Artificial Intelligence in Established of Industry 4.0

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Abstract: The purpose of scientific research is to present the features of digitization of business processes using artificial intelligence at enterprises as a foundation on which the gradual formation of Industry 4.0 is built and the search for reserves of socio-economic growth in the conditions of the development of digital ecosystem and digital entrepreneurship. Presentation of a number of positive and negative consequences of the influence of artificial intelligence on the operation of digital infrastructure, as well as to indicate possible approaches in the practical application of artificial intelligence based on the substantive characteristics of its construction. The results and forecasts of four waves of modern development of artificial intelligence are presented, including: increasing the profits of Internet companies, monetization of creative Internet applications; reducing the number of cases of non-repayment of loans, establishing objective diagnoses, court decisions, etc.; protection of phones and digital wallets; payment by face scan. It was determined that the expected high-quality product of the fourth wave of modern development of artificial intelligence will be computer intelligence that understands and changes the world, a direct economic benefit first of highly structured environments, and then of other spheres of human activity. The peculiarities of the application of artificial intelligence in the course of the formation of digital enterprises of Industry 4.0 are revealed. The possibilities and advantages of the application of technical capabilities on which the development of artificial intelligence technology is based are analyzed. Approaches to the practical use of artificial intelligence are indicated, including: the synthesis of a human likeness with an independent thinking platform; predictive analytics; methods of control, planning and dispatching; storage, processing and presentation of knowledge. Having conducted a thorough analysis in parts of the acceleration of deep digitalization of business processes with the help of artificial intelligence, authors determined the impact of digitalization process and the operation of digital platforms on the transformational

changes of enterprises. It has been found that digitalization lowers the barriers to market entry for small businesses, which have significantly expanded their niche and limited the monopoly of large companies, and the development of digital platforms determines the so-called network effects, when a large number of platform users creates conditions for the emergence of even more consumers. The directions for the development of artificial intelligence technologies are proposed, among which are named: creation of tools for users that allow to simplify the configuration of AI components of systems and to perform some actions without the involvement of developers. A step-by-step algorithm for setting up AI models is defined, namely: definition of the goal; tool selection; configuration and training of the model; hypothesis testing and model optimization; analysis of results.

Key-Words: artificial intelligence, Industry 4.0, digitization of business processes, cloud technologies, intelligent solutions, digital transformation, Fourth Industrial Revolution.

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1 Introduction

Digital transformation of large enterprises is a complex and multi-stage process. However, this transformation is extremely necessary today, as drones and artificial intelligence are already helping industry save significant resources. Of course, changing processes that have been established for years or even decades, moreover, on the scale of huge productions, is a serious challenge. Despite frequent discussions of the benefits of digitalization, the practical result of innovation efforts is far from always obvious.

In industry, digitization has its own characteristics. When a large industrial enterprise unites many structural units, it is possible to effectively manage a large-scale IT infrastructure only with the help of a single center of expertise. Previously, each enterprise had its own IT department, but over time, as a result of the scaling of IT projects, the IT function is being centralized.

Artificial intelligence is increasingly penetrating our lives today, artificial intelligence technologies are already with us. Yes, in modern smartphones, a large number of applications use artificial intelligence, and these aren't only the well-known voice assistants, but also many other applications: keyboards, image processing programs, etc.

However, artificial intelligence is in demand not only in the world of mobile devices. The advantages of machine intelligence technologies attract the attention of business as well – SME implementation, practice in the enterprise segment. And if for the most progressive companies' artificial intelligence has already become a working tool, the implementation and development of which are actively being worked on by business users and IT experts, then for many Ukrainian organizations smart technologies are still something unattainable.

The development of Industry 4.0 caused the need to find new approaches to managing business processes at enterprises, offering a significant range of the latest digital technologies for the high-quality functioning of various sectors of the economy. Each industry, each company, by means of a preliminary analysis of opportunities and evaluation of the effectiveness of implementation and improvement, makes a choice in favor of one or another tool of Industry 4.0, including artificial intelligence. In harmony with these processes, digital transformation of the economy is being implemented, as its role in the deployment of smart industry and the use of artificial intelligence is constantly growing. The issue of studying practical experience of working with artificial intelligence requires further in-depth research.

Experts in the field of IT technologies claim that artificial intelligence technologies ensure the quality of decision-making, increase the efficiency of internal and external processes of the organization, and also improve the customer experience. But these are not all the advantages of using artificial intelligence, because today artificial intelligence makes it possible to significantly speed up processes, and speed nowadays is the main competitive advantage for most business structures.

2 Problem Formulation

2.1 Literature Review

The question of the conditions for the formation and development of Industry 4.0 based on artificial intelligence is only beginning to attract the attention of foreign and domestic researchers [1], including Kai-fu Li [13], Raymond Kurzweil [18], [19]. According to Kurzweil, in the future humanity will achieve almost unlimited material wealth, and people can become immortal. He also provided a scientific rationale for the technological singularity

– phenomenally rapid scientific and technological progress based on powerful artificial intelligence (superior to human intelligence) and the cyborgization of humans.

Scientists see the ultimate goal of their research on "artificial intelligence" in uncovering the secrets of thinking and creating a model of the brain. The fundamental possibility of modeling intellectual processes follows from main epistemological result of cybernetics, which is that any function of the brain, any mental activity, described in a language with strictly unambiguous semantics using a finite number of words, can in principle be transferred to an electronic digital computing machine. Modern scientific ideas about the nature of the brain give reason to believe that, at least in the purely informational aspect, the most essential regularities of the brain are determined by a finite (although perhaps extremely large) system of rules.

Based on the analysis of the experience of working with artificial intelligence, scientists have concluded that this is a technology that is the basis of our future, as it intersects with all aspects of human life: health, medicine, housing, agriculture, transportation, sports, even love, sex and death. Artificial intelligence is no longer a technological trend, a buzzword or a temporary pastime, but the third computer era. In the midst of fundamental changes, not similar to those experienced by the generation of the first industrial revolution [31].

In the scientific article "Artificial Intelligence: Learning and Limitations" [39] the authors A.P. De Oliveira, H.F.T. Braga analyzed main technologies used in artificial intelligence, the history of their development, presented their considerations regarding artificial neural networks and failures that arise as a result of the learning processes and the equipment used. The researchers presented their understanding of three types of errors: adversarial examples, soft errors, and errors due to lack of appropriate training. The researchers managed to carry out a practical study related to the third type of error and propose actions based on the basis of experiments. Goal pursued by scientists was to change the way artificial intelligence models are trained, add some rare conditions and improve their ability to predict with greater accuracy in any situation, soft errors and errors due to lack of proper training.

Artificial intelligence is able to ensure the correct and prompt solution of various socio-economic tasks, which will contribute to increasing the efficiency of state regulation. At the same time, the rapid development of the latest technologies, in particular artificial intelligence systems, the Internet of Things, cloud technologies, necessitates the introduction of institutional changes. These results are presented in scientific papers and articles by S.J. Russell, P. Norvig [26], A. Bundy, R. Burstall [5], N.J. Nilsson [23]. Some other relevant studies can be found in [6], [7], [8], [9], [10], [14], [16], [25].

A galaxy of well-known researchers in the scientific world, such as V. Ifantis, K. Ntalianis, P. Ntalianis, are dealing with the issues of studying the possibilities of the introduction of artificial intelligence in the public sector and in the field of education [38]. Scientists have succeeded in presenting the concept of public offices without employees, where the concept of public administration is applied through the synergy of artificial intelligence and other technologies aimed at improving the service of citizens even in extreme conditions such as pandemics and physical disasters. The proposed design complements the out-of-office Amazon Go store and the latest cutting-edge e-government technologies.

Scientists S. Russell and P. Norvig in their book entitled "Artificial Intelligence: a Modern Approach" [26] made an attempt to present the stimulus for development of artificial intelligence as a science of designing rational agents. "Life 3.0. The Age of Artificial Intelligence" is a book by the Swedish-American astrophysicist, one of the most authoritative researchers of artificial intelligence, Professor M. Tegmark of the Massachusetts Institute of Technology [29], in which the author considers possible scenarios of the development of events in the event of the appearance of super intelligent artificial intelligence on Earth, analyzes the prospects for the development of high technologies, their opportunities and risks.

M. Tegmark calls on experts to join forces in the fight for cyber security and "friendly" artificial intelligence. M. Tegmark points out that humanity perceives the mind as something extremely mysterious from a biological point of view. At the same time, he claims: such ideas have no basis. The author insists that for the generation of machines, intelligence (which will be better than human) is not an obstacle. Organic matter has no effect on the mind. Physicists admits that artificial intelligence has high risks: it will either radically change everyone's life for the better, or it will become the most dangerous phenomenon in the history of mankind. And in order to eliminate these risks, humanity should conduct discussions on this issue more often.

Scientists K.R. El Helou, A.-B. M. Salem [36] in their research raised the issue of the role and

effective combination of artificial intelligence and machine learning in helping humanity cope with the coronavirus pandemic. Thus, researchers believe that machine learning can help make the right decision in time, save lives and reduce health care costs. The mediating effect of artificial intelligence is researched by scholars Y. Suleiman, M.A. Rahman, N.K.N. Mat in their work "A Conceptual paper on Re-Patronage Model for Syariah Compliance E-lodging Industry: The Mediating Effect of Artificial Intelligence" [37]. This study aims to analyze the predictors of Muslim tourists' online repeat patronage intentions towards Shariah compliance in the e-accommodation industry in Malaysia. The AI wave in the business landscape is said to combat human error and increase customer satisfaction through their efficiency and ability to meet human needs. Therefore, this study also aims to cover the implementation of AI in the hotel industry and specifically the Syariah compliance of hotels.

Despite the fact that the problem of "artificial intelligence" is closely related to the needs of practice, there is no single general practical task that would clearly determine the development of theory and methodology, but there are many tasks that are partial and narrow. Therefore, the problem of "artificial intelligence" is, in fact, a whole complex of problems characterized by varying degrees of generality, abstractness, complexity, and sophistication, each of which has its own fundamental and practical difficulties. These are such problems as pattern recognition, learning and self-learning, heuristic programming, creating a general theory of self-organizing systems, building a physical model of a neuron, many of which have great independent significance. Important results, both of a practical and theoretical nature, have been obtained for all these directions, and intensive research continues. Since, apart from a small number of optimists, almost no one is trying to "produce" intelligence similar to humans, then we are talking about creating a system that will be able to implement certain models of intelligence.

Among the cohort of researchers engaged in revealing the content of methods and systems of artificial intelligence in the era of digital economy can be named N. Andrusyak [31], V. Gitis, K. Hudkov [8], M. Hlybovets, O. Oletskyi [9], N. Shakhovska, R. Kaminskyi, O. Vovk [], N. Kraus, K. Kraus [17-19], D. Pchelyanskyi, S. Voinova [24], O. Manzhura [20-21], O. Yershova, L. Bazhan [35], O. Marchenko [22], O. Shtepa [28], N. Yasynska [34]. The analysis of the noted recent studies proved the need for a comprehensive approach to finding ways to implement the directions of artificial intelligence development, namely in solving problems related to the approximation of specialized artificial intelligence systems to human capabilities and their integration, which is realized by human nature, and in the creation of Artificial Intelligence, which represents the integration of already created artificial intelligence systems into a single system capable of solving humanity's problems.

2.2 Purpose of the Article

The purpose of the publication is to present the characteristic features of the application of artificial intelligence as the foundation on which the gradual formation of Industry 4.0 is built and the search for reserves of socio-economic improvement in the conditions of innovation and digitalization, which has every chance of becoming a decisive step in the formation of a virtual space with augmented reality in a harmonious combination with the real, the physical world.

2.3 Tasks of the Article

Among the tasks set in the article are: argumentatively reveal the peculiarities of the implementation of artificial intelligence in business processes by enterprises using the example of progressive companies; to determine and reveal the content of the possibilities of practical application of artificial intelligence in the course of digitizing the business processes of Industry 4.0 enterprises in the conditions of digitization; to present the results and forecasts of four waves of modern artificial intelligence development in parts of the formation of Industry 4.0; to reveal the step-by-step algorithm for setting up AI models; to analyze the effects of the digitization process and the operation of digital platforms on the transformational changes of companies; to present the possible directions of changes aimed at accelerating Industry 4.0 and implemented by managers of modern progressive enterprises as a result of the involvement of artificial intelligence; to indicate technologies on which the development of artificial intelligence technologies is determine directions of their development.

2.4 Methodology

On the basis of dialectical, systemic and matrix methods, the use of artificial intelligence capabilities by digital enterprises of the Industry 4.0 ecosystem, which determine socio-economic effects and virtual format of business work, was investigated. The research used general scientific methods, such as methods of analysis and synthesis,

induction and deduction, in order to find out the positive and negative consequences of the impact of artificial intelligence technology as the newest tool for the development of Industry 4.0. The method of scientific description made it possible to outline the main characteristic features of the use of artificial intelligence and to indicate correct and incorrect actions during its application. A comparative analysis was used in the part of revealing the step-by-step algorithm for setting up AI models; features of using artificial intelligence in business; elucidation of the influence of the digitization process and the operation of digital platforms on the transformational changes of companies; features of the application of technologies on which the development of artificial intelligence is based and to determine the directions of their development.

3 Problem Solution

3.1 The Essence of Artificial Intelligence and the Scope of Its Penetration

Cyber-physical systems and other breakthrough achievements of "Industry 4.0" radically change the world of people themselves and begin to compete with the latter. The activities of business entities, both new organizational forms and traditional ones that adopt digital technologies, are increasingly connected with virtual reality, as it includes the use of online services, cloud services, social networks, e-commerce and artificial intelligence. Digital initiatives using elements of artificial intelligence technologies have helped businesses adapt to the conditions of Covid-19 pandemic. It was digital initiatives that minimized the involvement of people in day-to-day operations and contributed to the optimization of business processes.

The use of AI is the ability of a digital computer or a computer-controlled robot to perform tasks usually associated with human activities. This term is often applied to the project of developing systems endowed with human-characteristic intellectual processes, such as the ability to reason, discover meaning, generalize, or learn from past experience [2]. Today, the concept of "artificial intelligence" is gaining more and more direct meaning. It is understood that developments correspond to the essence of the term, that is, systems are created that can process the information that comes to them, connect it with the knowledge they already have and form their own idea about the objects of knowledge. But at the beginning of the formation of such a phenomenon as artificial intelligence, the term had a different form of interpretation in accordance with the content and essence of the inventions of that time. Artificial intelligence could be defined as "a device for enhancing mental abilities".

An early example of artificial intelligence is Wilhelm Schickard's mechanical digital calculating machine (a device functionally similar to a calculator that could add and subtract six-digit numbers with a bell ringing when it overflowed), which dates back to 1623. At the end of the 18th century Austrian inventor Friedrich von Knaus designed a series of machines that could write rather long texts with a pen. The next person who achieved success in creating artificial intelligence at that time was the English mathematician Charles Babbage, who came up with the concept of a complex digital calculator – an analytical machine that could calculate moves for a game of chess [24].

In today's conditions of innovative development, artificial intelligence can be understood as a field of computer science that deals with the modeling of intellectual behavior in computers – Merriam-Webster Dictionary [4]. According to the interpretation of the Cambridge Dictionary, artificial intelligence is considered as "the ability to produce machines that have certain qualities of the human mind, such as the ability to understand language, recognize images, solve problems and learn" [3]. Examples of such AI include robot manufacturing, intelligent assistants, proactive healthcare management, automated financial investing, virtual travel booking agent, social media monitoring, cross-team chat tool, conversational marketing bot, and natural language processing (NLP) tools.

It would not be a mistake to interpret artificial intelligence as a new technology with a huge potential to forever change the world as we know it. Artificial intelligence finds application in many areas of human activity, including services, industry, education, social networks, transport. However, scientific publications rarely discuss the accuracy and reliability of such technology, which has found application in situations where a person's life depends on his decision-making process, which is the result of his training, one of the stages of development. It is known that the learning process of artificial intelligence, which can use the technology of artificial neural networks, presents an error of the predicted value in relation to the real value, which can compromise its application, being more critical in situations where the safety of the user is the main concern [39, p. 80].

Artificial intelligence can be considered as a complex of technological solutions that imitate the cognitive functions of a person and allow to achieve

results comparable to the results of human intellectual activity when performing tasks [15]. The scientific point of view is also interesting: artificial intelligence is the simulation of the processes of human intelligence by machines, especially computer systems. These processes include learning (acquiring information and rules for using information), reasoning (using rules to reach approximate or definite conclusions), and self-correction. Special applications of artificial intelligence include expert systems, speech recognition, and machine vision [32].

Artificial intelligence is present in all areas of digital transformation, as the growing amount of data exceeds the human capacity to process it. At the beginning of the development of computing technology, AI was considered as technologies that can reproduce human intelligence and even surpass it using electronic computing technology. Such technologies were used to develop theoretical and methodological foundations of forecasting, planning and optimization of procedures and parameters of technical and economic systems [35, p. 53].

3.2 Practical Application of Artificial Intelligence in Today's Conditions

Despite the fact that artificial intelligence is still far from perfect, its impact on the global economy has been felt since the beginning of 2018. Technologies such as computer vision, intelligent decision-making, and machine learning have already radically changed various sectors of the economy around the world, but this is only a small part of the overall capabilities of artificial intelligence.

Covid-19 pandemic accelerated the adoption of AI, changing the attitude of international business to new technologies, and in many ways served as a driver for the development of the market for AI solutions. In the future, business will show even more demand for more complex solutions that integrate AI with other digital technologies, including the Internet of Things, new generations of communication, and distributed ledger systems. In the near future, this will allow the transition from fragmented to systematic development of AI technologies throughout the value chain. In the future, AI solutions deployed in the cloud infrastructure will become widespread, showing that companies find the deployment of smart technologies in the cloud to be a more efficient and flexible process. Approaches in practical application of AI, based on the content characteristics of its construction, we tried to present in Figure 1. The results and forecasts of the four waves of the modern development of artificial intelligence are presented in Table 1.

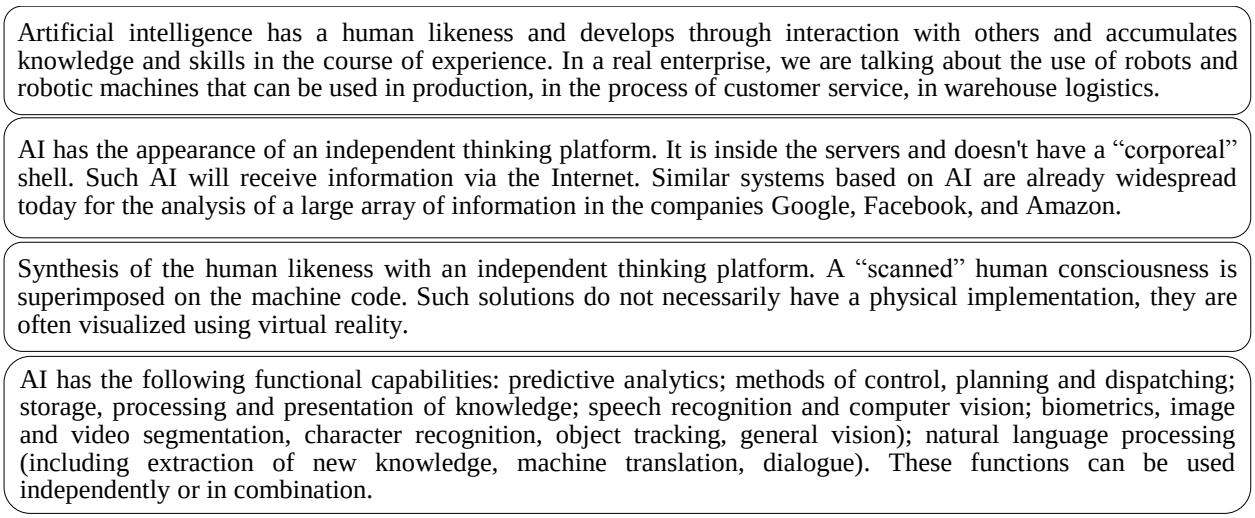

Fig. 1: Approaches in the practical application of AI based on the content characteristics of its construction
Source: composed by authors

Table 1. Results and forecasts of four waves of modern artificial intelligence development

Time period	Products	Practical application	Expected results
1	*2*	*3*	*4*
The first wave is Internet AI (status – implemented). The peak of success – 2012, the preparatory stage – 1997-2011	Recommender algorithms based on personal preferences, fake news recognition algorithms, targeted digital advertising, personalized Internet user content	Clicks and likes of Internet users	Increasing profits of Internet companies, monetization of creative Internet applications
The second wave is business AI (status – implemented, at the stage of completion). Peak of success – 2019-2022, preparatory stage – 2003-2018	Recommendation algorithms of banks' credit policy, algorithms for recognizing diagnoses based on patient analysis indicators, structuring of big data, speech recognition tools and natural voice processing during legal proceedings	The number of requests for technology use	Fewer loan defaults, establishing objective diagnoses, court decisions, etc., autonomous cyber-physical production, unmanned transportation, localization of production, ludic community practices, lifelong learning, LegalTech, FinTech, InsurTech. Artificial intelligence has caused the emergence of new jobs in terms of their functional content
The third wave is AI of perception (it affects people) (status is in the implementation stage). The year of implementation is 2020, the preparatory stage is 2003-2019	Algorithms for recognizing faces, sounds, city traffic flows, individual educational programs, digital models of human behavior (including financial)	The speed of proliferation of sensors and intelligent devices	The physical world is transformed into digital data, which will later become part of deep learning algorithms; protection of phones and digital wallets; payment by face scan, new learning system. Manufacturers of artificial intelligence and endowments try to make its application "transparent" and understandable for people (due to misunderstanding, fears arise among main mass of the population about products that act on the basis of artificial intelligence)
The fourth wave is autonomous AI (status – planned)	Computer intelligence, which understands and changes the world, is a direct economic benefit first of highly structured environments, and then of other spheres of human activity	There are no data yet	Artificial intelligence will perform tasks that meet two criteria: they can be optimized based on data analysis and do not require social interaction. Artificial intelligence will deepen its penetration into business. Artificial intelligence will increasingly become the subject of international politics (in particular, the issue of competition and struggle between states)

Source: compiled by authors based on sources 34; 13; 25

The development of hardware and software tools is necessary for the implementation of artificial intelligence technologies, namely:

- Hardware and software platforms for implementing methods and algorithms of artificial intelligence;
- Conclusion machines and their operating systems;
- Data repositories for machine learning.

The spheres of application of artificial intelligence technologies in various sectors of the digital economy are business processes in industrial production, agriculture, transport systems, logistics, construction, energy, the banking sector, trade, medicine, national security, education, urban infrastructure, public administration. The development of artificial intelligence is associated with the development of standards that should take into account both universal work on standardization of information systems and technologies, and areas specific to intelligent data processing systems. At the same time, for the development of products and services based on artificial intelligence, an unambiguous interpretation of the concepts used by all participants in the digital transformation of the economy is necessary [35, p. 53].

The development of basic artificial intelligence technologies is based on a number of technologies presented in Figure 2.

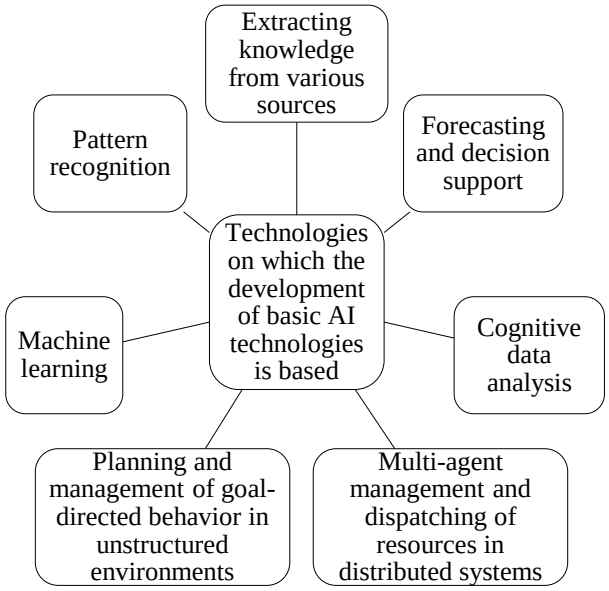

Fig. 2: Technologies on which the development of artificial intelligence technologies is based
Source: composed by authors

AI technologies are developing very quickly and in different directions. The tools of predictive analytics, natural language processing, etc. have already shown their effectiveness. So, with the use of machine learning models, the Creatio system can predict the values of various fields, carry out categorization, calculate the probability of given events, rank data and much more.

As part of the problem of the article, it should be noted that according to the Country-level digital competitiveness rankings worldwide 2020 [33], Ukraine received 48.81 points out of 100 possible. USA, which is recognized as the most competitive country in the world (100 points), has the best result, Singapore is in second place with 98.05 points. Digital competitiveness rating is aimed at analyzing the country's ability to apply digital technologies and implement these technologies at enterprises and government organizations.

The ranking showed that many Scandinavian countries took high positions in the list and are among the top ten: Denmark – 96.01 points, Sweden – 95.15 points, Norway – 92.17 points and Finland – 91.13 points. According to another study published by the company IoT Analytics Industry 4.0 & Smart Manufacturing, in 2020 the most common digital technologies used in the world are: 3D printing, 5G Internet, artificial intelligence (Artificial Intelligence), augmented reality, automated guided vehicles (Automated Guided Vehicles – AGV), blockchain technologies (Blockchain), cloud technologies, cobots (Cobot), cyber security, Digital Twin, drones, IoT and IoT platforms, quantum computing and virtual reality [11].

According to leading experts [40] in the field of cyber security, over the past few years there has been a transition from the stage of cybercrime to the stage of cyberwar. In order to adequately respond to new challenges, the expert environment has two main approaches: to adopt the philosophy and methods of military intelligence and to use artificial intelligence methods to counter cyber-attacks.

3.3 Use of Artificial Intelligence: Experience and Benefits

Already in 2020, about 30% of all B2B companies used AI in at least one of their main sales processes. Instead, according to experts' forecasts, by 2030 already 70% of these companies will use at least one AI tool. One of the first tasks that artificial intelligence developers were given was communication with real people in companies working in the B2C segment.

So, modern CRM systems – systems that manage relationships with customers – no longer provide for personal communication, but actively use bots, automatic responses and AI. Undoubtedly, this affects the management of communication with consumers. Such communication differs from communication with a real consultant, which affects the level of consumer loyalty and can lead to negative consequences [6, p. 5].

With AI, machines can perform human-like tasks, adapting to new data and continuously learning from experience. It is learning from experience that is the main driver of the development and application of technologies based on the use of a large amount of accumulated data. You can teach the system to make decisions the way a person would, and sometimes even find patterns and regularities that are difficult for a person to find, thus increasing the effectiveness of the decisions made. Moreover, receiving new, more relevant experience, systems are able to relearn or relearn, which makes it possible to always maintain the knowledge and skills of machines in an up-to-date state.

In addition to the undeniable advantages that AI technologies provide, there are also a number of difficulties that companies face in the process of their configuration and implementation. Research data on the use of artificial intelligence indicates that only 23% of organizations have implemented AI in their business processes, while 36% of companies do not use artificial intelligence technologies. The reasons for such indicators are, in particular, that these companies are not very knowledgeable about the use of such tools.

On the one hand, the development of most software for business is quite simple – there are many ready-made tools, and over the years of their design, best practices have been formed that can be easily applied. And things are going well with internal development – it is not difficult to find a specialist on the market who can design a system, develop or adapt it to business needs. After all, recently, leading software providers, in particular Terrasoft, have been offering clients so-called low-code and no-code tools that make it possible to create and adapt software products without knowledge of programming languages – only by the efforts of business analysts.

On the other hand, the implementation of AI technologies is accompanied by a number of difficulties. First, there is a lack of knowledge, because there are a large number of artificial intelligence algorithms that are quite complex, both mathematically and technically, and require specific skills and knowledge.

Secondly, the complexity of the design, since the stage of designing the model is difficult and very important. It is necessary to choose the right data for training the model; determine the parameters on the basis of which the system will operate; select the used algorithms. The presence of an error or inaccuracy at this stage can lead to a low accuracy of the system, which is unacceptable. In order to avoid errors and inaccuracies, it is worth practically using the possibilities of automatic and automated management. It is automatic control systems (ACS) that are a technical analogue of human intelligence. Modern automated control systems are built on the basis of digital devices – computers and microprocessors.

The basis of such systems is complex software that uses both simple calculation algorithms and algorithms based on artificial intelligence – neural networks and fuzzy logic. ACS is used to manage any modern processes and productions. A modern enterprise functions almost without human intervention. Intervention in the work of the enterprise is necessary only in the event of an emergency – an accident or equipment breakdown. Many enterprises have introduced remote control via the Internet or via mobile applications.

Thirdly, the complexity of the implementation, given that the modeling of AI systems is carried out iteratively and is based on the selection of a number of hypotheses, due to which the process becomes longer and more resource-intensive.

However, despite the apparent difficulties, there are prospects that the situation will change for the better, because artificial intelligence technologies are constantly evolving and developing (Figure 3).

Nevertheless, one of the most important stages – model design, which includes data preparation, their preliminary processing, selection of features on the basis of which system training and forecasting will be carried out – remains the field of activity of narrowly specialized specialists in data analysis and processing (data scientists). But even here, thanks to the expansion of knowledge about artificial intelligence, as well as the development of technologies themselves, the situation is changing for the better. Consequently, more and more companies are successfully innovating in the field of AI and getting good results.

Developers of computer games are forced to use AI of one degree or another. Standard tasks of AI in games are finding a path in two-dimensional or three-dimensional space, simulating the behavior of a combat unit, calculating correct economic strategy, and so on. In 2018, a portrait of a fictional person drawn by AI was sold for $432,000. Before drawing Edmond Bellamy, the algorithm examined 15,000 portraits dating from the 14th to 20th centuries.

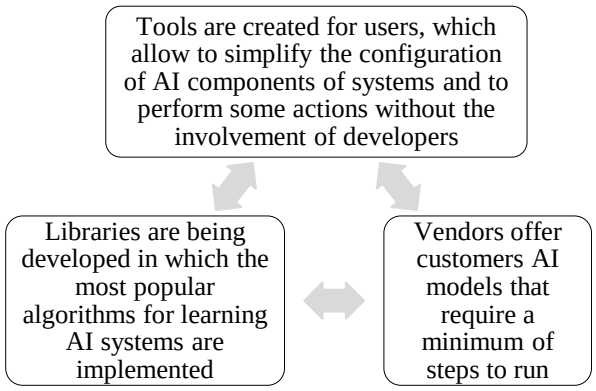

Fig. 3: Directions for the development of artificial intelligence technologies
Source: composed by authors

Companies using AI in sales have already been able to generate 50% more leads, 60-70% shorter call times and 40-60% lower costs. That is why 84% of modern companies implementing AI believe that it will provide them with a competitive advantage in the future. The use of AI technologies enables many advanced companies to focus their attention on achieving the result, leaving the system to analyze data and search for patterns. Therefore, the goal of the teams of these companies is to work on the development of AI technologies – to create tools that make it possible to use information from IT systems as efficiently as possible, to improve the quality of decisions made on the basis of historical

data, as well as to optimize processes.

Today, companies are trying in every possible way to set up AI tools in the simplest and fastest way possible, to minimize the need to involve expensive specialists to design models and explain the factors that affect one or another forecasting result. This makes it possible to increase trust in artificial intelligence, and also helps analysts of the Creatio system to quickly understand the logic of the model and its settings. Creatio's AI tools allow you to solve business tasks of various levels of complexity. But the practice of using artificial intelligence has shown that a solution does not have to be complex in order to be effective.

AI is a technical (in all modern cases of attempts at practical implementation – a computer) system that has certain signs of intelligence, i.e. is able to: recognize and understand; find a way to achieve results and make decisions; to learn in practical terms, the presence of only incomplete knowledge about the brain and its functioning doesn't prevent us from building approximate information models of it, simulating the most complex thinking processes, including creative ones, on digital computers.

3.4 Algorithm for Setting up AI Models

To implement a small and simple, but quite effective solution using Creatio AI tools, it is no longer necessary to involve developers and data specialists. The step-by-step algorithm for setting up AI models is not complicated (Table 2).

Table 2. Step-by-step algorithm for setting up AI models

Stage of setting up AI models	Procedure for achieving results
1	*2*
Stage 1 – Formation of the team	Finding a business expert who has a deep understanding of how the division works and can articulate the tasks that need to be solved. Thanks to working with such an expert, it is not necessary to involve narrow-profile specialists, because most of the answers are received from business representatives. They are the ones who can tell you what data is used in decision-making and what can potentially affect the performance of tasks.
Stage 2 – Defining the goal	Analysis of business unit goals and KPIs. So, for example, involved specialists are engaged in communications with potential clients (leads), and their task is to interest the interlocutor and arrange a meeting with him. Accordingly, the more scheduled meetings, the more efficient the unit's work.
Stage 3 – Tool selection	Creatio implements a platform for training models and solving tasks of classification (for example, to determine the category of sale, priority of the request), regression (for example, for predicting the amount of the order, processing time of the request) and scoring (for example, for calculating the probability of concluding a deal, the readiness of the lead to purchase). The most acceptable solution for the task is the use of scoring to predict the probability of the occurrence of a given event – successful communication with the client and the appointment of a meeting.
Stage 4 – Determination of model parameters	Consideration of the reasons for the expected result. The answer can be given by business experts. It is not at all necessary to engage a data scientist to analyze large arrays of historical data and search for correlations and patterns. Based on their experience, experts can show what will potentially affect the result, and based on this, you can choose the necessary parameters of the model. For example, the success of planning a meeting can potentially be influenced by: the presence of a contact's corporate e-mail; the number of other leads generated for the same client; number of newsletters read; ice source etc. Only about 10 parameters – and the hypothetical model is ready.
Stage 5 – Tuning and training the model	Machine Learning Models section of Creatio makes it possible to perform most of the settings by means of the user, using the basic capabilities of the system. It took 2-3 hours to set up all the necessary model parameters. After building the model, the process of learning it on a small amount of data is started. As a result, information is obtained about predictive accuracy and the degree of influence of each parameter on final result. This is a great opportunity to perform an initial analysis of the hypothesis, find parameters that do not affect the result and need to be excluded, or consider adding new factors and re-examine the model. After several iterations, a model of sufficient accuracy is obtained and a pilot project can be launched to evaluate the quality of the model on real data.
Stage 6 – Hypothesis testing and model optimization	To implement the model in the department's processes, it is worth setting up several queues with leads that are processed by employees. The first list includes leads with a probability of appointment (scoring score) from 75% to 100%, the second – with a probability from 0% to 75%. Within a few weeks after the launch of the pilot project, the conversion rate of the first stage was 32%, and the second stage was 12%, which proves the effectiveness of the adjusted model.
Stage 7 – Analysis of the results	Employees have changed the course of the process and now focus on a higher value of the scoring point when selecting leads. So, in a short period of time, with minimal costs, it is possible to increase the efficiency of the unit. It is based on three entities: historical data, intelligent self-learning algorithms and employee expertise. Work on process optimization does not end there. You can continue to iteratively experiment with parameters to improve the quality of the model, and add new intelligent features to further improve the results of the process.

Source: author's development

Revealing the content of the algorithm for setting up artificial intelligence models, it is worth noting that at Stage 5, a strategy for the development of cyber security education should be chosen based on:

international standardization documents; the conceptual model developed by the Joint Working Group on Cybersecurity Education; good practices of modular structure and dynamic building principles that allow for rapid content changes.

Based on the principles of "domains of knowledge" and "domains of application", each training course should be designed as a workflow for a specific application domain, consisting of modules that represent the relevant domains of knowledge. We share the opinion of scientists R. Trifonov, G. Tsochev, O. Nakov, G. Pavlova, S. Manolov regarding the need for decisive improvement of education through the introduction of dynamic principles and personalization in educational programs, which can be implemented with the help of so-called adaptive learning systems [41].

Nowadays, it is not the volume of collected data that matters, but how this information is organized, structured and how it is then used. The transformation of primary data into useful conclusions and specific actions is a complex and time-consuming task that a person faces every day and which machine intelligence technologies can quite successfully cope with. AI technologies are becoming more popular and in demand, and now the main thing is not to miss the right moment and start implementing smart algorithms into business processes in order to benefit from this in the future. Several main conclusions can be drawn from the experience of using Creatio artificial intelligence technologies and general trends in the development of artificial intelligence systems.

First of all, building intelligent solutions does not always require the involvement of specialized specialists and large investments. Instead, you can use the knowledge of internal experts and low-code tools, which make it possible to make settings in a simple and understandable interface for users.

Secondly, even the implementation of small and simple solutions based on artificial intelligence provides an opportunity to increase the effectiveness of internal and external processes and help businesses become more efficient.

But it is also worth noting that since the creation of the first information management systems, scientists have been constantly talking about the need to organize a secure information environment. The use of artificial intelligence was not an exception. Issues of cyber security come to the fore, so the more powerful the technology of artificial intelligence, the more resources will need to be spent on organizing the security of its use. However, the question of concern is: what will happen if artificial intelligence turns against us?

We are not talking about apocalyptic scientific scenarios. Rather, it is about the management of artificial intelligence technology in terms of the fulfillment of the tasks set before it, which can lead to unpredictable consequences. AI is a technology that is capable of self-development and self-learning, that is, it is able to propose and implement an innovative solution that can radically affect business processes, communication with customers, or technological processes. At the same time, it is important to remember that AI does not have feelings and does not understand where the limits of the implementation of tasks are, so it can become a real challenge for managers [5], [6].

3.5 Artificial Intelligence in Industry and Digital Transformation

Therefore, based on the above features of the work of artificial intelligence, there is a need to create a single digitalization control center – this is a global trend for large B2B companies and a market necessity. When the company is ready to embark on the path of digital transformation, the effectiveness of the introduction of new technologies will, first of all, depend on a comprehensive approach and the preparation of a digitalization strategy within the framework of all business processes.

For example, in metallurgy, the Indian Tata Group and the Korean Posco created their Digital companies. In Ukraine, there are few companies that have only centralized their IT departments, and even fewer that have separated the divisions into a separate company. Yes, Metinvest Digital is the first such IT company in the country [7].

Consolidation of IT functions helps to rebuild management processes, unify all service units, establish quality control, change management, monitoring and infrastructure development. If you need to automate not a single function, but the entire value chain, then advanced technologies can significantly help in this. Automating the work of specific nodes and technological processes, as well as combining aggregates, workshops and enterprises into single information systems allows to reduce the cost of products and increase quality, making the working conditions of employees more secure, intelligent and comfortable.

One of the steps in this direction is the use of drones for measuring bulk substances at the GZK. Drones make measurements, all received information is centrally entered into the ERP system. Up-to-date data is received throughout the entire product production chain, and it is possible to timely control resource stocks and promptly manage

logistics. Today, in order to remain competitive in the market, industrial enterprises cannot do without digital modernization of production. Given that there is regulation of gas consumption at the state level, and industrial enterprises need a lot of this resource, work is underway to minimize the cost due to accurate forecasting. To do this, a significant amount of historical data on about 20 parameters is loaded (steel grade specification, melting characteristics, actual volume of previous consumption, etc.) and artificial intelligence independently builds a correlation model of parameters, analyzes the dependence between data and predicts numerical trends. At the output, the predicted value of gas consumption for the next calculation day is obtained with an accuracy of more than 97% [7].

With the aim of digital transformation of the field of document management, there is an opportunity at industrial enterprises to use the innovative SAP Fiori technology. This is a convenient web interface to main functions and business operations in SAP systems, as well as a set of applications that can be used on any device. This step greatly facilitates the process of agreement of contractual documents.

Industrial enterprises cooperate with a number of large B2B companies, which also face the task of digital transformation. By providing complex solutions for business, end-2-end IT solutions, which include IT infrastructure, automated systems in production, accounting and information systems, systems for supporting key business processes and ensuring company's activities, the industrial company thereby implements a comprehensive approach – full cycle of IT solutions: implementation, monitoring, integration, support and further development.

Digital transformation is supported by innovations and technological solutions, but primarily the drivers of such changes are leaders who are open to change and able to quickly adapt to changing market and industry conditions. Some innovations of a transformative variable nature are presented in Figure 4.

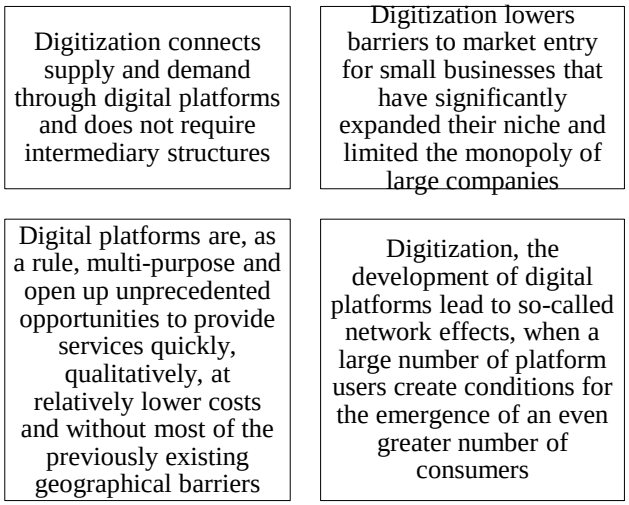

Fig. 4: The influence of the digitization process and the operation of digital platforms on the transformational changes of enterprises
Source: compiled by author based on source 14, p. 49

For example, the Ukrainian company Nova Poshta actively uses robots at its sorting terminals. In 2021, cargo and small shipment areas at 20 sorting centers were robotized. Depending on the weight of the parcel, the company uses different types of robots. A robot train consisting of two sections is used in the sorting areas of small shipments (up to 2 kg). This is an in-house development of Nova Poshta and the Ukrainian manufacturer SBR, which has no analogues in Ukraine.

The worker places the package on the robot, which takes it to the scanner and moves it to the box, which is responsible for a certain geographical direction. Robots work on a special platform with a monorail, which simultaneously serves as their charger. The use of such robots made it possible to increase the productivity of sorting small parcels by 2 times. Currently, 272 such robots are working [30]. Pirouette robots of Ukrainian company Deus Robots are used to sort shipments up to 30 kg. They got this name because they can rotate around their axis. From the unloading belt, the package falls on the robot. Next, he drives up to scan the parcel and then puts it on a roller conveyor, from which the shipment goes directly into a special bag for delivery. Due to their dexterity, such robots can work in different sorting areas.

The Nova Poshta company continues to improve the robotization of cargo terminals. In November 2021, a terminal with a fully robotic cargo shipment area opened in Dnipro. 50 robot trucks manufactured by SBR move goods inside the

terminal from the unloading area to the loading area. They move on a magnetic tape and can simultaneously carry up to 300 kg and pull another 1000 kg behind them. Such robotic trucks can transport up to 5,000 loads per day, which increases the productivity of the terminal by 30%. In total, the company already uses 180 robot trucks at various cargo terminals [30].

With the increase in the volume of shipments, the company aims to remain the fastest delivery in Ukraine and to create a flexible system for increasing sorting capacity using robots. Robotization of sorting terminals allows to increase productivity without additional burdens on employees. In addition, by automating processes, it is possible to achieve greater accuracy in sorting parcels, because reducing the influence of the human factor allows avoiding possible errors. Robots are already working at depots in Kyiv, Kharkiv, Dnipro, Odesa, Boryspil, Melitopol, Pokrovsk, Novomoskovsk, Korosten, Strya, Sambir, Kovel and Stoyanka. The Nova Poshta company plans to create a fully robotic sorting center.

The directions of changes intended to be carried out by the managers of modern progressive enterprises:

- Introduction of artificial intelligence creation system. It involves not only programming, but also a training phase, during which they learn to identify the correct patterns of actions and act on them, and a testing phase, where the artificial intelligence receives many examples that it can deal with in real life, allowing us to follow his work. However, in life there are non-standard situations that occur rarely, but artificial intelligence must also react to them. So, if we rely on this technology, which should theoretically create a world of efficiency and safety for us, we must first verify that the artificial intelligence works according to the plan and code [6, p. 5];
- Automation of your enterprise as soon as possible – in some cases, this is a more effective method than trying to retain workers. Unfortunately, the economic situation in the country will not change dramatically in the next 3-5 years;
- Maximum outsourcing of everything that does not relate to key production business processes and competencies;
- Formation of a targeted policy for the growth of personal incomes. The salary of an automation engineer (designer) should not be 2 times lower than a programmer of the same or even lower qualification;
- Formation of system policies of recruiting and personnel management. In particular, plan the number of new jobs to be created, review and standardize qualification requirements, and inform training centers that train specialists about this;
- Consolidation in its field – as well as with other high-tech industries – for the growth of the image of the engineering profession, their qualifications and working conditions. Use IT-like tools to: change the educational landscape – invest in schools and courses to improve skills and knowledge; implement new technical standards; adjust system work with media; together to lobby the interests of industrialists, first of all, in terms of improving the economic situation, attracting investments and creating new jobs in industries with high added value [12]. There are no secrets in what the IT industry has done. It is only about systematic approaches and consolidation of efforts.

In addition, it is important to exercise control over artificial intelligence. Given that this management function is the easiest to automate, it is advisable to come to the realization that complete automation of related business processes is impractical. It may be an impossible situation that we simply "unplug" artificial intelligence, because this technology can predict it and protect itself. Also, a modern manager must not only control the development of artificial intelligence, but also predict the vector of its development [6, p. 5].

3.6 Challenges in the Development of Artificial Intelligence

Among the challenges that, according to the expectations of experts, should be addressed by developing countries should be attributed:

1. Technology penetration, effective deployment and "capability threshold". Digital technologies have raised the "capability threshold" that companies need in order for new technologies to be truly effective.

This is explained by the fact that 4PR is about the "alloy" of existing and new technologies into new integrated technological systems. Accordingly, the management of complex, integrated technologies, such as fully automated production, the combination of robots with IoT technologies, requires appropriate expertise, knowledge and qualified personnel, which are often not available in developing countries.

2. Integration and modernization of existing production systems. One of the definitions of industrialization says that it is about the mobilization of resources in conditions of uncertainty. Most of such obligations require the involvement of physical capital, which is built into certain (production) technologies and cannot be

quickly transformed into other technologies. Such investments also require the use of specific, narrow expertise and skills. And all this becomes critical, because in the conditions of a specific industry and production technology, further change or use of such technologies for other purposes is unlikely.

For developing countries, such investments are risky. Existing companies have already invested in certain technologies and are currently considering how to modernize them, how to integrate digital technologies into production. And the construction of new plants requires developed access to capital and long-term investments, which is not possible everywhere.

3. Basic and digital infrastructure. Digital technologies are very demanding in terms of the infrastructure that enables them to function at full scale. Many developing countries still have significant challenges even in electrification, let alone reliable Internet communications. In certain cases, the infrastructure is a real bottleneck, but one that can be bypassed with new possibilities – for example, using new sources of electricity or wireless communication.

On the other hand, these new capabilities also require corresponding quality and reliability. Either way, improving the productivity and quality of digital manufacturing requires overcoming these infrastructural limitations. Otherwise, investments in digital technologies can take a very long time to pay off.

4. Technology diffusion, hubs of the Fourth Industrial Revolution and the digital divide. Despite the fact that most developing countries have their own hubs of the Fourth Industrial Revolution – that is, where there are individual advanced companies that have mastered digital manufacturing, most such examples are isolated. Often, such local breakthroughs are associated with the activities of suppliers in individual, large projects.

At the same time, most companies and sectors are still operating at the previous level of technology. This means that it is extremely difficult for new solution providers such as OEMs and Engineering companies to build equally sustainable manufacturing links in value chains at home. Digital divide between customer islands and advanced providers is significant and costly to bridge, limiting the diffusion of Fourth Industrial Revolution technologies.

5. Asymmetry in access to technologies. Digital technologies are complex and controlled by a limited number of leading firms from developed countries. Firms in developing country value chains rely on these technologies and in some cases, even as they mobilize their resources, are ultimately dependent on these technologies from advanced countries. In global corporations operating around the world and in global value chains, the type and use of standards and equipment is often determined by corporate and international standards. The value of the latter is increasing. The use of these technologies and standards means the growing weight of global corporations in global networks and access to their technologies is not the same for different countries.

The usefulness of modern research in the practical applicability of artificial intelligence lies in the fact that it has become an important trend in the creation of promising battlefield management systems and weapons. Banks use artificial intelligence systems (AI) in insurance activities (actuarial mathematics) when playing on the stock exchange and property management. In August 2001, robots beat humans in an impromptu trading competition (BBC News, 2001). Pattern recognition methods (including both more complex and specialized ones and neural networks) are widely used in optical and acoustic recognition (including text and voice), medical diagnostics, spam filters, in air defense systems (identification of targets), and also to ensure a number of other tasks of national security.

With the help of AI, it is possible to ensure an optimal and threat-adaptive selection of a combination of sensors and means of destruction, to coordinate their joint functioning, to detect and identify threats; assess the enemy's intentions. AI plays a significant role in the implementation of augmented reality tactical systems. For example, AI allows for classification and semantic segmentation of images, localization and identification of mobile objects in order to schematically reproduce the contours of objects as symbols of augmented reality for effective targeting. There are high hopes for the use of artificial intelligence to manage 6G cellular networks.

4 Conclusion

In conclusion, it should be noted that the importance of new technologies of the Fourth Industrial Revolution is growing everywhere. Many of them are not only a component and driver of innovation for classic industrial sectors, but also become self-sufficient economic sectors over time. What makes these technologies revolutionary is the effect they provide – we are talking about the "alloy", combining the physical and digital worlds, ubiquitous data processing and much greater

integration with science. This has already given significant improvements in economic indicators, for example, in automation or predictive (predictive) maintenance [10].

Digital transformation is a process of qualitative restructuring of the way of doing business or changing business model in order to obtain a significant optimization of resources or a competitive advantage due to the introduction of new technologies, including algorithms using artificial intelligence and machine learning.

Many countries in these sectors are on the threshold of mass use of artificial intelligence algorithms – this 4.0 technology is the most breakthrough. At the same time, the level of countries and the level of penetration of new 4.0 technologies in them are different – there are pioneers and those that are increasing their pace, and there are lagging countries.

Only 50 of the world's economies are considered to be truly engaged in digital technologies today. Yes, the Fourth Industrial Revolution is not the same asset for different countries. The effective application of these new technologies assumes that enterprises have passed the classic stages of industrialization, have the appropriate capabilities, standards and infrastructure. These conditions are still lacking in many developing countries.

In recent years, many countries are trying to embark on the path of the Fourth Industrial Revolution and are considering the presence of the necessary parameters and conditions in the industries on which success depends. Many of these are critical success factors, but some appeal to challenges those developing countries themselves must address. As the experience of different countries shows, mastering the industrial requirements for Fourth Industrial Revolution takes time and requires basic capabilities to accept the digital world.

Based on the results of our research, we came to the conclusion that artificial intelligence is a product of the development of Fourth Industrial Revolution. However, according to its content, Fourth Industrial Revolution itself should cover the automation of all stages and processes, and when products are not yet things, but exist in the virtual world in the form of information models.

On the eve of the future Industry 5.0, it is necessary to consider two worlds together: the virtual world, implemented with the application of artificial intelligence, and the real world, implemented by artificial intelligence. It is expedient to build the Internet of knowledge on the ontological methodology, which is based on the world of virtual agents representing object-functions capable of generating new data taking into account the available information.

Digital transformation of business based on the application of artificial intelligence changes the forms of activity, rebuilds organizations, lays the foundations for the possibility of using new business models, new sources and forms of income generation, attracting more consumers, and brings customer service to a new level. As a result of new opportunities provided by artificial intelligence for Industry 4.0, spheres of functioning are being mixed in new formats, including in the form of digital platforms. The practical application of various digital technologies provides maximum energy efficiency and sustainable development; smart, productive and profitable operations; optimal availability of resources and efficiency of their use; mobile intelligence gathering and proactive risk mitigation.

References:

[1] Andrusiak N.O., Kraus N.M., Kraus K.M. (2020). Digital Cubic Space as a New Economic Augmented Reality. *Sci. innov.*, Vol. 16, no. 3. 92–105.

[2] Artificial intelligence (2022). *Britannica.* URL: https://www.britannica.com/technology/artificial-intelligence (assessed 25 June 2022).

[3] Artificial Intelligence (2022). *Dictionary.* URL: https://dictionary.cambridge.org/dictionary/english/artificial-intelligence (assessed 12 June 2022).

[4] Artificial Intelligence. Essential Meaning (2022). *Merriam Webster.* URL: https://www.merriamwebster.com/dictionary/artificial%20intelligence (assessed 08 June 2022).

[5] Bundy A., Burstall R. (1984). Artificial Intelligence: an Introductory Course. Edinburgh: Revised. Edinburgh University Press. 200 p.

[6] Doroshkevych D.V., Lytvynenko I.S. (2022). Analysis of challenges for management due to the activation of the use of artificial intelligence in the digital society. *Efficient economy*, no. 1. 1–6. (in Ukrainian).

[7] Drones and artificial intelligence are already helping industry save resources (2019). *Metinvest Digital. Company news from May 24, 2019.* URL: https://metinvest.digital/page/drony-

iskusstvennyj-intellekt-pomogayut-promyshlennosti-ekonomit-resursy (assessed 15 June 2022). (in Ukrainian).

[8] Gitis V.B., Gudkova K.Yu. (2018). Methods of artificial intelligence. Kramatorsk: DDMA. 136 p. (in Ukrainian).

[9] Glybovets M.M., Oletskyi O.V. (2002). Artificial Intelligence. Kyiv: Kyiv-Mogyla Academy. 364 p. (in Ukrainian).

[10] Industrial policy tools for 4PR – the example of MedTech from Costa Rica (2020). *INDUSTRY4UKRAINE.* URL: https://www.industry4ukraine.net/publications/instrumenty-promyslovoyi-polityky-dlya-4pr-pryklad-medtech-z-kosta-riky/ (assessed 29 June 2022). (in Ukrainian).

[11] *Iot-analytics.* URL: https://iot-analytics.com/industry-4-0-adoption-2020-who-is-ahead/ (assessed 18 June 2022).

[12] Industry 4.0 in mechanical engineering, the state in Ukraine and prospects for development (2021). *Analytical report of APAU,* Vol. 1. (in Ukrainian).

[13] Kai Fu L. (2019). The superpowers of artificial intelligence. China, Silicon Valley and the New World Order. 233 p.

[14] Kolot A., Herasymenko O. (2020). Digital transformation and new business models as determinants of formation of the economy of nontypical employment. *Social and labour relations: theory and practice,* no. 10(1). 33–54.

[15] Kraus K., Kraus N., Nikiforov P., Pochenchuk G., Babukh I. (2021). Information and Digital Development of Higher Education in the Conditions of Innovatyzation Economy of Ukraine. *WSEAS Transactions on Environment and Development,* Vol. 17, Art. #64. 659–671. URL: https://wseas.com/journals/ead/2021/b305115-652.pdf (assessed 15 July 2022).

[16] Kraus K., Kraus N., Shtepa, O. (2021). Synergetic effects of network interconnections in the conditions of virtual reality. *Journal of Entrepreneurship, Management and Innovation,* no. 17(3). 149–188. URL: https://jemi.edu.pl/uploadedFiles/file/all-issues/vol17/issue3/JEMI_Vol17_Issue3_2021_Article5.pdf (assessed 20 July 2022).

[17] Kraus K.M., Kraus N.M., Manzhura O.V. (2021). E-commerce and Internet commerce: a textbook. Kyiv: Agrar Media Group. 454 p. (in Ukrainian).

[18] Kurzweil R. (1992). The era of intelligent machines. Massachusetts: MIT Press. 580 p.

[19] Kurzweil R. (2005). The Singularity is Near: When Humans Transcend Biology. New York: Viking Adult. 602 p.

[20] Manzhura O., Kraus K., Kraus N. (2021). Digitalization of Business Processes of Enterprises of the Ecosystem of Industry 4.0: Virtual-Real Aspect of Economic Growth. WSEAS Transactions on Business and Economics, Vol. 18, Art. #57. 569–580. URL: https://www.wseas.org/multimedia/journals/economics/2021/b165107-021(2021).pdf (assessed 5 January 2022).

[21] Manzhura O., Kraus K., Kraus N. (2021). Digitalization of Business Processes of Enterprises of the Ecosystem of Industry 4.0: Virtual-Real Aspect of Economic Growth Reserves. *WSEAS Transactions on Business and Economics,* Vol. 18, Art. #57. 569–580. URL: https://www.wseas.org/multimedia/journals/economics/2021/b165107-021(2021).pdf (assessed 11 July 2022).

[22] Marchenko O., Kraus N. (2021). Innovative-digital entrepreneurship as key link of Industry X.0 formation in the conditions of virtual reality. *Baltic Journal of Economic Studies,* no. 7(1). 47–56.

[23] Nilsson, N.J. (2009). The Quest for Artificial Intelligence. London: Cambridge University Press. 578 p.

[24] Pchelianskyi D.P., Voinova S.A. (2019). Artificial intelligence: prospects and development trends. *Automation of technological and business processes,* no. 3. 59–64. (in Ukrainian).

[25] Pyshchylina O. (2020). Digital economy: trends, risks and social determinants. Kyiv: Razumkov Center. 274 p. (in Ukrainian).

[26] Russell S., Norvig P. (2006). Artificial Intelligence: a Modern Approach. USA: Prentice Hall. 960 p.

[27] Shakhovska N.B., Kaminskyi R.M., Vovk O.B. (2018). Artificial intelligence systems. Lviv: Lviv Polytechnic. 392 p. (in Ukrainian).

[28] Shtepa O., Kraus K., Kraus N. (2021). Teaching Guidelines for Digital Entrepreneurship. Cracow University of Economics, Kiev-Cracow. 71 p. URL: https://ted.uek.krakow.pl/output-1-teaching-guidelines/ (assessed 18 January 2022).

[29] Tagmark M. (2019). Life 3.0. The age of artificial intelligence. Kyiv: Our format. 432 p. (in Ukrainian).

[30] The new post office introduces robots to sort parcels (2021). *GSMinfo. Hardnews from*

November 29, 2021. URL: https://gsminfo.com.ua/68352-nova-poshta-vprovadzhuye-robotiv-dlya-sortuvannya-posylok.html?fbclid=IwAR0nWJiysw35PvYvQTWbZU5x00ESyOpBNOtOL6PiLDSBE6tyYLdEi8SsflY (assessed 11 June 2022). (in Ukrainian).

[31] Vebb, E. (2020). The big nine: how the tech titans and their thinking machines could warp humanity. Kharkiv: Vivat. 352 p. (in Ukrainian).

[32] What is Artificial Intelligence? (2022). *TechTarget.* URL: http://searchcio.techtarget.com/definition/AI (assessed 21 June 2022).

[33] Worldwide digital competitiveness (2022). *Statista.* URL: https://www.statista.com/statistics/1042743/worldwide-digital-competitiveness-rankingsbycountry/ (assessed 14 June 2022).

[34] Yasynska N.A. (2022). Exism-challenges of personal finance in the cognitive capacity of trust, structure of employment and knowledge. *Efficient economy*, no. 1. 1–10. (in Ukrainian).

[35] Yershova O.L., Bazan L.I. (2021). Artificial intelligence is the technological basis of the digital transformation of the economy. *Statistics of Ukraine. New information technologies,* no. 3. 47–59. (in Ukrainian).

[36] Helow K.R., Salem A.M. (2020). Are artificial intelligence (AI) and machine learning (ML) having an effective role in helping humanity address the new coronavirus pandemic? *WSEAS Transactions on Biology and Biomedicine*, Vol. 17, pp. 119-124.

[37] Sulaiman Y., Rahman M.A., Mat N.K. (2020). A conceptual paper on re-patronage model for syariah compliance e-lodging industry: the mediating effect of artificial intelligence. *WSEAS Transactions on Business and Economics*, Vol. 17, pp. 153-163.

[38] Yfantis V., Ntalianis K., Ntalianis F. (2020). Exploring the implementation of artificial intelligence in the public sector: welcome to the clerkless public offices. applications in education. *WSEAS Transactions on Advances in Engineering Education*, Vol. 17, pp. 76-79.

[39] Oliveira A.P., Braga H.F.T. (2020). Artificial intelligence: learning and limitations. *WSEAS Transactions on Advances in Engineering Education*, Vol. 17, pp. 80-86.

[40] Trifonov R., Manolov S., Tsochev G., Pavlova G. (2019). Automation of cyber security incident handling through artificial intelligence methods. *WSEAS Transactions on Computers*, Vol. 18, pp. 274-280.

[41] Trifonov R., Tsochev G., Nakov O., Pavlova G., Manolov S. (2020). Possibilities for improving the quality of cyber security education through application of artificial intelligence methods. *Engineering World*, Vol. 2, pp. 145-149.

Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)

Kateryna Kraus, research the essence of artificial intelligence and the scope of its penetration, visualization of the presented material, writing conclusion, drawing up a list of references.

Nataliia Kraus, formulation of the purpose and tasks of research, research the practical application of artificial intelligence in today's conditions and challenges in the development of artificial intelligence selection of literature and its analysis.

Mariia Hryhorkiv, research the use of artificial intelligence: experience and benefits.

Ihor Kuzmuk, write an annotation of scientific research and highlighting the essence of the algorithm for setting up AI models.

Olena Shtepa, describe the artificial intelligence in industry and digital transformation.