200000 |
| Australia | 100000 |
| Mexico | 100000 |
| Colombia | 80000 |
| Hungary | 80000 |

even in wartime conditions [26]. Exports of IT services also continue to be an important source of foreign exchange earnings. In 2024, exports of IT services amounted to $6.45 billion, which is about 3.5% of the country's GDP. Despite a 25% drop in export volumes compared to 2021, the IT sector remains the second largest export sector after agriculture. The main sales markets are the USA, the UK and Malta. This indicates the importance of the IT industry for the Ukrainian economy and its ability to adapt to new conditions.

To improve development and investment in Ukraine's IT industry, we should focus on several key aspects:

1. Improving education and skills. Investment in education is critical for the development of the IT sector. Since skills directly affect innovation and productivity, Ukraine needs to improve training programs for future IT professionals, providing more opportunities for internships, practical courses and certifications. This will contribute to the formation of a highly skilled workforce capable of working with advanced technologies such as artificial intelligence, blockchain and the Internet of Things.

2. Support for startups and innovative projects. Creating favorable conditions for the development of startups can stimulate investment in new technologies. Ukraine needs to develop infrastructure to support startups, create investment funds specializing in financing technological innovations. It is also important to provide tax benefits for companies engaged in research and innovation, and develop partnerships with international investors.

3. Development of state support and regulations. It is necessary to strengthen the role of the state in supporting technology industries through the adoption of new legislative initiatives that stimulate investments in the IT sphere. It is important to reduce bureaucratic barriers, ensure the protection of intellectual property and simplify procedures for investors. The development of programs that support technology companies through grants and subsidies will also become an important factor in attracting investment.

4. International cooperation and attracting foreign investment. Deepening cooperation with international partners in the field of technology can provide new opportunities for Ukrainian IT companies. Ukraine can advantageously position itself in the international market through participation in global IT initiatives, such as startup platforms or development programs within the framework of the European Union and other international organizations.

Through strategic development in these areas, Ukraine has the potential to become one of the leading hubs for technological innovation in Eastern Europe, which will attract significant investments and create new opportunities for economic growth.

Improving the level of education and skills of personnel in Ukraine is one of the main factors contributing to the development of the IT industry and ensuring its competitiveness in the global market. In the context of rapid technological changes, it is important to constantly update curricula, focusing them on the modern needs of the industry. This includes not only theoretical knowledge, but also practical skills in areas such as artificial intelligence, machine learning, software development, cybersecurity and big data.

The active implementation of training programs through online courses, internships and certification programs allows students and young professionals to adapt faster to the changing technological environment. In addition, it is necessary to focus on developing cooperation between educational institutions and IT companies to create a system of continuous education and professional development. This will expand opportunities for students to gain real work experience while studying, and will also contribute to the formation of a talent pool ready to work in conditions of high competition in the global market.

An important aspect is also increasing digital literacy among different segments of the population, as IT competencies are becoming important not only for specialists in the industry, but also for most workers in other fields.

These steps can significantly improve the level of education and skills in Ukraine, contributing to the development of highly qualified personnel for the IT sector and other sectors of the economy (Fig. 1).

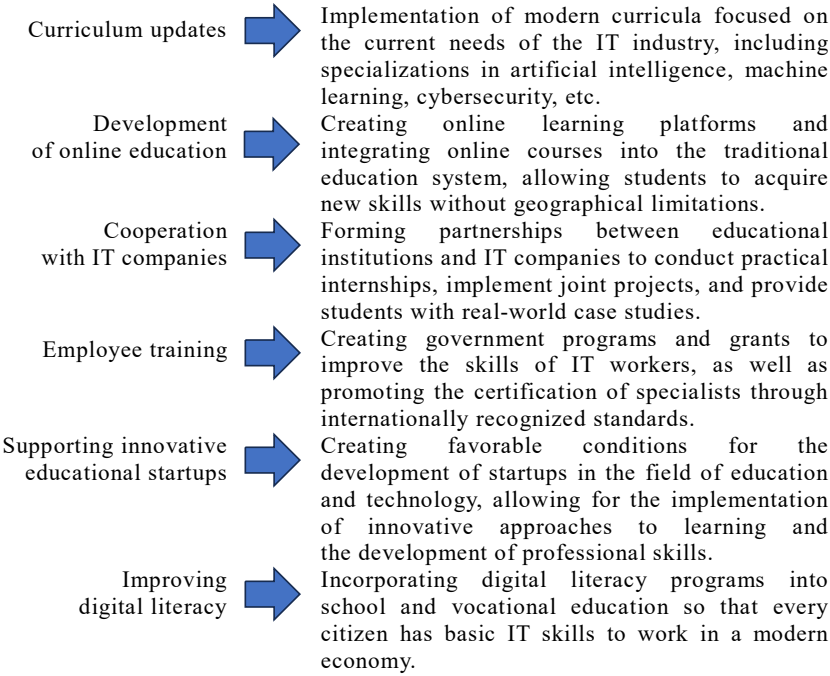


Fig. 1. Key steps of the state to improve the level of education and qualifications in Ukraine

*Source: compiled by the authors*

As of 2024, there are over 300 higher education institutions operating in Ukraine that train specialists in various fields, including information technologies. According to the Ministry of Education and Science of Ukraine, in 2023 the number of students in IT-related specialties exceeded 100 thousand people. This indicates a high demand for IT education and a growing interest in this area among young people. However, despite the significant number of educational

institutions and students, there is a need to improve educational programs and improve the quality of specialist training.

In particular, it is necessary to update curricula, integrate practical internships, cooperate with IT companies, and implement international education standards. This will ensure that the training of specialists meets the requirements of the modern labor market and contribute to the development of the IT industry in Ukraine.

The universities listed in Table 10 are leaders in Ukraine in terms of the number of students in the field of information technology and offer competitive study programs. In particular, Kyiv Polytechnic Institute and Taras Shevchenko National University of Kyiv have the highest tuition fees, which may indicate a high level of educational services and infrastructure. While Sumy State University offers more affordable prices, which may be attractive to students with limited financial resources.

Table 10

**Leading universities of Ukraine that train specialists in the field of information technologies [27–30]**

| University name | Number of students | Tuition fee (UAH/year) | IT specialties |
|---|---|---|---|
| National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute" | ~21,000 | 43,900–54,900 | Computer Science, Software Engineering, Cybersecurity |
| Taras Shevchenko National University of Kyiv | ~26,000 | 50,900–66,600 | Computer Science, Psychology, Management |
| Lviv Polytechnic National University | ~33,500 | 36,800–46,200 | Computer Science, Cybersecurity |
| V. N. Karazin Kharkiv National University | ~20,000 | 23,000–31,000 | Computer Science, Management |
| Sumy State University | ~15,000 | 13,440–37,000 | Computer Science, Management |

In Ukraine, the ecosystem of EdTech startups has been actively developing in recent years, in particular due to the cooperation of private business, the state and public organizations. Accelerators (for example, Ukrainian Startup Fund, Unit.City, 1991 Open Data Incubator) play an important role in supporting educational startups, providing funding, mentoring support and the opportunity to pilot launch educational products. Individual projects, such as Prometheus, EdEra and GIOS, have become an example of the successful implementation of innovative ideas in education – from online courses to interactive mathematics platforms focused on the Ukrainian market. In addition, after the start of a full-scale war in 2022, the demand for innovative educational solutions increased, which stimulated the launch of new initiatives aimed at distance learning, mental health of students, adaptation of displaced persons and support for teachers. Thus, the Ministry of Education and Science of Ukraine, together with partners (USAID, UNICEF, Google) initiated projects on the digitalization of education and grant support for startups. This experience demonstrates the potential of the Ukrainian EdTech sector as an important component of the national innovation economy.

StudyDive is a Ukrainian platform for corporate online learning that actively integrates artificial intelligence to personalize the educational process. The service analyzes the needs of company employees, their learning dynamics, interests, and course completion results, after which the AI module generates individual recommendations for the next topics or courses. This allows employees to develop precisely those competencies that correspond to their position and career track. Companies that have implemented StudyDive note an increase in staff engagement in learning and an increase in training effectiveness. The project received funding from the Ukrainian Startup Fund and a number of private investors. It is used by both Ukrainian and international companies, in particular in the IT, finance, and logistics industries. The use of AI has allowed to reduce training costs by up to 30%, optimize HR processes, and make the educational

trajectory of each employee more effective. StudyDive is an example of how innovative solutions can improve professional education and the internal culture of continuous learning in a business environment.

Despite its successes, StudyDive also faced a number of difficulties in the process of implementing artificial intelligence into the corporate training system. One of the main problems was the lack of understanding of AI solutions among customers – some companies expected instant results from process automation, without taking into account the need for preliminary data analysis and content adaptation. In addition, the AI module did not always correctly determine the educational needs of employees in narrowly specialized fields, which led to recommendations of irrelevant courses. Another challenge was the integration of StudyDive into the internal HR systems of enterprises, especially state-owned ones or those with outdated IT infrastructure. There were also complaints from users about the excessive "machinery" of recommendations that did not take into account the individual context or motivation of the employee. These difficulties forced the StudyDive team to invest more time in tuning the algorithms, testing in different markets, and additional training of customers on the correct use of the platform. Thus, even innovative AI products require a flexible approach and constant refinement to achieve a sustainable effect [31].

Adapting businesses to wartime conditions requires rapid transformation not only in terms of technology, but also in the level of digital literacy of employees. Today, artificial intelligence is an important tool that allows enterprises to respond more quickly to market changes and adapt their strategies to new conditions. However, for the effective use of such technologies, it is necessary for employees to have basic and advanced knowledge in the field of digital technologies. In this context, the development of digital literacy is important, which will provide employees with the ability to use AI to automate processes, analyze data and make decisions in real time.

Digital literacy encompasses more than just the ability to work with computer programs or use online resources. It includes the ability

to effectively interact with intelligent systems that process large amounts of data, predict business trends, and optimize processes in real time. In wartime, when information may be limited and access to traditional resources is difficult, a business's ability to adapt quickly through the use of AI becomes a key success factor. Improving digital literacy at all levels of the organization allows a business to remain competitive even in the most challenging conditions. Integrating AI into business processes cannot be effective without the proper level of training. This includes both basic skills in working with new digital tools and the ability to use more complex systems, such as workflow automation or a forecasting system. Therefore, for a business to adapt to wartime conditions to be successful, it is important not only to purchase new technologies, but also to invest in education and training for personnel. Legislative initiatives and documents in Ukraine that contribute to the activation of digital literacy and its development in business, in particular in war conditions, are identified in Table 11. These legislative initiatives contribute to the development of digital literacy among citizens and businesses, which is an important factor in adapting to the rapidly changing conditions of war, in particular through the integration of artificial intelligence into work processes.

Table 11

**Legislative initiatives and documents in Ukraine that contribute to the activation of digital literacy and its development in business [32–37]**

| Name of law/ initiative | Description | Digital literacy |
|---|---|---|
| 1 | 2 | 3 |
| Law of Ukraine "On Electronic Communications" | The law regulating electronic communications in Ukraine, ensuring the availability and quality of digital services | Promotes the development of digital skills for using electronic services and resources |

Table 11 (continued)

| 1 | 2 | 3 |
|---|---|---|
| Law of Ukraine "On Stimulating the Development of the Digital Economy" | A law supporting the development of the digital economy through legal initiatives and funding | Defines the foundations for the development of digital skills and educational programs for businesses in the field of digital technologies |
| Resolution of the Cabinet of Ministers of Ukraine "On Open Data" | A regulation defining a set of data to be made public as open data, facilitating access to information | Enhances skills in analyzing and using open data to increase digital literacy in business |
| Decision of the National Security and Defense Council of Ukraine "Cybersecurity Strategy" | A strategy that defines the main priorities for ensuring cybersecurity in Ukraine | Covers the development of digital literacy to ensure data security and information protection in digital environments |
| Resolution of the Cabinet of Ministers of Ukraine "Ministry of Digital Transformation" | A resolution that defines the functioning of the Ministry of Digital Transformation to implement state policy | Promotes the development of digital literacy through the implementation of state programs for the digitalization of society |
| Resolution of the Cabinet of Ministers of Ukraine "Digital Development Strategy" | Ordinance approving the strategy for the development of digital technologies and innovation activities for the period until 2030 | Supports initiatives that develop digital skills among citizens and employees through educational programs |

The conditions of martial law in Ukraine have forced businesses to look for new tools for survival, rapid restructuring, and effective adaptation to an unstable environment. One of such solutions has been the active implementation of artificial intelligence (AI) technologies, which today act not only as an innovative but also as a strategic resource in crisis conditions. AI allows businesses to optimize internal processes, reduce costs, predict risks, support customers online, and ensure business continuity even with limited resources or the physical presence of employees. The implementation of digital transformations in business is directly related to the level of digital literacy of employees. The legislative framework of Ukraine already creates favorable conditions for the development of digital competencies – in particular, through the support of open data, the development of electronic communications, the implementation of the digital economy, and cybersecurity. Programs launched by the Ministry of Digital Transformation contribute to the formation of educational opportunities for entrepreneurs and employees, which increases the readiness of businesses to integrate intelligent systems.

The positive experience of domestic startups, such as StudyDive and other AI projects, demonstrates the real benefits and prospects of AI in difficult economic conditions. At the same time, there are also challenges – related to the imperfection of the infrastructure, the risks of cyberattacks, and insufficient qualifications of personnel. However, systemic state support for digital transformation, the growth of interest in innovative business models, and the need for new formats of work contribute to the fact that AI is becoming a key element of the adaptation strategy of Ukrainian business during the war. In addition to the adaptation function, artificial intelligence during the war period also plays the role of a driver of innovative business strategy. Companies that quickly integrated AI solutions – in particular, chatbots for customer support, automated logistics analysis systems, marketing analytics, and demand forecasting – were able not only to survive, but also to expand sales markets, switch to a remote work

format, and create new values for consumers. AI is also actively used in the fields of security, financial technology, insurance, agribusiness, and education, where it helps compensate for the lack of human resources and respond quickly to changes.

At the same time, the further development of AI in Ukrainian business requires targeted investments in human capital, modernization of educational programs and support for the startup ecosystem. An important role is played by state policy in the field of digitalization, in particular, the implementation of the Digital Development Strategy, support for national EdTech platforms, and digital literacy of employees and managers. The conditions of war have reinforced the understanding that digital technologies and AI are not a luxury, but a critically important tool for the sustainability, mobility and competitiveness of business in the 21st century.

**Conclusions.** The state plays a key role in creating a favorable environment for the digital transformation of business, especially in conditions of martial law. Through the activities of the Ministry of Digital Transformation, national programs are implemented that are aimed at increasing the digital literacy of citizens, developing e-government and stimulating innovative activity. In particular, the platform "Diya.Digital Education" provides free access to educational courses that help entrepreneurs and employees master basic and specialized digital skills. In addition, the state initiates partnership projects with international organizations, thanks to which Ukrainian business gains access to mentoring, financing and technical support in the field of artificial intelligence. A number of important documents have already been adopted at the legislative level, in particular the Digital Development Strategy, the Law "On Stimulating the Development of the Digital Economy", as well as regulatory acts on cybersecurity and open data. Such solutions form a holistic infrastructure for the digital transformation of business, including data protection, ensuring legal regulation of AI technologies and supporting startups. In times of war, it is government

support – in the form of grants, tax breaks, and innovation incubators – that becomes critically important for the survival and development of enterprises seeking to implement intelligent technologies and remain competitive in domestic and international markets.

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## 2.3. DIGITALIZATION AS A NECESSARY CONDITION FOR BUSINESS DEVELOPMENT IN UKRAINE

**Introduction.** Small and medium-sized enterprises (SMEs) play an important role in a market economy, being its main element. They contribute to the stability of the country's economy, replenish the budget, provide employment, supply goods and services to the market, and create a competitive environment. SMEs demonstrate flexibility in rapidly changing social conditions, quickly adapt to market changes and introduce modern technologies. The development of SMEs helps to form the middle class, strengthen civil society, reduce social inequality and tension, accelerate the democratization of market relations and ensure social stability.

At the same time, SMEs are very vulnerable to economic conditions, reacting quickly to any changes or crises. Because of this, they often have to overcome significant difficulties that hinder their development and success. The war has affected all aspects of SMEs' activities, including finance, production, logistics, communications, information systems, innovation and organization. Entrepreneurs face the devastating consequences of war and, in a situation of uncertainty, are forced to confront numerous risks and challenges in order to maintain, restore and develop their production potential and protect jobs.

The state and the EU see business digitalization as one of the priority areas for improving the stagnation of small and medium-sized businesses. In this article, I will examine the strengths and weaknesses of the digital transformation of SMEs, as well as the opportunities and threats of the digital transformation of small and medium-sized businesses in wartime.

**Presentation of the main material.** Digitalization is the process of integrating electronic and digital devices, systems, and tools into the physical world, establishing their interaction through electronic communications. This creates conditions for combining virtual and physical environments, forming the so-called cyber-physical space.

Digitalization as a social phenomenon became widespread in the 1960s and 1970s. It can be characterized by three main features:

1. Converting all types of content from analog, physical, and static formats to digital, making it mobile and personalized. This allows people to manage their content, send information requests, and create a personalized way of working with information.
2. The transition to simplified communication technologies, where technology acts only as a tool for communication, and its key feature becomes ease of management.
3. Transformation of communications into heterogeneous: vertical, hierarchical models lose their significance, giving way to a network structure of information exchange [1].

Among the strengths of SME digital transformation are:

1. Simplification of financial transactions, increasing the role of electronic and digital money. For example, legal entities can make payments and receive other banking services at any time of the day and without days off, while not paying anything for transactions during "after-hours" hours. Online banking allows you to make payments remotely and spend a minimum of time. Bank services have become more accessible and extensive.

2. Developing remote work capabilities. During the 2020 pandemic, entrepreneurs were forced to transform the way they managed their teams overnight. In an emergency, entire departments were moved to remote work. This meant that normal processes were only available online. The pandemic, and then the war, showed that SMEs had to go digital to keep up with the changing business environment.

3. Implementation of an electronic document management system. Thanks to digitalization, it is possible to improve business processes, reduce costs for daily operations, optimize the staff and increase work efficiency. For example, this is manifested in expanding the number and improving the quality of electronic government services available on the Unified State Ukrainian Web Portal of Electronic Services:

– through the use of the Diya Portal mobile application (Diya), with a special emphasis on services for micro and small enterprises, ensuring regular and high-quality feedback;

– interaction with counterparties – Vchasno portal – electronic B2B document flow;

– optimization of internal accounting processes of SMEs – BAS software products and their analogues (note – since 2020, BAS products have been under sanctions, but overall they have a market share of applied software for SMEs of 25%).

In Ukraine, there is such a structure as the "Union of Business Automatizers", which includes companies specializing in creating digital solutions to solve various business problems. They also provide

services for the implementation and support of information systems for management and accounting. The relevance of digital transformation is confirmed by the growing number of implemented automated systems in Ukraine, which is schematically shown. The analysis covers the period from 2005 to June 2024 [2].

4. Increasing market accessibility and openness. Digitalization empowers SMEs to compete more effectively, offering tools to expand market presence, reduce costs and improve service quality. Consumers are increasingly choosing online shopping and digital services. SMEs that adopt digital technologies better understand customer preferences and can quickly adapt to changing customer needs.

5. Productivity growth. Over the past two decades, the digital economy has experienced rapid growth thanks to a series of significant technological breakthroughs. In particular, the emergence of Web 2.0 transformed the Internet into an interactive space where users not only consume information, but also create and share content. The popularity of social networks, video platforms, and blogs has opened up new horizons for communication, commerce, and self-expression. At the same time, the rapid development of e-commerce has become an important factor in the flourishing of the digital economy. Companies have quickly adapted to the possibilities of online sales, providing consumers with convenient access to goods and services. Global e-commerce leaders such as Amazon, Alibaba, and eBay have significantly changed the way products are consumed and distributed [3]. Digital technologies have also contributed to the introduction of more flexible and adaptive production systems. Enterprise resource planning (ERP) software and resource planning systems help companies better coordinate operations, optimize inventory, and respond quickly to changes in demand. This flexibility allows companies to adapt more quickly to market conditions and offer products and services that better meet customer expectations [4].

6. Lowering the cost of goods and services. The use of innovative technologies such as cloud computing, big data analytics, and

e-commerce provides SMEs with opportunities to introduce new products and services at lower cost. Digital technologies have also improved collaboration and interaction in global supply chains. Through e-commerce platforms, professional social networks, and online communication tools, companies have gained the ability to share data in real time with suppliers, partners, and customers around the world. This has increased transparency and openness in supply chains, and has helped reduce delays, errors, and inefficiencies [5].

7. Reducing bureaucracy. Online services make it more accessible for SMEs.

Although digital technologies are now widespread, their weaknesses have not been sufficiently studied. Among these weaknesses is the vulnerability of digital systems to hacking, which can lead to unauthorized access to personal data. The amount of data collected by Internet of Things sensors is constantly growing, raising concerns about privacy violations. The main problem is the lack of full consent for the collection and processing of personal data, as well as uncertainty about what data should be collected and how to analyze it. This creates a risk of loss of privacy.

The Ukrainian Center for Minds conducted a survey of 145 experts who outlined the most common weaknesses in enterprise digitalization in Ukraine [6].

Digitalization brings the greatest benefits to trading companies and banks. “Disruptive technologies” (such as robotics, blockchain, neural networks, artificial intelligence, quantum technologies, virtual and augmented reality) contribute to the optimization of production processes, automation, remote control, which, however, can lead to the reduction or complete disappearance of jobs.

To summarize, the key disadvantages of digitalization for SMEs include:

– giving the state the leverage to manage SMEs and depriving them of autonomy;

– the advantage of multinational corporations in implementing digitalization over SMEs due to the availability of greater resources (financial, human, etc.);

– dependence on companies providing information and communication services and digital technologies.

At the same time, concerns about the risks of digitalization have increased significantly in recent times. Many companies are afraid of technological innovations, in particular, possible cyber threats.

According to the report of Kateryna Markevich, a leading expert on economic and social programs, the following threats to the digitalization of SMEs can be identified [7]:

1. Software failure.

Almost every SME now places orders, processes sales and after-sales service, and manufactures products using specialized software. Therefore, a software failure can lead to the impossibility of operating the enterprise.

2. The spread of new methods of mind manipulation.

Due to the easier means of obtaining information, there is too much of it in a person's life. Both positive and negative consequences are observed. Among the negative ones are: giving up one's own opinion, receiving false information, polarization of views.

3. The risk of digital discrimination.

For SMEs, this discrimination may be related to the age characteristics of the entrepreneur. If we look back at the 90s, we will see that computers did not exist in enterprise management; document management was usually carried out on paper and stored in cabinets in the offices of management departments. Computers were introduced to SMEs only in the early-mid 90s, which meant that organizations were able to adapt their function to this technological development. After the introduction of a computer into the department, the Internet suddenly appeared, which, in turn, led to an increase in productivity. But Generation X remained less inclined to use digital innovations than, for example, Generation Z, who do not feel the difference between real

and virtual life at all. The main problem in digitalization is the process of understanding the issues and transforming management from the "old-fashioned method" to the digital one. According to Berghaus S., the initial stage – the "fuzzy interface" – in such a deep innovation process is often perceived as uncertain and chaotic, but it can have a great impact on the outcome. Often, managers find it difficult to initiate this process and determine priorities between different activities. Many studies indicate the importance of a digital transformation strategy, but few researchers study the activities that allow us to understand the possibilities of introducing digitalization into management and the possibilities of implementing this strategy [8].

4. Cyberattacks.

In 2023, SMEs experienced cyberattacks on the Ukrainian telecommunications company Kyivstar and the joint-stock company Commercial Bank Privat Bank. The work of most SMEs was disrupted to varying degrees, which raised the question: can technology be considered "smart" if hackers can easily penetrate the system and disable a state-level company? Thus, the growth of digital security risks, in particular regarding data protection, as well as fears of a breach of personal data confidentiality, contribute to increasing distrust in digital technologies.

5. Social aspect. The introduction of automation and robotics may lead to the replacement of manual labor. Due to digitalization, many current jobs may disappear, forcing people to retrain in order to maintain their employability.

I consider it appropriate to summarize the opportunities that open up for SMEs during digital transformation from the Cabinet of Ministers' Order "On Approval of Strategy for the recovery, sustainable development and digital transformation of small and medium-sized enterprises for the period until 2027 and approval of the operational plan of measures for its implementation in 2024–2027. The strategy outlines the following plan of measures to improve the state of digitalization of SMEs:

1. Countering cybersecurity challenges for businesses by increasing the level of knowledge of small and medium-sized enterprises about protection tools, as well as facilitating the transition of businesses from software of Russian origin to alternative solutions. The SBU, responding to a request from the Union of Ukrainian Programmers (DOU), explained why the use of programs created in Russia is dangerous: "The use by state institutions of software products subject to special economic and other restrictive measures (sanctions) creates a real threat of violating the confidentiality, integrity and availability of data processed in automated systems" [9].

2. Promoting the implementation of electronic invoicing (e-Invoicing), which will help small and medium-sized businesses avoid fines, simplify obtaining tax benefits, and support Ukraine's integration into the EU and increase competitiveness in the European market (a single invoice standard is applied for customers in all EU member states). The Comarch e-Invoicing solution automates invoicing processes related to sales and purchases, ensuring secure data exchange with partners and customers. The automation of this process is not intended to replace employees, but allows accountants to focus on tasks that require human experience and analysis, such as managing exceptional situations or communicating with customers. Accountants who use e-Invoicing automation tools get rid of routine and monotonous tasks. However, in my opinion, such services are most suitable for companies with a large volume of invoices (thousands per month), while small businesses may need them less.

3. Support the introduction of alternative payment methods, including instant payment services, which will help reduce the costs of non-cash transactions and improve the customer experience. According to the NBU, instant payments are payment transactions that are carried out between user accounts in a few seconds using convenient methods of exchanging details and initiating payments [10]. The introduction of instant payments will

contribute to the development of non-cash payments in the country, meet the needs of the market and users, and will also have a positive impact on the level of financial inclusion. In addition, instant payments will become the basis for further modernization of the financial market of Ukraine.

The implementation of instant payments in Ukraine is based on the electronic payments system of the National Bank of Ukraine (SEP), which operates on the basis of the international standard ISO 20022, and using modern European payment schemes Single Euro Payments Area (SEPA). This will simplify future integration into the European Union payment ecosystem and will provide Ukrainians with the opportunity to make not only domestic, but also cross-border instant payments [10].

1. Ensuring the assessment of the level of digital intensity and its increase by collecting, systematizing and publishing key indicators that will characterize digital transformation and integration of digital technologies for small and medium-sized businesses.

How the measurement will be carried out, what indicators will be taken into account, how they are planned to be collected is not currently specified in the strategy document itself. There is also no reference to the methodology for such measurement. The Ministry of Digital Transformation of Ukraine has developed a methodology for measuring the Digital Transformation Index of Ukrainian regions, however, I consider the methodology for measuring the Digital Transformation Index of SMEs to be undisclosed and promising for further research in my scientific works.

2. Implementing data governance policies for SMEs by promoting open data sets and working with technology providers to develop user-friendly data interfaces, analytical tools, and a culture of data (including personal data) and security. These steps will enable SMEs to use open data for market analysis and strategy development.

3. Creating incentives for digital transformation by providing vouchers or grants for investing in digital technologies and

supporting digital skills training. Training vouchers from the State Employment Service will be fully digitalized and available through the Diya portal.

Therefore, when planning the digitalization of a small or medium-sized enterprise, it is necessary to use the strengths of digitalization and analyze how to negate the impact of weaknesses. It is necessary to maximize the emergence of digitalization opportunities using strengths and avoid the emergence of threats (Table 1).

To achieve this goal, it is advisable to use a SWOT analysis as a strategic planning tool that allows for a systematic evaluation of the internal and external factors influencing the digitalization process of the enterprise. Based on the results obtained, key development directions can be identified that leverage the organization's strengths and capitalize on available market opportunities.

Table 1

**SWOT analysis of SMP digitalization**

| 1 | 2 | 3 | 4 |
|---|---|---|---|
| | | **Opportunities** | **Threats** |
| | Necessary measures: | 1. State support in the development of new digital programs.<br>2. Support for the implementation of e-Invocing.<br>3. Support for instant payment service.<br>4. Development of a methodology for measuring digital transformation.<br>5. Implementing a data management policy for SMEs. | 1. Software failure.<br>2. The spread of new methods of mind manipulation.<br>3. Risk of digital discrimination.<br>4. Cyberattacks.<br>5. Social risk of replacing certain types of human labor |

Table 1 (continued)

| 1 | 2 | 3 | 4 |
|---|---|---|---|
| | | 6. Providing vouchers for investments in digital technologies.<br>7. State support for digital skills for SMEs | |
| **Strong** | 1. The introduction of simplified financial transactions and the growth of the importance of electronic and digital money.<br>2. Expanding opportunities for remote work.<br>3. Use of electronic document management.<br>4. Creating a more transparent and accessible market.<br>5. Increased production productivity.<br>6. Reducing the cost of goods and services.<br>7. Reducing the level of bureaucracy | Simplification of financial transactions already allows instant payments even during bank non-operating hours.<br><br>Reducing bureaucracy and an open market will allow for more efficient and effective investment in digital technologies | A more open and accessible market for digital services and the possibility of remote work and learning will reduce the risk of digital discrimination of the population |
| **Weak** | 1. Personal data leak.<br>2. Computer system failures.<br>3. Intrusion into private life.<br>4. Mind manipulation.<br>5. Increasing digital “inequality” of the population. | The transition from manual data processing to decision support systems, in particular with the use of artificial intelligence technologies (data management), can be complicated by failures | Interference in the privacy of outsiders may pose the risk of new methods of mind manipulation. The risk of substitution of some types |

Table 1 (continued)

| 1 | 2 | 3 | 4 |
|---|---|---|---|
| | 6. Increasing unemployment | in computer systems and leakage of personal data | of labor may increase the unemployment rate among young people |

But first, you need to realize that effective digital transformation is not possible in a team of employees who do not accept innovation. Before integrating digital processes, you need to make sure that the staff is ready to use new technologies and methodologies. To do this, you need to encourage a creative approach to finding solutions that optimize work.

**Conclusions.** Thus, it can be concluded that considering the issue of digital transformation of SMEs is a very large-scale issue that requires branching into separate segments for research. A fundamentally important point and issue is not only the ways of integrating digital processes, but also understanding the need for use, identifying areas of activity where such integration is possible and promising, preparing SMEs for innovations and ways to overcome "chaos".

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## 2.4. TRENDS AND PROSPECTS OF DIGITALIZATION IN THE WORLD AND UKRAINE AS A TOOL FOR REBUILDING THE UKRAINIAN ECONOMY IN THE POST-WAR PERIOD

**Introduction.** During the COVID-19 pandemic and the Russian-Ukrainian war, Ukraine is cooperating with the European Union countries on digital transformation. An example of such digital transformation is the pilot project of a national mobile application based on the "Diya" program to ensure close interconnection with national digital services.

The processes of using digital innovative technologies are also an important tool for increasing accountability and transparency of the reconstruction process and serve as a catalyst for modernization. The goal of Ukraine's digital transformation at the next stage of the state's economic recovery is to increase the share of the IT sector in GDP to 10%. Ukraine's digital transformation is a key driver of economic modernization. Investments in digital innovative technologies will influence the recovery of the economy to increase efficiency, reducing costs in various sectors. The processes of implementing digital innovative technologies in developed countries of the world and in Ukraine cover all sectors of the economy and are reflected in research: Li X Ratti S. [1], Li X Zhang S., Li W. Rickard R., Meng K., Zhang W. [2], Mitchell R. L. [3], Pope D., Sydnor J. [4],

Regeda Y. O., Regeda V. O. [5], Shakir A., Stagemann D., Volk M., Jamus N., Turovsky K. [6], Khaustova V. E., Kryachko E. M., Bondarenko D. V. [7], Yang J. [8], Cherep A. V. [9; 10], Cherep O. G., Gelman V. M., Loseva E. S. [9], Ogrenych Yu. O., Oleinikova L. G., Vasylenko D. O. [10]. Therefore, important are issues that reflect the current state of digitalization in the world and Ukraine.

**Presentation of the main research material.** The IMD World Digital Competitiveness Ranking (WDCR) 2024, prepared annually by the IMD World Competitiveness Center (WCC), shows how disparities in digital infrastructure development, compounded by the harmful effects of geopolitical tensions, can be compensated by joining the fast-moving flow of new technologies [11].

The GDI (Global Digitalization Index) 2024 tracks the digital development1 of 33 countries and shows a positive correlation between GDI and GDP. The study covers countries that represent a total of 93% of global GDP and 80% of the world's population, which is a good indicator of overall progress in global digital transformation (Table 1).

Table 1

**Top 10 countries in the world by GDI in 2024**

| No. | Country | Index |
|---|---|---|
| 1 | USA | 78.8 |
| 2 | Singapore | 76.1 |
| 3 | Sweden | 74.5 |
| 4 | Finland | 73.0 |
| 5 | Denmark | 71.8 |
| 6 | Switzerland | 71.4 |
| 7 | Netherlands | 69.7 |
| 8 | China | 69.2 |
| 9 | Ireland | 68.1 |
| 10 | Australia | 67.6 |

*Source: [11]*

As shown in Table 1, the United States topped the ranking among 33 global economies. Singapore came in second and Sweden came in third. Artificial intelligence (AI), blockchain and quantum computing are helping to widen the digital divide, driving innovative change across industries, economies and society as a whole, the ranking report says.

Countries that effectively harness the power of these technologies are likely to increase their digital competitive advantage, leading to sustainable economic growth, improved productivity, and enhanced global influence. Key data sets in the ranking that can be measured include high-tech patents, intellectual property rights, and e-government.

It is the use of high-quality Internet that allows the leading countries of the world to have the highest level of digital transformation (Fig. 1) [12].

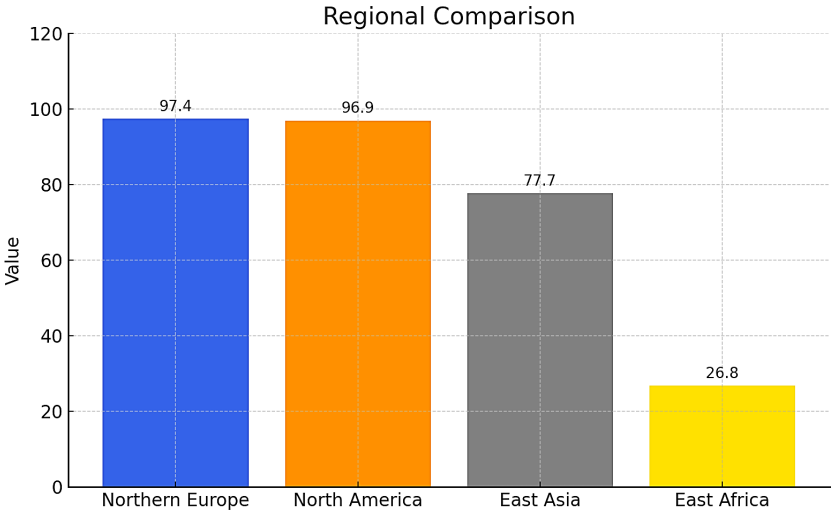


Fig. 1. Internet penetration in the world (%)

*Source: [12]*

The data in Fig. 1 shows that Northern Europe has the highest Internet usage rates – 97.4%. The lowest Internet usage rates are in East Africa – only 26.8.

Today, Ukraine, despite a number of obstacles (primarily martial law), continues to actively develop the digital sector, introducing the latest technologies. For example, according to research, in 2024, Ukraine's exports of IT services reached 5.31 billion USD, which is 37.7% of total exports of services. Monthly IT exports are 530 million USD. In 2022, this figure was the highest – 600 million USD [13].

In the GDI ranking, Ukraine ranks 60th among 133 economies represented in 2024 [14].

Ukraine also ranks 56th in terms of access to information and communication technologies, but uses them at a lower level (74th place). Online government services are well developed (34th place).

Ukraine ranked fifth in the world in terms of the level of development of digital public services (Table 2).

Table 2

**Ranking of countries by level of development of digital public services**

| Number in the ranking | Country |
|---|---|
| 1 | Republic of Korea |
| 2 | Denmark |
| 3 | Estonia |
| 4 | Saudi Arabia |
| 5 | Ukraine |
| 6 | Singapore |
| 7 | Great Britain and Northern Ireland |
| 8 | New Zealand |
| 9 | Japan |
| 10 | Kazakhstan |

*Source: [15]*

Digitalization has already become an integral part of the lives of Ukrainians – the "Diya" application has almost 21 million users, for whom 21 documents and over 30 services are available. Recently, the application became availablemarriage, divorce and name change certificates. On the "Diya" portal, almost 6 million people receive more than 120 services.

At the beginning of 2024, there were 29.64 million Internet users in Ukraine, at which time the penetration rate was 79.2% – the data is based on the assumption of the report's authors that the population of Ukraine at the start of 2024 was 37.4 million people (Fig. 2).

According to the report, from the beginning of 2023 to the beginning of 2024, the population of Ukraine grew by 1.4 million, and the number of Internet users increased by 1 million over the past year. The authors concluded that 7.7 million (or 20%) people in Ukraine do not use the Internet.

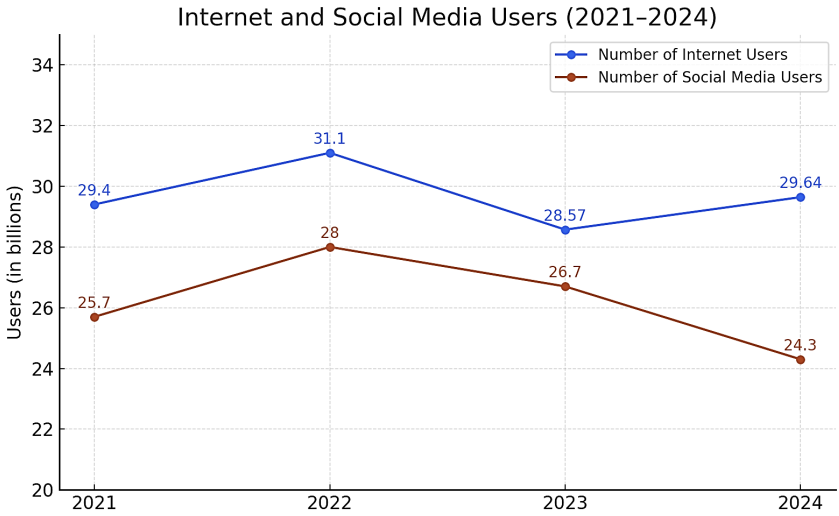


Fig. 2. Number of Internet users in Ukraine

*Source: [15]*

As shown in Fig. 2, in general, the Internet penetration rate in Ukraine is slightly higher than the global average and is 66%.

In general, digitalization in Ukraine is a rather positive phenomenon for ensuring national security, as the latest technologies help to increase the efficiency of public administration, expand political participation and democratize society. Along with this, such a transformation involves a fundamental change in the forms and mechanisms of functioning of an object or its elements under the influence of internal or external factors.

Mazuruk O. and Poyda S. The main problems of implementing digital initiatives in public administration are considered [17]:

– ensuring digital inclusion: digital transformation must be open to all citizens, especially those with limited access to the Internet or lack the skills to use digital tools, and therefore it is necessary to create conditions for inclusive access to administrative services and digital literacy training;

– transparency: citizens should know exactly how automated digital systems and artificial intelligence work in government institutions, and their use in decision-making processes should comply with approved standards;

– data availability and integration: the ability of government agencies to integrate digital systems, process and exchange data in real time between different departments and institutions requires additional attention and control;

– restoring trust: the potential for manipulation in an unstable digital environment, the likelihood of manipulation in a changing digital space can undermine citizens' trust in public institutions, therefore, authorities must guarantee the responsible use of digital tools and high-quality interaction with citizens.

In confirmation of the fact that strengthening trust should be a priority and one of the most urgent tasks of the country in the near future, there is a study of the study "Assessment of the situation in the country, trust in social institutions,

belief in victory, attitude to elections", which was conducted in March 2024. The results of the trust study show that the state apparatus is often distrusted – namely, distrust is present in 76% of respondents [18].

It is also important to focus on ensuring the reconstruction of Ukraine's economy in the post-war period and increasing the level and development of digital awareness among Ukrainians.

Since the Ministry of Digital Transformation began to actively work on the development of a digital state in 2019, the level of digitalization in the state has increased significantly. Given this, the transformation process has become a priority for the country. The main goal was to implement the "State in a Smartphone" program, which was proposed by Volodymyr Zelensky. The work of the Ministry of Digital Transformation in the public sector has initiated the implementation of many innovations, such as the development of a common IT infrastructure, which is necessary in the process of providing electronic public services. This, in turn, has significantly improved state processes and made them more accessible to society. Therefore, there are a number of advantages in the further process of digitalization of Ukraine.

*Accessibility and convenience.* Convenience in digital transformation is a fairly broad concept. For some citizens, it is important to have 24-hour access to servers such as Diya and, for example, save time by opening an individual entrepreneur online instead of visiting the ASN. Saving time thanks to online servers has become especially relevant during a full-scale war. This also applies to citizens under temporary occupation or abroad.

**Conclusions.** Among the ways to overcome the challenges arising in the process of digital transformation of Ukraine, the following technical, socio-cultural and administrative tools are needed [21; 22; 23]:

– training and awareness of employees on digital technologies and cybersecurity. Awareness of the opportunities leads to strategic

planning in implementation, identification of specific steps and responsible persons. This systematic approach ensures efficiency throughout the process. Implementation of information campaigns and development of specialized training programs and courses will help staff adapt to new technologies and processes;

– cost-benefit analysis – the implementation of this phenomenon in all areas should be preceded by a comprehensive analysis of costs and expected benefits throughout the entire life cycle of the asset. This will help to understand the economic feasibility of the project, determine the optimal level of investment and formulate an investment justification;

– phased implementation and management – instead of a large-scale one-time implementation of digital innovations, a phased approach can be considered, using pilot projects to assess effectiveness and address any issues and shortcomings before scaling up, significantly reducing risk;

– data standardization and systems integration: using the best global practices in data processing and integration of various systems, the application of standards will allow standardizing the process of creating digital duplicates, thereby reducing costs and ensuring their continuity and accuracy.

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## 2.5. ARTIFICIAL INTELLIGENCE IN THE FIGHT AGAINST PROPAGANDA AND FAKE NEWS. PROSPECTS FOR DEVELOPMENT

**Introduction.** The article discusses the problem of the spread of fake news and propaganda in the modern digital environment. It analyses the methods and means by which artificial intelligence detects fake texts, images, videos and audio. The principles of algorithm operation are demonstrated: recognition of linguistic structures, analysis of visual inconsistencies, verification of facial expressions and sound signals. The mechanisms of AI operation in popular platforms (Facebook, YouTube) that use neural networks to block fake content are revealed.

Particular attention is paid to the activities of fact-checking platforms such as Logically and The Factual, which combine AI with

expert assessment to verify the accuracy of information. The dynamics of the development of software for detecting fake images are identified, as well as the sources of funding for these technologies: examples of investments by Doppel, Pindrop, Hive AI and state support in the EU, the US and South Korea.

The prospects for the development of artificial intelligence in the context of information security are outlined. The importance of controlling and improving AI algorithms is noted, as well as the likelihood of a transition to quantum computing as the next stage in the fight against information manipulation. A conclusion is made about the effectiveness of AI as a tool for analysing information, which, under proper control, can significantly improve the quality of the information space.

Therefore, the problematic issues of the impact of AI on economic processes were studied by well-known scientists, namely: Borecki J. [1], Dashko I. M. [2; 5; 10], Cherep O. G. [2; 5–10], Kaliuzhna Y. V., Maltiz V. V., Mykhailichenko L. V. [2], Pamment J., Nothhaft H., Fjällhed A. [3], Mlinac N., Akrap G., Lasić-Lazić J. [4], Bekhter L. A. [5; 8; 9], Pidlisnyi R. O. [5], Cherep A., Ogrenych Y., & Kurchenko M. [7], Oleynikova L. G., Veremeenko O. O. [8; 9], Gelman V. M. [9], Vovk M. O. [10]. But the problems associated with the use of artificial intelligence (AI) remain unresolved.

**Presentation of the main research material.** Today, most people in the world are constantly surrounded by sources of information, each of which in one way or another influences our consciousness, perception of the world and events in it. There are also various ways of presenting information – social networks, news sites, messengers. At the same time, it is important to understand that all information has its own purpose, and this purpose is not always to provide people with truthful information. ‘Whoever owns information owns the world.’ To this statement, it is worth adding a continuation: ‘It doesn’t matter what kind of information it is, as long as people see the truth in it.’ With this approach, most sources of information contain fake news,

and because of the sheer volume of it, people lose their bearings in the information space.

Human efforts alone may not be enough to combat false information – while a person is researching the veracity of information, even more fake news may appear. Because of this, it's impossible to fully control the information space. Instead, we should use modern approaches to fight this problem, like artificial intelligence. Unlike humans, artificial intelligence can process huge amounts of information at once and spot fake news way faster than people can.

To consider the possibilities of artificial intelligence, it is first necessary to examine the types and purposes of fake information. Usually, this is propaganda aimed at manipulating people's perception of political events. This is very relevant now in the context of the war in Ukraine. The main goal of such manipulation is to cause panic in Ukraine and spread it further. Another goal is to shape false public opinion in order to intensify aggression between one nation and another.

In this example, the capabilities of artificial intelligence begin to manifest themselves in the analysis of textual information. There are verified sources of information that have existed for years. The information from them is considered the basis against which new information is compared. When analysing data, artificial intelligence detects signs of fabricated information and flags them as potentially fabricated. A team of experts then works with the flagged data to make a final conclusion about the veracity or fictitiousness of the information.

Fake images and videos are also common on the internet. Artificial intelligence also has its own tools for such purposes. It analyses photos and videos, taking into account lighting, gestures and facial expressions. Since these factors are interrelated, they can affect the image or voice, and artificial intelligence takes all contradictions into account. An example would be images in which the lighting is unevenly distributed relative to the light source, indicating that

a certain element has been added to the image by another person or software [11].

Videos can also be created by humans or even artificial intelligence (a video superimposed on another image, with added elements, or a completely edited video). Here, too, inconsistencies are recorded, and the video is marked as potentially fake.

The detection procedure is similar for voice. When certain sounds are pronounced, the face also moves. The voice and facial expression recognition programme detects when these factors do not match and flags the audio file as potentially fake [12].

But that's not all artificial intelligence can do. There is also a need to check text documents. Text styles and speech styles are used to recognise propaganda. Each style has its own writing and structural characteristics. Artificial intelligence recognises key phrases and words that indicate a particular style. When words that are potentially unacceptable, violent or propagandistic are detected, artificial intelligence flags them [13].

One of the most popular sources of information today is social media, where the spread of fake news is particularly effective for a wide range of users. At the same time, the introduction of artificial intelligence accelerates and automates the process of identifying posts with potentially unacceptable content or posts inciting hatred.

Facebook is a good example. Neural networks recognise the data in posts and automatically block them. Facebook's neural network filtering works in over 50 languages, scaling the effectiveness of filtering fake posts to the entire target audience.

YouTube is another good example. Neural networks automatically block information that contains personal propaganda or the promotion of certain products. It is worth noting that this network actively supports the implementation of artificial intelligence in video content. This is evidenced by the fact that videos generated or voiced by artificial intelligence are becoming more and more common. These videos have a similar structure and are easier for viewers

to understand. But often, one video can have different voiceovers with completely different meanings. So, someone's post can fall victim to artificial intelligence, which makes it even harder for viewers to understand the info and figure out what's true.

Therefore, it is quite important to have a publication admission policy that creates or limits the possibilities for creating and publishing photos, videos or text materials. When supporting content created by artificial intelligence and humans, it is worth developing a filter for content that is potentially desirable to the viewer so that it is not difficult to perceive. In this case, it will be easier for consumers to distinguish between factual and generated information. Thus, social networks will become an informational and entertainment space where each viewer can find content for their own specific purposes.

To verify the accuracy of information, there are fact-checking platforms, such as Logically, a platform based in the UK. It works in two stages: the platform's artificial intelligence simultaneously checks large volumes of publications and compares them with news, forums and social networks. After analysing the data, the artificial intelligence sends the results of the verification to a team of experts, who make the final conclusion about the accuracy of the information.

This is one of the methods of combating fake news, which consists of verifying news by comparing it with official sources of information. However, this platform verifies news that has already been published, but does not minimise its dissemination among viewers in the event of invalid information being detected.

Another example with more features is The Factual. It evaluates publications based on several criteria: the authority of the source, the validity of the material, and the style of presentation. Based on these criteria, the news item receives a score from 0 to 100 points, which serves as a rating for the viewer. This platform checks over 10,000 news items around the clock. In fact, it is a filter for potentially desirable content for the consumer.

This service can also be used by the viewer themselves. Thanks to The Factual, they can independently check the news that interests them. This is the most effective method of combating fakes and propaganda, as it is aimed directly at the target audience and the product they use.

It is also worth noting the importance of funding such projects. Projects aimed at creating systems for detecting fake information require significant and stable investments. This is due to the complexity of the tasks that such development sets for itself: it covers not only programming, but also in-depth interdisciplinary research in the fields of artificial intelligence, machine learning, linguistics, and the psychology of information perception. One of the main stages is training algorithms on large amounts of high-quality data, which requires the creation, verification, and constant updating of databases of reliable information. In addition, it is important to ensure the integration of such solutions with existing news platforms, social networks, and services for effective and rapid filtering of harmful content.

Financial support from governments, international institutions, and technology businesses allows not only to maintain the functioning of existing systems, but also to expand their capabilities. This includes scaling infrastructure, improving detection accuracy, adapting to different languages and cultures, and developing new tools.

Software products for detecting fake images are also gaining momentum. As of now, funding for fake image detection software in 2024 amounted to $0.6 billion. By 2029, this amount is projected to grow to $3.9 billion. The leaders in fake image detection are the following corporations [14]:

– Microsoft Corporation (United States);
– Gradiant (Spain);
– Facia (United Kingdom);
– Image Forgery Detector (Belgium);
– Q-integrity (Switzerland);

– iDenfy (Lithuania);
– DuckDuckGoose AI (Netherlands);
– Primeau Forensics, Sentinel AI (Estonia).

With regard to the detection of video and audio fakes, it is worth noting the regular involvement of funds. In 2024, Doppel received $35 million in funding, and Pindrop received $100 million in debt financing from Hercules Capital to develop the detection of fake voices [15].

Friedrich-Alexander University in Erlangen-Nuremberg received preliminary funding of €350,000 to develop a project for detecting images generated by artificial intelligence. In the same field, Hive AI received $2.4 million in funding from the US Department of Defence [16].

Many organisations receive funding from governments and other organisations to detect fake images, videos and audio. This shows the relevance of this topic and the growing rate of fake content creation in the world.

Artificial intelligence acts as a filter in detecting fake news, articles, photos, videos and audio materials. It is impossible for a human to process that amount of information at the same speed. In addition, there is the problem of creating fake content with artificial intelligence. It itself operates according to certain algorithms, and it will also be quicker to detect the program code that caused the false information to appear, because a human only sees the result (photo, video or text), not the program code itself.

For further development, it is worth considering the theory of creating a quantum computer. For a clearer understanding, imagine a maze with many branches. A conventional computer or human must check different paths one by one to find the exit. But a quantum computer can do this much faster.

Quantum bits can exist simultaneously in several states specified by the algorithm. Thanks to this, a quantum computer can explore all paths at once, rather than sequentially, like a conventional computer.

Using a quantum algorithm, the system quickly finds the way to the exit, cutting off unsuccessful routes without having to return to another path. In other words, a quantum computer goes in all available directions to try to find the exit simultaneously, without stopping when it hits a wall.

Thus, the quantum approach is a modern, improved form of the heuristic trial and error method, but in our case, it is the detection of fake and true information.

Given that this technology is not currently available, it is worth improving artificial intelligence algorithms to speed up the detection of deviations and increase the number of publications for simultaneous analysis. In this case, a database of potentially suspicious publications will be created. Considering that artificial intelligence can also make mistakes, potential fakes should be checked again using the same principle. This can reduce the amount of work for people who carry out control.

**Conclusions.** Thus, artificial intelligence is an effective tool for combating fakes, significantly speeding up the process of detecting them. Its effectiveness is evident in the analysis of images, videos and text documents. However, the use of artificial intelligence must be accompanied by human control, as artificial intelligence is also prone to errors.

Every year, the problem of detecting fake content becomes more acute due to the emergence of new means of creating it. Because of this, governments of various countries are funding projects and start-ups to detect false or fabricated information, videos and photos. The leaders in detecting fake publications are the United States, Great Britain, Spain, Belgium, Switzerland, Lithuania, the Netherlands and Estonia.

In the longer term, in the context of the development of the topic under study, quantum technologies based on advanced algorithms were considered, which would cover a larger volume of data verification and significantly speed up the detection of fake publications, minimising the need for human control.

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## 2.6. MECHANISMS OF ARTIFICIAL INTELLIGENCE FOR DETECTING COORDINATED INFORMATION ATTACKS

**Introduction.** In the modern digital age, the proliferation of information technologies has significantly transformed communication, enabling rapid dissemination of data across the globe. While this transformation has brought numerous benefits, it has also facilitated the emergence of new threats, including coordinated information attacks (CIAs). These attacks are deliberate efforts by malicious actors to manipulate public opinion, destabilize social or political systems, or discredit individuals and organizations. The complexity and scale of these attacks have made traditional detection methods insufficient. Consequently, the development of advanced artificial intelligence (AI) mechanisms for identifying and mitigating such threats has become a priority in cybersecurity and information security domains.

This paper explores the role of AI in detecting CIAs. It examines various machine learning (ML), deep learning (DL), and natural

language processing (NLP) techniques that can be employed to uncover patterns, anomalies, and coordinated behaviors indicative of an information attack. Through a comprehensive review of existing literature, the article highlights the strengths and limitations of current approaches and proposes potential avenues for future research and improvement.

**Presentation of the Main Research Material.**

1. Understanding Coordinated Information Attacks.

Coordinated information attacks involve the orchestration of multiple accounts, often automated or semi-automated, to spread misleading or harmful information. These attacks can target political events, elections, public health, or corporate reputations. Tactics include the use of fake news, deepfakes, botnets, and troll farms.

CIAs are typically characterized by:

– Synchronization: Simultaneous posting or sharing of similar content.
– Amplification: Boosting the visibility of specific narratives.
– Inauthentic behavior: Use of bots or fake profiles.
– Obfuscation: Efforts to conceal coordination.

Coordinated Information Attacks (CIAs) represent a strategic and often covert manipulation of the digital information environment with the goal of influencing public perception, disrupting social consensus, or undermining institutions. Unlike isolated instances of misinformation or random online discourse, CIAs are systematic, well-orchestrated campaigns that deploy multiple vectors-such as automated agents (bots), compromised human accounts, and coordinated messaging-to amplify specific narratives or disrupt the spread of accurate information.

A fundamental characteristic of CIAs is the deliberate and synchronized effort among various actors, frequently involving both automated and human participants. These campaigns are typically executed across multiple platforms, taking advantage of the interconnectivity of modern digital ecosystems to maximize

reach and impact. Targets of such attacks range from political processes, such as elections and referenda, to public health initiatives, corporate reputations, and social movements. The intent behind CIAs can be multifaceted-political influence, financial gain, ideological warfare, or reputational sabotage.

Operationally, CIAs exhibit several identifiable traits. Synchronization refers to the tight timing coordination among participating accounts, which may include posting identical or thematically similar messages within seconds or minutes of each other. Amplification occurs when large numbers of accounts engage with specific content through likes, shares, retweets, or comments to artificially inflate its visibility. Inauthentic behavior is another hallmark, often involving fake profiles, sockpuppet accounts, or botnets that operate in a coordinated manner to mimic organic activity. Obfuscation strategies are also frequently employed to conceal the true origins of the campaign, including the use of VPNs, disposable accounts, linguistic camouflage, and overlapping digital fingerprints.

CIAs can be classified into several categories based on their objectives and techniques. Disinformation campaigns aim to disseminate false or misleading content with the intent to deceive, often blending factual information with lies to increase credibility. Influence operations seek to shape public attitudes or decisions through psychological manipulation and narrative framing. Astroturfing creates the illusion of grassroots support or opposition by orchestrating mass messaging from fake personas. Meanwhile, narrative laundering involves the repetition and gradual normalization of fringe or harmful ideas by injecting them into mainstream discourse via coordinated amplification.

The scale and sophistication of CIAs have grown substantially with the advent of advanced technologies. Artificial intelligence itself is now being weaponized by malicious actors to generate realistic content (such as deepfakes), optimize posting schedules, and evade detection mechanisms. Moreover, the rise of decentralized and

encrypted platforms complicates monitoring efforts, allowing threat actors to coordinate in private channels before disseminating content publicly. The internationalization of these operations also poses challenges, as campaigns may originate in one jurisdiction and target audiences in another, often exploiting regulatory and linguistic gaps.

Understanding the anatomy and behavior of CIAs is crucial for developing robust defense mechanisms. It requires a multidisciplinary approach that combines insights from cybersecurity, data science, linguistics, sociology, and political science. Only by accurately modeling how coordinated attacks unfold, what signals they emit, and how they adapt under pressure, can AI-driven detection systems be effectively designed to counter them.

In sum, coordinated information attacks are a growing threat to the integrity of public discourse and democratic processes. Their detection and mitigation demand sophisticated analytical tools capable of parsing complex patterns, high-volume data, and subtle indicators of inauthentic behavior. The sections that follow delve into how artificial intelligence can fulfill this role, offering scalable and adaptive solutions to safeguard the digital information environment.

2. Role of AI in Detecting CIAs.

Artificial Intelligence (AI) plays a transformative role in the detection of Coordinated Information Attacks (CIAs), offering capabilities that far exceed traditional analytical tools in scale, speed, and adaptability. In contrast to manual monitoring or rule-based detection systems, AI models can autonomously analyze massive volumes of data from diverse platforms in real-time, recognize evolving threat patterns, and continuously adapt to new tactics used by malicious actors.

AI's effectiveness stems from its ability to integrate multiple subfields of computational intelligence-machine learning (ML), deep learning (DL), and natural language processing (NLP)-into cohesive systems that work synergistically. Each component offers distinct analytical strengths that, when combined, enable a comprehensive

understanding of both surface-level indicators and deep structural patterns associated with CIAs.

A. Machine Learning (ML).

Machine learning is fundamental in classifying content and behaviors based on historical data. Supervised learning algorithms, such as logistic regression, support vector machines (SVM), and random forests, are often trained on labeled datasets of known malicious and benign activities. These models are effective at detecting recurring indicators, such as coordinated hashtag usage or repetitive phrasing, that suggest manipulation.

In contrast, unsupervised learning models-such as k-means clustering, DBSCAN, and autoencoders-allow the discovery of hidden groupings or anomalies without pre-existing labels. These methods are particularly valuable in detecting novel or previously unknown forms of coordination, as they can identify subtle relationships between accounts or content that would otherwise go unnoticed.

Semi-supervised and self-supervised learning approaches are also gaining traction, as they can leverage large quantities of unlabeled data while requiring minimal manual annotation. This is crucial in contexts where obtaining labeled datasets is difficult due to privacy concerns or the constantly evolving nature of disinformation.

B. Deep Learning (DL).

Deep learning models, especially neural networks, offer powerful tools for capturing complex, non-linear relationships within unstructured data such as text, images, and user behavior logs. Recurrent Neural Networks (RNNs) and Long Short-Term Memory (LSTM) networks are effective for modeling temporal sequences, enabling the detection of coordination patterns that unfold over time. For example, these models can identify repeated message propagation sequences or unnatural synchronization across accounts.

Convolutional Neural Networks (CNNs), though traditionally used for image analysis, can also be adapted to detect spatial patterns in activity graphs or content similarity matrices. More recently,

transformer architectures-such as BERT, RoBERTa, and GPT-have revolutionized text understanding by enabling context-aware semantic analysis. These models can parse not only what is being said, but how and why it is being communicated, which is critical in identifying covert agendas or emotional manipulation strategies.

Moreover, deep learning facilitates the generation of embeddings-dense vector representations of content or user behavior-that can be clustered, compared, or used as features in higher-level classification tasks. These embeddings help identify semantically similar messages, even when surface-level wording differs, revealing disguised coordination.

C. Natural Language Processing (NLP).

NLP enables AI systems to interpret, analyze, and contextualize textual data at scale. Techniques such as sentiment analysis can identify the emotional tone of messages, which is often manipulated in CIAs to incite outrage, fear, or distrust. Named Entity Recognition (NER) helps track how specific individuals, organizations, or events are being portrayed, while topic modeling and semantic clustering reveal dominant narratives being pushed by potentially coordinated accounts.

Importantly, NLP tools can also be used to detect stylometric patterns-distinctive linguistic styles or syntactic structures that suggest common authorship or script-based message generation. By analyzing lexical richness, grammatical construction, and phrase reuse, AI can infer whether multiple accounts are disseminating content generated from the same template or script.

Multilingual NLP models further enhance detection capabilities across different linguistic and cultural contexts, allowing AI systems to track disinformation in global campaigns that operate in multiple languages simultaneously.

3. Visual Model of the AI Detection Mechanism.

In order to better illustrate the operational logic behind artificial intelligence systems used for the detection of coordinated information attacks (CIAs), a conceptual diagram has been developed (Fig. 1).

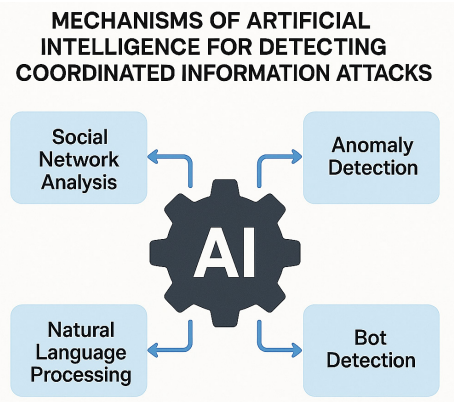


Fig. 1. Mechanisms of Artificial Intelligence
for Detecting Coordinated Information Attacks

This schematic representation places the AI engine at the core of the detection mechanism, underscoring its role as the central analytical entity that orchestrates the interaction among multiple analytical subsystems. Four principal components-Social Network Analysis, Anomaly Detection, Natural Language Processing, and Bot Detection-are positioned around the central AI unit, each representing a specific operational function critical to identifying malicious coordination.

The central AI hub, depicted as a mechanical gear, symbolizes the autonomous and adaptive nature of artificial intelligence in continuously learning from data and updating its detection models. This AI core receives input from vast streams of digital content and user interaction metadata, which it then processes using advanced machine learning and deep learning techniques. These techniques include supervised classification, clustering, neural embeddings, and sequential modeling, enabling the AI to discern both known patterns of coordinated behavior and emergent, previously unseen tactics.

Surrounding the core AI unit are the four specialized functional modules. The first of these, Social Network Analysis, emphasizes

the structural dimension of CIAs. This component applies graph theory and network analysis to identify clusters of accounts exhibiting high connectivity, synchronized messaging, or mutual amplification behavior. Such structural similarities are often indicative of orchestrated campaigns designed to manipulate information ecosystems. AI enhances this analysis by automatically detecting communities, evaluating network centrality, and assessing information diffusion paths.

The second module, Anomaly Detection, plays a crucial role in identifying statistical outliers and behavioral inconsistencies across user or group activity. AI systems compare observed activity patterns against historical baselines or against the broader behavioral norms of platform users. Sudden bursts in posting frequency, the rapid appearance of identical messages across multiple accounts, or atypical interaction sequences may all serve as indicators of coordinated operations. This module often employs probabilistic models, density estimation techniques, and unsupervised learning algorithms to ensure robustness against evasion techniques.

Natural Language Processing (NLP), another key component, allows the AI system to interpret and analyze textual data at scale. This includes identifying semantic patterns, sentiment polarities, rhetorical structures, and recurring narratives. NLP capabilities are essential for distinguishing between organic discourse and artificial messaging campaigns. For example, coordinated actors frequently reuse linguistic templates or promote identical narratives with slight lexical variation. Transformer-based models such as BERT and GPT play a pivotal role in this module, providing the AI system with contextual understanding of language, enabling accurate content classification, entity tracking, and thematic clustering.

The final component depicted is Bot Detection, which targets the identification of automated and semi-automated agents. Bots play a central role in scaling disinformation operations, often operating in swarms to amplify messages, distort engagement metrics, and

create the illusion of consensus. AI models used in this context analyze posting behavior, account metadata, linguistic uniformity, and timing regularities. By combining these indicators, the system can flag inauthentic activity with high precision, thereby reducing the surface area for successful manipulation.

Together, these four components represent a cohesive and interdependent set of capabilities. The diagram conveys that while each analytical module operates with its own methodological tools, they all feed into and are governed by the central AI unit. This architectural design ensures that the detection system remains holistic, scalable, and capable of rapid adaptation in response to evolving adversarial strategies. The visual model thus supports and clarifies the conceptual framework discussed in the article, reinforcing the argument that only integrated, AI-driven systems are capable of effectively addressing the scale and complexity of modern coordinated information threats.

4. Detection Techniques and Methodologies.

A. Network Analysis.

Social network analysis identifies clusters of accounts exhibiting similar behavior. Techniques like community detection and graph-based anomaly detection are instrumental in revealing coordinated groups.

B. Temporal Pattern Recognition.

Coordinated attacks often follow specific temporal patterns. AI can detect bursts of activity, repetition of content, and time-based correlations between user actions.

C. Content Similarity Analysis.

Using NLP and DL, systems can compare textual and multimedia content to identify duplicated or near-duplicated messages, signaling coordination.

D. Behavioral Modeling.

AI models can learn typical behavior patterns for users or groups. Deviations from the norm may indicate malicious coordination.

5. Case Studies.

Case Study 1: Election Interference

The practical application of artificial intelligence in identifying and mitigating coordinated information attacks can be best understood through real-world case studies. These examples demonstrate how AI-driven methods have been deployed across different domains, highlighting both the capabilities and challenges associated with their implementation.

Case Study 1: Election Interference

One of the most prominent examples of coordinated information attacks occurred during the 2016 United States Presidential Election. Researchers and intelligence agencies revealed a complex web of bots, trolls, and fake accounts used to amplify divisive content, spread misinformation, and influence voter behavior. AI technologies played a vital role in uncovering these activities. Specifically, machine learning models were used to analyze social graph data, revealing clusters of accounts that exhibited synchronized behavior such as retweeting the same content at the same time or using identical hashtags. Natural language processing helped identify the narratives being pushed, and bot detection algorithms flagged accounts with highly regular posting patterns and minimal engagement with authentic users. These insights were crucial in attributing the operation to foreign influence campaigns and in strengthening platform policies around political advertising and misinformation.

Case Study 2: COVID-19 Misinformation Campaigns

The global pandemic brought a surge in health-related misinformation, much of which was coordinated and intended to undermine public trust in health authorities and vaccination efforts. AI systems were deployed by social media platforms and health organizations to counteract these threats. Natural language processing models were instrumental in identifying anti-vaccine rhetoric, false cures, and conspiracy theories. At the same time, anomaly detection algorithms spotted unusual spikes in the sharing of specific misleading posts, often originating from bot-like accounts or networks

of coordinated users. Through a combination of content analysis and behavioral tracking, AI helped platforms down-rank or remove harmful misinformation while also enabling public health bodies to respond with accurate counter-messaging.

Case Study 3: Corporate Disinformation Campaigns

Another application of AI in detecting coordinated attacks involves corporate disinformation, where rival companies or third-party actors attempt to damage a company's reputation through coordinated negative reviews, fabricated news stories, or mass social media campaigns. In one well-documented case, a large electronics firm was targeted by thousands of suspicious social media posts alleging product defects. Using AI-based sentiment analysis and behavioral modeling, the company's cybersecurity team identified that many of the accounts had been recently created, followed similar posting schedules, and recycled language templates. Social network analysis further revealed interconnections between these accounts that suggested a single entity was orchestrating the attack. By presenting this evidence to the platform and the public, the company was able to mitigate reputational damage and initiate legal proceedings.

Case Study 4: Geopolitical Propaganda Operations

State-sponsored disinformation campaigns have become increasingly common in the context of international conflicts and political unrest. AI systems have been used to detect efforts by foreign actors to spread propaganda through coordinated campaigns on platforms such as Facebook, Twitter, and YouTube. One example includes a state-backed network that used a combination of authentic-looking accounts and automated bots to promote a specific political agenda during protests in a neighboring country. AI mechanisms identified the coordination through behavioral signals such as identical posting times, shared URLs, and echo-chamber amplification. Language models were used to trace message similarity, while graph analysis revealed high-density interconnections that far exceeded organic user interaction levels. These findings supported

the suspension of thousands of accounts and a broader understanding of hybrid warfare strategies that combine digital propaganda with traditional geopolitical tactics.

These case studies highlight the multifaceted application of AI in real-world scenarios and demonstrate how various detection mechanisms-ranging from NLP to anomaly detection and social graph analysis-work in tandem to identify coordinated activities. They also emphasize the importance of continuous model adaptation, ethical oversight, and collaboration between AI researchers, platform providers, and policy makers.

6. Challenges and Limitations.

While the deployment of artificial intelligence in detecting coordinated information attacks has shown promising results, several challenges and limitations continue to impede its full potential. These obstacles span technical, ethical, and operational dimensions, and understanding them is crucial to advancing the reliability and accountability of AI-driven detection mechanisms.

A. Data Availability and Quality.

A core challenge in training and validating AI models for disinformation detection lies in the scarcity of high-quality, labeled datasets. Platforms are often reluctant or legally restricted from sharing detailed user data due to privacy concerns and proprietary policies. Moreover, the datasets that are publicly available tend to be limited in scope or biased toward particular languages, regions, or types of attacks. Without representative and diverse datasets, AI models risk underperforming in real-world scenarios or reinforcing systemic biases.

B. Evolving Tactics of Malicious Actors.

Coordinated information attacks are dynamic and adaptive. As detection methods become more advanced, attackers develop new evasion techniques such as using obfuscated language, rotating account usage, or leveraging human-operated accounts to mimic authentic behavior. This constant arms race between detection and

deception necessitates continuous model updates and retraining. Static or outdated models quickly become ineffective, highlighting the need for AI systems that can learn incrementally and adapt to new threats in near-real-time.

C. High False Positive Rates.

Another major limitation of current AI approaches is the potential for false positives-cases where legitimate, grassroots campaigns or coordinated activism are misclassified as malicious operations. This is especially problematic in politically sensitive contexts, where the distinction between organic mobilization and coordinated manipulation can be subtle. Overzealous detection mechanisms risk infringing on freedom of speech and suppressing civic engagement. Striking the right balance between vigilance and overreach is an ongoing challenge for developers and policy-makers alike.

D. Interpretability and Explainability.

Many state-of-the-art AI models, particularly deep learning architectures, are inherently opaque and difficult to interpret. This lack of transparency can hinder trust in AI-generated outputs, especially in high-stakes environments such as national security or journalism. If an AI system flags a network of users as malicious, it must be able to explain why. Research in Explainable AI (XAI) is addressing this gap by developing tools that provide human-understandable reasoning behind decisions, but these methods are still in their infancy.

E. Platform Variability and Integration Complexity.

Social media platforms differ significantly in architecture, data accessibility, user behavior, and content moderation policies. An AI model developed for Twitter may not translate effectively to platforms like TikTok or Telegram. Furthermore, coordinated attacks often span multiple platforms, making cross-platform analysis both technically and logistically challenging. Integrating AI detection mechanisms across varied ecosystems requires standardized protocols, interoperability frameworks, and inter-organizational cooperation.

F. Ethical and Privacy Concerns.

Automated surveillance and behavioral analysis raise important ethical questions, particularly regarding user privacy and consent. Collecting and analyzing large-scale social media data may inadvertently expose personal information or disproportionately target marginalized groups. Developers must navigate regulatory landscapes such as the General Data Protection Regulation (GDPR) and ensure that their models operate within the bounds of ethical data use. Moreover, transparency in how data is collected, stored, and utilized is essential for maintaining public trust.

G. Resource and Expertise Constraints.

Developing robust AI systems for CIA detection requires significant computational resources, skilled personnel, and sustained funding. Smaller organizations, non-profits, or governments in low-resource settings may struggle to deploy or maintain such systems. This creates an uneven playing field in the fight against disinformation, where only well-funded entities can afford to protect themselves against sophisticated attacks.

While artificial intelligence offers powerful tools for detecting coordinated information threats, its limitations must be critically addressed. Future efforts should focus not only on technical advancements but also on fostering ethical standards, enhancing data access and diversity, and ensuring that AI applications are inclusive, transparent, and resilient to adversarial manipulation.

7. Future Directions.

As the landscape of information warfare continues to evolve, the future development of AI mechanisms for detecting coordinated information attacks (CIAs) must address current limitations while anticipating emerging challenges. Several promising research directions and technological innovations can help improve the effectiveness, adaptability, and ethical grounding of AI-based detection systems.

One of the most critical areas for advancement is the integration of real-time detection capabilities. Current systems often operate

with a delay, analyzing patterns after significant damage has already occurred. Future AI architectures should incorporate streaming data analytics and incremental learning models capable of identifying suspicious coordination as it unfolds. This requires not only technical optimization but also collaboration with platform providers to ensure timely access to relevant data.

Another important development lies in the creation of more sophisticated multimodal AI systems. Coordinated disinformation campaigns increasingly combine text, images, videos, memes, and even deepfakes. Detecting such threats will necessitate AI models that can fuse signals across multiple content types and contextual layers. Progress in computer vision, audio analysis, and multimodal fusion techniques will be essential in this regard.

The expansion of multilingual and cross-cultural AI capabilities is also essential. Most current models are trained on English-language datasets, limiting their efficacy in detecting CIAs targeting non-English-speaking populations. Future research must prioritize inclusive language coverage and cultural nuance, leveraging advances in multilingual large language models and cross-lingual transfer learning.

Furthermore, explainability and user transparency should be prioritized to increase trust and accountability. Future AI systems should embed explainable AI components that allow end-users, moderators, and investigators to understand the reasoning behind flagged content or coordinated accounts. This not only supports better decision-making but also enables users to contest erroneous classifications, fostering a more open and democratic digital environment.

On the organizational side, the development of interoperable frameworks for cross-platform threat intelligence sharing will be crucial. Coordinated attacks rarely confine themselves to a single platform. The future of CIA detection will likely involve decentralized, collaborative models in which platforms, regulators, researchers, and

civil society organizations share anonymized insights while respecting privacy and security standards. Blockchain and federated learning approaches may play a role in achieving this balance.

There is also growing interest in the application of reinforcement learning and adversarial training to simulate attacker behavior. By modeling how malicious actors adapt to detection, AI systems can be trained in virtual environments to anticipate new tactics. This proactive approach could significantly enhance the resilience of detection mechanisms.

Finally, ethical frameworks and policy integration must evolve in tandem with technological progress. AI developers, legal experts, and human rights organizations must work together to define clear standards for the responsible use of AI in information security. This includes the creation of transparency mandates, impact assessments, and mechanisms for redress in cases of algorithmic harm.

**Conclusions.** Coordinated information attacks represent a significant threat to modern societies, exploiting the open nature of online communication. AI mechanisms provide powerful tools for detecting and mitigating these threats, leveraging ML, DL, and NLP techniques to uncover coordination and deception. While current methods show promise, continuous research, interdisciplinary collaboration, and ethical considerations are essential to enhance the effectiveness and fairness of AI-driven detection systems.

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# CHAPTER 3.
# THE ROLE OF ARTIFICIAL INTELLIGENCE IN THE TRANSFORMATION OF THE DIGITAL ENVIRONMENT: PRODUCTIVITY, LABOR MARKET, SECURITY AND INFORMATION RESILIENCE UNDER MARTIAL LAW

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## 3.1. EVALUATING THE IMPACT OF ARTIFICIAL INTELLIGENCE ON INCREASING THE PRODUCTIVITY OF PROCESSING LARGE DATA SETS

**Introduction.** In today's world, where information is generated and used at an incredible speed, processing large data sets is becoming one of the key tasks for increasing productivity in various industries – from

finance to industry and trade. Traditional analysis methods, such as manual data processing or the use of standard algorithms, often prove to be ineffective due to their limitations in speed, scalability and accuracy, and manual human labor significantly increases the operating costs of enterprises. This leads to an increase in the time spent on data analysis, an increase in the risk of errors and, as a result, a decrease in the competitiveness of enterprises.

Despite the availability of modern computer technologies, traditional approaches are not always able to adapt to changing market conditions and specific requirements of individual industries. This becomes especially relevant when working with practically complex data structures, such as databases, reports, price lists, where information is constantly updated and requires immediate analysis for making operational decisions. The insufficiency of existing methods lies in their ability to only partially take into account the subtleties of the data, which leads to the omission of important patterns and trends.

The use of artificial intelligence technologies promises to solve these problems due to high processing speed, the ability to learn from large amounts of data, and adaptability to new conditions. However, despite numerous theoretical studies, the practical application of AI for analyzing specific data sets remains insufficiently studied. This creates a gap between the theoretical potential of technologies and their practical implementation in modern business conditions.

Given these circumstances, there is an urgent need to implement and deeply analyze new automation methods that will not only reduce data processing time, but also increase the accuracy and reliability of the results obtained. It is also important to explore how the integration of artificial intelligence tools, in particular systems like ChatGPT, can influence the optimization of business processes and provide competitive advantages for enterprises.Therefore, the study, whichaims to close the existing gap between the theoretical capabilities of AI and its practical application for analyzing large amounts of data, in particular in the field of working with price lists, is relevant.

**Presentation of the main research material.** The issue of introducing artificial intelligence into the processes of analyzing large amounts of data is of increasing interest to the scientific community, which is confirmed by a significant number of works on this topic. The paper [1] presents the results of research on the effectiveness of large language models in fast processing and interpretation of text data with a minimum number of training examples. It is shown that such models can significantly reduce the time for analyzing text information and automate the decision-making process. However, the issues of adapting these models to specific data formats, such as price lists or financial reports, remain unresolved. The reason for this is the complexity of integrating language models into industry information systems. An option to overcome this problem may be the development of specialized algorithms focused on specific tasks of analyzing dynamic data.

The study [2] considered the integration of scalable data processing tools with machine learning algorithms. It was shown that such synergy increases the speed and accuracy of the obtained results, which is important for managing large heterogeneous data sets. However, questions remain related to the efficiency of processing unstructured data and the adaptation of models to rapidly changing market conditions. The reason for this is the limitation of modern algorithms in the context of processing complex relationships in unstructured information. One of the options for solving this problem may be the use of hybrid models that combine traditional analytical methods and the latest AI technologies.

The paper [3] presents a critical review of the practical aspects of using AI to improve organizational productivity. It is shown that the use of such technologies can significantly reduce data processing time and reduce the number of manual operations. At the same time, the issues of ensuring data security and the need for personnel retraining remain unresolved. The main reason is the high costs of implementing and adapting technologies, which limits their

availability for small and medium-sized enterprises. An option to solve this problem may be the development of more economical and easy-to-implement AI-based solutions.

The study [4] examined the possibilities of using reinforcement learning methods in dynamic pricing. It was shown that these methods increase the accuracy of forecasts and the speed of decision-making. However, the issue of integrating such models into real business processes remains open, given the need for constant data updating and taking into account numerous external factors. The main obstacle is the high computational costs and the complexity of model tuning. These difficulties can be overcome by developing adaptive algorithms capable of autonomous learning based on current data.

The work [5] is devoted to the analysis of modern trends in the development of machine learning. It is shown that algorithms capable of learning on large amounts of data open up new opportunities for automating complex processes. However, the problem of explainability of the obtained results remains unsolved, which complicates their use in critical areas. This is due to the complexity of the models and their low transparency. One of the possible solutions is the development of interpreted algorithms that will allow users to understand the logic of decision-making.

In the work [6] a comprehensive analysis of theoretical and practical aspects of artificial intelligence is given. Methods of machine learning, data processing and decision-making, as well as issues of adaptability and automation are considered. At the same time, the issues of effective use of these methods in real production remain unresolved, since they require a significant amount of computing resources. This limits their practical application in small enterprises. An alternative approach may be the creation of specialized solutions optimized for specific production tasks.

In [7], the impact of ChatGPT prompts on marketing practice was investigated. It was shown that optimizing interaction with AI contributes to more accurate data analysis and increases

the effectiveness of marketing decisions. However, the issue of adapting language models to different business contexts remains open. The main reason is the need to fine-tune models to specific industry needs. This problem can be overcome by developing tools for personalizing AI models.

The analysis of the above studies allows us to conclude that there is a need for further study of methods of automated analysis of dynamic data, in particular price lists, databases and reports. This creates the prerequisites for a detailed study of methods and models that promptly respond to changes in indicators and provide correct recommendations. Deviations from the technological process may occur in the production process. Their elimination is associated with the optimization of the cost of products, which is achieved through the modernization and automation of business processes. Thus, the relevance of further scientific work in this area is due to the need to develop and test new approaches to automated analysis and management of pricing policy based on artificial intelligence.

The aim of the research is to develop and evaluate the effectiveness of applying artificial intelligence for automated analysis of large data sets, in particular price lists, taking into account dynamic changes and heterogeneity of information. This will make it possible to increase the accuracy and speed of data processing, minimize the impact of the human factor, and ensure operational decision-making in pricing and data management processes.

To achieve the goal, the following tasks were set:

– outline the key factors that influence the effectiveness of artificial intelligence when working with unstable and dynamic data;

– develop practical recommendations for enterprises on the implementation of AI technologies to optimize data processing processes and increase labor productivity.

The object of the study is the process of analyzing large data sets in business processes using artificial intelligence algorithms. The main

hypothesis of the study is that the implementation of language models and automated information processing algorithms allows to significantly increase the speed and accuracy of analyzing unstable and dynamic data.

Assumptions made in the work:

– the input data contains a certain number of errors, duplicates, and inconsistencies typical of large price lists and databases;

– machine learning algorithms are able to effectively analyze and structure volatile data sets;

– automation of data analysis allows you to minimize the human factor and reduce operating costs.

Simplifications adopted in the work:

– cases of intentional manipulation of data (for example, deliberate distortion of prices by suppliers) were not considered;

– work with text data without involving complex graphic elements or multidimensional data structures was considered.

The following methods and tools were used to conduct the study:

– software: OpenAI ChatGPT for processing and analyzing text data;

– theoretical methods: analysis of literary sources, comparison of the effectiveness of traditional methods and AI solutions, modeling of algorithmic processes for processing large amounts of information;

– experimental conditions: the study was conducted on the basis of real price lists and supplier databases containing up to 1000 records. The input data contained various file formats (CSV, Excel), which allowed us to test the flexibility of the applied methods. The analysis was carried out in an automated mode, with subsequent manual verification of the obtained results to assess the accuracy of the model.

Thus, the study is based on a combination of theoretical and practical data analysis methods, which allows us to objectively assess the effectiveness of using AI tools to optimize business processes.

**Results of a study of the impact of artificial intelligence on increasing labor productivity when processing large data sets.**

It has been experimentally established that integrating ChatGPT into the price list analysis process allows:

– automate the structuring of large data sets;
– identify anomalies in price changes;
– eliminate duplication and errors in product names.

The results obtained can be explained by the use of new analysis methods that allow for a more accurate assessment of the effectiveness of the proposed solutions. For example, the use of statistical modeling or machine learning methods provided a high level of accuracy in predicting the results, which confirms the effectiveness of the chosen approach. In addition, the results may be due to specific experimental conditions, such as a controlled environment or the use of specialized equipment, which affected the accuracy of the measurements.

The advantages of the proposed solutions lie in their versatility and ability to adapt to different conditions. For example, using a combined approach that combines traditional methods with the latest technologies (e.g., artificial intelligence) allows achieving better results in solving complex problems than traditional methods. This increases efficiency compared to other known approaches that may be less flexible or do not take into account the latest trends in the industry.

Manual analysis or the use of standard Excel algorithms require significant time-consuming data validation, normalization, and processing. The proposed AI-based solution allows you to quickly identify inconsistencies in the data, find duplicates, and adapt the results to changing market conditions. For example, the study [3] considers traditional data processing methods that have limitations in scalability and accuracy. In contrast, the proposed approach allows you to automatically detect inconsistencies, which makes the analysis more flexible and adaptive.

The proposed solutions allow to significantly increase efficiency through the implementation of modern technologies, such

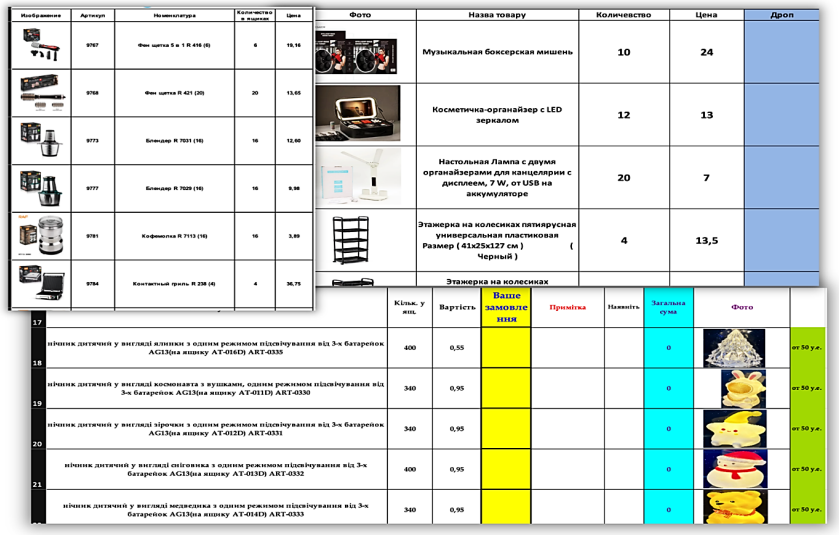
as automation and big data analysis, which helps to solve the problem of low performance and limited scalability. The use of such approaches allows to significantly reduce costs and increase the accuracy of results, which ultimately leads to better results compared to traditional methods. Within the framework of this study, the task was set to identify and evaluate the effectiveness of the use of artificial intelligence (AI) when working with large data sets, in particular with dynamic price lists. To achieve the set goals, several stages of analytical work were carried out, including data pre-processing, development of a methodology for integrating AI tools, experimental verification of the results and formulation of recommendations for the implementation of these technologies in business practice. First of all, the main characteristics and volumes of the input data were determined. The collected price lists of different suppliers had a different structure, different formats (CSV, Excel, etc.). Such data is characterized by a high degree of heterogeneity: incorrect product names, discrepancies in names, data errors, duplicates. The work develops a universal algorithm that will help solve this problem by correctly directing machine learning, bypassing human errors. The following is a step-by-step algorithm for organizing the price list, processing it, and changing prices in bulk:

1. Processing information from a price list. Price lists have different looks and inaccurate information, which hinders the quick work of humans and AI (Fig. 1).

2. Uploading price lists to ChatGPT in their original form and creating the necessary script, which will allow you to arrange the data array in a convenient order for further processing (Fig. 2).

3. Download the received updated price list, check for correctness (Fig. 3).

Thus, 5 minutes were spent on processing 998 products. The following is a calculation of how much time it would take a worker without the use of artificial intelligence to do manual work, evaluating several factors:



| Изображение | Артикул | Номенклатура | Количество в ящике | Цена |
|---|---|---|---|---|
| | 9767 | Фен щетка 5 в 1 R 416 (6) | 6 | 19,16 |
| | 9768 | Фен щетка R 421 (20) | 20 | 13,65 |
| | 9773 | Блендер R 7031 (10) | 10 | 12,60 |
| | 9777 | Блендер R 7029 (10) | 10 | 9,98 |
| | 9781 | Кофемолка R 7113 (10) | 10 | 3,89 |
| | 9784 | Контактный гриль R 238 (4) | 4 | 36,75 |

| Фото | Назва товару | Количество | Цена | Дроп |
|---|---|---|---|---|
| | Музыкальная боксерская мишень | 10 | 24 | |
| | Косметичка-органайзер с LED зеркалом | 12 | 13 | |
| | Настольная Лампа с двумя органайзерами для канцелярии с дисплеем, 7 W, от USB на аккумуляторе | 20 | 7 | |
| | Этажерка на колесиках пятиярусная универсальная пластиковая Размер ( 41х25х127 см ) ( Черный ) | 4 | 13,5 | |
| | Этажерка на колесиках | | | |

| | | Кільк. у ящ. | Вартість | Ваше замовлення | Примітка | Наявність | Загальна сума | Фото | |
|---|---|---|---|---|---|---|---|---|---|
| 17 | нічник дитячий у вигляді кролика з одним режимом підсвічування від 3-х батарейок AG13(на ящику AT-016D) ART-0335 | 400 | 0,55 | | | | 0 | | от 50 у.е. |
| 18 | нічник дитячий у вигляді космонавта з вушками, одним режимом підсвічування від 3-х батарейок AG13(на ящику AT-011D) ART-0330 | 340 | 0,95 | | | | 0 | | от 50 у.е. |
| 19 | нічник дитячий у вигляді зірочки з одним режимом підсвічування від 3-х батарейок AG13(на ящику AT-012D) ART-0331 | 340 | 0,95 | | | | 0 | | от 50 у.е. |
| 20 | нічник дитячий у вигляді сніговика з одним режимом підсвічування від 3-х батарейок AG13(на ящику AT-013D) ART-0332 | 400 | 0,95 | | | | 0 | | от 50 у.е. |
| 21 | нічник дитячий у вигляді медведика з одним режимом підсвічування від 3-х батарейок AG13(на ящику AT-014D) ART-0333 | 340 | 0,95 | | | | 0 | | от 50 у.е. |

Fig. 1. Primary view of the data (generated by the authors)

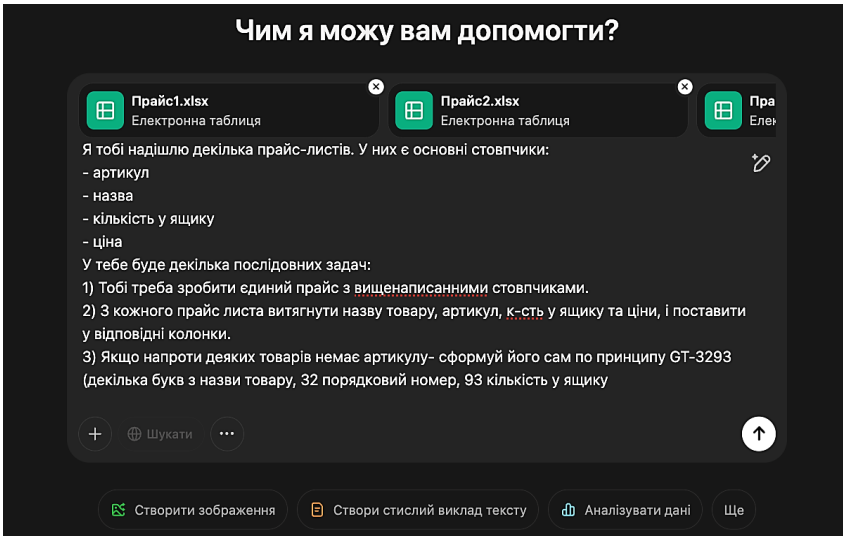



Fig. 2. Forming a request for ChatGPT (formed by the authors)

1. Merging price lists – copying and formatting data (~5–10 minutes per file, depending on their quantity and quality).

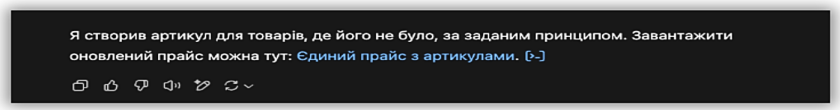
2. Article generation – creating unique codes (~15–30 seconds for each product without an article number).

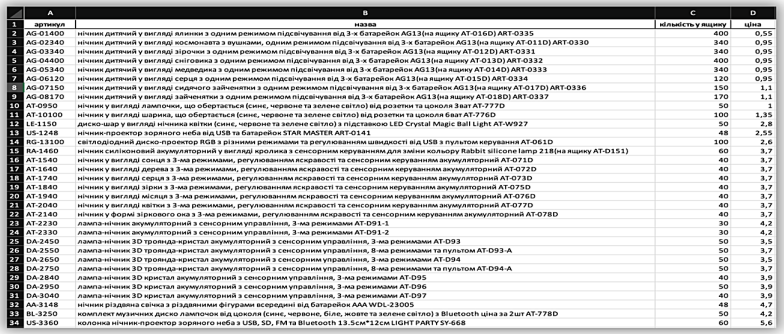
3. Clean up names – removing extra spaces and correcting errors (~5–10 seconds per line).

4. Price adjustment – analysis and change of values (~5–10 seconds for each product).

5. Adding "Y-" to article numbers – simple formatting (~1–2 seconds per product).

6. Saving and checking data – final verification (~10–20 minutes).



| | A | B | C | D |
|---|---|---|---|---|
| 1 | артикул | назва | кількість у ящику | ціна |
| 2 | AG-01400 | нічник дитячий у вигляді ялинки з одним режимом підсвічування від 3-х батарейок AG13(на ящику AT-016D) ART-0335 | 400 | 0,55 |
| 3 | AG-02340 | нічник дитячий у вигляді космонавта з вушками, одним режимом підсвічування від 3-х батарейок AG13(на ящику AT-011D) ART-0330 | 340 | 0,95 |
| 4 | AG-03340 | нічник дитячий у вигляді зірочки з одним режимом підсвічування від 3-х батарейок AG13(на ящику AT-012D) ART-0331 | 340 | 0,95 |
| 5 | AG-04400 | нічник дитячий у вигляді сніговика з одним режимом підсвічування від 3-х батарейок AG13(на ящику AT-013D) ART-0332 | 400 | 0,95 |
| 6 | AG-05340 | нічник дитячий у вигляді медведика з одним режимом підсвічування від 3-х батарейок AG13(на ящику AT-014D) ART-0333 | 340 | 0,95 |
| 7 | AG-06120 | нічник дитячий у вигляді серця з одним режимом підсвічування від 3-х батарейок AG13(на ящику AT-015D) ART-0334 | 120 | 0,95 |
| 8 | AG-07150 | нічник дитячий у вигляді сидячого зайченяти з одним режимом підсвічування від 3-х батарейок AG13(на ящику AT-017D) ART-0336 | 150 | 1,1 |
| 9 | AG-08170 | нічник дитячий у вигляді зайченятки з одним режимом підсвічування від 3-х батарейок AG13(на ящику AT-018D) ART-0337 | 170 | 1,1 |
| 10 | AT-0950 | нічник у вигляді лампочки, що обертається (синє, червоне та зелене світло) від розетки та цоколя 3ват AT-777D | 50 | 1 |
| 11 | AT-10100 | нічник у вигляді шарика, що обертається (синє, червоне та зелене світло) від розетки та цоколя 6ват AT-776D | 100 | 1,35 |
| 12 | LE-1150 | диско-шар у вигляді нічника квітки (синє, червоне та зелене світло) з підставкою LED Crystal Magic Ball Light AT-W927 | 50 | 2,8 |
| 13 | US-1248 | нічник-проектор зоряного неба від USB та батарейок STAR MASTER ART-0141 | 48 | 2,55 |
| 14 | RG-13100 | світлодіодний диско-проектор RGB з різними режимами та регулюванням швидкості від USB з пультом керування AT-061D | 100 | 2,6 |
| 15 | RA-1460 | нічник силіконовий акумуляторний у вигляді кролика з сенсорним керуванням для зміни кольору Rabbit silicone lamp 218(на ящику AT-D151) | 60 | 3,7 |
| 16 | AT-1540 | нічник у вигляді сонця з 3-ма режимами, регулюванням яскравості та сенсорним керуванням акумуляторний AT-071D | 40 | 3,7 |
| 17 | AT-1640 | нічник у вигляді дерева з 3-ма режимами, регулюванням яскравості та сенсорним керуванням акумуляторний AT-072D | 40 | 3,7 |
| 18 | AT-1740 | нічник у вигляді серця з 3-ма режимами, регулюванням яскравості та сенсорним керуванням акумуляторний AT-073D | 40 | 3,7 |
| 19 | AT-1840 | нічник у вигляді зірки з 3-ма режимами, регулюванням яскравості та сенсорним керуванням акумуляторний AT-075D | 40 | 3,7 |
| 20 | AT-1940 | нічник у вигляді місяця з 3-ма режимами, регулюванням яскравості та сенсорним керуванням акумуляторний AT-076D | 40 | 3,7 |
| 21 | AT-2040 | нічник у вигляді квітки з 3-ма режимами, регулюванням яскравості та сенсорним керуванням акумуляторний AT-077D | 40 | 3,7 |
| 22 | AT-2140 | нічник у формі зіркового ока з 3-ма режимами, регулюванням яскравості та сенсорним керуванням акумуляторний AT-078D | 40 | 3,7 |
| 23 | AT-2230 | лампа-нічник акумуляторний з сенсорним управлінням, 3-ма режимами AT-D91-1 | 30 | 4,2 |
| 24 | AT-2330 | лампа-нічник акумуляторний з сенсорним управлінням, 3-ма режимами AT-D91-2 | 30 | 4,2 |
| 25 | DA-2450 | лампа-нічник 3D троянда-кристал акумуляторний з сенсорним управлінням, 3-ма режимами AT-D93 | 50 | 3,5 |
| 26 | DA-2550 | лампа-нічник 3D троянда-кристал акумуляторний з сенсорним управлінням, 8-ма режимами та пультом AT-D93-A | 50 | 3,7 |
| 27 | DA-2650 | лампа-нічник 3D троянда-кристал акумуляторний з сенсорним управлінням, 3-ма режимами AT-D94 | 50 | 3,5 |
| 28 | DA-2750 | лампа-нічник 3D троянда-кристал акумуляторний з сенсорним управлінням, 8-ма режимами та пультом AT-D94-A | 50 | 3,7 |
| 29 | DA-2840 | лампа-нічник 3D кристал акумуляторний з сенсорним управлінням, 3-ма режимами AT-D95 | 40 | 3,9 |
| 30 | DA-2950 | лампа-нічник 3D кристал акумуляторний з сенсорним управлінням, 3-ма режимами AT-D96 | 50 | 3,9 |
| 31 | DA-3040 | лампа-нічник 3D кристал акумуляторний з сенсорним управлінням, 3-ма режимами AT-D97 | 40 | 3,9 |
| 32 | AA-3148 | нічник різдвяна свічка з різдвяними фігурами всередині від батарейок AAA WDL-23005 | 48 | 4,7 |
| 33 | BL-3250 | комплект музичних диско лампочок від цоколя (синє, червоне, біле, жовте та зелене світло) з Bluetooth ціна за 2шт AT-778D | 50 | 4,2 |
| 34 | US-3360 | колонка нічник-проектор зоряного неба з USB, SD, FM та Bluetooth 13.5cm*12cm LIGHT PARTY SY-668 | 60 | 5,6 |

Fig. 3. Download and verification (created by the authors)

4. Formation of the final script, which will help to correctly change prices, correct errors, and take the necessary actions with a large array of data (Fig. 4).

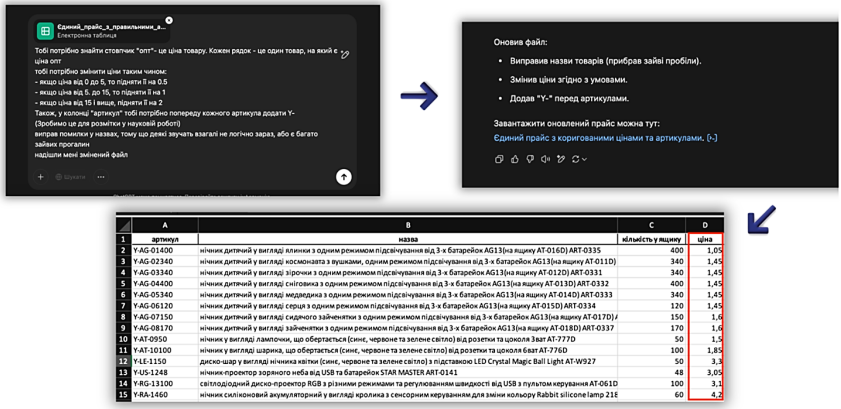
Time estimate:

– if there are 100 products in the price list, manual work will take approximately 2–3 hours;

– if 500 products – the working time is 10–15 hours;
– if there are 1,000 products, then without automation it may take 20–30 hours (almost 3–4 working days).

Automating this work would save a person dozens of hours of work.

A key element of the research was the integration of the ChatGPT 4o language model, which was used for semantic analysis and comparison of the necessary parameters of the products. The model allowed not only to effectively recognize different variants of names or wordings, but also to identify potential errors or inconsistencies in the data. This made it possible to minimize manual intervention in the process of comparing data from different suppliers.




| | A | B | C | D |
|---|---|---|---|---|
| 1 | артикул | назва | кількість у ящику | ціна |
| 2 | Y-AG-01400 | нічник дитячий у вигляді глинки з одним режимом підсвічування від 3-х батарейок AG13(на ящику AT-016D) ART-0335 | 400 | 1,05 |
| 3 | Y-AG-02340 | нічник дитячий у вигляді космонавта з вушками, одним режимом підсвічування від 3-х батарейок AG13(на ящику AT-011D) | 340 | 1,45 |
| 4 | Y-AG-03340 | нічник дитячий у вигляді зірочки з одним режимом підсвічування від 3-х батарейок AG13(на ящику AT-012D) ART-0331 | 340 | 1,45 |
| 5 | Y-AG-04400 | нічник дитячий у вигляді сніговика з одним режимом підсвічування від 3-х батарейок AG13(на ящику AT-013D) ART-0332 | 400 | 1,45 |
| 6 | Y-AG-05340 | нічник дитячий у вигляді медведика з одним режимом підсвічування від 3-х батарейок AG13(на ящику AT-014D) ART-0333 | 340 | 1,45 |
| 7 | Y-AG-06120 | нічник дитячий у вигляді серця з одним режимом підсвічування від 3-х батарейок AG13(на ящику AT-015D) ART-0334 | 120 | 1,45 |
| 8 | Y-AG-07150 | нічник дитячий у вигляді сидячого зайченятки з одним режимом підсвічування від 3-х батарейок AG13(на ящику AT-017D) / | 150 | 1,6 |
| 9 | Y-AG-08170 | нічник дитячий у вигляді зайченятки з одним режимом підсвічування від 3-х батарейок AG13(на ящику AT-018D) ART-0337 | 170 | 1,6 |
| 10 | Y-AT-0950 | нічник у вигляді лампочки, що обертається (синє, червоне та зелене світло) від розетки та цоколя 3ват AT-777D | 50 | 1,5 |
| 11 | Y-AT-10100 | нічник у вигляді шарика, що обертається (синє, червоне та зелене світло) від розетки та цоколя 6ват AT-776D | 100 | 1,85 |
| 12 | Y-LE-1150 | диско-шар у вигляді нічника квітки (синє, червоне та зелене світло) з підставкою LED Crystal Magic Ball Light AT-W927 | 50 | 3,3 |
| 13 | Y-US-1248 | нічник-проектор зоряного неба від USB та батарейок STAR MASTER ART-0141 | 48 | 3,05 |
| 14 | Y-RG-13100 | світлодіодний диско-проектор RGB з різними режимами та регулюванням швидкості від USB з пультом керування AT-061D | 100 | 3,1 |
| 15 | Y-RA-1460 | нічник силіконовий акумуляторний у вигляді кролика з сенсорним керуванням для зміни кольору Rabbit silicone lamp 21E | 60 | 4,2 |

Fig. 4. Finished result (generated by the authors)

During the experimental verification, a comparative analysis of two approaches to price list processing was conducted. The first approach was based on traditional methods of manual and partially automated analysis, while the second was based on the integration of AI technologies. The results obtained showed that the use of ChatGPT and related algorithms significantly reduces data analysis time (on average

by 40–50% depending on the volume and complexity of the data. However, in this case, the result was achieved 99.9% faster) and increases the accuracy of detecting incorrect records and duplicates. In addition, AI technologies allowed us to detect incorrect names, taking into account their relevance, which would have remained unnoticed during manual analysis.

It is important to note that the implementation of AI solutions in business processes is associated with a number of challenges. First, it is a question of the quality of input data: even the most advanced language models cannot fully compensate for the lack of relevant and reliable information. Second, setting up and training AI models requires a certain level of expertise, which requires additional investments in staff training or the involvement of specialists. Third, constant work with big data requires the construction of flexible and continuously operating data processing pipelines, where AI tools can quickly adapt to changes in the structure or format of information.

As a result, the study confirmed the hypothesis that the integration of artificial intelligence can significantly increase labor productivity when working with large dynamic data sets. Based on the results, a number of recommendations for enterprises were formulated:

– implement comprehensive solutions that combine traditional processing methods with AI tools, ensuring maximum analysis efficiency;

– regularly update and supplement the set of input data, monitoring their quality and relevance;

– create conditions for continuous training and retraining of AI models so that they remain relevant in a dynamic market;

– involve specialists from different fields (analysts, IT specialists, marketing specialists) to customize the data processing process according to specific business tasks.

Thus, the use of artificial intelligence in the analysis of large data sets, in particular price lists, proves its effectiveness

in increasing productivity. Further research can focus on improving language models for better understanding of context. An important direction is the development of software solutions that take into account industry specifics.

This will facilitate flexible integration into existing enterprise information systems. The results of the study confirm that AI solutions can effectively address key problems. In particular, automation of the analysis process has significantly reduced data processing time and minimized the risk of errors. Thanks to the integration of the language model, it has become possible to take into account complex data structures and dynamic changes in price lists, which previously required significant manual intervention.

The main limitations of the study are related to the quality of the input data. Despite the effectiveness of AI in structuring information, the model depends on the accuracy of the provided data. In the case of a significant number of errors in the output files, the system may process them incorrectly. In addition, it is necessary to configure the algorithms for specific business processes, which may require additional resources.

One of the key drawbacks is the need for prior standardization of input data. Despite the capabilities of AI to correct errors, certain types of incorrect records remain beyond the scope of automatic processing. In addition, integrating AI solutions into business processes requires staff training and additional model tuning to optimally work with dynamic data sets.

When processing data using ChatGPT, an important element of the analytical process is the integration of specialized tools for "deep research." This approach is based on the use of multi-level machine learning algorithms that are able not only to quickly process data, but also to reveal hidden patterns that often go unnoticed by traditional analysis methods.

The Deep Research tool implements a comprehensive data analysis methodology that includes semantic and syntactic information

splitting, anomaly detection, and clusters using deep learning methods. Its main advantage is the ability to work with high-dimensional data that is characterized by heterogeneity and dynamics. Thanks to self-organizing algorithms and neural networks, the tool can conduct a multi-level assessment of data quality, identify inconsistencies in the structure of price lists, and also predict future changes based on the analysis of historical data. At the same time, it perfectly performs the work of analyzing competitors and can accurately analyze the variability of prices on the market.

One of the key features of this tool is the ability to "deep dive" into the data, which allows you to not just identify superficial inconsistencies, but to analyze each link in the information chain. This provides a comprehensive analysis of processes related to changes in market conditions and contributes to making more informed management decisions. For example, when analyzing price dynamics, the tool is able to identify not only existing trends, but also predict potential price spikes or declines based on the identified anomalies, which allows you to adjust your business strategy in a timely manner.

The application of "deep research" has several important aspects:

1. Advanced semantic analysis. Thanks to the use of modern deep learning algorithms, the tool is able to analyze text data with much greater accuracy. It takes into account both contextual dependencies between individual data elements and their relationship with external factors, such as seasonal fluctuations or the specifics of regional markets. This allows not only to reduce the number of errors, but also to improve the accuracy of data classification and normalization.

2. Adaptability to changes. In modern business environments, data is constantly changing, which creates significant problems for static algorithms. The tool has adaptive properties that allow models to update their algorithms in real time. Thanks to this, the system is able to quickly respond to changes in the data structure, which is especially important when processing dynamic price lists and databases, where new data arrives at a high speed.

3. Integration of multidimensional analysis. One of the main advantages is the ability to process multidimensional data. The tool is not limited to the analysis of simple numerical values or text fields, but can take into account complex dependencies between different characteristics of products. This allows for detailed analysis that includes not only comparing price values, but also considering additional factors such as product description, specifications, regional differences and even consumer behavioral characteristics.

4. Improving data quality. Using "deep exploration" allows you to significantly improve the quality of input data. The tool automatically detects inconsistencies, duplicates and errors that may occur in both the structure and content of the data. Thanks to this, preliminary data standardization, which is one of the key shortcomings of traditional analysis, can be carried out more efficiently and quickly. This, in turn, ensures high quality of the final analysis results.

5. In-depth analysis of market trends. In addition to technical capabilities, the tool allows for a comprehensive analysis of market trends. It analyzes not only the current state of the data, but also historical changes, which allows you to build forecasts based on the revealed patterns. This is important for making strategic decisions in business, as it provides the opportunity to respond to market changes in a timely manner, adjust sales strategies and optimize the product range.

6. Synergy with other AI technologies. It is especially worth noting the synergistic effect when combining the capabilities of ChatGPT and the "deep research" tool. While ChatGPT demonstrates high efficiency in semantic analysis and processing of text data, "deep research" complements it by providing multidimensional analysis and recognition of complex structural dependencies. This combination allows you to create an integrated analytical system capable of working with both qualitative and quantitative indicators, which provides a more complete picture of business processes.

The research results became the basis for developing recommendations for the effective implementation of AI in data analysis:

– use of combined AI solutions for integration with existing management systems;

– periodic updating of training models to improve their adaptability;

– development of standards for input data quality to improve the efficiency of processing algorithms.

In practical application, the integration of this tool can be carried out through the development of special modules that allow it to be connected to existing data processing systems. For example, when working with price lists or databases, the module can analyze unstructured data coming from different suppliers and perform a preliminary classification of the data according to several parameters. The results obtained are then transferred to the main analytical system, where ChatGPT performs the final normalization and correction of information.

In addition, the use of this tool helps reduce the risks associated with the human factor. Since the system is based on automated algorithms, the possibility of human errors is practically eliminated. This is especially true for large volumes of data, where even a minor error can lead to serious losses. Automation of analysis using this tool allows you to significantly increase the accuracy of data processing, which has a positive effect on the overall productivity of business processes.

At the same time, it should be noted that the implementation of this tool requires careful tuning and constant monitoring. Although deep learning algorithms are highly effective, their quality directly depends on the quality of the input data and the correctness of the model parameterization. Therefore, to achieve optimal results, it is necessary to regularly retrain the model using current data, as well as constantly monitor its performance. It is also important not

to forget about the provision of information and preparation of AI for reception and processing.

Discussion of the research results allows us to explain the obtained results through the specifics of the applied approach. Fig. 1–4 demonstrate the sequence of actions that made it possible to significantly reduce the data processing time: from the unstructured primary price list (Fig. 1) to the formation of an adjusted array (Fig. 4). The key factor in efficiency is the ability of the ChatGPT language model to automatically perform structuring, cleaning and unification of information, which traditionally requires significant human resources. The table with the calculation of the time spent on processing 998 products clearly confirms the increase in productivity – from a potential 20–30 hours of manual work to 5 minutes when using AI.

The peculiarity of the proposed method is the combination of classical data cleaning principles with modern natural language processing tools, which ensured high accuracy of the results. Compared to traditional approaches, which, as noted in [3], are characterized by limited scalability, the proposed model provides dynamic adaptation to the input data without the need for prior hard formatting.

In [2] it is substantiated that the combination of scalable data processing tools with machine learning algorithms significantly increases the speed and accuracy of information analysis. In the conducted study, this thesis is confirmed by empirical data: the use of ChatGPT allowed to reduce the time for processing price lists by more than 100 times. However, unlike the methods described in [2; 5], which are mainly aimed at analytical processing of structured data, the study demonstrates the effectiveness of working with heterogeneous sources of information, in particular with price lists containing a significant number of errors and heterogeneities. The integration of in-depth analysis – as noted in the last section of the results – allows to identify clusters, anomalies and trends that remain unnoticed during traditional analysis.

Comparison of the results of the experimental and traditional approaches confirms the superiority of AI tools in labor productivity. While in previous studies, such as [1; 4], efficiency was measured mainly by the accuracy of predictions or the flexibility of models, in this case the main indicator was the speed of analysis while maintaining accuracy. The reduction in processing time by 99.9% indicates an extremely high level of optimization, unattainable when using standard solutions.

Thus, the results are reasonably explained by a set of factors: the use of modern language models, optimization of data preprocessing algorithms, and adaptability to variable formats. This allows us to assert that the proposed approach has not only local, but also broad applied value, in particular for those industries where the speed and accuracy of processing large amounts of information are critical. In the future, research can be deepened by comparing the results with other models, in particular with the systems presented in [6–8], as well as through testing in other sectors – logistics, retail or finance.

The limitations of the study are that some of the results may be specific to the conditions of a particular experiment or the limited data used in the study. In addition, there are some limitations in applying the proposed solutions to other industries or contexts.

Further research can be focused on improving language models for more accurate analysis of unstable data. A promising direction is the development of algorithms for working with multilingual data, which will allow expanding the scope of AI in international business processes. It is also possible to integrate ChatGPT into complex business analytics systems to improve the efficiency of management decisions. This will contribute to further automation of the analysis of large data sets and will minimize the cost of time and resources in various areas of activity.

In the context of further research, it is worth considering the possibility of integrating “deep research” with other modern technologies, such as Big Data analysis and the Internet

of Things (IoT). The combination of these technologies will allow creating complex systems that can quickly respond to changes in the market environment, analyze not only static data, but also information in real time. This opens up new prospects for predicting market changes and optimizing business processes.

Another important area is the development of interfaces for visualizing the results of in-depth analysis. The presence of interactive panels that display key indicators and trends allows managers to quickly navigate a large amount of information and make informed decisions. Such visualization tools can include graphs, charts, and other means of presenting data.

Implementing such solutions in combination with ChatGPT creates a synergistic effect, thanks to which it is possible to achieve significant results in data processing automation. This allows not only to reduce time spent on analysis, but also to optimize resource provision of enterprises, minimize the risk of errors, and ensure stable data quality.

Given the above, the following steps can be taken to further integrate the tool into business processes:

– creation of a pilot project that will combine the capabilities of ChatGPT and the "deep research" tool, will allow testing their effectiveness in real data processing conditions;

– conducting a series of tests to determine the optimal parameters of the models, which will ensure the most accurate detection of anomalies and prediction of changes;

– organization of training programs for employees to familiarize them with the capabilities of modern AI technologies and the optimal use of data analysis tools;

– development of interfaces to provide information in a format convenient for making management decisions, which will facilitate rapid analysis of the results of model work.

In addition to directly affecting the quality of analysis, the implementation of such tools stimulates the development of new

approaches to information flow management. Automated systems based on deep analysis are able to detect even minor changes in the data structure, which allows you to quickly respond to potential problems. This is especially important for enterprises that work with large volumes of information and are faced with the constant need to update data.

**Conclusions.** The study found that using AI tools in business processes reduces the risk of errors and minimizes time spent on data correction. Unlike standard software tools that are limited in their adaptability, the ChatGPT language model can dynamically adapt to market changes and information updates, which makes its use more effective. ChatGPT integration into the process of analyzing volatile and dynamic data allows you to automate the structuring and comparison of large amounts of information. This ensures rapid elimination of duplications and increases the accuracy of price data correction. Experimental data from the study show that automation of analysis reduces the likelihood of errors in product names and increases the speed of decision-making by 99.9% compared to manual processing.

Practical recommendations are offered for integrating AI tools to optimize the analysis of large data sets in business processes. The study showed that the combined use of traditional methods and AI models provides increased analysis efficiency. In particular, the implementation of AI solutions allows enterprises to minimize the risks associated with incorrect information and significantly accelerate the process of making management decisions.

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## 3.2. THE IMPACT OF AI ON THE LABOR MARKET AND EMPLOYEE PERFORMANCE

**Introduction.** Even in its "weak form," artificial intelligence (AI) is already having a huge impact on various areas of life and business, including the labor market. And this impact will only grow over time.

According to Reid Hoffman, a partner at venture capital firm Greylock Partners and co-founder of LinkedIn and Inflection AI, we should think of generative AI as a "steam engine of the mind" that promises to revolutionize our professional and personal lives. The advent of steam power in the late 18th century revolutionized manufacturing, transportation, and construction. A new kind of revolution has already begun-and it will give new impetus to all language-based skills, such as communication, reasoning, analytics, sales, and marketing [1].

Even if AI doesn't directly impact a profession or industry right now, it could change in the near future. It will become an integral part of business processes and change the perception of what qualifications and skills are needed for a successful career.

**Presentation of the main research material.** One of the main ways AI is impacting the job market is through the automation of labor-intensive tasks and processes. This means that many routine tasks that were previously performed by humans can now be performed by computers and robots. For example, in manufacturing industries, AI is used to control robots on production lines, which can increase productivity and reduce labor costs. AI is also used in banking to automate accounting operations and financial analysis.

The use of AI to solve labor-intensive tasks is leading to changes in the demand for certain qualifications and skills. In particular, computer literacy and knowledge of algorithms are becoming increasingly important for many professions. New professions related to the development and support of AI systems are also emerging, including machine learning engineers and algorithm developers.

At the same time, in some professions, the demand for "human" skills and expert opinion remains high, as AI will not be able to completely replace human activity. For example, doctors, teachers and social workers will remain in demand, as they have skills and knowledge that cannot be completely replaced by machines. In many professions, interaction with customers (consumers or patients) plays an important role, which requires human interaction and communication skills.

Automation, however, raises concerns about the threat of job losses. According to the latest global survey by Censuswide, commissioned by the world's largest professional network LinkedIn, which surveyed more than 20,000 professionals across all industries, aged 18–77, in the UK, US, France, Germany, India, Australia, Brazil, the Netherlands, Singapore, Saudi Arabia and the UAE between 2 and 11 September 2024, almost two-thirds (64%) of professionals worldwide are overwhelmed by how quickly work is changing, with 68% looking for more support than ever before. The pace of change has led 49% of respondents to worry that they could lose their job altogether [2]. This suggests a growing need for adaptation, mentoring and learning in the workplace. Organizations have a chance to support their employees by creating conditions for continuous development and psychological comfort.

AI may indeed lead to a reduction in demand for certain professions and skills. It is important to note that automation may affect not only low-skilled but also high-skilled professions. For example, according to the report "A new future of work: The race to deploy AI and raise skills in Europe and beyond" published on May 21,

2024 by the McKinsey Global Institute, up to 10% of high-skilled professions, such as doctors, lawyers and finance professionals, could be affected by automation. On the other hand, low-skilled professions, such as production line operators and cashiers, could also be affected by automation [3].

AI is evolving rapidly, and it is important to prepare now to ensure that workers and the labor market are ready for the new era and benefit from it. Historically, the impact of technology on labor demand-it is a story of the confrontation between the forces of labor replacement and job creation, which tend to balance out in the long run.

Unemployment is expected to rise initially as some companies decide to take advantage of the time savings that AI can provide and reduce their workforces. However, these losses will not happen all at once, but will occur gradually as AI becomes more widespread in the economy. Furthermore, the increase in unemployment is likely to be limited and eventually offset by the creation of new demand for labor, which will attract laid-off workers back into the market. AI will thus increase labor market dynamics, forcing more workers to change jobs. As a result, labor market infrastructure will need to be modernized to adapt to the AI era.

It should be noted that the potential time savings and associated productivity gains will also contribute to economic growth. The scale of this effect is highly unpredictable and will depend on both how widely AI is implemented across industries and the cost of implementing it. Most types of AI are expected to be able to deliver significant cost savings, but not across the board. For example, specialized AI tools that train on a company's unique data, as well as sophisticated AI hardware, are likely to be too expensive for most small companies. For small businesses to gain access to such technologies, they will need to be scaled, "platformized" (converted into tools that can be easily deployed across an industry), and sold as a service (similar to how the cloud computing market has evolved).

The challenges arising from the development of AI technology, as well as their impact on the labor market and employee performance, can be considered from the perspectives of both employers and employees.

Current employer predictions about the prospects for AI technology are presented in this year's "The Future of Jobs Report 2025," prepared by the World Economic Forum [4].

The Report notes that technology will be the biggest driving force shaping the marketjobs, outpacing all other macro job creation and displacement trends. Over the next five years, advances in AI and information technology will accelerate digital transformation. This will lead to significant changes in labor market dynamics, with the three fastest-growing skills becoming the most important: data analysis usingAI, networking, cybersecurity, and technological competence.

For employers, this means prioritizing candidates who demonstrate analytical and systems thinking to effectively make decisions based on the analysis and interpretation of data coming from digital sources. In addition, other emerging technologies, such as the emergence of robots and autonomous systems, highlight the growing demand for programming experience and adaptation to automated technologies. To remain competitive in all industries, employers must seek professionals with the core technology skills to integrate and collaborate with evolving systems.

According to a survey of company executives, by 2030, positions related to technological development, in particular the promotion of AIand robotics, as well as access to digital technologies (Fig. 1). Among the leaders of the list in terms of growth rates are specialists in working with large volumes of information, specialists in AIand machine learning, software and application developers, Internet of Things specialists, as well as analysts and data scientists [4].

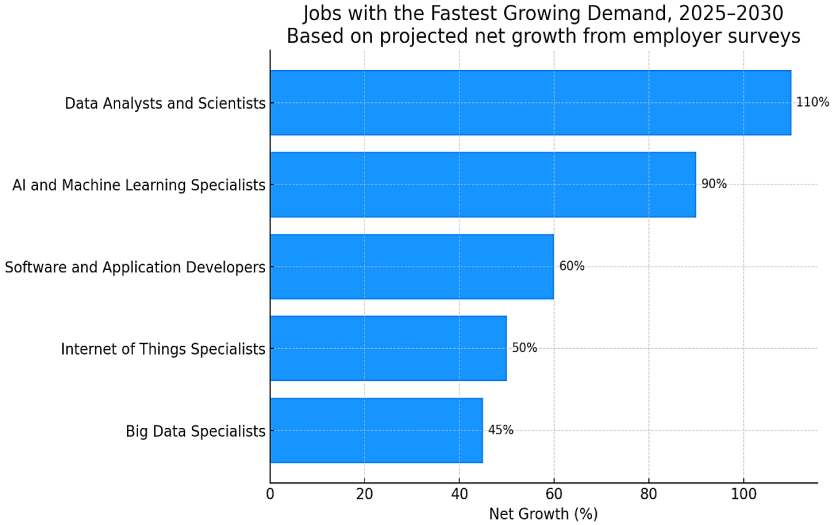


Fig. 1. Professions with the fastest growing demand

The evolving relationship between humans, machines, and algorithms will transform many roles across industries. The report highlights how the balance between automation and augmentation will reshape the workforce. Executives estimate that 47% of work tasks in their companies are currently performed primarily by humans, 22% are performed primarily by technology (including machines and algorithms), and 30% involve collaborative work. However, by 2030, these proportions are expected to shift significantly, with tasks being split almost evenly between humans, machines, and hybrid approaches. For employers, this signals the need to rethink workforce strategies, implementing models that leverage the increasing versatility of technology while also capitalizing on human ingenuity and adaptability. This shift underscores the importance of preparing for a future where work is dynamically divided between humans and AI-driven technology [4].

Human-machine collaboration, or complementarity, is a critical concept for future workplaces. Rather than replacing human work, this approach involves developing and using technology

to complement and enhance human capabilities. It is predicted that by 2030, the proportion of tasks performed solely by humans will decline in every industry. However, the degree of transition that will be achieved through automation or complementarity will vary by sector. This finding highlights the opportunity for employers to align technological advances with workers' strengths, fostering a balance between efficiency and human ingenuity.

When the World Economic Forum published its Future of Jobs Report in 2016, employers surveyed predicted that 35% of their workforce's skills would be lost in the future. This prediction has taken on particular relevance during the COVID-19 pandemic, as the rapid development of advanced technologies has brought profound changes to the work environment and skill requirements. Subsequent editions of the report have highlighted the increasing level of skills volatility. However, employers have adapted well to these challenges since the pandemic. While uncertainty remains, particularly around the long-term impact of generative AI, the rate of skills loss appears to be stabilizing. According to this year's Report, employers expect 39% of workers' core skills to change by 2030, up from 44% in 2023 (Fig. 2). This trend should reflect the growing emphasis on continuous learning, upskilling and reskilling initiatives, providing businesses with the ability to adapt proactively to future employee skill needs and reduce workforce volatility [4].

Employers expect employees to balance professional and soft skills to succeed in today's workplace. Companies identified key competencies such as technical proficiency, interpersonal skills, emotional intelligence and a commitment to lifelong learning as critical communication skills. These findings highlight the growing emphasis on combining technical expertise with collaborative and adaptive capabilities to meet the evolving needs of the industry.

Currently, some of the most important skills are considered to be leadership and social influence, AI and working with large amounts of information, talent management, and service orientation.

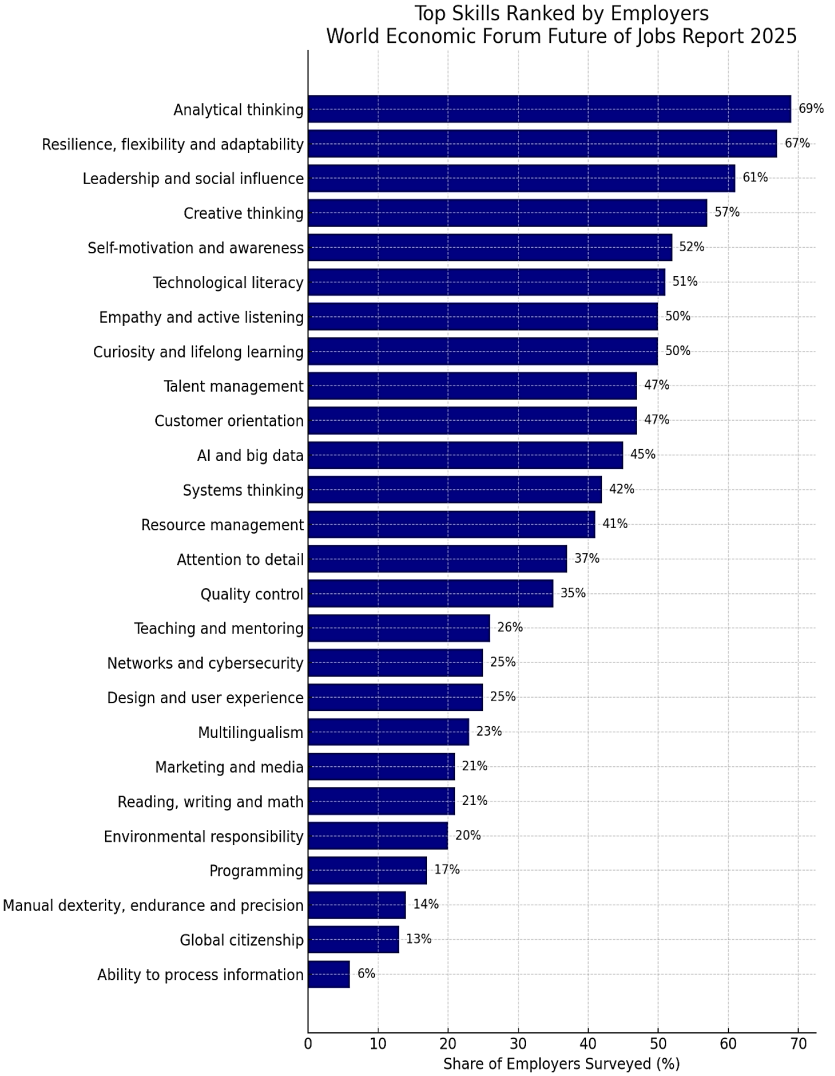


Fig. 2. Key skills of 2025

According to employer forecasts for the next five years, technological skills are expected to overtake other types of skills in importance. AIand working with large amounts of information are leading this growth, followed by networking, cybersecurity and technology competencies. Creative thinking and social-emotional skills such as resilience, flexibility, agility, curiosity and lifelong learning are also gaining importance, complementing technology competencies. Employers should consider integrating these skill sets into workforce development strategies.

Since the launch of Chat GPT in November 2022, there has been a rapid surge in investment in generative AI (GenAI) and its implementation across sectors. Generative AI allows users to interact with technology as if they were communicating with another person, significantly reducing the level of technical skills required for the widespread use of this technology. As a result, skills related to the use of generative AI are in the highest demand. It is not surprising that AI finds its greatest application in the information technology sector.

Generative AI could transform the future of work through human-machine collaboration. Human-centric skills remain critical even in a technology-driven work environment. This finding highlights the urgent need to reskill and upskillongoing strategies to address emerging skills gaps. These strategies should be a priority for employers, allowing workers to transition into roles that combine technical expertise with core human-centered skills.

By investing in adaptive talent development, companies can create a workforce ready to meet the challenges of tomorrow.

Trend towards increasing volumesThe prevalence of training and development programs is widespread across almost all industries, underscoring the recognition that continuous skills development is critical regardless of industry. While training needs vary across industries and regions, most employers are looking to fund their own programs to improve productivity and competitiveness.

"Future of Jobs Report 2025"highlights a significant shift in workforce strategies as companies prepare for the disruptive impact of AI on employment. By 2030, 77% of employers plan to prioritize reskilling and upskilling their employees to better collaborate with AI systems. While this strategy is receiving particular attention in high-income countries, it remains a top priority across the globe, regardless of income level.

Process and task automation is being actively implemented, and 73% of employers plan to accelerate it. It is worth noting that 63% of employers are interested in integrating new technologies as a complement to existing employees, highlighting the growing focus on AI-driven processes.

Another trend that is gaining traction is skills-based hiring. Eliminating degree requirements is gaining traction as an effective strategy to broaden the talent pool. According to "The Future of Jobs Report 2025", employers are beginning to rely heavily on work experience when evaluating candidates, with 81% planning to prioritize it as a key assessment method from 2025 to 2030. This trend is consistent with previous reports that highlight the continued importance for companies of on-the-job learning experiences and concrete achievements in candidates in the hiring process. For employers looking to remain competitive, the emphasis on skills and experience aligns with labor market trends and talent acquisition strategies [4].

Of course, while other macro trends are also influencing the future of work, the role of technology cannot be overstated. As such, companies must plan for workforce changes that are aligned with rapid technological developments.

In turn, to meet the new demands of the labor market, employees must have the skills necessary to work with AI and automated systems. Therefore, training in the field of AI is becoming increasingly popular. As noted, many companies provide their employees with the opportunity for professional development and training in the field of AI, but now there are many platforms and resources where you

can get education and practical experience in the field of artificial intelligence on your own. Some of them offer free access, and some require a paid subscription.

Some of the most well-known international platforms and resources are:

Coursera – provides users with access to hundreds of online courses in a variety of fields. Upon successful completion of the course, the participant can receive a certificate. The platform collaborates with a large number of leading universities and companies. Educational institutions around the world use Coursera for professional development, retraining of personnel, and training of students in areas such as AI, data analytics, information technology, and business. Most courses are available for free, but certificates with personal identification of the participant are paid [5].

EdX – Founded in 2012 by Harvard University and the Massachusetts Institute of Technology, the educational platform has now become one of the leading centers for online learning. It operates on the basis of the open free platform OpenEdX and provides access to massive open online courses (MOOCs) in more than 24 academic areas, including computer science, statistics, literature and others. The content of the courses is based on real lecture programs taught at leading universities, in particular Harvard and Cornell University. Education is free, but if you need to receive a certificate of completion of the course, a fee is provided [6].

Udacity offers about 30 courses, structured by difficulty level: beginner, intermediate (experienced), and advanced (professional). Each course consists of several lessons that include videos and practical tasks to test the acquired material. The main part of the content is focused on technical disciplines, in particular, such areas as AI, machine learning, and neural networks [7].

Additionally, many large technology companies such as Google, Microsoft, Amazon, IBM, and others also offer their own AI training programs, both online and offline and in the form of corporate training.

Massive open online course platforms have also been created and are actively operating in Ukraine. They provide an opportunity to master academic disciplines in the Ukrainian language, including those that were previously presented mainly by foreign resources and inaccessible to the Ukrainian public due to the language barrier. In addition to adapting Western content, Ukrainian online courses offer curricula focused on national characteristics.

The most famous Ukrainian online resources with free educational courses are:

Prometheus is a platform that not only independently develops and hosts MOOCs on its website, but also enables leading universities and teachers, as well as companies that occupy leading positions in their field, to publish educational materials for free and distribute them to a wide audience. The project, founded in 2014, aims to create not just individual courses, but full-fledged educational cycles covering the most relevant areas for the country – business, information technology, foreign languages, law, history, and others [8].

EdEra is a Ukrainian online education studio founded in 2014 that develops educational content, including online courses, learning platforms, interactive games, and digital textbooks. Its activities are aimed at popularizing modern forms of learning and increasing the availability of quality education in Ukraine [9].

"Action.Education" is a continuation of the "Action.Digital Education" project, which was launched in 2020 with the aim of increasing the level of digital literacy of the population and developing basic digital skills. The current version of the project has a broader vision: it is aimed at forming comprehensive modern competencies necessary for successful functioning in a dynamic digital society. The main goal of "Action.Education" is to provide access to relevant knowledge and skills, contributing to the transformation of the educational landscape of Ukraine. [10]

As noted, to succeed in today's workplace, employees need to combine professional and soft skills. In general, the skills needed

by employees in the age of artificial intelligence can be divided into four groups:

1. Technical skills.

– Digital literacy – proficiency in office programs, cloud services, and basic knowledge of Internet technologies.

– Data Analysis (Data Literacy)- the ability to work with large amounts of data, interpret statistics, and visualize information.

– Fundamentals of Machine Learning and Artificial Intelligence – understanding the principles of algorithm operation, knowledge of process automation.

– Working with digital tools – mastery of modern platforms (CRM, ERP, analytical panels, low-code tools).

– Cybersecurity – basic knowledge of data protection, privacy, and digital hygiene.

2. Social and communication skills.

– Critical thinking – the ability to evaluate information, to question solutions generated by AI.

– Flexibility and adaptability – the ability to learn quickly and respond to technological changes.

– Communication skills – effective interaction with colleagues, presentation of ideas, explanation of technical concepts in accessible language.

– Creativity – creating new solutions and approaches in collaboration with AI.

– Emotional intelligence – understanding other people's emotions, the ability to empathize.

3. Continuous learning skills.

– Self-education – participation in online courses, trainings, obtaining certificates (Coursera, edX, Prometheus, etc.).

– Readiness for retraining – openness to changing career paths in response to changes in the labor market.

– Interdisciplinarity – combining technical knowledge with humanitarian knowledge (ethics, law, social sciences).

4. Skills for interacting with AI.

– Prompt engineering – formulating effective queries to AI.

– Control and verification of results – the ability to verify answers generated by AI.

– Ethical use of AI – understanding the social and legal consequences of the application of AI in various fields.

Thus, to be ready to work with AI, an employee must combine technical knowledge, humanity, the ability to learn, and the ability to effectively collaborate with technology.

In conclusion, I would like to draw attention to how AI not only directly but also indirectly affects both employees and employers.

After all, AI can help both teachers and students in their learning and increase the level of educational achievement. A more educated workforce will be more productive, so over time, students trained with AI will increase their productivity. Although this is a slow process, its effect can be significant.

AI can also support a healthier society and, consequently, a healthier workforce, leading to fewer lost workdays, longer and more productive careers, and reduced social costs. Although the use of AI in healthcare is still in its infancy, there is already enormous potential to accelerate medical research, introduce a preventive approach to treatment, more effectively identify, treat, and discharge patients, and develop assistive technologies that can help people with disabilities or temporary health problems return to work.

In addition, AI can contribute to better recruitment and more efficient use of labor resources-just as the Internet did in its time. However, design and control become especially important in this area, as biases arising from algorithms and data patterns can have negative consequences for employment. The principle of employee autonomy remains important: AI should not just passively select people for positions, but should provide them with strategies and information that will allow them to present themselves effectively.

Overall, AI has the potential to improve the quality of work, reduce the number of routine tasks, make jobs more accessible to a wider range of people, and increase occupational safety. Thus, it can contribute to a more engaged, inclusive, and safe work environment.

**Conclusions.** AI is already transforming work at both the individual and corporate levels, increasing employee efficiency.

AI has significant potential to improve labor supply by increasing the quantity, quality, and efficient use of workers in the economy as a whole.

Introducing AI into the economy and using its capabilities to improve education and skills will help realize the potential of AI as a tool for social equalization.

Workers' fears about job losses due to AI are not unfounded, but any attempts to halt progress are likely to be ineffective and harmful in the long run. On the contrary, creating new demand for labor will help attract workers back into new roles.

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## 3.3. WHAT AREAS WILL ARTIFICIAL INTELLIGENCE CHANGE DURING MARTIAL LAW IN UKRAINE?

**Introduction.** When writing the article, the topic of the impact of artificial intelligence technologies on the venture business and the military-industrial complex (MIC) of Ukraine was considered. The ongoing martial law in Ukraine has led to significant changes in the economy and the actual use of artificial intelligence technologies by companies in their business processes, which will have an impact on their further development. It has been studied that during the period of martial law in Ukraine, investments in venture business have increased significantly, the basis of which in our country is the development of AI. The use of artificial intelligence technologies in the process of risk analysis and forecasting is especially relevant, which is actually proposed to be studied in more detail. Artificial intelligence technologies have also influenced the military-industrial complex of Ukraine, which has also begun to actively introduce modern technologies

both in weapons production and in its internal business processes. It is studied that the development of AI in Ukraine during the war has changed in two areas – risk management in the company and its use in the military-industrial complex of Ukraine, which are proposed to be studied in more detail. Thus, the use of artificial intelligence and machine learning can process large amounts of data in real time, identify patterns and make predictions based on this data, thus allowing enterprises to make quick and informed decisions. It is noted that to minimize risks in Ukrainian companies, it is necessary to implement a programGRC, which works on the basis of artificial intelligence and allows you to effectively identify and predict the occurrence of risks. As a result, it was determined thatIn Ukraine, the process of creating an innovative ecosystem of a renewed domestic defense industry based on the use of AI has been initiated and is being actively implemented, the products of which are able to meet the needs of the Ukrainian army, and after the end of the war, foreign buyers as well.

**Presentation of the main research material.** The ongoing martial law in Ukraine has led to significant changes in the economy and the actual use of artificial intelligence technologies by companies in their business processes, which will have an impact on their further development. It has been studied that during the period of martial law in Ukraine, investments in venture business have increased significantly, the basis of which in our country is the development of AI. The use of artificial intelligence technologies in the process of risk analysis and forecasting is especially relevant, which is actually proposed to be studied in more detail. Artificial intelligence technologies have also influenced the military-industrial complex of Ukraine, which has also begun to actively introduce modern technologies both in weapons production and in its internal business processes. That is why researching the main areas that artificial intelligence will change in a martial law environment is a relevant issue for deeper analysis.

Research on the impact of artificial intelligence on changing venture business and the military-industrial complex of Ukraine was carried out by the following scientists and researchers, such as: Nosova E. A., Mohe D. B. [1], Bondarchuk N. V. [2], Philip I. [13], and others.

So, under the conditions of martial law in Ukraine, the development of venture investment in our country intensified, which was based on investments in artificial intelligence and Ukrainian startups that were engaged in the development of AI on a global scale. In Ukraine, venture funds were created as collective investment institutions (CIIs), the purpose of which is to attract investors' funds and invest them in assets in order to receive a profit from investments [1–2]. The dynamics of the number of CIIs in Ukraine is given in Table 1.

Table 1

**Dynamics of the number of CII in Ukraine for the period 2017–2023 [3]**

| Year | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|
| Number of CII | 1183 | 1190 | 1326 | 1478 | 1711 | 1742 | 1762 |
| Absolute growth (chain) | 13 | 7 | 136 | 152 | 233 | 31 | 20 |
| Growth rate, % chain-linked | 101.11 | 100.59 | 111.43 | 111.46 | 115.76 | 101.81 | 101.15 |
| Growth rate,% chain-wise | 1.11 | 0.59 | 11.43 | 11.46 | 15.76 | 1.81 | 1.15 |

So, analyzing the data in Table 1, it is clear that the number of CII in Ukraine is growing significantly and, despite the war and the general economic crisis in our country, CII grew by 1.81% in 2022 and by 1.15% in 2023.

Next, it is proposed to examine the assets of CII (Table 2).

Table 2

**Dynamics of CII assets in Ukraine for the period 2017–2023, billion UAH [3]**

| Year | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|
| CII assets | 275.6 | 296.8 | 339.1 | 414.2 | 520.4 | 534.9 | 598.2 |
| Absolute growth (chain) | 45.3 | 21.2 | 42.3 | 75.1 | 106.2 | 14.5 | 63.3 |
| Growth rate, % chain-linked | 119.7 | 107.7 | 114.3 | 122.1 | 125.6 | 102.8 | 111.8 |
| Growth rate,% chain-wise | 19.7 | 7.7 | 14.3 | 22.1 | 25.6 | 2.8 | 11.8 |

Based on the analysis of the data in Table 2, it should be noted that over the past 7 years, CII assets have grown 3.2 times, which is twice the growth rate of Ukrainian banks' assets, so the ratio of CII assets to banks in 2010–2022 increased from 11.2 to 22.7%.

The level of development of CII in Ukraine can be described as moderate, but with huge growth potential. Even during the war, Ukraine is actively developing its financial system and investment industry and creating a favorable environment for attracting both domestic and foreign investors.

Next, we will analyze the volume of investments in the development of venture business in Ukraine (Table 3).

We see that every year the value of concluded agreements in Ukraine increased, and despite the martial law in our country, in 2022 we managed to attract $17 million in investments, exceeding the indicators of 2021. Therefore, such an increase in investments in Ukraine indicates high prospects for the development of the AI sphere.

The development of AI in Ukraine during the war has changed in two areas – risk management in the company and use in the military-industrial complex of Ukraine, which are proposed to be studied in more detail.

Table 3

**Analysis of the dynamics of venture investments and the number of deals in Ukraine for the period 2015–2023**

| Year | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|
| **Investment volume, million USD** | **3.9** | **2.4** | **8** | **32** | **12.8** | **15.7** | **10.8** |
| Absolute growth (chain) | 1.6 | –1.5 | 5.6 | 24 | –19.2 | 2.9 | –4.9 |
| Growth rate, % chain-linked | 169.57 | 61.54 | 333.33 | 400.00 | 40.00 | 122.66 | 68.79 |
| Growth rate,% chain-wise | 69.57 | –38.46 | 233.33 | 300.00 | –60.00 | 22.66 | –31.21 |
| **Number of deals** | **9** | **16** | **15** | **22** | **30** | **17** | **22** |
| Absolute growth (chain) | –3 | 7 | –1 | 7 | 8 | –13 | 5 |
| Growth rate, % chain-linked | 75.00 | 177.78 | 93.75 | 146.67 | 136.36 | 56.67 | 129.41 |
| Growth rate,% chain-wise | –25.00 | 77.78 | –6.25 | 46.67 | 36.36 | –43.33 | 29.41 |

*Source: [3]*

To date, the use of artificial intelligence models to assess the probability of risk occurrence is most common in the following areas (Table 4).

We believe that the use of AI allows us to assess the probability of crisis events occurring at enterprises, which reduces the errors of the occurrence of risky situations. The use of AI allows us

Table 4

**Characteristics of the application of AI in risk management in economic sectors**

| Sector of the economy | Characteristic |
|---|---|
| Finances | Artificial intelligence models are successfully used to solve credit scoring problems. Intelligent models are also successfully used to analyze financial transactions for fraud and to assess insurance risks |
| Healthcare | Artificial intelligence models allow predicting the likelihood of risk of disease occurrence and exacerbation, as well as associated events, such as unplanned re-hospitalization, which leads to a decrease in the level of patient care and overload of the healthcare system |
| Public administration | As an example of the application of artificial intelligence methods for risk management in the field of public administration, we can cite a model of automated risk assessment of public contracts, aimed at increasing the efficiency of public procurement and optimizing budget expenditures |
| Education | In the educational sphere, the application of artificial intelligence methods can also be quite diverse and can be used, for example, to analyze the probability of a student's risk of expulsion or unsatisfactory academic performance |
| Security | Intelligent models can be used to detect administrative and criminal offenses and prevent them in a timely manner |
| Business | Implementing AI into a company's business processes will allow it to predict sales and price increases for raw materials, which will allow it to develop an inventory system and conclude additional contracts with suppliers |

*Source: [5–6]*

to conduct a deep analysis of risks and plan for reducing such risks by processing large amounts of information in real time. The use of AI allows us to identify patterns and affects the speed and efficiency of management decisions. In order to minimize risks, Ukrainian companies are proposed to implement a program GRC, which works on the basis of artificial intelligence and allows you to effectively identify and predict the occurrence of risks. Fig. 1 shows the main advantages of GRC for Ukrainian companies in the context of risk reduction.

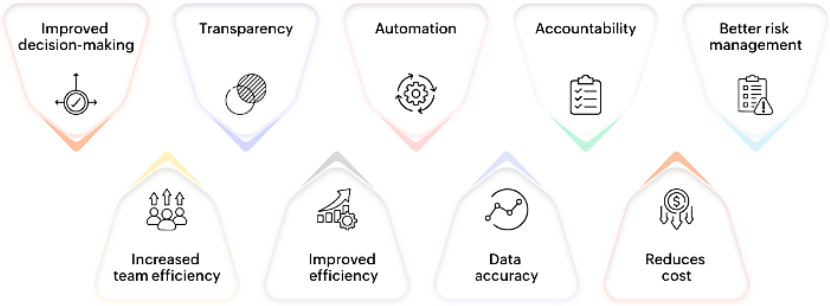


Fig. 1. Key benefits of implementing GRC into a company's risk management system

*Source: [7]*

So, the main advantage of this program for a Ukrainian company is the reduction of commercial risks, because GRC can provide sales volume forecasts for each client and predict possible increases or decreases in sales levels depending on the state of the partner company and the market situation in Ukraine.

The defense industry has identified several priority areas of development in the context of the use of AI technologies (Fig. 2).

GRC will help the company's management develop policies, meet regulatory requirements, optimize audit management, proactively

monitor the commercial risk environment, optimize compliance efforts, obtain risk information, satisfy key stakeholders, improve reporting capabilities, and increase compliance. That is why the implementation of this program will be effective for the Ukrainian company and will help not only to predict the occurrence of risks, but also to improve financial performance through management optimization.

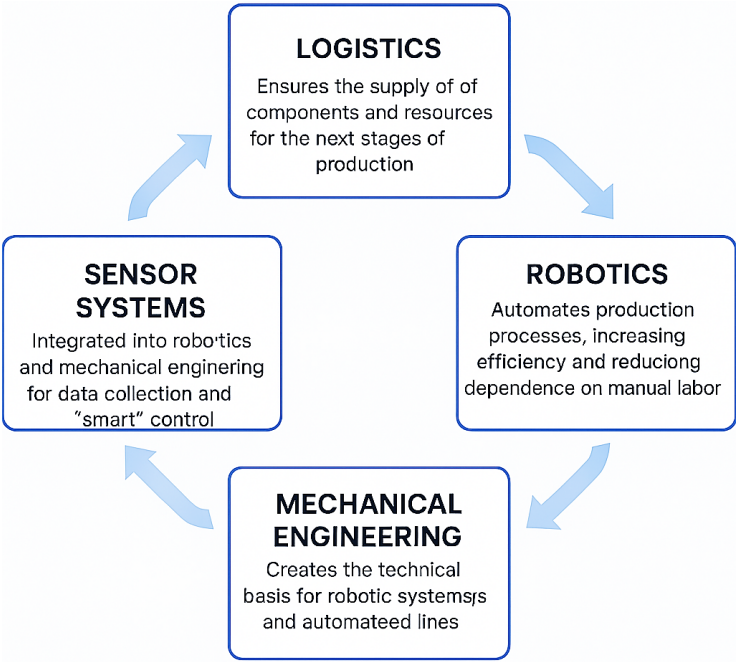


Fig. 2. Main areas of use of AI technologies in the defense industry

*Source: [8]*

So, let's move on to the analysis of technologies in robotics in the defense industry. The most striking example of the use of technologies in the robotics of the military-industrial complex is unmanned aerial vehicles (UAVs), which can operate on the basis of AI and be controlled by a person. It is worth mentioning

the development of sensor technologies in the defense industry separately. Touch screens are used in the armed forces everywhere. They are used in radio engineering troops, chemical troops, space troops, etc. A touch screen allows you to visualize information, control devices using an intuitive approach, and work much faster and more efficiently. But sensor technologies are not limited to screens, they include all kinds of innovative monitoring and data collection systems that are actively used in military equipment and radar equipment. Logistics is an equally important area of activity in the defense industry. Often the success of a military operation depends on the timely supply and support of combat units. Innovations are driven by the use of big data technologies, warehouse management systems (WMS), artificial intelligence technologies in flow management and inventory tracking, as well as the introduction of robotics, including drones. Sensor logistics and RFID tags are being developed, allowing for real-time monitoring of deliveries. This provides constant monitoring of cargo, storage conditions and transportation, which is useful in the defense industry, since military cargo has special requirements for storage and transportation, and tracking movement helps to eliminate force majeure situations [9].

Fig. 3 shows a list of public and private companies that are currently the largest players in the drone industry.

So, analyzing Fig. 3, it is clear that the majority of UAV manufacturing companies are American, whose share in this market is dominant.

Having analyzed innovations in the defense industry, it is necessary to analyze the financial component and determine Ukraine's share among the countries of the world in terms of defense industry spending (Fig. 4).

Therefore, Ukraine's share in defense industry spending is 2.7% of global spending, which is a relatively large amount for our country.

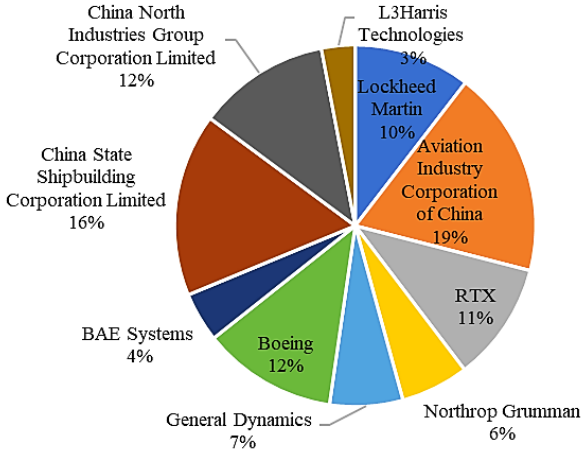


Fig. 3. Structure of global UAV manufacturers by sales revenue as of 2024, %

*Source: [10]*

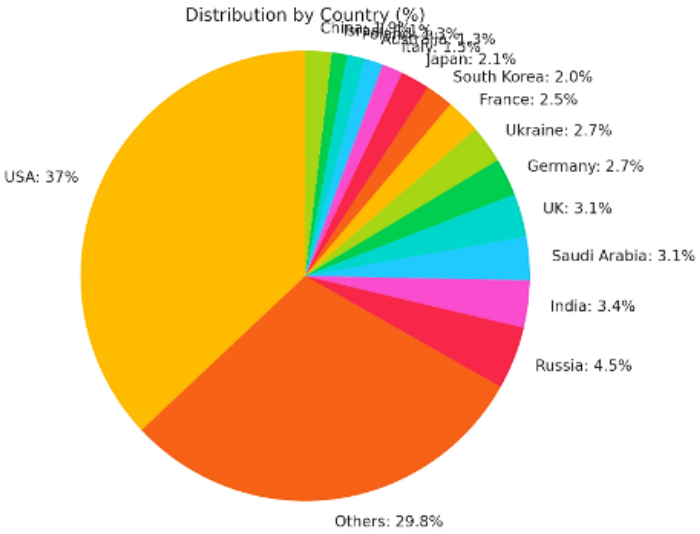


Fig. 4. Global share of Ukraine's spending
on defense industry development in 2023, %

*Source: [11]*

At the beginning of the Russian-Ukrainian war, the Brave1 coordination platform in the field of Defense Tech was created [12]. This platform unites Defense Tech companies and all interested organizations and institutions that direct their activities towards Victory based on the use of digital technologies. At the moment, 35 developments using artificial intelligence (AI) are registered in Brave1, of which 29 have already passed military expertise. In conditions of active hostilities, the main task of Ukrainian developers is to create AI solutions for the front. One of such solutions is the Griselda system, which uses AI to collect intelligence and increase the situational awareness of troops. It is able to analyze a huge array of data from satellites, drones, social networks, media and hacked enemy bases. The technology is integrated with the Delta situational awareness system and applications for artillerymen and tankers, such as Bronya, Nettle, Dill and GisArt [13].

To accelerate technological development, the Ministry of Defense of Ukraine launched the Innovation Development Accelerator. Its goal is to accelerate the implementation of innovative projects for the benefit of the Armed Forces. Using modern management methods and IT solutions, the accelerator combines the expertise and powers of specialized departments of the Ministry of Defense and a special Project Office. Applications for cooperation with the Ministry of Defense are submitted through the RIA system on the principle of a "single window" and using process automation [14].

In Ukraine, the process of creating an innovative ecosystem of a renewed domestic defense industry based on the use of AI has been initiated and is being actively implemented, the products of which are able to meet the needs of the Ukrainian army, and after the end of the war, foreign buyers as well.

**Conclusions.** Thus, having determined the change in the military state on the use of AI, it was investigated that the greatest impact and changes were experienced by venture investments and the military sector of Ukraine, which first of all began to actively apply artificial

intelligence technologies in their activities. Under the conditions of martial law in Ukraine, developments began in the defense sector, which have already been tested and are a promising direction in the future of our country, especially after the victory.

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## 3.4. CHALLENGES AND PROMISING DIRECTIONS FOR USING ARTIFICIAL INTELLIGENCE IN COUNTERING DISINFORMATION

**Introduction.** In the current conditions of hybrid warfare, Ukraine is facing an unprecedented wave of disinformation aimed at destabilizing society, lowering morale, and undermining trust in state institutions. At the same time, in the post-war period, the country faces the task of restoring the economy, which requires a stable information environment. In this context, there is a need to involve innovative technologies, in particular artificial intelligence, in ensuring information security.

**Presentation of the main research material.** Recent years have been characterized by an increase in the number of studies devoted to the use of AI in the field of security and information processing. Authors such as Claire Wardle & Hossein Derakhshan have considered the impact of automated systems on the detection of fake news [1]. Developments aimed at creating content verification systems and filtering harmful information are also emerging in Ukraine.

Highlighting previously unresolved parts of the overall problem. Despite the existing achievements, the issue of integrating AI tools into the system of state information policy in the context of war and post-war reconstruction remains insufficiently researched. There

is a lack of applied models adapted to the Ukrainian context, taking into account cultural, linguistic, and regional peculiarities.

Formulation of the article's goals (definition of tasks). The aim of the article is to analyze the potential of artificial intelligence as a tool for countering disinformation in Ukraine during the war and during the post-war economic recovery.

Objectives of the article:

1. To reveal the essence and danger of disinformation in war and post-war conditions.
2. Describe the main AI technologies that can be used to combat fake news.
3. Analyze the practical aspects of using AI for monitoring, analyzing, and verifying information.
4. Consider existing Ukrainian and global practices of using AI against disinformation.
5. Identify the main challenges, limitations, and prospects for the application of AI in this area for Ukraine.

The full-scale invasion of Ukraine by the Russian Federation on February 24, 2022, is accompanied by an information war of unprecedented scale. Disinformation, propaganda, and manipulation have become an integral part of hybrid aggression aimed at undermining the morale of Ukrainians, discrediting the state leadership, splitting society, and distorting the real picture of events for the international community. In times of war, the speed of information dissemination, especially fake information, increases significantly, which creates serious threats to national security.

Disinformation will remain no less dangerous during the post-war reconstruction of Ukraine. At this stage, hostile narratives can be aimed at disrupting reconstruction processes, discrediting aid programs, undermining trust in the authorities and international partners, manipulating the investment climate, and inflaming social tensions. Effective counteraction to these threats requires a comprehensive approach and the involvement of the latest technologies.

One of the most promising tools in the fight against disinformation is artificial intelligence (AI). Its ability to process huge amounts of data, detect hidden patterns, analyze text, images, and video in real time opens up new opportunities for monitoring the information space, quickly detecting fakes, identifying sources of disinformation, and automating verification processes.

Disinformation is the deliberate dissemination of false or distorted information with the aim of misleading, manipulating public opinion, damaging reputations, or achieving political, military, or economic goals [1]. In times of war, disinformation becomes a powerful weapon that the aggressor uses to gain an advantage not only on the battlefield but also in the information space.

The main types of disinformation actively used against Ukraine:

– outright lies (fake news):reports about non-existent events, victories, losses, crimes (for example, fakes about "biolaboratories", "dirty bomb", "Nazi regime" in Ukraine);

– manipulation of facts: using true facts in a distorted context, selective quoting, shifting emphasis to create a false impression;

– propaganda: systematic dissemination of certain ideas, narratives, and stereotypes to shape desired public opinion (e.g., narratives about "historical unity," "liberation mission");

– Deepfakes: AI-generated realistic photo, video, and audio fakes, where one person's face or voice is replaced by another [2]. This can be used to discredit political and military leaders;

– astroturfing: creating the illusion of mass support for a certain idea or position through the use of fake accounts, bots, and comments;

– spreading rumors and panic: launching information aimed at destabilizing society, instilling fear, distrust of the authorities and the army (for example, rumors of surrender, lack of resources).

The dissemination of such information occurs through various channels: social networks, messengers, media outlets controlled by the aggressor, anonymous Telegram channels, as well as through hacked accounts and websites.

The consequences of spreading disinformation in wartime are extremely devastating:

– undermining national unity and trust: attempts to divide society along linguistic, regional, or political lines, to sow distrust in the authorities, the Armed Forces of Ukraine, and volunteers;

– demoralization of the population and the military: spread of panic, disbelief in victory, discrediting the command;

– obstruction of mobilization and defense: spreading fakes about losses, service conditions, and weapon effectiveness;

– complication of the humanitarian situation: spreading false information about evacuation, the operation of humanitarian corridors, and the distribution of aid;

– discrediting Ukraine in the international arena: attempts to present Ukraine as a failed state, to justify aggression, to disrupt the supply of weapons and the provision of financial assistance [3];

– economic losses: Although the direct impact on the economy during active hostilities is difficult to assess, disinformation can indirectly affect financial markets (when it comes to international aid), logistics (fakes about road hazards), and trust in the banking system.

After the end of active hostilities, the information space will remain a battlefield. Disinformation campaigns will be adapted to the new realities and aimed at disrupting the country's recovery process. Main threats:

– discrediting the reconstruction process: spreading narratives about corruption in the distribution of reconstruction funds, inefficiency in the use of international aid, and low quality of work. The goal is to undermine the public's trust in the authorities and international partners, and slow down the reconstruction processes;

– manipulation of the investment climate: dissemination of negative or distorted information about the economic situation, security risks, and the legislative framework to scare away foreign investors;

– social destabilization: inciting conflicts between different groups of the population (for example, between those who left and those who stayed, between military and civilians, residents of different regions) through the dissemination of manipulative messages;

– undermining trust in international partners: spreading fakes about non-fulfillment of obligations, "Ukraine fatigue", ulterior motives for assistance;

– distortion of historical memory: continuing attempts to rewrite history, justify aggression, impose one's own vision of the past and future.

Countering these threats will require no less vigilance and resources than in wartime, and technological solutions, including those based on AI, will play a key role in protecting the information space during the recovery phase.

Table 1 lists the key AI technologies used to monitor the information space.

Table 1

**AI technologies and their application for monitoring**

| AI technology | Monitoring and analysis applications | Examples of tasks |
|---|---|---|
| NLP | Analysis of text content in news, social networks, blogs | Identifying key themes/narratives, tone analysis, identifying propaganda markers, hate speech |
| ML | Classification of large volumes of data, detection of distribution patterns | Identification of coordinated campaigns, detection of bot activity, prediction of content virality |
| Computer Vision | Visual content analysis (photos, videos) | Search for image manipulation, track the spread of memes and visual fakes |
| Network Analysis | Analysis of connections and interactions in social networks | Detection of botnets, identification of influential nodes (influencers) in the spread of disinformation |

*Source: developed by the authors*

Artificial intelligence (AI) is a branch of computer science that deals with creating systems that can perform tasks that normally require human intelligence, such as learning, problem solving, pattern recognition, and language understanding [4]. The potential of AI to counter disinformation lies in its ability to analyze vast amounts of data much faster and more efficiently than humans.

Different AI technologies complement each other, providing a comprehensive approach to monitoring and analyzing the information space. NLP works with text, Computer Vision with images, ML and Network Analysis help detect complex patterns and connections, which allows us to not just capture individual fakes, but to see holistic disinformation campaigns.

In addition to monitoring, AI can become an important tool for fact-checkers and analysts in the process of verifying information:

– automated fact checking: AI systems can automatically match claims in publications with fact-checked databases, encyclopedias (such as Wikipedia), official statements, and reports. This significantly speeds up the process of verifying large amounts of news;

– source reliability assessment: AI can analyze a website or account's publication history, its connections to other sources, and the presence of contact information to assess its level of trustworthiness. Some tools provide "trust ratings" for information sources [7];

– identifying authorship and style: by analyzing the style of a text, AI can help determine whether the text was written by a human or generated automatically, and in some cases, even identify the likely author or group of authors if there are samples of their texts;

– identification of deepfakes: specialized AI algorithms are trained to recognize microscopic artifacts and inconsistencies in deepfake video and audio that are difficult for the human eye or ear to notice [2];

– aggregation of evidence: AI can collect and structure information from various sources (text, photos, videos, data from

social networks) related to a certain event or statement, helping analysts form a complete picture and draw a conclusion about reliability.

It is important to note that at this stage, AI is seen primarily as an auxiliary tool for verification, which significantly speeds up and automates routine processes, but the final decision on the veracity of information often requires human expert assessment.

Combating disinformation using AI is a trend that is actively developing both in Ukraine and around the world.

In Ukraine:

1. Government agencies. The Center for Countering Disinformation at the National Security and Defense Council of Ukraine and other government agencies actively monitor the information space, although there is still little public information about the widespread use of complex AI systems. The main focus is on identifying and refuting hostile narratives [8]. Cyber police use analytical tools to detect bot farms and coordinated attacks.

2. Civil society organizations and fact-checking projects. Initiatives such as StopFake, VoxUkraine, and Detector Media are actively working to refute fake news. They can use available AI tools to monitor social media, find original sources, and verify images, but often the main work is done by analysts [9].

3. Technology sector. Ukrainian IT companies and startups are developing their own solutions for data analysis and manipulation detection. For example, YouControl has created a tool for checking connections between individuals and companies, which can be useful for detecting hidden influences. Respeecher, a company working with voice cloning technologies, is also researching methods for detecting voice deepfakes [10]. Osavul is a Ukrainian startup that uses AI to detect hostile information operations [11].

International experience:

1. Large technology companies. Google, Meta (Facebook, Instagram), Twitter (X), TikTok are investing significant resources

in developing AI algorithms to automatically detect and limit the spread of disinformation, hate speech, spam, and fake accounts on their platforms [12]. They use a combination of AI and human moderation.

2. Academic research. Many universities and research centers around the world are working to create new, more advanced AI models to detect various types of disinformation, including deepfakes.

3. International organizations and projects. The European Union funds research and development of tools to combat disinformation under the Horizon Europe programs. There are projects aimed at creating common databases of fake news and developing verification standards. For example, the European Digital Media Observatory (EDMO) brings together fact-checkers, researchers, and media experts [13].

Table 2 provides examples of AI applications to counter disinformation, demonstrating the use of NLP, ML, Computer Vision, and Network Analysis technologies to detect fake information, monitor information operations, and develop specialized tools in social media, fact-checking, public security, and technology startups.

The use of AI to combat disinformation is multifaceted and spans sectors from global technology platforms to specialized government agencies and community initiatives. While the technologies used are often similar (NLP, ML, Computer Vision), their specific application and scale vary depending on the organization's goals and resources.

Despite its significant potential, the use of AI to counter disinformation faces a number of serious challenges and limitations:

– "Arms race": Disinformation technologies, especially deepfakes, are also constantly being improved with the help of AI. This creates a constant need to update and improve detection algorithms [2];

– complexity of context and sarcasm: AI often has difficulty understanding context, irony, sarcasm, or cultural nuances, which can lead to false positives or false negatives;

Table 2

**Examples of using AI to counter disinformation**

| Scope of application | Organization / platform | AI technologies | Goal |
|---|---|---|---|
| Social networks | Meta, Google (YouTube), X | NLP, ML, Computer Vision, Network Analysis | Automatic detection and labeling/removal of fakes, hate speech, spam, bots, deepfakes |
| Fact-checking | StopFake, EDMO, others | NLP (support), Computer Vision (image search), ML (source evaluation) | Acceleration of the verification process, monitoring the spread of fakes, analysis of sources |
| State security | Central Security and Defense Council of Ukraine, Cyber Police | ML (anomaly detection), Network Analysis (bot networks), NLP (topic monitoring) | Detecting information operations, identifying hostile narratives, investigating cyberattacks |
| Technology startups | Osavul, Respeecher | ML, NLP, voice analysis technologies | Development of specialized tools for detecting IPSOs and deepfakes |

– the problem of "Novyzna": AI models are trained on known examples of disinformation. New, previously unseen types of fake news or narratives may be missed by the system until it is retrained;

– data manipulation and bias: the quality of AI depends on the data it is trained on. If the training data contains biases or is unrepresentative, the AI may reproduce these biases. There is also the risk of malicious actors deliberately poisoning the training data;

– language barriers: Most advanced AI models are designed for English. Their efficiency with Ukrainian may be lower, although this area is actively developing;

– need for human control: Full automation of the process of combating disinformation is currently impossible and undesirable. Human oversight and expert assessment remain critical to avoid errors and abuses [5; 6];

– ethical dilemmas: Where is the line between combating disinformation and censorship? How to ensure the transparency of AI algorithms? These issues require thorough public and expert discussion;

– resource intensity: Developing, training, and supporting complex AI systems requires significant computing resources, large amounts of data, and highly skilled professionals, which can be a challenge for many organizations.

Table 3 lists the main challenges of using AI against disinformation, including the adaptability of disinformation, insufficient understanding of context, data bias, the problem of novelty, the need for human control, ethical issues, and high resource intensity.

Effective use of AI to counter disinformation requires understanding and overcoming a number of technical, ethical, and resource challenges. The "arms race" with fake news creators, the difficulty of understanding context, the potential bias of algorithms, and the need for human oversight are key limitations that need to be considered when designing and implementing AI solutions.

During the post-war economic recovery of Ukraine, the role of AI in countering disinformation may become even more significant. Promising directions:

– monitoring of targeted economic attacks: AI can track and analyze information campaigns aimed at discrediting specific recovery projects, economic sectors (e.g., agriculture, energy), or international financial institutions providing assistance;

– analysis of public sentiment regarding recovery: Using NLP to analyze discussions on social networks and the media will allow authorities and international partners to better understand citizens' concerns, identify points of social tension fueled by disinformation, and respond in a timely manner;

Table 3

**Key challenges in using AI against disinformation**

| Challenge / Limitation | Description | Possible consequences |
|---|---|---|
| The adaptability of disinformation | Constant improvement of methods for creating fakes (especially deepfakes) | Decreased efficiency of detection systems, need for constant updating of algorithms |
| Understanding context and nuance | AI does not recognize irony, sarcasm, or cultural context well | Content misclassification (false positives/negatives) |
| Data Bias (Bias) | Training data may contain hidden biases that are reproduced by AI | Discriminatory decisions, unfair blocking of content for certain groups |
| "The problem of novelty" | AI is bad at detecting new, previously unknown types of disinformation | Skipping new threats before updating the model |
| The need for human control | AI is a tool, not a human replacement; expert supervision is needed | Risk of errors with full automation, need for resources for experts |
| Ethical issues | Balance between security and freedom of speech, transparency of algorithms | Risk of censorship, public distrust of technology |
| Resource intensity | High requirements for computing power, data, and personnel qualifications | Limited access to advanced technologies for smaller organizations or countries |

*Source: developed by the authors*

– investment image protection: AI systems can help quickly detect and refute fakes aimed at scaring off investors, providing

potential investors with access to verified information about the business climate and opportunities in Ukraine;

– information verification for businesses and citizens: creating accessible AI-based tools (e.g., chatbots, browser extensions) that would help citizens and entrepreneurs quickly check the reliability of news related to the economy, support programs, and business conditions;

– forecasting information threats: the development of AI models capable of predicting the likely directions of future disinformation attacks on the economic sphere will allow preventively strengthening relevant communication channels and preparing rebuttals;

– increasing media literacy: AI can be used to create personalized media literacy curricula tailored to the needs of different populations, helping them better recognize manipulation.

Successful implementation of these prospects will require coordinated efforts by the state, the technology sector, civil society, and international partners, as well as continued investment in technology development and training of specialists.

Conclusions. Disinformation is a serious threat to Ukraine both during a full-scale war and during the post-war recovery phase. It is aimed at undermining national security, social unity, economic stability, and international support. The scale and speed of the spread of fake news in the modern information space require the use of the latest technological solutions for effective countermeasures.

Artificial intelligence shows significant potential as a tool in this fight. Technologies of natural language processing, machine learning, computer vision and network analysis allow to automate and significantly accelerate the processes of monitoring the information space, detecting fakes and manipulations, analyzing propaganda narratives, identifying sources of disinformation, including botnets and coordinated campaigns, as well as verifying content, in particular detecting deepfakes.

The practical application of AI to counter disinformation is already taking place at the level of global technology platforms, government agencies, public organizations, and technology companies both in Ukraine and around the world. However, there are significant challenges and limitations: the constant improvement of fake news creation technologies, the complexity of analyzing the context and nuances of human language, the risks of algorithmic bias, ethical dilemmas, and the need for significant resources and human control.

In the future, especially in the context of the post-war recovery of Ukraine's economy, the role of AI may grow. It can help monitor targeted economic attacks, analyze public sentiment, protect the investment climate, verify information important to citizens and businesses, and predict new information threats.

To maximize the potential of AI in countering disinformation, Ukraine needs to:

– invest in developing our own and adapting existing AI solutions focused on the Ukrainian context and language;

– promote cooperation between government agencies, the IT sector, scientists, and civil society;

– to ensure the training of qualified specialists in the field of AI and data analysis;

– develop a clear ethical and legal framework for the use of AI for content moderation, ensuring a balance between security and freedom of speech;

– to increase the overall level of media literacy of the population, as technology is only part of a comprehensive solution.

**Conclusions.** Artificial intelligence is not a panacea for disinformation, but it can become a powerful tool in the hands of those who seek to protect the truth and ensure the sustainable development of Ukraine in the context of information challenges of war and peace. A comprehensive approach that combines technological innovation, human expertise, media literacy, and effective regulation is the key to building a society resilient to disinformation.

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## NOTES

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