ARTIFICIAL INTELLIGENCE AS A BASIS FOR THE DEVELOPMENT OF THE DIGITAL ECONOMY

Textbook

Edited by

Irina Tatomyr

Drohobych State Pedagogical University after Ivan Franko (Ukraine)

Zenovii Kvasnii

Precarpathian Institute named of M. Hrushevsky of Interregional Academy of Personnel Management (Ukraine)

eBook **ISBN 978-80-88415-17-6**

Print **ISBN 978-80-88415-18-3**

OKTAN PRINT
PRAHA 2021

Recommended for publication by the Precarpathian Institute named of M. Hrushevsky of Interregional Academy of Personnel Management (Protocol №10 dated 27.05.2021)

The work was performed within the research topic of the Mykhailo Hrushevsky Precarpathian Institute «Ukraine in the context of world and national modernization processes of statehood and civil society: political, legal, economic, social, psychological and administrative aspects» (Registration number 0119U100492. Date of registration - February 12, 2019)

Reviewers:

Levan Jakeli Professor, Dean of the Faculty of Law of Batumi State University. Sh. Rustaveli (Georgia)

Justyna Krzywkowska Doctor of Law, assistant professor Department of Legal Theory and History Faculty of Law and Administration University of Warmia and Mazury in Olsztyn (Poland)

Yeliseyeva Oksana Doctor of Economics, Professor, Head of the Department of Statistics, Accounting and Economic Informatics of Dnipro National University named after Oles Honchar (Ukraine)

Editors:
Irina Tatomyr PhD in Economics, Associate Professor
Zenovii Kvasnii Ph.D in Economics, Associate Professor

ARTIFICIAL INTELLIGENCE AS A BASIS FOR THE DEVELOPMENT OF THE DIGITAL ECONOMY: *textbook*; Edited by I. Tatomyr, Z. Kvasnii. Praha: OKTAN PRINT, 2021, 376 p.

The publication is assigned with a DOI number: **https://doi.org/10.46489/aiabftd-07**

The paper version of the publication is the original version. The publication is available in electronic version on the website: **https://www.oktanprint.cz/p/artificial-intelligence-as-a-basis-for-the-development**

Passed for printing 31.05.2021
Circulation 50 copies
Cover design: *Irina Tatomyr*

eBook **ISBN 978-80-88415-17-6**
Print **ISBN 978-80-88415-18-3**

OKTAN PRINT s.r.o.
5. května 1323/9, Praha 4, 140 00
www.oktanprint.cz
tel.: +420 770 626 166
jako svou 59. publikací
Vydání první

Contents

•••••••••••••••••••••

III. CHANGES IN THE FINANCIAL SERVICES MARKET UNDER THE INFLUENCE OF AI
Zoia Pestovska

IV. ARTIFICIAL INTELLIGENCE AND THE FUTURE OF HEALTHCARE

V. THE IMPACT OF AI TECHNOLOGIES ON THE MODERNIZATION OF TRANSPORT INFRASTRUCTURE

VI. ARTIFICIAL INTELLIGENCE IN INDUSTRY AND ENERGY

VII. MANAGEMENT ASPECTS OF THE USE OF ARTIFICIAL INTELLIGENCE

I. FEATURES OF FORMATION AND DEVELOPMENT OF ARTIFICIAL INTELLIGENCE

Olha Pizhuk
Doctor of Sciences (Economy),
Associate professor of Enterprise economy department
State Tax University, Irpin'
E-mail: opizhuk@gmail.com
ORCID 0000-0002-5802-1053

1.1. Basic concepts of Artificial Intelligence

Efforts to improve artificial intelligence (AI) concepts over the past 20 years have led to genuinely unique innovations that are the basis of a real technological breakthrough. Since the invention of computers or machines, their capability to perform various tasks went on growing exponentially. Humans have developed the power of computer systems in their diverse working domains, increasing speed and reducing size concerning time. Big data, medical research and autonomous vehicles are just some of the incredible applications that emerge in developing AI [1]. Today Artificial Intelligence has made its breakthrough in almost all existing fields – from science to business. AI can be found everywhere. For instance, it is on the front page of your favourite newspaper into your smartphone in your pocket, on your desk, in your car, and so on [2]. If we look at Google Trends for AI data, it has reached its highest level in the last five years *(see Figure 1)*.

Interest over time and popularity by region

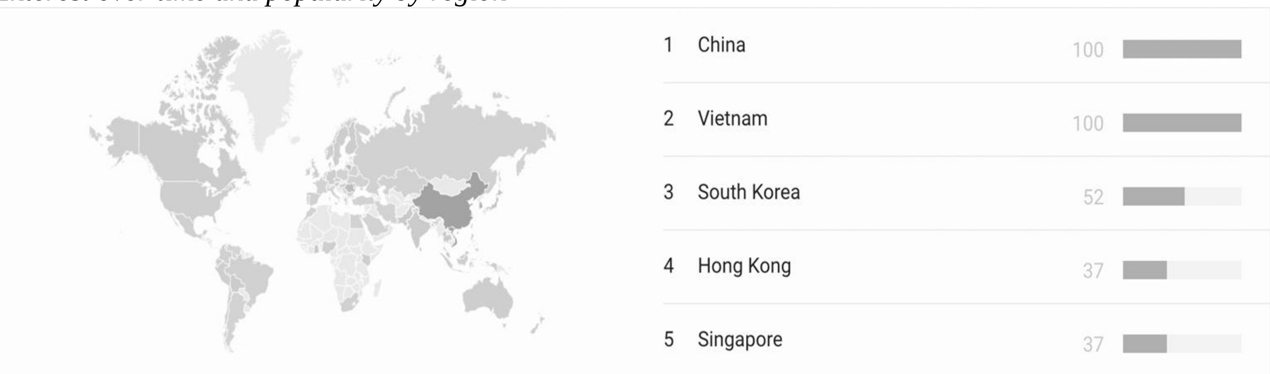


Figure 1. Worldwide Google Trends on Artificial Intelligence based on Google Search

Source: Developed by the author based on https://trends.google.com/trends/explore?date=today%205-y&q=%2Fm%2F0mkz

AI is one of the fascinating and universal fields of Computer science that has a great future scope. According to the father of Artificial Intelligence, John McCarthy, it is "The science and engineering of making intelligent machines, brilliant computer programs". Artificial Intelligence is a way of making a computer, a computer-controlled robot, or software think intelligently, similar to the intelligent humans think. Artificial Intelligence is composed of two words Artificial and Intelligence, where Artificial defines "man-made," and intelligence defines "thinking power"; hence AI means "a man-made thinking power." So, we can define AI as:

"It is a branch of computer science by which we can create intelligent machines which can behave like a human, think like a human, and able to make decisions" [3].

AI is accomplished by studying how the human brain thinks and how humans learn, decide, and work while trying to solve a problem and then using the outcomes of this study as a basis for developing intelligent software and systems.

Philosophy of AI. The very nature of the term “artificial intelligence” brings up philosophical questions about whether intelligent behaviour implies or requires the existence of a mind and to what extent is consciousness replicable as computation. While exploiting the power of the computer systems, the curiosity of human, lead him to wonder, “Can a machine think and behave as humans do?” Thus, the development of AI started with the intention of creating similar intelligence in machines that we find and regard high in humans [4].

The definition of intelligence, natural or artificial, and consciousness appears to be extremely evasive and leads to apparently never-ending discourse. However, as John McCarthy pointed out, the philosophy of AI is “unlikely to have any more effect on the practice of AI research than the philosophy of science generally has on the practice of science.” Thus, we will continue investigating systems that help solve practical problems without asking too much whether they are intelligent or just behave as if they were. Before Learning about Artificial Intelligence, we should know the importance of AI and why we should learn it. Following are some main reasons to learn about AI:

Firstly, with the help of AI, we can create software or devices which can solve real-world problems very easily and with accuracy, such as health issues, marketing, traffic issues, etc.

Secondly, with the help of AI, we can create personal virtual Assistant, such as Cortana, Google Assistant, Siri, etc.

Thirdly, With the help of AI, we can build Robots that can work in an environment where the survival of humans can be at risk.

Fourthly, AI opens a path for other new technologies, new devices and new opportunities [3].

Key goals of AI:

− to create expert systems – the systems which exhibit intelligent behaviour, learn, demonstrate, explain, and advise its users;

− to implement human intelligence in machines: creating systems that understand, think, learn, and behave like humans [4].

Fundamental disciplines that contribute to AI. rtificial intelligence is a science and technology based on disciplines such as Computer Science, Biology, Psychology, Linguistics, Mathematics, and Engineering. A major thrust of AI is in developing computer functions associated with human intelligence, such as reasoning, learning, and problem-solving. Out of the following areas, one or multiple areas can contribute to building an intelligent system.

Two types of artificial intelligence. Artificial Intelligence can be divided based on capabilities and functionalities *(see Figure 2)*.

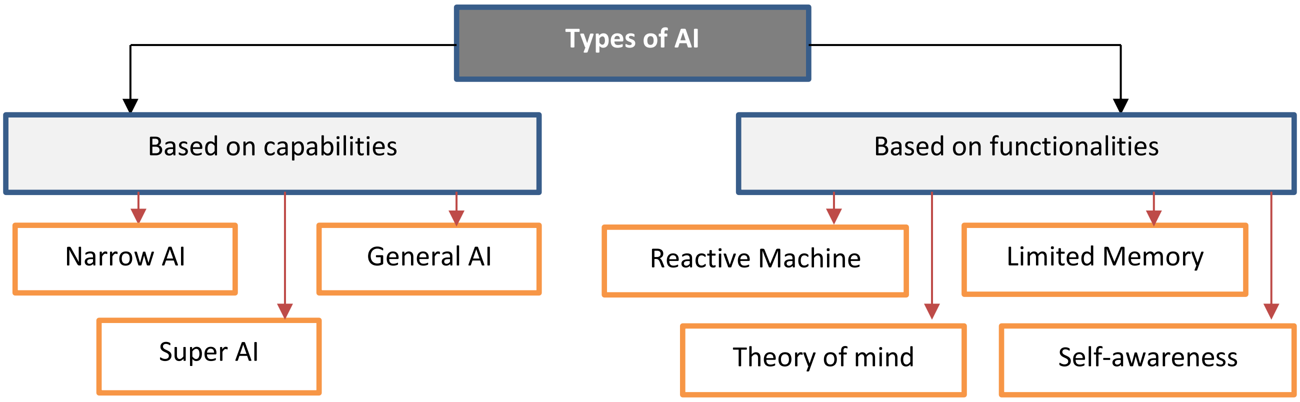


Figure 2. Seven types of Artificial Intelligence

Source: Formed by the author based on Avijeet Biswal (2021). *7 Types of Artificial Intelligence that you should know in 2020* [Tutorials]. Retrieved from: https://www.simplilearn.com/tutorials/-artificial-intelligence-tutorial/types-of-artificial-intelligence

There are types of AI based on capabilities: narrow AI and general AI. It is the narrow AI that permeates our world today, in all fields from medical to mechanic, financial to engineering, and everything in between. General AI is still a ‘pipe dream’ that computer engineers are working to creating. Most experts say we’re still a decade or two away from achieving true general AI because of its complexity. The third type of Artificial Intelligence – Super AI that surpasses human intelligence and can perform any task better than a human.

1. ***Narrow Artificial Intelligence***. Most computers use narrow AI. They’re intelligent systems that know how to conduct specific tasks without having been explicitly programmed to do so. Apple’s Siri is a perfect example. So is Amazon’s Alexis, Google’s new virtual assistant, and IBM’s Watson supercomputer. These systems simulate a human being’s knowledge and cognitive ability within specific parameters. The systems can include self-driving cars and spam filters. Why? Because the systems use pattern recognition, natural language processing, machine learning, and data recognition to make decisions. In addition to telling you a joke or the weather, Narrow AI has a host of applications. These systems can identify inappropriate content online or in emails, respond to customer service requests, read video feeds from drones, organise and coordinate business/personal calendars, analyse data to make predictions, and more.

2. ***General Artificial Intelligence***. This AI also referred to a human-level, strong, and superintelligence Artificial Intelligence can understand and reason within its environment, just like a human. Think Data from Star Trek: The Next Generation, or Hal from 2001 A Space Odyssey. It's "strong" because this AI will be stronger than us humans and "general" because we'll be able to apply it to all problems. However, it's nearly impossible to create a computer that can think abstractly, innovate, or plan. Experts agree that it's really difficult at this point still impossible to teach the computer how to invent something that doesn't exist. AI is gaining strength; it can produce more accurate predictions about the data it's fed. That DeepMind algorithms can win more games and transfer learning from one game to another is another indication that Artificial Intelligence is growing stronger.

3. ***Super Artificial Intelligence.*** The concept of artificial superintelligence sees AI evolved to be so akin to human sentiments and experiences that it doesn't merely understand them; it also evokes emotions, needs, beliefs, and desires of its own. Its existence is still hypothetical. Some of the critical characteristics of super AI include thinking, solving puzzles, making judgments, and decisions on its own.

The different types of Artificial Intelligence based on functionalities such as reactive machine, limited memory, theory of mind, self-awareness.

1. ***A reactive machine*** is the primary form of artificial intelligence that does not store memories or use past experiences to determine future actions. It works only with present data. They perceive the world and react to it. Reactive machines are provided with specific tasks, and they don't have capabilities beyond those tasks. IBM's Deep Blue that defeated chess grandmaster Garry Kasparov is a reactive machine that sees the chessboard pieces and reacts to them. Deep Blue cannot refer to any of its prior experiences or improve with practice. It can identify the pieces on a chessboard and know how each move. Deep Blue can make predictions about what moves might be next for it and its opponent. It ignores everything before the present moment and looks at the chessboard pieces as it stands right now and chooses from possible next moves.

2. ***Limited Memory AI*** trains from past data to make decisions. The memory of such systems is short-lived. They can use this past data for a specific period of time, but they cannot add it to a library of their experiences. This kind of technology is used in self-driving vehicles. Limited Memory AI observes how other vehicles are moving around them, at present, and as time passes. This ongoing, collected data gets added to the AI machine's static data, such as lane markers and traffic lights. They are included when the vehicle decides when to change lanes, avoid cutting off another driver, or hit a nearby vehicle. Mitsubishi Electric has been figuring out how to improve such technology for applications like self-driving cars.

*3. **Theory of mind AI*** represents an advanced class of technology and exists only as a concept. Such a kind of AI requires a thorough understanding that the people and things within an environment can alter feelings and behaviours. It should understand people's emotions, sentiments, and thoughts. Even though many improvements are there in this field, this kind of AI is not fully complete yet. One real-world example of the theory of mind AI is Kismet. Kismet is a robot head made in the late 90s by a Massachusetts Institute of Technology researcher. Kismet can mimic human emotions and recognise them. Both abilities are key advancements in the theory of mind AI, but Kismet can’t follow gazes or convey attention to humans. Sophia from Hanson Robotics is another example where the theory of mind AI was implemented. Cameras present in Sophia's eyes, combined with computer algorithms, allow her to see. She can sustain eye contact, recognise individuals, and follow faces.

*4. **Self-awareness AI*** only exists hypothetically. Such systems understand their internal traits, states, and conditions and perceive human emotions. These machines will be more intelligent than the human mind. This type of AI will not only be able to understand and evoke emotions in those it interacts with but also have emotions, needs, and beliefs of its own.

Dr Hiroshi Yamakawa, Director of Dwango AI Laboratory, is one of the world’s foremost authorities on AI. He says that currently, AI can solve particular issues or address specific problems. His organisation uses the Whole Brain Architecture Approach, an engineering-based approach to “create a human-like artificial general intelligence (AGI) by learning from the architecture of the entire brain.” This AGI uses the human brain’s hard-wiring as a model to integrate machine learning modules and artificial neural networks. He theorises that the WBAI will be achieved by 2030 and will help to find solutions for global problems that include environmental, food, and space issues [6]. To understand some of the more profound concepts, such as data mining, natural language processing, and software management, you need to know three basic concepts of artificial intelligence: machine learning, deep learning, and neural networks.

Machine Learning (ML). The goal of ML is to construct computer programs that can learn from data. The inductive inference of machine learning, i.e. the generalisations from a set of observed instances, can be contrasted to early Artificial Intelligence (AI) approaches that dealt mostly with deductive inference (cf. Krötzsch et al. [7] in this volume), i.e., the derivation of theorems from axioms. Although ML is considered a subfield of AI, it also intersects with many other scientific disciplines such as statistics, cognitive science, and information theory1. An area closely related to ML is data mining [8,9], which deals with discovering new and interesting patterns from large data sets. Although ML and data mining are often used interchangeably, one might state that ML is more focused on adaptive behaviour and operational use.

In contrast, data mining focuses on handling large amounts of data and discovering previously unknown patterns (implicit knowledge, regularities) in the data. Most of this chapter discusses ML in the context of a formal AI system, although when suitable, as in the discussion of graphical models, we assume a more statistical perspective. ML approaches can be distinguished in terms of representation and adaptation. A machine learning system needs to store the learned information in some knowledge representation structure which is called (an inductive) hypothesis and is typical of the form of a model. Following Ockham's razor principle, the hypothesis should generalise the training data giving preference for the simplest hypothesis; the hypothesis should be more straightforward than the data itself to obtain valid generalisation. A learning algorithm specifies how to update the learned hypothesis with new experience (i.e. training data) such that the performance measure concerning the task is being optimised *(see Figure 3).*

The tasks of classification and regression deal with the prediction of the value of one field (the target) based on the values of the other fields (attributes or features). If the target is discrete (e.g. nominal or ordinal) then the given task is called classification. If the target is continuous, the task is called regression. Classification or regression normally are supervised procedures: based on a previously correctly labeled set of training instances, the model learns to correctly label new unseen instances.

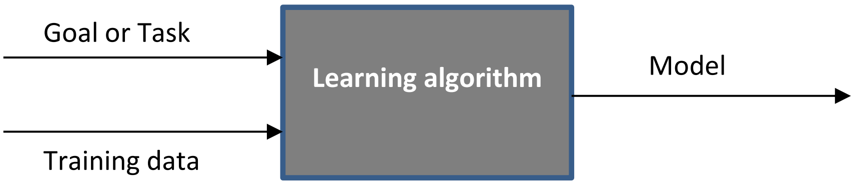


Figure 3. A generic machine learning method

Source: Ławrynowicz, Agnieszka & Tresp, Volker (2014). Introducing Machine Learning

An association describes a relation between objects or measured quantities, which results from some interaction or a dependency between the objects. Typically, the learned associations are in the form of association rules or sets of frequent items. The motivation for this type of task has been provided by market basket analysis, where the methods for finding associations between products bought by customers are studied. For example, consider that customers who buy X (e.g. beer) typically also buy Y (e.g. chips); then, if we encounter a customer who buys X but does not buy Y, we may target this customer via cross-selling as a potential customer for Y. An itemset is called frequent if it appears in at least a given percentage (called support) of all transactions. Frequent itemsets are often the prerequisite for the learning of association rules.

Clustering is an unsupervised task whose aim is to group a set of objects into classes of similar objects. A cluster is a collection of similar objects within the same cluster and dissimilar to the objects in other clusters. Therefore, an important notion in clustering (also known as cluster analysis in statistics) is the notion of similarity (or distance). In conceptual clustering, a symbolic representation of each cluster is extracted, and we may consider each cluster to be a concept closely related to a class in classification.

Some examples of other machine learning tasks are: reinforcement learning, learning to rank and structured prediction. The reinforcement learning task consists of learning sequential control strategies. It deals with situations where the system's output is a sequence of actions that are performed to achieve some goal. An example may be game playing, where the complete sequence of moves is important rather than a single movement. Learning to rank is a type of (semi-) supervised learning problem where the goal is to automatically construct a ranking model from training data, e.g., to learn to rank the importance of returned Web pages in a search application. Structured prediction deals with prediction problems in which the output is a complex structure. Such issues arise in disciplines such as computational linguistics, e.g. in natural language parsing, speech, vision, and biology.

Data. It is useful to characterize learning problems according to the type of data they use. This is a great help when encountering new challenges since, quite often, problems on similar data types can be solved with very similar techniques. For instance, natural language processing and bioinformatics use very similar tools for natural language text strings and DNA sequences.

Vectors constitute the most basic entity we might encounter in our work. For instance, a life insurance company might be interested in obtaining the vector of variables (blood pressure, heart rate, height, weight, cholesterol level, smoker, gender) to infer the life expectancy of a potential customer. A farmer might be interested in determining the ripeness of fruit based on (size, weight, spectral data). An engineer might want to find dependencies in (voltage, current) pairs. Likewise, one might want to represent documents by a vector of counts that describe words' occurrence. The latter is commonly referred to as bag of words features. One of the challenges in dealing with vectors is that the scales and units of different coordinates may vary widely. For instance, we could measure the height in kilograms, pounds, grams, tons, stones, all of which would amount to multiplicative changes. Likewise, when representing temperatures, we have a full class of affine transformations, depending on whether we represent them in terms of Celsius, Kelvin or Fahrenheit. One way of dealing with those issues in an automatic fashion is to normalize the data. We will discuss the means of doing so in an automatic fashion.

Lists: In some cases, the vectors we obtain may contain a variable number of features. For instance, a physician might not necessarily decide to perform a full battery of diagnostic tests if the patient appears healthy. Sets may appear in learning problems whenever there are many potential causes of an effect, which are not well determined. For instance, it is relatively easy to obtain data concerning the toxicity of mushrooms. It would be desirable to use such data to infer the toxicity of a new mushroom given information about its chemical compounds. However, mushrooms contain a cocktail of compounds, out of which one or more may be toxic. Consequently, we need to infer the properties of an object given a set of features, whose composition and number may vary considerably.

Matrices are a convenient means of representing pairwise relationships. For instance, in collaborative filtering applications, the rows of the matrix may represent users, whereas the columns correspond to products. Only in some cases, we will have knowledge about a given (user, product) combination, such as the rating of the product by a user. Images could be thought of as two-dimensional arrays of numbers, that is, matrices. This representation is very crude, though, since they exhibit spatial coherence (lines, shapes) and (natural images exhibit) a multiresolution structure. That is, downsampling an image leads to an object which has very similar statistics to the original image. Computer vision and psychooptics have created a raft of tools for describing these phenomena [11].

Training data. One distinguishes three important classes of feedback: feedback in the form of labelled examples, input in the form of unlabeled samples, or feedback in the form of reward and punishment, as in reinforcement learning.

Supervised learning consists of learning a function from training examples, based on their attributes (inputs) and labels (outputs). Each training example is a pair (x, f(x)), where x is the input, and f(x) is the output of the underlying unknown function. Supervised learning aims: given a set of examples of f, return a function h that best approximates f. For instance, given symptoms and corresponding diagnoses for patients, the goal is to learn a prediction model to make a diagnosis based on symptoms for a new patient.

Unsupervised learning is concerned with learning patterns in the input, without any output values available for training. Continuing our example, only symptoms of patients may be available and the goal may be to discover groups of similar patients.

In *semi-supervised learning*, both labeled and unlabeled data is used for training, with typically only a small amount of labeled data, but a large amount of unlabeled data. In the clinical example, diagnoses might be available for only a few patients, and the goal would be to use this information for making most probable diagnoses for all patients.

In *reinforcement learning*, input/output pairs are not available to the learning system. Instead, the learning system receives some sort of a reward after each action, and the goal is to maximize the cumulative reward for the whole process. For example, in case of treatment planning, the learning system may receive reinforcement from the patient (e.g., feels better, feels worse, cured) as an effect of actions taken during a treatment. Typically, a training data set comes in the simple form of attribute-value data table. However, more complex input data has also been studied, for example sequences, time series or graphs. From the point of view of this book, an interesting setting is presented by Inductive Logic Programming (ILP), originally defined as a subfield of machine learning that assumes Logic Programming as a representation formalism of hypotheses and background knowledge. Since then ILP has been further refined to a broader definition that considers not only Logic Programs as a representation, but also other subsets of the first-order logic. In particular, its methodology is well-suited for the tasks where Description Logics are used as representation formalism. The distinguishing feature of the ILP methods is their ability to take into account background knowledge, that is the knowledge generally valid in some domain, represented, for example, in the form of ontologies.

Models. Machine learning hypotheses may come in a variety of knowledge representation forms, such as equations, decision trees, rules, distances and partitions, probabilistic and graphical models. Classically, a division is made between symbolic and sub-symbolic forms of knowledge representation. The first category consists of representation systems in which the atomic building blocks are formal symbolic representations, often easily readable by a human. Such representation systems have compositional syntax and semantics, and their components may be assigned an interpretation. The system may, for example, be composed of a set of rules such as the one presented in *Figure 4a*. A good example of a symbolic system is an interpreted logical theory.

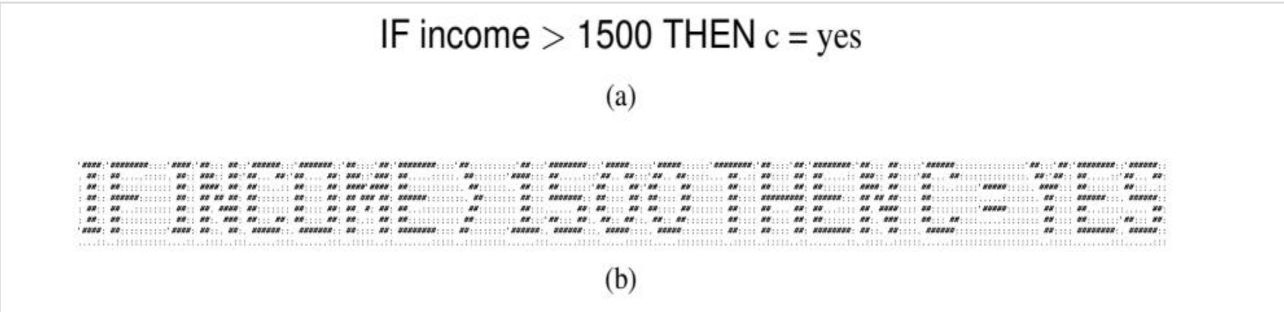


Figure 4. An illustration of the distinction between symbolic and subsymbolic representatio

Source: Ławrynowicz, Agnieszka & Tresp, Volker (2014). Introducing Machine Learning

In turn, the components of a sub-symbolic representation system *(see Figure 4b)* do not have a clear interpretation, and are not formal representations by themselves. Knowledge in this approach is represented as numerical patterns determining the computation of an output when being presented a given input. Good examples of sub-symbolic systems are neural networks, where the patterns are represented in the form of interconnected groups of simple artificial neurons.

Typical machine learning algorithms induce models, that is hypotheses that characterize globally an entire data set.

Generative models simulate a data generating process. In an unsupervised learning problem, this would involve a model for P(X), i.e., a probabilistic model for generating the data (in the discussion on generative models, X and Y stand for random variables). In supervised learning, such as classification, one might assume that a class $Y \in \{0, 1\}$ is generated with some probability P(Y) and the class-specific data is generated via the conditional probability P(X|Y). Models are learned for both P(Y) and P(X|Y) and Bayes rule is employed to derive P(Y|X), i.e., the class label probability for a new input X. In contrast, discriminative models model the conditional probability distribution P(Y|X) directly, they learn a direct mapping from inputs X to class label probabilities. To illustrate the difference between generative and discriminative models let us discuss an example task consisting in determining the language of a given speaker. In a generative modeling approach this task would be solved by learning language models for each language under consideration, i.e. by learning P(X|Y) for each language Y and by then applying Bayes rule to infer the language for a new text x. A discriminate model would not bother modeling the distribution of texts but would focus on the task of language classification directly and could focus on only the differences between languages.

Popular examples of generative models are Naive Bayes, Bayesian Networks and Hidden Markov Models. Popular examples of discriminative probabilistic models are logistic regression and support vector machines.

In a simple maximum likelihood model, one assumes a model P(X|w), i.e. a probabilistic model for generating a data point given parameter vector w. The maximum likelihood parameters estimate is then defined by the parameters that maximize the likelihood, where the likelihood is L(w) defined as the product of the probabilities of generating the N independent training data points given the parameters and assumes the form

$$\mathrm{L(w)} = \prod_{i=1}^{N} P\ (X_i = xi|w) \tag{1}$$

In a Bayesian approach the model is completed with an a priori distribution over models P(M) and a prior distribution over parameters given model, i.e., P(w|M). Based on observed data D, one can now calculate the most likely model as the one that maximizes

$$\mathrm{P(M|D)} = \frac{\mathrm{P(D|M)P(M)}}{\mathrm{P(D)}} \tag{2}$$

or the parameter distributions given model and data as

$$\mathrm{P(w|D,M)} = \frac{\mathrm{L(w)P(w|M)}}{\mathrm{P(D|M)}} \tag{3}$$

A maximum a posteriori (MAP) estimate is achieved by taking the most likely model and selecting the parameters that maximize P(w|D,M). A more truthfully Bayesian approach would consider the uncertainties in the estimates by integrating over unobserved quantities in the prediction.

Over the years, machine learning methods have been applied to solve many real world problems such as spoken language recognition, fraud detection, customer relationship management, gene function prediction etc. To provide a concrete example where machine learning has been effective on a Web service, consider the task of categorising email messages as spam or non-spam, where the performance of the machine learning method is assessed by the percentage of email messages correctly classified. The training experience in this problem may come in the form of a database of emails that have been labelled as spam or no-spam by humans.

Deep learning (DL) is one of the subsets of machine learning that uses deep learning algorithms to implicitly come up with important conclusions based on input data. Deep learning is based on representation learning. Instead of using task-specific algorithms, it learns from representative examples. For example, if you want to build a model that recognises cats by species, you need to prepare a database that includes a lot of different cat images.

The main architectures of deep learning are convolutional neural networks, recurrent neural networks, generative adversarial networks, recursive neural networks. Machine learning attempts to extract new knowledge from a large set of pre-processed data loaded into the system. Programmers need to formulate the rules for the machine, and it learns based on them. Sometimes, a human might intervene to correct its errors. However, deep learning is a bit different *(see Table 1).*

Table 1

Difference between machine learning and deep learning

Deep learning	***Machine learning***
large amounts of data	small datasets as long as they are high-quality
computation-heavy	not always
draw accurate conclusions from raw data	carefully pre-processed data
take much longer to train	can be trained in a reduced amount of time
you can't know what are the particular features that the neurons represent	logic behind the machine's decision is clear
can be used in unexpected ways	algorithm is built to solve a specific problem

Source: *Yulia Gavrilova* (October 8th, 2020). *A Guide to Deep Learning and Neural Networks*. Retrieved from: https://serokell.io/blog/deep-learning-and-neural-network-guide

Now that we know the difference between DL and ML let us look at some advantages of deep learning.

In 2015, a group of Google engineers was researching how NN carry out classification tasks. By chance, they also noticed that neural networks could hallucinate and produce rather interesting art.

Identifying patterns and anomalies in large volumes of raw data enables deep learning to efficiently deliver accurate and reliable analysis results to professionals. For example, Amazon has more than 560 million items on the website and 300+ million users. No human accountant or even a whole army of accountants would be able to track that many transactions without an AI tool.

Deep learning doesn't rely on human expertise as much as traditional machine learning. DL allows us to make discoveries in data even when the developers are not sure what they are trying to find. For example, you want your algorithms to be able to predict customer retention, but you're not sure which characteristics of a customer will enable the system to make this prediction.

Deep learning also has some Problems. Large amounts of quality data are resource-consuming to collect. For many years, the most extensive and best-prepared collection of samples was ImageNet, with 14 million different images and more than 20,000 categories. It was founded in 2012, and only last year, Tencent released a larger and more versatile database. Another difficulty with deep learning technology is that it cannot provide reasons for its conclusions. Therefore, it is difficult to assess the model's performance if you are not aware of what the output is supposed to be. Unlike in traditional machine learning, you will not be able to test the algorithm and find out why your system decided that; for example, it is a cat in the picture and not a dog. It is very costly to build deep learning algorithms. It is impossible without qualified staff who are trained to work with sophisticated maths.

Moreover, deep learning is a resource-intensive technology. It requires powerful GPUs and a lot of memory to train the models. A lot of memory is needed to store input data, weight parameters, and activation functions as an input propagate through the network. Sometimes deep learning algorithms become so power-hungry that researchers prefer to use other algorithms, even sacrificing the accuracy of predictions. Today, DL is applied across different industries for various use cases such as:

1) *speech recognition.* All major commercial speech recognition systems (like Microsoft Cortana, Alexa, Google Assistant, Apple Siri) are based on deep learning.
2) *pattern recognition*. Pattern recognition systems are already able to give more accurate results than the human eye in medical diagnosis.
3) *natural language processing*. Neural networks have been used to implement language models since the early 2000s. The invention of LSTM helped improve machine translation and language modeling.
4) *discovery of new drugs*. For example, the AtomNet neural network has been used to predict new biomolecules that can potentially cure diseases such as Ebola and multiple sclerosis.
5) *recommender systems*. Today, deep learning is being used to study user preferences across many domains. Netflix is one of the brightest examples in this field.

“Artificial neural networks” and “deep learning” are often used interchangeably, which isn’t really correct. Not all neural networks are “deep”, meaning “with many hidden layers”, and not all deep learning architectures are neural networks. There are also deep belief networks, for example.

***A neural network (NN)** is a series of algorithms that endeavors to recognize underlying relationships in a set of data through a process that mimics the way the human brain operates [13].*

There are so many different neural networks out there (feedforward neural networks – FNN, convolutional neural networks – CNN, recurrent neural networks – RNN and so on) that it is simply impossible to mention them all. The simplest neural network algorithm is *feed-forward neural networks (see Figure 5).*

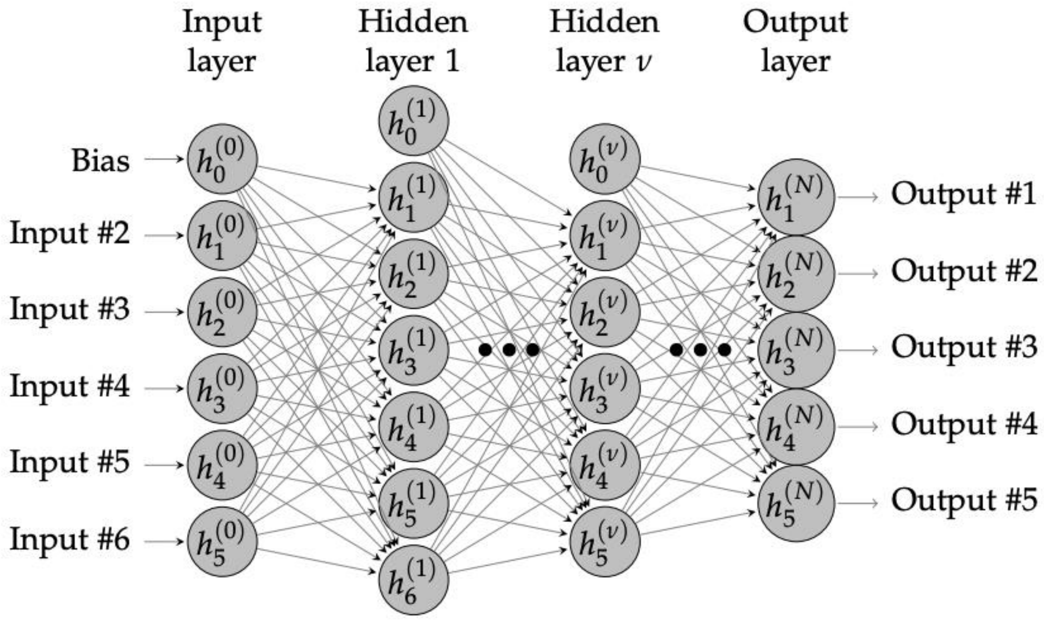


Figure 5. Neural Network with N + 1 layers (N − 1 hidden layers)

Source: *Thomas Epelbaum* (2017). *Deep learning: Technical introduction*. Retrieved from: https://arxiv.org/pdf/1709.01412.pdf

This network does not take into account any particular structure that the input data might have. Nevertheless, it is already a very powerful machine learning tool, especially when used with the state of the art regularization techniques. These techniques – that we are going to present as well – allowed us to circumvent the training issues that people experienced when dealing with “deep” architectures: namely the fact that neural networks with an important number of hidden states and hidden layers have proven historically to be very hard to train (vanishing gradient and overfitting issues). For example, when we work with text, the words form a certain sequence, and we want the machine to understand it. Feedforward neural networks can be applied in supervised learning when the data that you work with is not sequential or time-dependent. You can also use it if you don’t know how the output should be structured but want to build a relatively fast and easy NN.

A FNN is formed by one input layer, one (shallow network) or more (deep network, hence the name deep learning) hidden layers and one output layer. Each layer of the network (except the output one) is connected to the following layer. This connectivity is central to the FNN structure and has two main features in its simplest form: a weight averaging feature and an activation feature.

Recurrent neural networks. A recurrent neural network can process texts, videos, or sets of images and become more precise every time because it remembers the results of the previous iteration and can use that information to make better decisions. Recurrent neural networks are widely used in natural language processing and speech recognition.

Convolutional neural networks. Convolutional neural networks are the standard of today's deep machine learning and are used to solve the majority of problems. Convolutional neural networks can be either feed-forward or recurrent.

Generative adversarial neural networks. A generative adversarial network is an unsupervised machine learning algorithm that is a combination of two neural networks, one of which (network G) generates patterns and the other (network A) tries to distinguish genuine samples from the fake ones. Since networks have opposite goals – to create samples and reject samples – they start an antagonistic game that turns out to be quite effective. GANs are used, for example, to generate photographs that are perceived by the human eye as natural images or deepfakes (videos where real people say and do things they have never done in real life).

Neural networks are used to solve complex problems that require analytical calculations similar to those of the human brain. The most common uses for neural networks are:

1) *classification*. NNs label the data into classes by implicitly analyzing its parameters. For example, a neural network can analyse the parameters of a bank client such as age, solvency, credit history and decide whether to loan them money.
2) *prediction.* The algorithm has the ability to make predictions. For example, it can foresee the rise or fall of a stock based on the situation in the stock market.
3) *recognition*. This is currently the widest application of neural networks. For example, a security system can use face recognition to only let authorised people into the building.

Every technology has some advantages and disadvantages. It is the same goes for Artificial intelligence, and we need to keep it in our mind while creating an AI system. Following are the advantages some main advantages and disadvantages of Artificial Intelligence *(Table 2).*

Table 2

The advantages and disadvantages of AI

Advantages	***Disadvantages***
High Accuracy with fewer errors: AI machines or systems are prone to fewer errors and high accuracy as it takes decisions as per pre-experience or information.	High Cost: The hardware and software requirement of AI is very costly as it requires lots of maintenance to meet current world requirements.
High-Speed: AI systems can be of very high speed and fast-decision making; AI systems can beat a chess champion in the Chess game.	Can't think out of the box: Even we are making smarter machines with AI, but still, they cannot work out of the box, as the robot will only do that work for which they are trained or programmed.
High reliability: AI machines are highly reliable and can perform the same action multiple times with high accuracy.	Increase dependency on machines: With the increment of technology, people are getting more dependent on devices, and hence they are losing their mental capabilities.
Useful for risky areas: AI machines can be helpful in situations such as defusing a bomb, exploring the ocean floor, where employing a human can be risky.	No feelings and emotions: AI machines can

Digital Assistant: AI can be beneficial to provide digital assistant to the users such as AI technology is currently used by various E-commerce websites to show the products as per customer requirement.	be an outstanding performer, but it does not feel so it cannot make any emotional attachment with human and may sometimes be harmful to users if the proper care is not taken.
Useful as a public utility: AI can be beneficial for public utilities such as a self-driving car which can make our journey safer and hassle-free, facial recognition for security purpose, etc	No Original Creativity: As humans are so creative and can imagine some new ideas, AI machines cannot beat this power of human intelligence and cannot be creative and imaginative.

Source: Formed by the author based on J*avaTpoint* (2018). *Artificial Intelligence* [Tutorial]. Retrieved from: https://www.javatpoint.com/artificial-intelligence-tutorial

The success of commercial AI-based products offered by many important companies such as Google, IBM, Microsoft, Intel, Amazon and several interpret as the coexistence of successful synergy among what we call computational intelligence, natural intelligence, brain computing and neural engineering.

1.2. History of Artificial intelligence

In the first half of the 20th century, science fiction familiarized the world with the concept of artificially intelligent robots. It began with the “heartless” Tinman from the Wizard of Oz and continued with the humanoid robot that impersonated Maria in Metropolis. By the 1950s, we had a generation of scientists, mathematicians, and philosophers with the concept of artificial intelligence (or AI) culturally assimilated into their minds. One such person was Alan Turing, a young British polymath who explored the mathematical possibility of artificial intelligence. Turing suggested that humans use available information and reason to solve problems and make decisions, so why can’t machines do the same thing? It was the logical framework of his 1950 paper, Computing Machinery and Intelligence, in which he discussed how to build intelligent machines and test their intelligence.

The paper itself began by posing the simple question, “Can machines think?” *(see Figure 6).* Turing then proposed a method for evaluating whether machines can think, which came to be known as the Turing test. The test, or “Imitation Game” as it was called in the paper, was put forth as a simple test that could be used to prove that machines could think. The Turing test takes a simple, pragmatic approach, assuming that a computer that is indistinguishable from an intelligent human actually has shown that machines can think. The original game upon which Turing’s idea was based required a man, a woman and an interrogator. The goal was for the interrogator to identify which of the participants was a man and a woman. Since the interrogator would be able to identify the gender of the respondent by their voice (and maybe handwriting), the answers to the interrogator’s questions would be typewritten or repeated by an intermediary. For the Turing. A machine would replace the test, one of those two participants, and the interrogator's goal would not be to identify the gender of the participants but which is human and a machine.

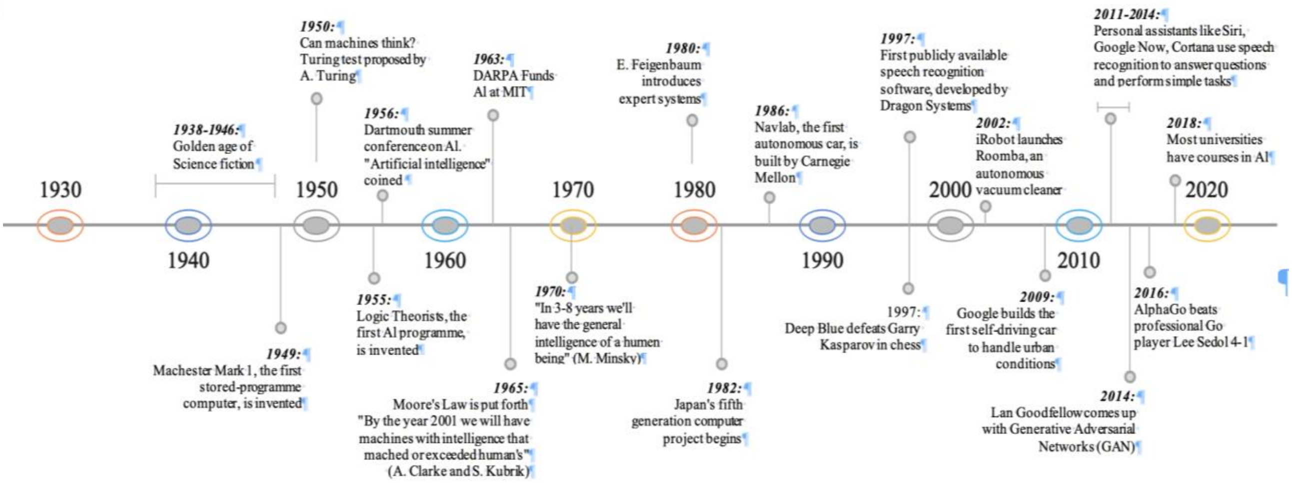


Figure 6. Artificial Intelligence timeline

Source: Developed by the author based on *Rockwell Anyoha* (2017). *The History of Artificial Intelligence*. Retrieved from: https://sitn.hms.harvard.edu/flash/2017/history-artificial-intelligence/ and *Queensland brain institute* (2019). *History of Artificial Intelligence*. Retrieved from: https://qbi.uq.edu.au/brain/intelligent-machines/history-artificial-intelligence

As described above, the Turing Test has a few key components that define what Turing means when he wonders if machines can think. First, the interrogator knows that there is one human and one machine. The test doesn't just require a computer to fool a human into thinking it is sentient; it asks the computer to fool a suspicious human. Second, physical nature isn't important – the goal is not to tell the difference between man and machine when comparing the output of the machine and the true human. The communication medium is such that there are absolutely no hints beyond what can be expressed with written language. Also, the test doesn't include anything specific – no complex problem solving or requests to create art. As described, it seems a machine would pass the Turing test if it could make small talk with another human and understand the conversation context. For Turing, passing such a test was sufficient for him to believe that machines could think.

Beyond defining the game, the paper continues with an introduction to digital computers and how they can be used for arbitrary computation – harkening back to the description of the Turing machine. Taken with Godel's incompleteness theorem and Turing's formalization of what can and cannot be computed, the Turing test seems to strike at the simple question of whether that ability to appear sentient falls into the realm of computable problems that a Turing machine can handle, or if it falls under the tiny subset of things that are true but cannot be proven so. The test is simple, but the question is hugely significant and tied into Turing's earlier work towards formalizing what can be computed.

The idea of such a long term, difficult problem was a key to defining the field of AI because it cuts to the heart of the matter – rather than solving a small problem, it defines an end goal that can pull research down many paths. Without a vision of what AI could achieve, the field itself might never have formed or remained a branch of math or philosophy. The Turing test is still discussed, and researchers attempt to produce software capable of passing. It indicates that Alan Turing and the proposed test provided a strong and useful vision to AI.

What stopped Turing from getting to work right then and there? First, computers needed to change fundamentally. Before 1949 computers lacked a fundamental prerequisite for intelligence: they couldn't store commands, only execute them. In other words, computers could be told what to do but couldn't remember what they did. Second, computing was costly. In the early 1950s, the cost of leasing a computer ran up to $200,000 a month. Only prestigious universities and big technology companies could afford to dillydally in these uncharted waters. A proof of concept and advocacy from high profile people were needed to persuade funding sources that machine intelligence was worth pursuing.

Five years later, the proof of concept was initialized through Allen Newell, Cliff Shaw, and Herbert Simon's [17]. The Logic Theorist was a program designed to mimic problem-solving skills and was funded by Research and Development (RAND) Corporation. It's considered by many to be the first artificial intelligence program and was presented at the Dartmouth Summer Research Project on AI (DSRPAI) [18] hosted by John McCarthy and Marvin Minsky in 1956. McCarthy, imagining a tremendous collaborative effort in this historic conference, brought together top researchers from various fields for an open-ended discussion on artificial intelligence, which he coined at the same event. Sadly, the conference fell short of McCarthy's expectations; people came and went as they pleased, and there was the failure to agree on standard methods for the field. Despite this, everyone whole-heartedly aligned with the sentiment that AI was achievable. The significance of this event cannot be undermined as it catalyzed the next twenty years of AI research.

From 1957 to 1974, AI flourished. Computers could store more information and become faster, cheaper, and more accessible. Machine learning algorithms also improved, and people knew which algorithm to apply to their problem. Early demonstrations such as Newell and Simon's General Problem Solver and Joseph Weizenbaum's ELIZA showed promise toward the goals of problem-solving and the interpretation of spoken language, respectively. These successes and the advocacy of leading researchers (namely the attendees of the DSRPAI) convinced government agencies such as the Defense Advanced Research Projects Agency (DARPA) to fund AI research at several institutions. The government was particularly interested in a machine that could transcribe and translate spoken language and high throughput data processing. Optimism was high, and expectations were even higher. In 1970 Marvin Minsky told Life Magazine, "from three to eight years, we will have a machine with the general intelligence of an average human being." However, while the basic proof of principle was there,

there was still a long way to go before the end goals of natural language processing, abstract thinking, and self-recognition could be achieved.

Breaching the initial fog of AI revealed a mountain of obstacles. The biggest was the lack of computational power to do anything substantial: computers couldn't store enough information or process it fast enough. To communicate, for example, one needs to know the meanings of many words and understand them in many combinations. Hans Moravec, a doctoral student of McCarthy at the time, stated that "computers were still millions of times too weak to exhibit intelligence." As patience dwindled, so did the funding, and research came to a slow roll for ten years.

In the 1980s, AI was reignited by two sources: an expansion of the algorithmic toolkit and a boost of funds. John Hopfield and David Rumelhart popularized "deep learning" techniques that allowed computers to learn using experience. On the other hand, Edward Feigenbaum introduced expert systems that mimicked a human expert's decision-making process. The program would ask an expert in a field how to respond in a given situation, and once this was learned for virtually every situation, non-experts could receive advice from that program. Expert systems were widely used in industries.

The key technological issues faced expert systems lie in the areas of software standards and methodology, knowledge acquisition, handling uncertainty, and validation [19].

Software Standards and Interoperability. There are no general standards in expert system software and development methodology. Neither do commonly adopted expert system protocols and infrastructure exist. The knowledge systems are often developed uniquely with little consideration for interoperability. Recent efforts in defining expert system standards have been actively pursued by a coalition of the American Association of Artificial Intelligence (AAAI), the IEEE Computer Society, DARPA, and the US government. Development complexity, costs, and risks could be greatly reduced once widely accepted standards are established and a new generation of expert system tools is in place.

Knowledge Acquisition and Analysis. Knowledge acquisition is usually considered as a way to discover static facts of the world and the relationships of various events that human uses in solving real life problems. The problem-solving skills in humans oftentimes are far more complicated and complex than what knowledge collection can achieve. For example, humans learn how to walk at an early age through practice and sometimes painful experience. This kind of trial and error know-how is not accessible in the form of facts and rules. If humans are asked to articulate a set of rules based on their knowhow, more often than not it will not accurately reflect their skill. More over, knowledge system does not learn from its experience.

Case-based reasoning (CBR) theory that focuses on solving new problems based on similar past problem solutions seems to be able to eliminate the complex task of maintaining rules and facts through the use of adaptive acquisition of problem-solving techniques [20]. The CYC project developed by Cycorp Inc. aims to assemble and process commonsense knowledge which CBR does not handle. Future expert systems could possibly integrate the commonsense knowledge from CYC project with application-specific modules captured from CBR to enhance their knowledge acquisition and analysis process.

Handling Uncertain Situation. The ability of expert system to derive correct output is often compromised by the lack of precision in rules and inputs. Inference engine is built upon algorithms that manipulate knowledge in the form of decision tree which is not designed to handle uncertainty. Some expert systems in areas such as linear and nonlinear control, pattern recognition, financial systems and data analysis incorporate fuzzy logic to cope with imprecise rules and inputs. The fuzzy logic in such systems usually uses preset labels to categorize real-time inputs, and utilizes fuzzy inference to calculate numerical conclusions from imprecise rules.

System Integration. Knowledge database are not easily accessible. Expert system tools are often LISP-based, which lacks the ability to integrate with other applications written in traditional languages. Most systems are still not portable among different hardware. All these system integration issues can contribute to higher costs and risks. New system architectures are required to fully integrate external systems and knowledge databases.

Validation. The quality of expert systems is often measured by comparing the results to those derived from human experts. However, there are no clear specifications in validation or verification techniques. How to adequately evaluate an expert system remains an open question, although attempts have been made to utilize pre-established test cases developed by independent experts to verify the performance and reliability of the systems [21].

The Japanese government heavily funded expert systems and other AI-related endeavours as part of their Fifth Generation Computer Project (FGCP). From 1982-1990, they invested 400 million dollars in revolutionising computer processing, implementing logic programming, and improving artificial intelligence. Amid the AI Winter in the United States, an epic attempt to realize the ‘AI dream’ was underway in Japan in the form of the Fifth Generation Computer System (FGCS) project during the 1980s. For years, Japan (and the rest of the world) lagged behind the United States in technology and played follow-the-leader for the most part.

In 1978 Japan’s Ministry of International Trade and Industry (MITI) commissioned a study of what the future would hold for computers, and three years later attempted to construct fifth generation computers – creating what project heads described as an ‘epochal’ leap in computer technology, to give Japan the technological lead for years to come. This new generation of machines would not be built on standard microprocessors but multiprocessor machines specializing in logic programming. The bet was that these high-power logic machines would catalyze the world of information processing and realize artificial intelligence. After 10 years of research and more than a billion dollars in funding, we still don’t have brilliant computers. Most of the research done didn’t push state of the art, and where it did, it was only in areas specific to the scale and scope of FGCS applications. However, the story of the FGCS project is an interesting one, well worth examining. Both the grand vision of intelligent machines and the epic failure of the project are worthy of investigation.

The motivation for Japan to build FGCS machines was a simple one to create new technology and take the lead in the computer industry. (Much like Japan's successful push into the automotive industry.) The study concluded that 'knowledge processing' would be the future of computers. If Japan played an active role in developing specialized machines for this task, the country could control this information for huge financial gains [22]. This view was widespread and was summed up by the IOTC's (discussed later) director and visionary of the FGCS project, Kazuhiro Fuchi: *"The route to knowledge information processing represents a practical philosophy and an inevitable direction for developing information processing technology. The question is ... whether to stand still or proceed, as there are no other plans to choose from."* More than pushing ahead to give Japan a lead in the technology industry, the FGCS was to push computing technology into an entirely new area: knowledge processing. One of the key goals of the FGCS project was to produce KIPS or Knowledge Information Processing Systems. The idea is that AI wouldn't be done through fancy algorithms or learning but iterating over massive knowledge bases and inferring things from that data. Specifically hardware-based syllogism engines. For example, hardware to deduce: a dove is a type of bird, and all birds fly, therefore a dove can fly.

Logic programming had been well studied in the US during the 60s and 70s, and while effective, they weren't able to make machines really that intelligent outside of an academic environment. The FGCS project supposed that with specialized hardware capable of inferences across massive databases, enough relevant knowledge could generate meaningful data. With a scale as large as the FGCS project had hoped, a critical mass of knowledge could be contained in a database file system and processed instantaneously.

Initial plans had specified machines capable of making a million logical inferences per second. Project heads had estimated that capability as powerful enough to translate natural speech, prove theorems, and other intelligent activities. To achieve this was MITI formed the Institute for New Generation Computer Technology (ICOT). The ICOT then embarked on a 10-year journey to realize an FGCS. The first three years would be for initial research, followed by four years of production/completing minor modules, and a final three years to develop prototype machines. MITI, overseeing the IOCT, would negotiate the budget with Japan's Ministry of Finance. The budget for the first three years was to include salaries for workers 'on loan' from Japanese technical firms, which were expected to invest in the FGCS project after demonstrating results and loan more workers to help out in the national effort.

With so much money, effort, and national pride riding on the success of the FGCS project, it isn't easy to imagine it not being successful. The FGCS project did produce both sequential and parallel knowledge processing machines. Near the end of 1980, parallel KIPS machines, such as the 256-processor PIM/m, produced over half a million logical inference per second [23, 24]. Unfortunately, most of the ambitious goals were not met. However, it could be argued that the indirect effects of the FGCP inspired a talented young generation of engineers and scientists. Regardless, funding of the FGCP ceased, and AI fell out of the limelight.

The failure of the FGCS project was best summarized in a report on the conference preceding the completion of the intermediary stage of the FGCS project: “Most of the applications presented at the conference were interesting because they were ‘X has done in logics programming’ – not because they were ‘X done better than before.’ The hope, of course, is that the final computer will be fast enough to run programs that are infeasible on normal computers [25].

The main issue was the failure to realize ‘intelligent’ software. The IOTC had researchers working on difficult problems such as natural language processing, automatic theorem proving, and even a program capable of playing the game of Go [26]. However, none of these areas experienced significant breakthroughs due to new hardware capabilities. Even with ultra-powerful logic machines teaching software to be intelligent was too daunting of a task. Similar to Type-A vs Type-B chess programs, you can convert computational power into increased perceived intelligence in some situations. However, the bottleneck typically understands how to teach the computer to think – by abstracting the problem space. Another problem with the project was the assumption that parallel logic chips would be required to perform advanced computations. Microprocessor technology advanced steadily during the 10 years of the FGCS project. Although FGCS hardware was superior in pure logic programming, commodity hardware was competitive, especially compared to low-end single-processor KIPS systems.

Ironically, in the absence of government funding and public hype, AI thrived. During the 1990s and 2000s, many of the landmark goals of artificial intelligence had been achieved. In particular, in 1997 year, speech recognition software, developed by Dragon Systems, was implemented on Windows. This was another great step forward but in the direction of the spoken language interpretation endeavour. It seemed that there weren’t a problem machines couldn’t handle. Even human emotion was fair game, as evidenced by Kismet, a robot developed by Cynthia Breazeal that could recognize and display emotions.

IBM's Deep Blue made history in 1997 when a chess-playing computer program defeated reigning world chess champion and grandmaster Garry Kasparov. This highly publicised match was the first time a reigning world chess champion lost to a computer and served as a huge step towards an artificially intelligent decision-making program. Nonetheless, Deep Blue’s story began in 1985, when Hsu, then a Carnegie Mellon graduate student, started working on his dissertation project: ChipTest, a chess-playing machine [27]. Hsu worked with Campbell, a research associate at the university, and graduate student Thomas Anatharaman, an IEEE member, to develop ChipTest. Hsu and Campbell later joined IBM Research in Yorktown Heights, N.Y., in 1989. The duo continued developing a chess-playing machine, but this time with other computer scientists working on the Deep Blue project. The final version of the machine consisted of two 2-meter-tall towers, more than 500 processors, and 216 accelerator chips designed for computer chess, according to a paper Campbell and Hsu wrote about Deep Blue for the Artificial Intelligence journal. The machine’s software would calculate the basic moves it could make in response to its opponent before the accelerator chips carried out more complex calculations such as assessing possible outcomes of various moves and determining the best one. The computer would decide which route to take based on the information gathered by the chips. Deep Blue could explore up to 100 million possible chess positions per second. According to IBM, the development of Deep Blue inspired researchers to create supercomputers that could tackle other complex problems such as evaluating marketplace trends and risk analysis in finance; mining data; and analyzing molecular dynamics which helped medical researchers develop new drugs.

In the early 1990s, Artificial Intelligence research shifted its focus to something called an intelligent agent.

An ***intelligent agent*** *is a type of software application that searches, retrieves and presents information from the Internet. This application automates extracting data from the Internet, such as information selected based on a predefined criterion, keywords or any specified information/entity to be searched [28].*

These intelligent agents can be used for news retrieval services, online shopping, and browsing the web. Intelligent agents are also sometimes called agents or bots. With Big Data programs, they have gradually evolved into personal digital assistants or virtual assistants.

In 2011-2014 giant tech businesses such as Google, Facebook, IBM, and Microsoft were researching a number of Artificial Intelligence projects, including virtual assistants. They are all competing to create assistants such as Facebook’s M, or Cortana from Microsoft, or Apple’s Siri. The goal of Artificial Intelligence is no longer to create an intelligent machine capable of imitating human conversation with a teletype. The use of Big Data has allowed AI to take the next evolutionary step. The goals are to develop software programs capable of speaking in a natural language, like English, and acting as your virtual assistant. These virtual assistants represent the future of AI research. They may take the form of robots for physical help, or maybe housed in laptops and help make business decisions, or they may be integrated into a business’s customer service program and answer the phone. Artificial Intelligence is still evolving and finding new uses [29].

GANs were introduced in a paper by Ian Goodfellow and other researchers at the University of Montreal, including Yoshua Bengio, in 2014. Referring to GANs, Facebook’s AI research director Yann LeCun called adversarial training “the most interesting idea in the last 10 years in ML.”

***Generative adversarial networks (GANs)** are algorithmic architectures that use two neural networks, pitting one against the other (thus the "adversarial") in order to generate new, synthetic instances of data that can pass for real data [30].*

GANs' potential for both good and evil is huge because they can learn to mimic any data distribution. That is, GANs can be taught to create worlds eerily similar to our own in any domain: images, music, speech, prose. They are robot artists in a sense, and their output is impressive – poignant even. But they can also be used to generate fake media content and are the technology underpinning Deepfakes.

To understand GANs, we should know how generative algorithms work, and for that, contrasting them with discriminative algorithms is instructive. Discriminative algorithms try to classify input data; given the features of an instance of data, they predict a label or category to which that data belongs. For example, given all the words in an email (the data instance), a discriminative algorithm could predict whether the message is spam or not pam. Spam is one of the labels, and the bag of words gathered from the email is the features that constitute the input data. When this problem is expressed mathematically, the label is called y, and the features are called x. The formulation p (y|x) is used to mean "the probability of y given x", which in this case would translate to "the probability that an email is a spam given the words it contains." So discriminative algorithms map features to labels. They are concerned solely with that correlation. One way to think about generative algorithms is that they do the opposite. Instead of predicting a label given certain features, they attempt to predict features given a specific label. A generative algorithm tries to answer: Assuming this email is spam, how likely are these features? While discriminative models care about the relation between y and x, generative models care about "how you get x." They allow us to capture p (x|y), the probability of x given y, or the probability of features given a label or category. (That said, generative algorithms can also be used as classifiers. It just so happens that they can do more than categorize input data.)

One neural network, called the generator, generates new data instances, while the other, the discriminator, evaluates them for authenticity; i.e. the discriminator decides whether each instance of data that it review belongs to the actual training dataset or not. Let us say we are trying to do something banaler than mimic the Mona Lisa. We will generate hand-written numerals like those found in the MNIST dataset taken from the real world. When shown an instance from the accurate MNIST dataset, the goal of the discriminator is to recognize those that are authentic. Meanwhile, the generator is creating new, synthetic images that it passes to the discriminator. It does so in the hopes that they, too, will be deemed authentic, even though they are fake. The goal of the generator is to generate passable hand-written digits: to lie without being caught. The goal of the discriminator is to identify images coming from the generator as fake.

GANs are not the only generative models based on deep learning. The Microsoft-backed think tank Open AI has released a series of powerful natural language generation models under the name GPT (Generative Pre-trained Transformer). In 2020, they released GPT-3 and made it accessible through an API. GPT-3 is a surprisingly powerful generative language model capable of emulating net new human speech in response to prompts. In 2015, Alphabet's DeepMind launched software to play the ancient game of Go against the best players in the world. It used an artificial neural network that was trained on thousands of human amateur and professional games to learn how to play. In 2016, AlphaGo beat the world's best player at the time, Lee Sedol, four games to one. AlphaGo's developers then let the program play against itself using trial and error, starting from completely random play with a few simple guiding rules. The result was a program (AlphaGo Zero) that trained itself faster and was able to beat the original AlphaGo by 100 games to 0. Entirely from self-play – with no human intervention and using no historical data – AlphaGo Zero surpassed all other versions of AlphaGo in 40 days [31].

Over the past few years, the availability of big data, cloud computing and the associated computational and storage capacity and breakthroughs in an AI technology called "machine learning" (ML) have dramatically increased the power, availability, growth and impact of AI. Continuing technological progress leads to better and cheaper sensors, which capture more reliable data for use by AI systems. The amount of data available for AI systems continues to grow as these sensors become smaller and less expensive to deploy. The result is significant progress in many core AI research areas such as: natural language processing, autonomous vehicles and robotics, computer vision, language learning.

Some of the most interesting AI developments are outside of computer science in health, medicine, biology and finance. In many ways, the AI transition resembles the way computers diffused from a few specialised businesses to the broader economy and society in the 1990s. It also recalls how Internet access expanded beyond multinational firms to most of the population in many countries in the 2000s. Economies will increasingly need sector "bilinguals". These are people who specialised in one area such as economics, biology or law, but also skilled at AI techniques such as ML. The present chapter focuses on applications that are in use or foreseeable in the short and medium-term rather than possible longer-term developments such as artificial general intelligence (AGI) [32].

That said, we haven't gotten any smarter about how we are coding artificial intelligence, so what changed? It turns out, the fundamental limit of computer storage that was holding us back 30 years ago was no longer a problem. Moore's Law, which estimates that the memory and speed of computers double every year, had finally caught up and, in many cases, surpassed our needs. This is precisely how Deep Blue was able to defeat Gary Kasparov in 1997 and how Google's Alpha Go was able to defeat Chinese Go champion Ke Jie. It offers a bit of an explanation to the roller coaster of AI research; we saturate the capabilities of AI to the level of our current computational power (computer storage and processing speed) and then wait for Moore's Law to catch up again.

We now live in the age of "big data," an age in which we have the capacity to collect huge sums of information too cumbersome for a person to process. In this regard, the application of artificial intelligence has already been quite fruitful in several industries such as technology, banking, marketing, and entertainment. We've seen that even if algorithms don't improve much, big data and massive computing allow artificial intelligence to learn through brute force. There may be evidence that Moore's law is slowing down a tad, but the increase in data certainly hasn't lost any momentum. Breakthroughs in computer science, mathematics, or neuroscience all serve as potential outs through the ceiling of Moore's Law.

1.3. Attitude to artificial intelligence in society

It should be noted that public views of AI's impact on society are often mixed *(see Figure 7).* Public views of artificial intelligence, described for survey respondents as computer systems designed to imitate human behaviours, are generally viewed positively by the public in the Asia-Pacific region. A median of two-thirds in the Asia-Pacific says that AI has been a good thing for society, while a median of 20% say it has been a bad thing. Elsewhere public views are mixed. In Europe, a median of 47% says the development of AI has been good for society. Roughly half view AI positively in Brazil (53%), Russia (52%), the U.S. (47%) and Canada (46%).

Opinions about the impact of robotics to automate jobs also are mixed. A median of 48% says such automation has mostly been a good thing, while 42% say it has been bad. As with AI views, assessments of job automation are generally more positive in the Asia-Pacific region (median of 61% say it's been a good thing). Fewer in Europe (a median of 48%) share this positive view. Those in France (35%), Spain (37%) and Brazil (29%) are among the least likely to say robots and automation in the workplace have been a good thing for society. In the U.S., slightly more say this type of automation has been bad than good for the country (50% vs 41%). Across places surveyed, those with higher levels of education and who have taken more science courses in their schooling are especially likely to consider AI and workplace automation as a positive development for society. Views tend to be less positive among those with lower levels of education.

The survey results can be explained by the fact that Artificial intelligence (AI) is reshaping economies, promising to generate productivity gains, improve efficiency and lower costs. It contributes to better lives and helps people make better predictions and more informed decisions. These technologies, however, are still in their infancy, and there remains much promise for AI to address global challenges and promote innovation and growth. At the same time, Artificial

Intelligence is also fuelling anxieties and ethical concerns. There are questions about the trustworthiness of AI systems, including the dangers of codifying and reinforcing existing biases, such as those related to gender and race, or infringing on human rights and values, such as privacy. Concerns are growing about AI systems exacerbating inequality, climate change, market concentration and the digital divide [32].

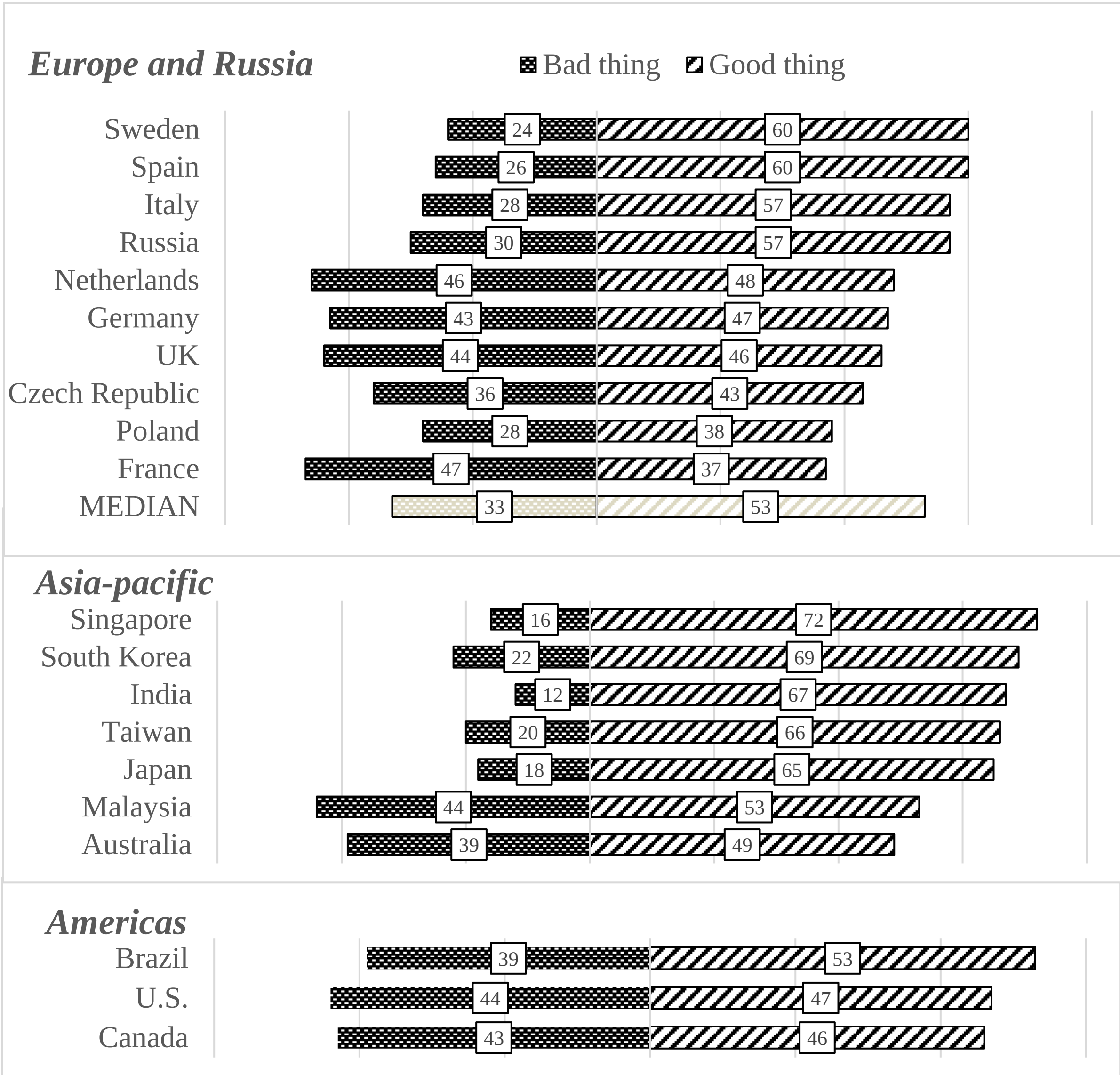


Figure 7. Who say the development of artificial intelligence has mostly been a bad thing or good thing for society, %

Source: Developed by the author based on *"Science and Scientists Held in High Esteem Across Global Publics"*. International Science Survey 2019-2020. Q11b. *Note:* Respondents who did not give an answer are not shown. Ukrainian society did not participate in the survey.

Due to the ways AI has evolved from existing technologies, including in terms of both sophistication and scale, AI may exacerbate existing questions and introduce new problems to consider, with huge impacts on accountability and reliability. To illustrate this, consider two recent tech trends: big data and the rise of algorithmic decision-making. Today, algorithmic decision-making is largely digital. In many cases, it employs statistical methods similar to those used to create the pen-and-paper sentencing algorithm that we discussed above. Before AI, algorithms were deterministic, that is, pre-programmed and unchanging. Because they are based on statistical modelling, these algorithms suffer from the same problems as traditional statistics, such as poorly sampled data, biased data, and measurement errors. But because they are pre-programmed, the recommendations they make can be traced.

The use of AI in algorithmic decision-making has introduced a new set of challenges. Because machine learning algorithms use statistics, they also have the same problems with biased data and measurement error as their deterministic predecessors. However, ML systems differ in a few key ways. First, whereas traditional statistical modelling is about creating a simple model in the form of an equation, machine learning is much more fine-tuned. It captures a multitude of patterns that cannot be expressed in a single equation. Second, unlike deterministic algorithms, machine learning algorithms calibrate themselves.

Because they identify so many patterns, they are too complex for humans to understand, and thus it is not possible to trace the decisions or recommendations they make. In addition, many machine learning algorithms constantly re-calibrate themselves through feedback. An example of this is e-mail spam filters, which continually learn and improve their spam detection capabilities as users mark an email as spam. Another issue is the impact of error rates. Because of their statistical basis, all ML systems have error rates. Even though ML systems are far more accurate than human beings in many cases, there is danger in assuming that simply because a system's predictions are more accurate than a human's, the outcome is necessarily better. Even if the error rate is close to zero, in a tool with millions of users, thousands could be affected by error rates. Consider the example of Google Photos. In 2015 Google Photos' image recognition software was found to have a terribly prejudicial and offensive error: it occasionally labelled photos of black people as gorillas. Because the system used a complex ML model, engineers could not figure out why this was happening. The only "solution" they could work out to this "racist" ML was merely a band-aid: they removed any monkey-related words from the list of image tags [33].

Now, imagine a similar software system used, for instance, by the U.S. Customs and Border Patrol that photographs every person who enters and exits the U.S. and cross-references it with a database of photos of known or suspected criminals and terrorists. In 2016, an estimated 75.9 million people arrived in the United States. Even if the facial recognition system were 99.9% accurate, the 0.1% error rate would result in 75,900 people being misidentified. How many of these people would be falsely identified as wanted criminals and detained? And what would the impact be on their lives? Conversely, how many known criminals would get away? Even relatively narrow error rates in cases such as these can have severe consequences.

In the bottom line, the proliferation of AI in data analytics has come with the rise of big data. In her 2015 book Weapons of Math Destruction data scientist Cathy O'Neil [34] documented how algorithmic decision-making is now ubiquitous in the West, from assigning credit scores to identifying the best candidates for a job position to ranking students for college admissions. Today, these algorithmic decision-making systems are increasingly employing machine learning, and they are spreading rapidly. They have many of the same problems as traditional statistical analysis. However, the scale and reach of AI systems, the trend of rapid, careless deployment, the immediate impact they have on many people's lives, and the danger of societies viewing their outputs as impartial pose a series of new problems.

Every major technological innovation brings the potential to advance or damage society. The data processing and analysis capabilities of AI can help alleviate some of the world's most pressing problems, from enabling advancements in diagnosis and treatment of disease to revolutionising transportation and urban living to mitigating the effects of climate change. Yet these same capabilities can also allow surveillance on a scale never seen before, can identify and discriminate against the most vulnerable, and may revolutionise the economy so quickly no job retraining program can keep up. And despite significant strides in the development of AI, the so-called "artificial intelligence revolution" is only a decade old, meaning there are many unknown possibilities in what is to come [35].

Today, artificial intelligence is becoming one of the fastest-growing technological segments, offering intelligent solutions in various economic and social spheres. Yes, banks intend to introduce robotic employees to work with customers. Many structures are already testing prototypes of artificial assistants, focused on solving 80% of the issues that most often arise in consumers. Intelligent technologies control employees' decisions, promptly responding to illegal actions on their part, thereby preventing violations of legislation by the bank itself. Large financial institutions Goldman Sachs, Morgan Stanley Citigroup and UBS Group, are investing in AI development for hiring staff. A number of financial institutions use AI in the personnel management system. It is expected that in the next few years, AI will be used in the field of finance ten times more often than the current practice. For example, half of all surveyed heads of US banks stated plans to implement intelligent systems in the work of the institution, of which 39% - to prevent illegal money transfers and 26% - to monitor the legitimacy of the bank's actions [36].

Below we identify some of the ways AI is being used to help or harm societies. It is important to note that even the "helpful" uses of AI have potentially harmful implications. For example, many AI applications in healthcare pose severe threats to privacy and risk discriminating against underserved communities and concentrating data ownership within large companies. At the same time, the use of AI to mitigate harm may not solve underlying problems and should not be treated as a cure for societal ailments. For example, while AI may alleviate the need for medical professionals in underserved areas; it isn't providing the resources or incentives those professionals would need to relocate. Similarly, some of the use cases categorised as "harmful" came about due to good intentions yet are causing significant harm.

1. Helpful Artificial Intelligence.

One of the most well-known examples of the *use of AI in the industry* is the initiative of the Port of Hamburg and the Harley-Davidson motorcycle company: the former used smart technology to increase bandwidth by more than 2.5 times, and the latter reduced motorcycle assembly time from 21 days to 6 hours. Cisco, AT&T, IBM and Intel have joined the Industrial Internet Consortium, IIC, which aims to promote IoT technology and AI projects. It is expected that in the next ten years, the use of AI in the industry can radically transform all its sectors. The exploitation of intelligent technologies will become a mass culture. Experts believe that in the foreseeable future, the most popular AI will be, above all, in those processes: where the direct algorithmic calculation is impossible or extremely difficult; where there are many variables and unknowns; where the engineer evaluates the necessary actions "by eye" and on their own experience [37].

Artificial Intelligence has become a large-scale tool and resource for retailers. It is increasingly used to improve customer service in online stores and other services, interactive mobile applications, and even loyalty programs. Intelligent technology allows retailers to more than successfully interact with customers in a mutually beneficial conversation, rather than just talking to them, often without getting the right feedback. Chatbots and intelligent assistants in 2018 exceeded all expectations of developers and those who use them directly. Digital personalized programs perform high-quality communication and customer support, audience analysis and potential pooling, dialogue and analysis of all possible user requests. Moreover, as AI technologies improve in this direction, such systems increasingly learn to perceive human speech and intonation and maintain a whole conversation necessarily. AI has also become safer and, at the same time, more "open". It has learned to be tolerant in communicating with people in the field of services to conduct full-fledged dialogues, to process verbal and visual information from customers. That is why many experts today believe that about 85% of interaction with consumers controlled by AI.

Improving access to healthcare and predicting disease outbreaks. Already, there have been significant advancements through the use of AI in disease diagnosis and prevention. AI is also being used to improve access to healthcare in regions where there is a lack of access. For instance, IBM's Watson is being used in hospitals around the world to help doctors diagnose and treat disease. Another example is Aajoh, a Nigerian start-up developing an AI system for remote medical diagnosis. Users share their symptoms via text, audio, and photographs, and Aajoh uses AI to provide possible diagnoses [38]. Victims of disease outbreaks also benefit from the use of AI to enable health officials to intervene early to contain an outbreak before it starts [39].

Making life easier for the visually impaired. Tools for image recognition are helping people who are visually impaired better navigate both the internet and the real world [40, 41]. For example, Facebook launched automatic alt text. It is a new development that generates a description of a photo using advancements in object recognition technology. People using screen readers on iOS devices (39 million people who are blind and over 246 million who have a severe visual impairment) will hear a list of items a photo may contain as they swipe past photos on Facebook. Before today, people using screen readers would only hear the name of the person who shared the photo, followed by the term "photo" when they came upon an image in News Feed. Now we can offer a more detailed description of what is in a photo thanks to automatic alt text. For instance, someone could now hear, "Image may contain three people, smiling, outdoors." It was possible because of Facebook's object recognition technology, which is based on a neural network that has billions of parameters and is trained with millions of examples.

Optimizing agriculture and helping farmers adapt to change. AI combines information from global satellite imagery with weather and agronomic data to help farmers improve crop yields, diagnose and treat crop disease, and adapt to changing environments. This approach to farming is known as precision agriculture, and it can help increase farm productivity to feed more of the world's growing population.

Mitigating climate change, predicting natural disasters, and conserving wildlife. With the effects of climate change appearing around the world, machine learning is being used to make more accurate climate models for scientists. Already, AI is used to rank climate models and predict extreme weather events [42], as well as to better predict extreme weather events and respond to natural disasters [43]. Artificial Intelligence is also helpful for identifying and apprehending poachers and locating and capturing disease-spreading animals.

Making government services more efficient and accessible. Despite often being slow to adopt new technologies, governments around the world are using AI, from the local to the national levels, to make public services more efficient and accessible, with an emphasis on developing "smart cities". AI is also being used to allocate government resources and optimize budgets [44, 45].

In collaboration with Frontier Economics, Accenture has modelled the potential economic impact of AI on 16 industries *(see Figure 8),* covering a wide range of activities, from manufacturing and healthcare services. As an evaluation criterion, they used the growth rate of gross value added (GVA), which considers the value of goods and services produced in a particular sector. The result of the study was an assessment of the future impact of Artificial Intelligence, which was conducted by comparing two scenarios for each industry: the first scenario – the baseline, which shows the expected economic growth for industries in modern conditions; second, the expected growth given the integrated into economic processes AI. As the introduction of the new technology takes time, the forecast period is 2035. Studies show that information and communication services, manufacturing and financial services are the three sectors that will have the highest annual gross value-added growth rate if Artificial Intelligence is integrated into economic processes (4.8%, 4.4% and 4.3%, respectively) by the 2035 year.

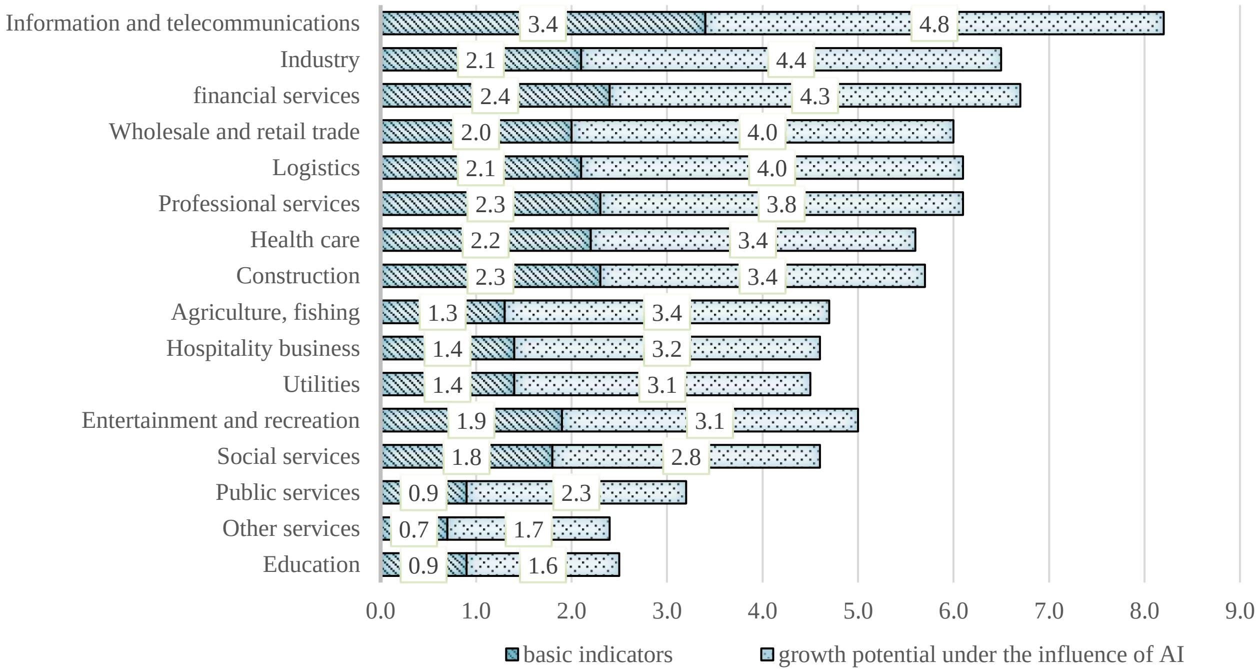


Figure 8. Annual rates of growth of airborne forces under the condition of integration of AI into economic processes different industries as of 2035, %

Source: Developed by the author based on Mark Purdy and Paul Daugherty (June 21, 2017). How AI boosts industry profits and innovation. Retrieved from: https://www.accenture.com/_acnmedia/PDF-84/ Accenture-AI-Industry-Growth-Full-Report.pdf

One of the main benefits of artificial intelligence is its ability to reduce the drudgery involved in many work tasks. Repetitive, tedious tasks in any job are the bane of many human workers around the world. Some are so boring that mistakes are commonplace, as human attention can be difficult to sustain when conducting repetitive tasks. Such tasks, however, are perfectly suited for computer automation. It is where sophisticated AIs could come to the rescue. Machines excel in taking care of standardized processing work like data entry, etc., freeing up human operatives to concentrate on the more creative and interpersonal aspects of their jobs or lives.

Let us take the example of the banking sector, which has seen something of a breakthrough in this area, thanks to AI applications. Today, financial institutions are seen taking full advantage of this technology to make banking quicker and more accessible for consumers. It has already gone some way in giving financial workers some reprieve from the tedious aspects of their jobs and focus on deeper research and analysis of all-around consumer experience. In fact, a recent survey of IT leaders by MIT found that a large proportion of respondents welcomed the use of AI to do the heavy lifting when it comes to repetitive tasks. Nearly half (47%) of them strongly agreed with the statement that thanks to AI, “We could dedicate more time to thinking creatively about the business challenges we (and our clients) face" [47].

While there are some genuine concerns about the potential to eliminate or make some types of jobs redundant, AI could also open entirely new areas of work. The application of AI in businesses will also force the job market to evolve, which, with the right preparation, could be a perfect thing. From various maintenance and supporting roles to entirely new careers not yet dreamed of, the widespread adoption of AI could be a brighter future for all of us. And we've been here before. Similar fears to those around AI have surfaced around most new forms of technology. Sometimes, the fears are well-founded, and sometimes not, but either way, the genie of new technology cannot be put back in the bottle. All we can do is learn how to use it wisely and to our advantage.

2. Harmful Artificial Intelligence.

Perpetuating bias in criminal justice. There are many documented cases of AI gone wrong in the criminal justice system. The use of AI in this context often occurs in two different areas: risk scoring-evaluating whether or not a defendant is likely to re-offend in order to recommend sentencing and set bail or so-called "predictive policing," using insights from various data points to predict where or when crime will occur and direct law enforcement action accordingly. A 2016 ProPublica investigation revealed that not only was COMPAS, an ML-powered software widely used in the U.S. criminal justice system, was inaccurate at forecasting future crime and heavily biased against black defendants. The investigators looked at risk scores of over 7,000 people arrested in Broward County, Florida and compared them with subsequent criminal records. They found that only 20% of the people predicted to commit violent crimes went on to do so. And when looking at the full range of crimes, only 61% of defendants deemed likely to reoffend were actually arrested for a future crime [48]. In many cases, these efforts are likely well-intentioned. The use of machine learning for risk scoring of defendants is advertised as removing the known human bias of judges in their sentencing and bail decisions. An investigation by the Science and Technology Committee of Parliament of HART, ML-powered software being used by police in Durham, England to evaluate recidivism risk, revealed that it was calibrated to avoid false negatives, incorrectly classifying a person as low risk when they in fact go on to commit serious crimes [49]. And predictive policing efforts seek to allocate the best often-limited police resources to prevent crime, though there is always a high risk of mission creep. Public records suggest that software developed by Palantir and used by police in criminal investigations in New Orleans was used beyond its original intended scope. After a series of investigative reports and significant public outcry, the city ended its six-year contract with Palantir in March 2018 [51]. However, the recommendations of these AI systems often further exacerbate the very bias they are trying to mitigate, either directly or by incorporating factors that are proxies for bias.

Facilitating mass surveillance. Given that AI provides the capacity to process and analyse multiple data streams in real-time, it is no surprise that it is already being used to enable mass surveillance worldwide [52]. The most pervasive and dangerous example of this is the use of Artificial Intelligence in facial recognition software. In 2018, Australia unveiled a plan to connect its network of CCTV cameras to existing facial recognition and biometric databases [53]. Although the technology is still imperfect, governments are looking to facial recognition technology as a Tool to monitor their citizens, facilitate profiling of certain groups and even identify and locate individuals. Recently, Amazon has come under fire for directly marketing a facial recognition product called Rekognition to law enforcement agencies for use in conjunction with police body cameras, which would allow police to identify people in real time. The product was piloted with police departments in Orlando, Florida and Washington County, Oregon [54].

Enabling discriminatory profiling. Facial recognition software is not just being used to survey and identify, but also to target and discriminate. One example is an Israeli company called Faception, which bills itself as a "facial personality analytics technology company," and claims it can categorize people into personality types based solely on their faces. The classifiers it uses include "white collar offender," "high IQ," "paedophile" and "terrorist." The company has not released any information about how its technology can correctly label people based only on their faces. See: Paul Lewis, "'I was shocked it was so easy': meet the professor who says facial recognition can tell if you're gay," The Guardian, July 7, 2018.

Assisting the spread of disinformation. AI can be used to create and disseminate targeted propaganda. That problem is compounded by AI-powered social media algorithms driven by "engagement," which promote content most likely to be clicked on. Machine learning powers the data analysis social media companies use to create profiles of users for targeted advertising. In addition, bots disguised as real users further spread content outside of narrowly targeted social media circles by both sharing links to false sources and actively interacting with users as chatbots using natural language processing. Given bots are estimated to make up at least half of all internet traffic, their reach should not be underestimated [55] In addition, the spectre of "deep fakes," AI systems capable of creating realistic-sounding video and audio recordings of real people, is causing many to believe the technology will be used in the future to create forged videos of world leaders for malicious ends. Although it appears that deep fakes have yet to be used as part of real propaganda or disinformation campaigns, and the forged audio and video are still not good enough to seem completely human, the AI behind deep fakes continues to advance. There is potential for sowing chaos, instigating conflict, and further causing a crisis of truth that should not be discounted.

Perpetuating bias in the job market. Hiring processes have long been fraught with bias and discrimination. In response, an entire industry has emerged that uses AI with the goal of removing human bias from the process. However, many products ultimately risk perpetuating the very bias they seek to mitigate. As in other areas, a major cause of this is the prevalent use of historical data of past "successful" employees to train the ML models, thus naturally reproducing the bias in prior hiring [56].

Driving financial discrimination against the marginalized. Algorithms have long been used to create credit scores and inform loan screening. However, with the rise of big data, systems are now using machine learning to incorporate and analyse non-financial data points to determine creditworthiness, from where people live, to their internet browsing habits, to their purchasing decisions. The outputs these systems produce are known as e-scores, and unlike formal credit scores, they are largely unregulated. As data scientist Cathy O'Neil has pointed out, these scores are often discriminatory and create pernicious feedback loops. For example, a would-be borrower who lives in a rough part of town, where more people default on their loans, may be given a low score and targeted with financial products offering less credit and higher interest rates. This is because such systems group people together based on the observed habits of the majority. In this case, a responsible person trying to start a business could be denied credit or given a loan on unfavorable terms, perpetuating existing bias and social inequality [34, 141-160]. One company O'Neil singled out is ZestFinance, which uses machine learning to offer payday loans at lower rates than typical payday lenders. The company's philosophy is "all data is credit data." Some of the data has been found to be a proxy for race, class, and national origin. This includes whether applicants use proper spelling and capitalization on their application, and how long it takes them to read it. Punctuation and spelling mistakes are analyzed to suggest the applicant has less education and/or is not a native English speaker, which are highly correlated with socioeconomic status, race, and national origin. This means those who are considered to have poor language skills – including non-native speakers – will have higher interest rates. This can lead to a feedback loop that entrenches existing discriminatory lending practices – if the applicants have trouble paying these higher fees, this tells the system that they were indeed higher risk, which will result in lower scores for other similar applicants in the future [34, 157-158].

Nonetheless, most researchers agree that a superintelligent AI is unlikely to exhibit human emotions like love or hate and that there is no reason to expect AI to become intentionally benevolent or malevolent. Instead, when considering how AI might become a risk, experts think two scenarios most likely [58]:

Firstly, the AI is programmed to do something devastating: Autonomous weapons are artificial intelligence systems that are programmed to kill. In the hands of the wrong person, these weapons could easily cause mass casualties. Moreover, an AI arms race could inadvertently lead to an AI war that also results in mass casualties. To avoid being thwarted by the enemy, these weapons would be designed to be extremely difficult to simply "turn off" so humans could plausibly lose control of such a situation. This risk is one that's present even with narrow AI but grows as levels of AI intelligence and autonomy increase.

Secondly, the AI is programmed to do something beneficial, but it develops a destructive method for achieving its goal: This can happen whenever we fail to fully align the AI's goals with ours, which is strikingly difficult. If you ask an obedient, intelligent car to take you to the airport as fast as possible, it might get you there, chased by helicopters and covered in vomit, doing not what you wanted but literally what you asked for. If a superintelligent system is tasked with an ambitious geoengineering project, it might wreak havoc with our ecosystem as a side effect and view human attempts to stop it as a threat to be met.

As these examples illustrate, the concern about advanced AI isn't malevolence but competence. A super-intelligent AI will be extremely good at accomplishing its goals, and if those goals aren't aligned with ours, we have a problem. You're probably not an evil ant-hater who steps on ants out of malice, but if you're in charge of a hydroelectric green energy project and there's an anthill in the region to be flooded, too bad for the ants. A key goal of AI safety research: to never place humanity in the position of those ants.

Therefore, given that AI's impacts permeate our societies, its transformational power must be put at the service of people and the planet.

REFERENCES

1. *Paul Sciglar* (2018). *What Is Artificial Intelligence?* [Understanding 3 Basic AI Concepts]. Retrieved from: https://www.roboticsbusinessreview.com /ai/3-basic-ai-concepts-explain-artificial-intelligence/ (Last accessed: 12.05.2021)
2. Robert Kozma, Cesare Alippi, Yoonsuck Choe, Francesco Carlo Morabito (2019). Artificial Intelligence in the Age of Neural Networks and Brain Computing, Academic Press. Pages 324, ISBN 9780128154809, https://doi.org/10.1016/B978-0-12-815480-9.02001-6.
3. J*avaTpoint* (2018). *Artificial Intelligence* [Tutorial]. Retrieved from: https://www.javatpoint.com/artificial-intelligence-tutorial (Last accessed: 20.04.2021)
4. *Tutorials point* (2015). *Artificial Intelligence: intelligent systems* [Tutorial]. Retrieved from: https://www.tutorialspoint.com/artificialintelligence/ index.htm (Last accessed 25.04.2021)
5. *Avijeet Biswal* (2021). *7 Types of Artificial Intelligence that you should know in 2020* [Tutorials]. Retrieved from: https://www.simplilearn.com/tutorials/-artificial-intelligence-tutorial/types-of-artificial-intelligence (Last accessed 25.04.2021)
6. *Quantilus* (July 31st, 2020). *AI Explained: Understanding the Basics of Artificial Intelligence.* Retrieved from: https://quantilus.com/ai-explained-understanding-the-basics-of-artificial-intelligence/ (Last accessed 25.04.2021)
7. Markus Krötzsch, Frantisek Simancík, and Ian Horrocks (2014). A description logic primer. In Jens Lehmann and Johanna Völker, editors, Perspectives on Ontology Learning, Studies on the Semantic Web. AKA Heidelberg / IOS Press.

8. Jiawei Han and Micheline Kamber (2006). Data Mining. Concepts and Techniques. Morgan Kaufmann, 2nd edition.
9. David J. Hand, Padhraic Smyth, and Heikki Mannila (2001). Principles of data mining. MIT Press, Cambridge, MA, USA.
10. Ławrynowicz, Agnieszka & Tresp, Volker (2014). Introducing Machine Learning.
11. Alex Smola and S.V.N. Vishwanathan (2008) Introduction to Machine Learning. Cambridge University Press. 252 p. Retrieved from: https://alex.smola.org/drafts/thebook.pdf (Last accessed 25.04.2021).
12. *Yulia Gavrilova* (October 8th, 2020). *A Guide to Deep Learning and Neural Networks*. Retrieved from: https://serokell.io/blog/deep-learning-and-neural-network-guide (Last accessed 25.04.2021).
13. *James Chen* (Dec 23, 2020). *Neural Network*. Retrieved from: https://www.investopedia.com/terms/n/neuralnetwork.asp (Last accessed 25.04.2021).
14. *Thomas Epelbaum* (2017). *Deep learning: Technical introduction*. Retrieved from: https://arxiv.org/pdf/1709.01412.pdf (Last accessed 25.04.2021).
15. *Rockwell Anyoha* (2017). *The History of Artificial Intelligence*. Retrieved from: https://sitn.hms.harvard.edu/flash/2017/history-artificial-intelligence/ (Last accessed 25.04.2021).
16. *Queensland brain institute* (2019). *History of Artificial Intelligence*. Retrieved from: https://qbi.uq.edu.au/brain/intelligent-machines/history-artificial-intelligence (Last accessed 25.04.2021).
17. *Computer history* (2021). *Logic Theorist – Complete History of the Logic Theorist Program*. Retrieved from: https://history-computer.com/logic-theorist-complete-history-of-the-logic-theorist-program/ (Last accessed 25.04.2021).
18. *James Moor* (2006). The Dartmouth College Artificial Intelligence Conference: The Next Fifty Years. *AI Magazine* Volume 27 Number 4. P 87-91.
19. Goel, A. Winter (1994). The reality and future of expert systems. *Information Systems Management*, Vol. 11, p. 1.
20. Aamodt, Agnar and Plaza, Enric (1994). Case-Based Reasoning: Foundational Issues, Methodological Variations, and System Approaches. *Artificial Intelligence Communications*, Vol. 7. P 39-52.
21. *Chris Smith, Brian McGuire, Ting Huang and Gary Yang* (2006). *The History of Artificial Intelligence*. Retrieved from: https://courses.cs.washington.edu/-courses/csep590/06au/projects/history-ai.pdf (Last accessed 05.05.2021).
22. Feigenbaum, Edward and McCorduck, Pamela (1983). The Fifth Generation. Addison-Wesley.
23. Nakashima, Hiroshi; Kondo, Seiichi; Inamura, Yu; Onishi, Satoshi; Masuda, Kanae (1992). Architecture and Implementation of PIM/m. Proceedings of the International Conference on Fifth Generation Computer Systems.

24. Kruozumi, Takashi (1992). Overview of the 10 years of the FGCS project. Proceedings of the international conference on fifth generation computer systems.
25. Nielsen, Jakob (1988). Trip report for the international conference on Fifth Generation Computer Systems. Retrieved from: http://www.useit.com/papers/-tripreports/fifthgeneration.html (Last accessed 05.05.2021).
26. Sei, Shinichi; Oki, Hiroaki; and Akaosugi, Takashi (1991). The experimental version of the parallel computer Go-playing system GOG. Technical Report TR718, ICOT, Japan.
27. *Joanna Goodrich* (2021). *How IBM's Deep Blue beat World Champion Chess Player Garry Kasparov*. Retrieved from: https://spectrum.ieee.org/the-institute/ieee-history/how-ibms-deep-blue-beat-world-champion-chess-player-garry-kasparov (Last accessed 05.05.2021).
28. *Techopedia* (2021) *Intelligent Agent*. Retrieved from: https://www.techopedia.com/definition-/28055/intelligent-agent (Last accessed 25.04.2021).
29. *Keith, D.* (2016). *A Brief History of Artificial Intelligence*. Retrieved from: https://www.dataversity.net/brief-history-artificial-intelligence/ (Last accessed 05.05.2021).
30. *A. I. Wiki* (2020). *A Beginner's Guide to Generative Adversarial Networks (GANs)*. Retrieved from: https://wiki.pathmind.com/generative-adversarial-network-gan (Last accessed 05.05.2021).
31. Silver, D. et al. (2017), "Mastering the game of Go without human knowledge", *Nature*, Vol. 550/7676, pp. 354-359, http://dx.doi.org/10.1038/nature24270.
32. *OECD* (2019), *Artificial Intelligence in Society*, OECD Publishing, Paris, https://doi.org/10.1787/eedfee77-en.
33. *WIRED* (May 13, 2018). *When it comes to Gorillas, Google Photos Remains Blind*. Retrieved from: https://www.wired.com/story/when-it-comes-to-gorillasgoogle-photos-remains-blind/ (Last accessed 15.05.2021).
34. *O'Neil, Cathy* (2016). *Weapons of math destruction: how big data increases inequality and threatens democracy*. First edition. New York: Crown Publishers. Retrieved from: https://lccn.loc.gov/2016003900
35. *Accessnow.org* (2018). *Human rights in the age of Artificial Intelligence*. Retrieved from: https://www.accessnow.org/cms/assets/uploads/2018/11/AI-and-Human-Rights.pdf (Last accessed 1.05.2021).
36. *Narasimhan S Raghavan* (November 22, 2018). How AI is driving Digital Transformation. Retrieved from: https://www.linkedin.com/pulse/how-ai-driving-digital-transformation-narasimhan-s-raghavan
37. Pizhuk, O. (2019). Shtuchnyi intelekt yak odyn iz kliuchovykh draiveriv tsyfrovoi transformatsii ekonomiky [Artificial intelligence as one of the key drivers' digital transformation of the economy]. Economics, management and administration. № 3 (89). P 41-46. (Ukr.) DOI: https://doi.org/10.26642/jen-2019-3(89)-41-46

38. *Stephen, Timm* (April 24, 2017). *6 Artificial Intelligence Startups in Africa to Lookout for*. Retrieved from: http://ventureburn.com/2017/04/five-artificial-intelligence-startups-africa-look-2017/?platform=hootsuite (Last accessed 15.05.2021).
39. *Zeena Saifi, Victoria Brown and Tom Page* (March 6, 2018). *AI and big data joins effort to predict deadly disease outbreaks*. Retrieved from: https://www.cnn.com/2018/03/06/health/rainier-mallol-tomorrows-hero/index.html (Last accessed 15.05.2021).
40. *Facebook Newsroom* (April 4, 2016). *Using Artificial Intelligence to Help Blind People 'See' Facebook.* Retrieved from: https://newsroom.fb.com/news/-2016/04/using-artificial-intelligence-to-help-blind-people-see-facebook/ (Last accessed 15.05.2021).
41. Microsoft's work: "Seeing AI: An app for visually impaired people that narrates the world around you," Microsoft, https://www.microsoft.com/en-us/garage/wall-of-fame/seeing-ai/.
42. Jones, Nicola (August 23, 2017). "How Machine Learning could help to improve climate forecasts". *Nature magazine*. Retrieved from: https://www.scientificamerican.com/article/how-machine-learning-could-help-to-improve-climate-forecasts/ (Last accessed 15.05.2021).
43. McConnon, Aili (June 26, 2018). "AI Helps Cities Predict Natural Disasters" *The Wall Street Journal*. Retrieved from: https://www.wsj.com/articles/ai-helps-cities-predict-natural-disasters-1530065100 (Last accessed 15.05.2021).
44. Mehr, Hila (August 2017). "Artificial Intelligence for Citizen Services and Government," Ash Center for Democratic Governance and Innovation. Harvarf Kennedy School. Retrieved from: https://ash.harvard.edu/ files/ash/files-/artificial_intelligence_for_citizen_services.pdf (Last accessed 15.05.2021).
45. IBM Cognitive Business (January 31, 2017). "Watson helps cities help citizens: the 411 on how artificial intelligence transforms 311 services." *Medium*. Retrieved from: https://medium.com/cognitivebusiness/watson-assists-cities-with-311-3d7d6898d132 (Last accessed 15.05.2021).
46. Purdy, Mark and Daugherty, Paul (June 21, 2017). How AI boosts industry profits and innovation. Retrieved from: https://www.accenture.com/_acnmedia/-PDF-84/Accenture-AI-Industry-Growth-Full-Report.pdf
47. *Vyas, Kashyap* (2021). *7 Benefits of AI that will help humanity, not harm it.* Interesting engineering. Retrieved from: https://interestingengineering.com/7-ways-ai-will-help-humanity-not-harm-it (Last accessed 17.05.2021).
48. Larson, Jeff and Angwin, Julia (May 23, 2016). "Machine Bias." text/html. ProPublica. Retrieved from: https://www.propublica.org/article/machine-bias-riskassessments-in-criminal-sentencing (Last accessed 15.05.2021).

49. *Big brother watch team* (April 6, 2018). *A closer look at experian big data and artificial intelligence in durham police.* Retrieved from: https://bigbrother-watch.org.uk/2018/04/a-closer-look-at-experian-big-data-and-artificial-intelligence-in-durham-police/ (Last accessed 15.05.2021).
50. *BBC* (9 April 2018). *Durham police criticised over 'crude' profiling*. Retrieved from: https://www.bbc.co.uk/news/technology-43428266 (Last accessed 17.05.2021).
51. *Winston, Ali* (Feb 27, 2018). *Palantir has secretly been using New Orleans to test its predictive policing technology.* Retrieved from: https://www.theverge.com/-2018/2/27/17054740/palantir-predictive-policing-tool-new-orleans-nopd (Last accessed 15.05.2021).
52. Mozur, Paul (July 8, 2018) "Inside China's Dystopian Dreams: AI, Shame and Lots of Cameras." *The New York Times*. Retrieved from: https://www.nytimes.com/2018/07/08/business/china-surveillance-technology.html. (Last accessed 17.05.2021).
53. *Accessnow.org* (July 7, 2018). *Human Rights in the Digital Era an international perspective on Australia.* The proposed measure is pending in Parliament. Retrieved from: https://www.accessnow.org/cms/assets-/uploads/2018/07/-Human-Rights-in-the-Digital-Era-an-international-perspective-on-Australia.pdf (Last accessed 28.04.2021).
54. *Wong, Julia Carrie* (23 May 2018). *'Recipe for authoritarianism': Amazon under fire for selling face-recognition software to police.* Retrieved from: https://www.theguardian.com/technology/2018/may/22/amazon-rekognition-facial-recognition-police (Last accessed 17.05.2021).
55. *Horowitz, Michael; Scharre, Paul; Allen, Gregory C.; Frederick, Kara; Cho, Anthony and Saravalle, Edoardo* (July 10, 2018). "*Artificial Intelligence and International Security.*" Center for a New American Security. Retrieved from: https://www.cnas.org/publications/reports/ artificial-intelligence-and-internatio-nal-security (Last accessed 17.05.2021).
56. *Torres, Monica* (August 25, 2017). "*Companies Are Using AI to Screen Candidates Now with HireVue.*" Ladders. Retrieved from: https://www.theladders.com/careeradvice/ai-screen-candidates-hirevue (Last accessed 27.04.2021).
57. *Pewresearch.org* (2020). *"Science and Scientists Held in High Esteem Across Global Publics"*. International Science Survey 2019-2020. Q11b. Retrieved from: https://www.pewresearch.org/science/2020/09/29/science-and-scientists-held-in-high-esteem-across-global-publics/ps_2020-09-29_global-science_00-06/ (Last accessed 17.05.2021).
58. *Tegmark, Max* (2016). *Benefits & Risks of Artificial Intelligence*. Retrieved from: https://futureoflife.org/-background/benefits-risks-of-artificial-intelligen-ce/ (Last accessed 17.05.2021).

1.4. Artificial intelligence and its possibilities

Irina Khmarska
PhD in Economics,
Head of department of Economics and Organization
Admiral Makarov National University of Shipbuilding of Mykolayiv
E-mail: hmarska@ukr.net
ORCID ID https://orcid.org/0000-0002-6022-6197

Natalia Hryshyna
PhD in Economics,
Head of department of Economics and Organization
Admiral Makarov National University of Shipbuilding of Mykolayiv
E-mail: natalia.gryshyna@nuos.edu.ua
ORCID ID http://orcid.org/0000-0003-1768-750X

Natalia Mihai
PhD in Economics,
Head of department of Economics and Organization
Admiral Makarov National University of Shipbuilding of Mykolayiv
E-mail: nataliamihai@ukr.net
ORCID IDhttp://orcid.org/0000-0001-7610-5093

In the current functioning of the global world, an important place is occupied by the processes associated with the transition to a knowledge economy and information society, which determine the directions of economic and social development of international and national economies. According to modern realities, the pace of scientific and technological development, globalization processes, informatization of all spheres of society cause significant changes in economic and social policy, and accordingly changes the attitude to the use of artificial intelligence. Artificial intelligence (AI) can expand and strengthen human abilities and skills, and its technologies are a valuable business resource in today's environment of information technology. The use of AI helps to meet the demand of ordinary citizens for better personalized goods and services, and allows officials to save time on routine tasks, ensuring the search for creative and innovative approaches to improve services.

AI is a strategic imperative of any business, as the use of various forms of its implementation has helped many companies to gain a competitive advantage, gain additional profits and achieve their goals [1,2,3,4]. Among such forms of AI can be noted such as:

- chatbots use AI to quickly analyze customer and supplier requests and the ability to respond in a timely manner to customer responses and comments;
- "smart helpers" use AI to extract the necessary information from large amounts of data, optimize planning;

- referral systems automatically select applications for viewers based on information they have previously viewed,
- digital platforms, such as the Trans.eu Platform, offer state-of-the-art solutions such as: optimization of permanent routes, automated customer search and proposals using algorithms, etc.

Artificial intelligence technologies can be used in many areas, summarizing which in some of the most active, it should be noted their characteristics (Fig. 9)

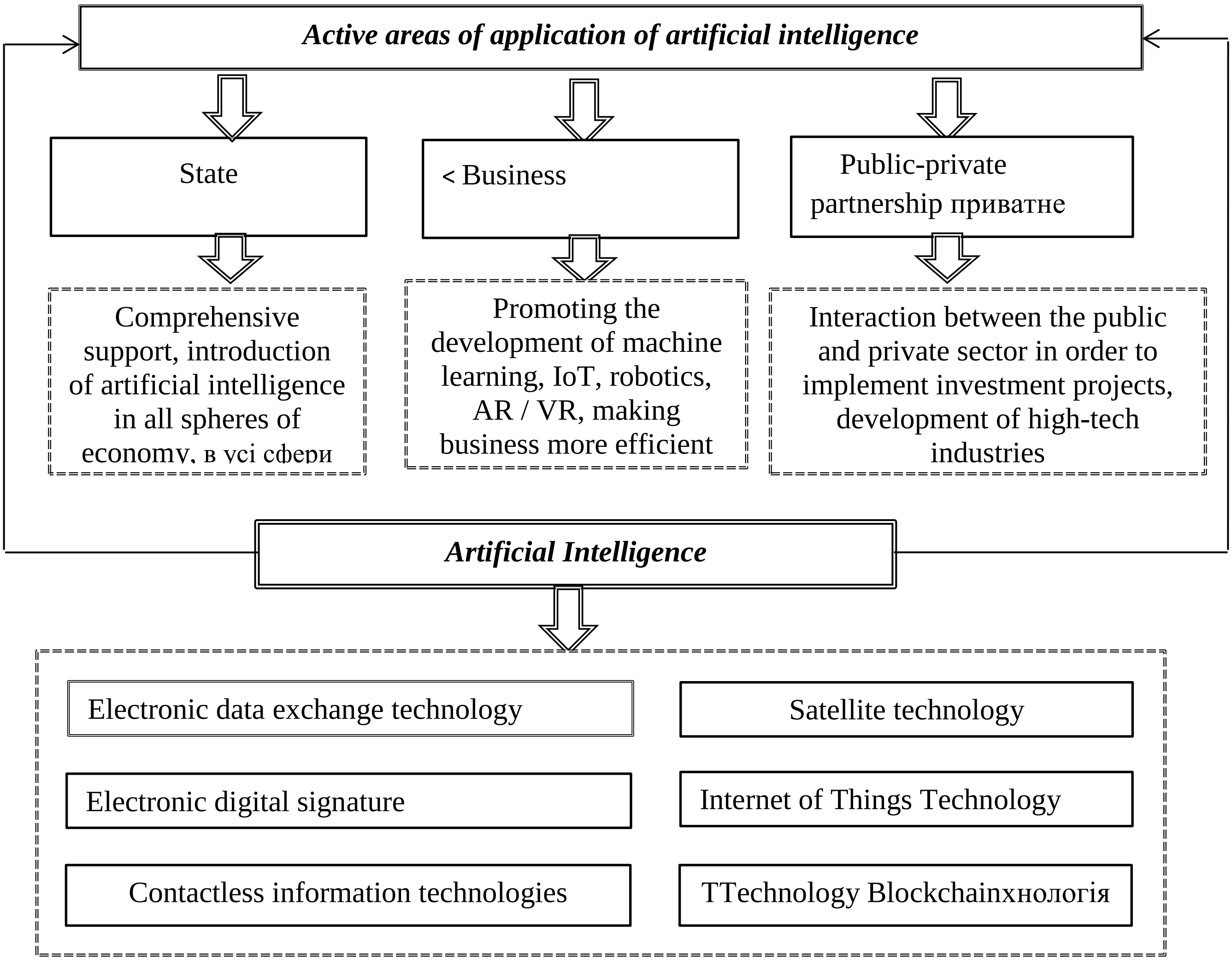


Figure 9. Components of artificial intelligence

Source: Artificial intelligence in the system of managerial decision-making (2012), Blockchain Association of Ukraine (2019)

Thus, the state forms policies and priorities, government procurement, investment and project financing (use of AI systems in public services, formation of open data policy, development of support programs for AI startups and their involvement in GOVTech activities, etc.). A business that, thanks to flexibility, quality management and high speed of implementation, can build machine learning, IoT, AR / VR, robotics. Public-private partnership is considered the most optimal option for the formation of a new industry for the development of outer space, the development of smart cities, new energy, transport. By pooling resources and sharing risks and rewards, the state and the private sector implement cost-effective projects, create or renovate cost-effective facilities that require investment. Such synergy contributes to the creation of new markets for high-tech products, solving social and economic problems, improving the business climate in general.

Strategic directions of AI-based technology development

1. **Production optimized with artificial intelligence**
   Improving product quality, saving costs and time, while reducing total production waste by up to 50%

2. **Large-scale energy transformation**
   Significant reduction of carbon emissions due to the emergence of a large-scale carbon management industry that will work on the absorption and use of carbon dioxide through the use of innovative technologies in the energy sector

3. **A new era of computer technology**
   Quantum computers will allow you to model complex chemical reactions, develop drugs, materials with the desired properties, etc.

4. **Healthcare paradigm**
   Ensuring the benefits of plant-based and high-nutrient diets that promote health (especially in a post-pandemic environment) through the use of artificial intelligence and systems biology-based technologies

5. **Introduction of 5G in economics and medicine**
   It will help to solve problems of unreliable telecommunication networks and will open a way to increase of production efficiency, use of service computers in real time, for rendering of a number of urgent modern services.

6. **New norm in cancer treatment**
   Introduction of new technologies in the medical field for early detection, treatment and prevention of cancer, which will include gene editing and immunotherapy as measures with fewer side effects

7. **Blurring of physical and virtual spaces**
   Development of technologies in the field of social and communication relations to support and facilitate communication, work and build real emotional connections, when the boundary between physical and virtual spaces is blurred and important is the digital format.

Figure 10. Strategic directions of AI-based technology development
Source: Seven technologies that can change the world by 2025 (2020).

According to analysts and researchers in the field of AI, among the many technologies that in the next five years can significantly expand the capabilities of mankind and cause a significant impact on the lifestyle and standard of living of a large proportion of the population should pay attention to those who will be flagships of technological progress (Fig. 10). It should be noted that among such technologies are widely used various search engines, information servers, interactive stores, browsers - programs that allow you to find and view hypertext documents posted on the Internet, e-mail programs, communication programs, and more. Consider the characteristics of some of them:

- ✓ Electronic Data Interchange (EDI) technology allows you to optimize the creation, sending, receiving and processing of any electronic documents and integrate them with existing business applications.
- ✓ Electronic digital signature (EDS) - details of an electronic document designed to protect an electronic document from forgery, which allows you to identify the owner of the signature key certificate and establish the absence of distortion of information in the electronic document; has legal status.
- ✓ Contactless information technologies - technical means, organizational measures, sequence of actions that ensure the registration of objects and rights. Entering this information into the media is carried out without the use of a real-time keyboard (card, biometric technology, bar coding technology).
- ✓ Radio Frequency Identification (RFID) technologies - RFID chip transmits information in the radio range to a special device or scanner. International Automatic Identification System (EAN UCC) - used to identify units of account with a unique global trade item number GTIN (Global Trade Item Number). This number is displayed on the packaging of goods in the form of a bar code of the international coding system EAN / UCC. The EPCglobal Network should form the basis of the global supply chain management of the future. EPCglobal's mission is to develop and promote standards for all elements of the network and to ensure immediate, automatic identification of goods and exchange of information in the supply chain.
- ✓ Satellite technologies - satellite communication systems, radio navigation systems, commercial transport control systems. The use of WMS (Warehouse Management System) for warehouse management is a hardware and software complex that allows you to effectively manage the placement and movement of goods in the warehouse, has a management role, optimizes the tasks and routes of loading equipment. MRP (Materials Requirement Planning), MRP II (Manufacturing Resource Planning), ERP (Enterprise Resource Planning) - technologies for planning and resource management of different levels of coverage.
- ✓ Internet of Things (IoT) technology allows you to integrate physical means into a single network, making them "smart", that is, to connect the digital and material worlds. According to a joint study by GT Nexus and Campegini,

today about 70% of retailers with their own logistics services use IoT to optimize the supply chain.

✓ Big Data services are becoming the center of the logistics business - they help reduce costs, increase the level of customer service, make forecasts (for example, identify problem points in the supply chain). Internet of Things technology is responsible for collecting large amounts of information, the analytical system transforms this data into routes to traffic directions. This gives impetus to the development of autonomous vehicle technology (unmanned vehicles, drones). Robotization is one of the contradictory trends. According to St. Onge Company in 2016, only 5% of the world's warehouses were automated and 15% mechanized. Therefore, the penetration of this technology is still small, but is already widely used by large corporations.

✓ Blockchain technology, which allows you to reduce the supply chain, reduce contractors and replace it all with productive management. benefits. To properly understand this concept, it is necessary to gradually consider the components of blockchain technology. Thus, the technology can be divided into three main parts: the blockchain itself, peer-to-peer networks and the consensus-building mechanism..

First and foremost, Blockchain is a revolutionary technology, decentralized storage of large amounts of information, with the inability of its users to re-modify or edit it, for their own benefit. To properly understand this concept, it is necessary to gradually consider the components of blockchain technology. Thus, the technology can be divided into three main parts: the blockchain itself, peer-to-peer networks and the consensus-building mechanism. Among the important tasks facing the implementation of Blockchain technology in the enterprise, it should be noted: minimize logistics costs so that its share in the price of goods is minimal, ensure transparency of supply processes and solve the problem of trust of contractors; control of cargo flows, when all actions are recorded in Blockchain, which allows you to have up-to-date information on the status of unloading;

From a technical point of view, a smart contract is a computer code that, in the event of a certain condition or condition, is able to work automatically according to predefined functions. This is a fragment of program code that performs certain tasks in the case of compliance with a pre-established condition in the program [5]. This code can be stored in a distributed registry and write any changes to it. If blockchain technology or other distributed registers are used, the smart contract is stored and duplicated in it, the algorithms of the smart contract are determined by its program code within the network of the distributed register. Therefore, anyone who has access to the distributed registry can verify that the smart contract operates in accordance with the conditions, which ensures that they cannot be changed [5].

A fairly common definition of the concept of smart contract from a legal point of view is its understanding as an agreement of the parties, which exists in the form of program code that operates in a distributed data register and ensures self-fulfillment of such agreement in case of pre-defined circumstances (Fig. 11).

Therefore, it should be understood that the concept of a smart contract is a kind of agreement in the form of coded mathematical algorithms, the conclusion, change, execution and termination of which is possible only with the use of computer programs (Blockchain platforms) within the Internet.

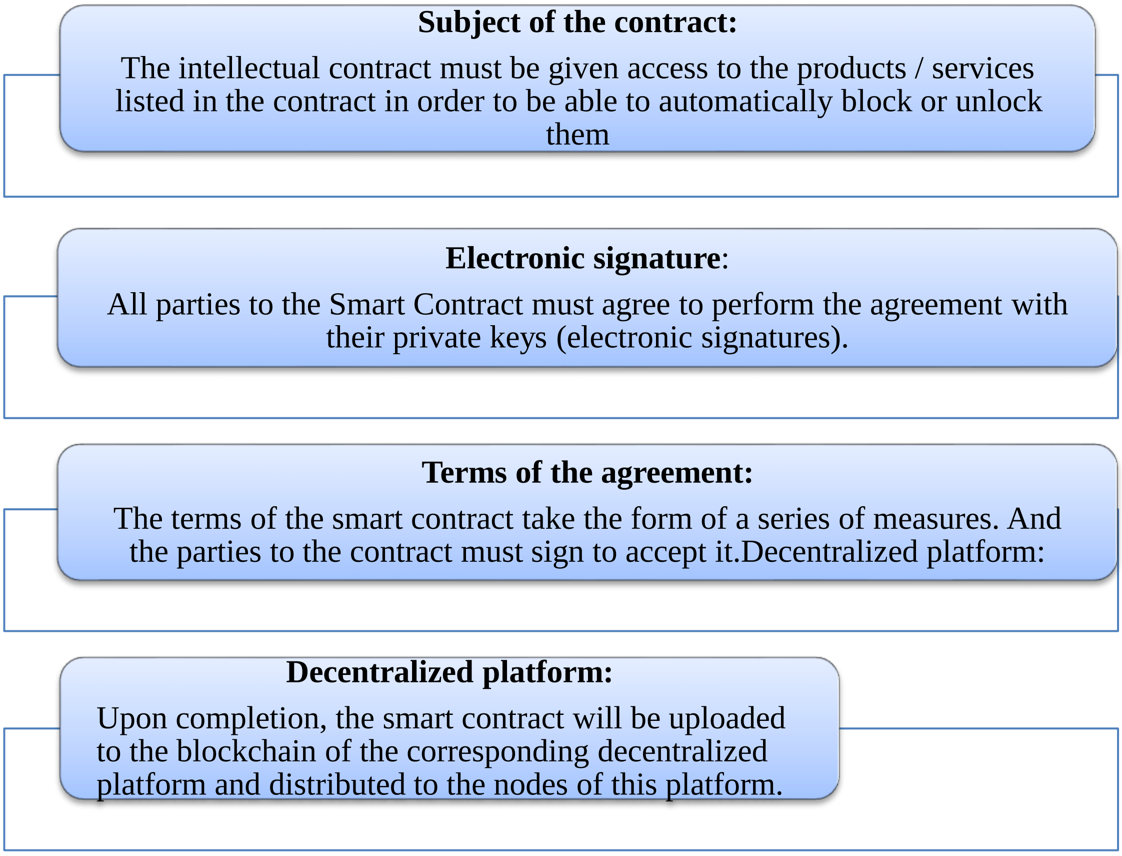


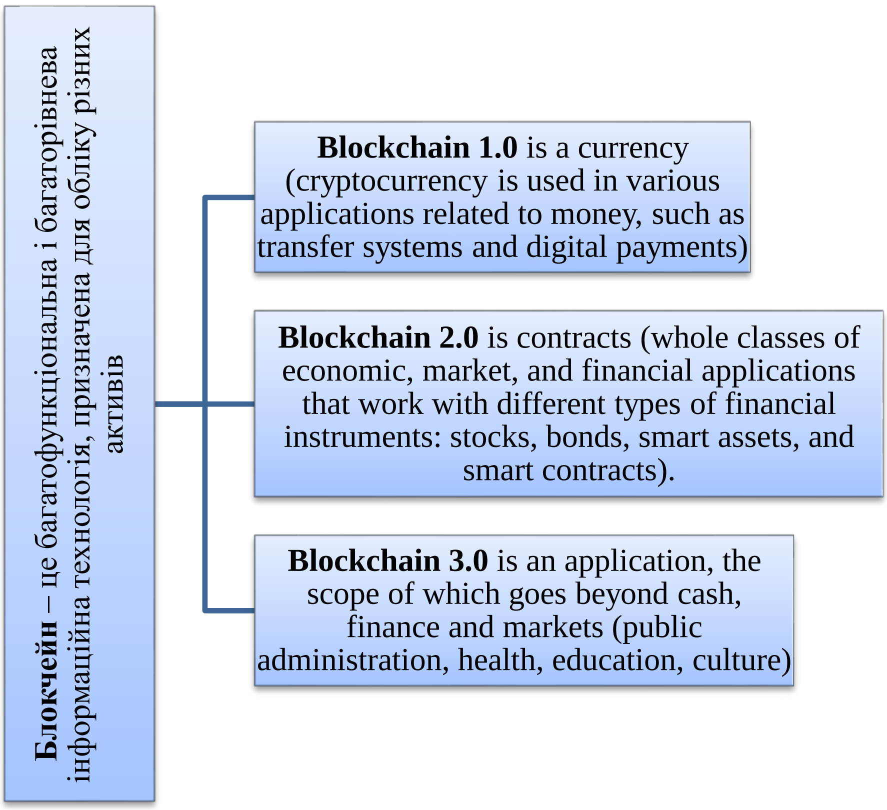
Figure 11. Conditions for creating a smart contract

Source: Blockchain Association of Ukraine (2020), Prospects for the use of blockchain technology in the Internet of Things (2016)

The principle of operation of the Smart Contract can be described in 3 steps: 1. The option contract between the parties to the agreement is written to the blockchain using a code. The parties to the agreement remain anonymous, but the contract is entered in the register; 2. There is an event that is initiated by, the arrival of the expiration date or the strike price is reached, and the contract is executed in accordance with the coded conditions; 3. With the help of the blockchain, regulators can investigate market activities, while information about the terms of specific conditions is kept confidential.

The "reasonable contract" mechanism of action means that they automatically fulfill pre-programmed conditions only before they meet the necessary requirements. First, the terms of the contract will be written in a programming language, then encrypted and transmitted to the Blockchain block. Once transferred to the unit, this smart contract will be distributed and reproduced by the nodes running on this platform. Upon receipt of the deployment order, the contract will be executed in accordance with pre-defined conditions. In this case, Smart Contract will automatically check the process of fulfillment of obligations and conditions specified in the contract. The ideal supply chain contains only the "seller" and the "buyer", they must be connected by one goal, and they must meet in a single unified database, such as Blockchain. At present, several elements are not enough to become such a Blockchain system: - international legal support; - unification of all logistics laws and regulations in all countries; - legal framework.

As a transparent public registry, such a system will provide customers and auditors with simple and effective tools to track the entire route. One important aspect is that the blockchain can be used when all members of the supply chain have access to the network. In addition to addressing industry-specific issues, the blockchain brings a package of instant benefits. Not only does it eliminate unnecessary resellers and significantly reduce workflow, but it also offers reliable protection, error reduction, prevention of mislabeling of illegal goods and other attempted fraud. Blockchain – technology is a kind of data storage in the form of a digital register of transactions, agreements or contracts. The analysis of the use of blockchain taking into account technological aspects (Fig. 12) showed that the main advantage of this technology is that such a register is not stored in any one place.



Blockchain is a multifunctional and multilevel information technology designed to account for various assets

Figure 12. Using the blockchain from a technological point of view

Source: Blockchain Association of Ukraine (2020), Transparency and Security: What Blockchain Technology Can Give to the Economy and Law

Blockchain technology can become the most transparent means of communication between the state and the population, excluding any intermediary bodies on the way, first of all, to financial regulatory interaction (grants, benefits, subsidies) between the person and the government.

Principle Blockchain operation is very simple but at the same time is unique, due to the specially written code of process algorithms.

Blockchain technology provides transparency of all transactions that can be tracked, recorded, analyzed and stored, ie are in the area of access of government agencies. One of the main reasons why the blockchain is so attractive to business and other human activities is decentralization and transparency. Blockchain is more than a decentralized network. Unlike a conventional decentralized network, where there are certain connecting points, a blockchain is a distributed registry in which all participants are directly interconnected.

As more and more global logistics market participants become concerned about increasing the transparency and reliability of supply chains, leading IT companies are promoting the idea of using blockchain technology for this purpose. For example, the international IT company IBM has already invited some large companies from various fields of activity to test their developments based on the principle of blockchain. The Hyperledger International Blockchain Consortium was launched by the Linux Foundation in 2015 and currently brings together more than 115 companies from a variety of fields, including finance, automotive, healthcare, IoT and aviation. The main goal of the consortium is to create a single open source blockchain platform that will allow organizations around the world to implement blockchain technology in their business processes. WalMart retailer was one of the first to believe in the bright future of blockchain, it is testing new IBM technology on deliveries of mango in the US and pork in China. According to the company, its implementation will increase the efficiency of inventory management and ensure the safety of food supplied, which WalMart considers especially important after the outbreak of salmonellosis in 2006. At that time, using paperwork, it took the company about two weeks to identify the source of the infection. Blockchain will provide complete information about any batch of goods entered into the database, in seconds, say supporters of the technology [7].

The introduction of these technologies will be considered on the example of an industrial enterprise for the production of dairy products. For more efficient functioning of the logistics system it is necessary to develop an algorithm that will include three generalized stages:

1) introduction of the process of transferring the management of the entire logistics system into an innovation system Blockchain;

2) determining the form in which the Blockchain system of the concern will be integrated;

3)implementation of unification of all document flow to standardize the process of concluding Smart Contracts.

Of course, we choose such a Blockchain system as IBM Food Trust, and as it has a number of advantages over industrial enterprises for the production of dairy products, including:

- The IBM Food Trust is an ecosystem of manufacturers, suppliers, retailers and others involved in building a smarter, safer and more sustainable food supply system for the world;
- IBM Food Trust was created by the logistics giant IBM, which has a wide network of partners.

It should be noted that the use of IBM Food Trust involves three main steps, namely:

- select and set up a subscription depending on the size of your company (small, medium, large business) and business needs;
- select best integration option (automatic XML loading, Excel loading, direct data entry);
- choose the best version of the onboard algorithm (homing board, virtually controlled board, onboard assistance).

The IBM Food Trust cloud blockchain solution provides network members with open, flexible, and reliable ways to share product information, leverage the experience of others, develop advanced functionality, and choose where and how to deploy.

A special feature of Blockchain technology is that it creates a new environment for collaboration with data, in which even direct competitors can cooperate. All participants can set access levels and collaborate securely, as this technology stores data digitally and is distributed and unchanged. Trusted members, leading members of the IBM Food Trust network, are collectively responsible for maintaining the integrity of the shared registry and assisting all members of the community in ensuring security, confidentiality, and compliance with data access permissions. The node of each trusted participant receives a full copy of the encrypted registry. This allows participants to see blockchain hashes, check events, view sender access logs, and check for data forgery. However, they do not have access to decrypt the data, so they can only access the allowed data.

It is worth noting that IBM Food Trust has already developed several modules to implement a number of features that help create the IBM Food Trust network you want. The APIs are offered as additional components to the available subscription options. The system has four types of online subscription to the service:

- small business (available modules according to the needs of the company and only for companies that send and receive goods in the food supply chain for less than $ 50 million);
- medium business (available modules according to the needs of companies that send and receive goods in the food supply chain in the amount of 50 million to 1 billion US dollars);

- large enterprises (available modules according to the needs of companies that send and receive goods in the food supply chain worth more than 1 billion US dollars);

- virtual learning (Virtual learning under the guidance of IBM Food Trust experts, which is available as a supplement to such a system).

Note that the price for these types of subscriptions is different, confidential and set individually for each member of the IBM Food Trust. The system consists of many complex algorithms that are automatically executed for almost all users. In this case, the basic digital algorithms that are listed in one block and are responsible for the same functions are called modules. There are 4 main types of modules in the system structure:

1. Trace module (provides complete tracking of the supply chain).
2. Certificate module (provides transfer of certification documents and their management).
3. Virtual learning module (aimed at faster development of data transfer).
4. Neural networks module (module based on the algorithm of artificial intelligence and neural networks, for self-learning and automatic addition of the algorithm or replacement of inefficient codes).

The IBM Food Trust interface has a special algorithm for determining the savings from the use of the IBM blockchain system, which provides for the appropriate calculation of such savings for key players, including retailers, large manufacturers, distributors. This algorithm is provided for informational purposes only and is based on individual interviews and evaluations, not on actual performance data for any IBM product.

Thus, the use of artificial intelligence in the logistics of any enterprise aims to accelerate all processes, ensuring their more accurate and continuous implementation. The use of paper and pencils in the logistics industry, long-distance transportation of goods, opaque supply chains - all these are the realities of the modern world, which lead to excessive consumption of energy, materials and time. In modern conditions, data conversion, the use of new methods of delivery, automation and robotics are changing the logistics market. In this case, information technology in logistics reflects a set of production and software tools, combined into a technological chain that provides collection, storage, processing and dissemination of information to reduce the complexity of the use of information resources, increase reliability and efficiency with them.

Thus, the comprehensive penetration of artificial intelligence, quantum computing, tighter control over CO_2 emissions, new strategic directions of medical development based on the development of modern technologies in the near future will significantly expand the capabilities of mankind and affect their living standards and socio-economic development of each state.

REFERENCES

1. ZestFinance Introduces Machine Learning Platform to Underwrite Millennials and Other Consumers with Limited Credit History (2017).

Businesswire. (Los Angeles) Retrieved from: https://www.businesswire.com/news /home/20170214005357/en/ZestFinance- Introduces-MachineLearning-Platform-Underwrite-Millennials (Last accessed: 29.04.2021)

2. Marr B. The Amazing Ways How Unilever Uses Artificial Intelligence To Recruit & Train Thousands Of Employees (2018). Retrieved from: https://www.forbes.com/sites/bernardmarr/2018/12/14/the-amazing-ways-how-unileveruses-artificial-intelligence-to-recruit-train-thousands-of-employees/#1dc0386e6274 (Last accessed: 29.04.2021)

3. Künstliche Intelligenz in der Logistik. Begriffe, Anwendungen und Perspektiven (2018) SSI Schäfer. Whitepaper. P. 18 Retrieved from: https://www.ssi-schaefer.com/resource/blob/504700/ec6d618fc32d0544d280b5f5ffd312e6/white-paper-artificial-intelligence-in-logistics--dam-download-en-16560--data.pdf (Last accessed: 30.04.2021)

4. Wilde Th. Customer Engagement mit Chatbots und Collaboration Bots: Vorgehen, Chancen und Risiken zum Einsatz von Bots in Service und Marketing (2018) / Edit.board: P. Gentsch, Kuenstliche Intelligenz für Sales, Marketing und Service. Springer Fachmedien Wiesbaden GmbH. P. 138-149.

5. Blokchejn Asociacija Ukrajiny [Blockchain Association of Ukraine]. Retrieved from: https://bau.ai/ru/ (Last accessed: 01.05.2021)

6. Prozoristj ta bezpeka: shho tekhnologhija blokchejn mozhe daty ekonomici ta pravu. [Transparency and security: what blockchain technology can give to the economy and law]. Retrieved from: https://ua.interfax.com.ua/news/press-release/641996.html (Last accessed: 01.05.2021)

7. Tekhnologhyja Blockchain: chto эto y komu nuzhno. [Blockchain technology: what is it and who needs it] Retrieved from: https://fb.ru/ article/248921/tehnologiyablockchain-chto-eto-i-komu-nujno (Last accessed: 01.05.2021)

8.Yatskiv N.G.(2016) Perspektyvy vykorystannja tekhnologhiji blokchejn u merezhi internet rechej [Prospects for the use of blockchain technology in the Internet of Things] Scientific Bulletin of NLTU of Ukraine. Vip. 26.8. p. 381–387.

9. Vitlinsky V.V. (2012) Shtuchnyy intelekt u systemi pryynyattya upravlinsʹkykh rishenʹ [Artificial intelligence in the system of managerial decision-making]. Neuro-fuzzy modeling technologies in economics. № 1. p. 97-118. Retrieved from: http://nbuv.gov.ua/UJRN/Nntm_2012_1_7

10. Sim tekhnologhij, jaki do 2025 roku mozhutj zminyty svit (2020) [Seven technologies that can change the world by 2025]. Ukrainian Pravda. Economic truth. Retrieved from: https://www.epravda.com.ua/publications/ 2020/12/10/669019/ (Last accessed: 27.04.2021)

II. ARTIFICIAL INTELLIGENCE AS A FACTOR OF THE GLOBAL LABOR MARKET TRANSFORMATION

Svitlana Tul
Ph.D. in Economics,
Associate Professor of the Department of International Economics and International Economic Relations
Higher Educational Establishment of Ukoopspilka
"Poltava University of Economics and Trade"
E-mail: tulsvetlana@ukr.net
ORCID ID: 0000-0003-3637-4197

Olha Shkurupii
Doctor of Sciences (Economics),
Professor of the Department of Economics and International Economic Relations
Poltava State Agrarian Academy
E-mail: olga.sh0123@gmail.com
ORCID ID: 0000-0002-5818-7651

The modern period of human life can reasonably be determined as the beginning of the post-industrial era because its formation is potentiated by the Fourth Industrial Revolution. Klaus Schwab (2016), studying the process of the deployment of the Fourth Industrial Revolution, notes a number of changes that have become significant for humanity now and will remain significant for many future generations. He indicates the exponential (in speed, scale and impact) growth of innovation, which leads to increased efficiency, productivity and cost reduction in production, as well as an extraordinary increase in data sets and opportunities for their use. All this is accompanied by the implementation of a new generation of technologies based on artificial intelligence, the importance of which can be traced from mass robotization to biotechnology.

According to analysts (Lane & Saint-Martin, 2021), artificial intelligence will have a strong impact on the transformation of the labor market. The number of intelligently equipped devices, applications and interconnected systems is growing significantly today and will continue to grow in the future. In combination with other new technologies, artificial intelligence is becoming the driving force of the Fourth Industrial Revolution. This is primarily due to the spread of its use in all spheres of human life.

Olha Pyshchulina (2020) considers digitalization and the creation of artificial intelligence to be the new growth driver after the era of the computer revolution. The McKinsey Global Institute predicts the digital economy will reach its maximum level of development by 2030. By this time, as a result of the active use of artificial intelligence, global GDP, according to the findings of PricewaterhouseCoopers (PwC, 2019), will grow by 14 %; that is, almost USD 16 trillion.

Noting the role of digital technologies, robotics, artificial intelligence, and other breakthrough innovations, it should be emphasized that the basis of these changes is human labor. Human intelligence and creativity became the source of the modeled ability of artificially created systems to act and make decisions like an individual. Compared to this, artificial intelligence, even extremely perfect, will still remain a derivative of human activity.

The use of digital technologies predetermines labor efficiency while reducing the workload per employee. It should be noted the importance of artificial intelligence, with the use of which there are ample opportunities to operate with large amounts of information, which facilitates decision-making in production, business, scientific and research activities. According to the forecast of the World Economic Forum (WEF, 2018), the share of machines and algorithms in working hours will be 42 % in 2022. Robots with integrated artificial intelligence will do more and more work for humans, but they will be able to perform only part of the tasks. According to experts, only a quarter of workplaces can be automated by over 70 %. Automation rates may vary depending on the industry and the sphere of economic activity. For example, about 47 % of all processes in information and data processing are currently automated, projected that by 2022 the automation of this activity will be 62 %, however in reasoning and decision-making – only 19 %, by 2022 it will be 28 % (Table 3).

Table 3

Projected automation rates in 2022

Activity	Ratio of human-machine working hours, %	
	Human	Machine
Reasoning and decision-making	72	28
Coordinating, developing, managing and advising	71	29
Communicating and interacting	69	31
Administering	56	44
Performing physical and manual work activities	56	44
Identifying and evaluating job-relevant information	54	46
Performing complex and technical activities	54	46
Looking for and receiving job-related information	45	55
Information and data processing	38	62

Source: Developed by authors based on the Future of Jobs Report (2018).

The development of technologies reduces the working hours that people spend producing goods or providing services. However, this does not mean that robotization, which in the post-industrial perspective is likely to become almost all-encompassing, will provoke fatal consequences in the form of technological unemployment, since only routine tasks are being automated. Moreover, the emergence of new technologies can lead to an increase in the demand for workers with new competencies. Creativity, research and invention acquire special value in modern society. Therefore, people will concentrate on intellectual work providing unique and customized services. The COVID-19 pandemic has accelerated the transformation of the labor market and transition to new jobs. According to the post-COVID-19 scenario of the McKinsey Global Institute (Lund et al., 2021), 100 million workers (1 in 16) from examined countries (China, India, United States, Germany, Japan, United Kingdom, France and Spain) will change their job by 2030.

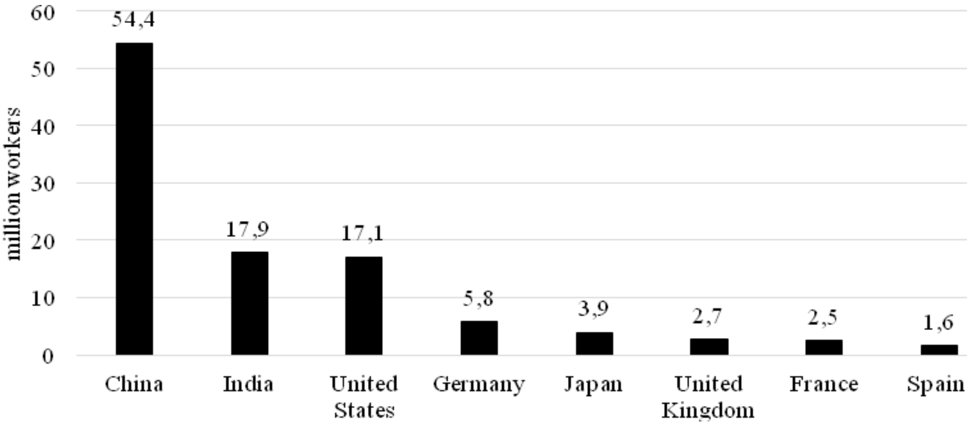


Figure 13. Job transitions in different countries by 2030, million workers

Source: Developed by authors based on the Future of Work after COVID-19 Report (2021).

Digitalization processes affect the emergence of new professions not only in the IT sector but also have a significant impact on sectoral changes in the world labor market as a whole. For instance, the banking and financial sector is undergoing significant changes under the influence of processes of automation, robotization, and the use of artificial intelligence. In the near future, in the banking and financial sector, there will be a decrease in the number of employees with basic skills (the ability to count, data entry into accounting systems and their processing), while the demand for employees with high-tech skills (software development for financial transactions) and social-emotional skills (customer orientation) will grow. The spread of digital technologies has a significant impact on the transformation of the retail industry: automated self-service systems are replacing cashiers, robotic technology performs the work of loaders, machine learning allows predicting consumer demand for goods and services. Therefore, in the near future, there will be a decrease in the number of employees who are responsible for weighing, warehousing, loading or unloading goods.

Researchers (Herweijer & Waughray, 2018) prove that by 2030 the further development of artificial intelligence and other technologies of the Fourth Industrial Revolution can bring innovations such as a digital geospatial dashboard for the planet, an autonomous farming and end-to-end optimized food system, a home supercomputer and artificial intelligence-based research assistants, quantum and distributed computing that can significantly increase the computing power of artificial intelligence. However, even with an extremely high level of development of these technologies, as well as those of which we now do not even know, intellectual activity will always be inherent only in humans. Therefore, nowadays, the main task for resolving the “human / machine” contradiction is not their opposition, but the mutual supplement of human intelligence with artificial and vice versa.

New technological advances in areas such as artificial intelligence, robotics, the Internet of Things, augmented and virtual reality influence the formation of the concept of the global labor market. Researchers from the McKinsey Global Institute (Farrell et al., 2005) consider the global labor market as the process of global recruitment of labor that involves the formation of real demand and supply for remote work through offshoring. International Labour Organization experts (Kuptsch et al., 2010), examining the trends in the formation of the global labor market, note that nowadays there is a process of internationalization of national labor markets, namely the formation of cross-border supply and demand for labor. Richard B. Freeman (2008) and Niels Beerepoot (2014) define the global labor market as a global Internet job market, which forms international competition between workers for a vacancy.

Taking into account the achievements of the modern theory of international economic relations, Ukrainian scientists pay considerable attention to the problem of the formation of the global labor market. Yaroslava Stolyarchuk and Svitlana Poruchnyk (2014) contemplate the term “global labor market” as “a system of relations concerning the coordination of supply and demand of labor, regulation of its interstate flows, wages and social security”. According to the study of Anatoliy Kolot (2018), the global labor market is formed under the influence of “large-scale changes in the social division of labor, unprecedented mobility of production, the washing out of jobs in some countries and the creation of a new job market in others, depending on changes in the structure and scale of international trade”.

In our opinion, the global labor market correlates directly with the spread of digitalization and the formation of the digital economy that provides the conditions for the integrity of the space of modern labor relations on the indicated (global) scale. A new phenomenon is acquiring special significance in the digital economy – the digitalization of the global labor market. The development of digital technologies directly affects the quality of life, the economic efficiency of business and the state, and also contributes to the emergence of new forms of work. The digitalization of business operations “blurs” the geographical borders between countries and creates a single digitalized global labor market in the modern world.

Nowadays, the labor market is acquiring global characteristics, while remaining heterogeneous and contradictory. There are several trends that indicate the formation of the global labor market: 1) the interdependence of national economies contributes to the formation of an integral system of interacting national labor markets; 2) spreading Internet access in different countries leads to the development of the global digital market; 3) expanding the influence of digital companies that generate new jobs all over the world; 4) the systematic movement of highly skilled labor to countries with a high level of digitalization, which leads to a deepening of technological specialization on a global scale; 5) changes in the qualitative characteristics of the labor market (increasing requirements for the level of education and qualification); 6) the rapprochement of cultures in the process of transformation of the structure of values and social norms of workers of generation "Y" and "Z"; 7) changing the work-life balance leads to the emergence of new forms of employment; 8) increase in the number of global digital labor platforms that facilitate interstate operations in the field of employment.

In the context of the evolution of socio-economic systems, the following structural transformations of the global labor market are observed:

1. The reconfiguration of the boundaries of the traditional division of labor. New professions are emerging at the request of the digitalization of economic sectors. For example, a manager of crowdfunding and crowdinvesting platforms appears in finance; an operator of automated transport systems – in logistics; a medical data manager – in healthcare, etc. A contradiction arises between the rigid consolidation of functions in a particular profession (according to the International Standard Classification of Occupations), on the one hand, and the dynamics and flexibility of the social and labor sphere, on the other hand. The introduction of artificial intelligence, robotization and automation of the production process radically change the essence of labor in all industries and form new requirements for the competencies of workers. Narrow professional training is being replaced by the need to form cross-cutting competencies (communication skills, critical thinking, digital literacy), the importance of which is growing every year.

2. Changing the ways and forms of employment. Along with the traditional contractual forms of implementation of labor relations, employment is actively developing in terms of freelancing, outsourcing and crowdsourcing (OECD, 2016).

3. Increasing human mobility. This is due to both the intensification of migration processes and interprofessional, interbranch, intrafirm mobility. Lifelong learning as a principle and concept is increasingly being developed and implemented in practice. The situation is becoming more and more common when a person changes his / her professional affiliation throughout his / her working life.

4. Creating jobs for the employee's tasks and competencies, customer requests and technology. As a result, there is a need for such a mechanism that would allow, in conditions of exponential changes, to carry out in advance the connection between technological change and transformations in the division of labor.

5. The priority of human talent over the capital in the system of factors of production. In the context of the gradual digitalization of the global economy, talent, rather than capital, is becoming the most important factor of production, which leads to the transformation of the labor market, within which the segments of "low skills –low wages" and "high skills – high wages" are formed.

Under the influence of these trends, the system of the global labor market is gradually being formed. It is characterized by a specific culture and institutions that have arisen as a result of the intertwining and interpenetration of various national organizational and business cultures, which are embedded in the created global institutions and manifest themselves in a new quality. At the macroeconomic level, supply and demand for labor depend on the dynamics of the national and international markets, as well as factors such as immigration, age, level of education.

Digitalization is an important factor in the formation of the digital ecosystem of the global labor market, which is a structural element of the global market ecosystem. The digital ecosystem of the global labor market should be understood as a system of digitalized relationships between representatives of international business and the economically active population of different countries regarding the buying and selling of labor, which is formed within the framework of scientific and educational and digital spaces and is coordinated by national governmental and non-governmental organizations, regional organizations and associations, international intergovernmental and non-governmental organizations (Tul & Shkurupii, 2020). The mechanism of the functioning of the global digitalized labor market is distinguished by the fact that the intermediate states of the buying and selling relationship and current processes take place within the global digital ecosystem. The mechanism of the functioning of the global digitalized labor market is a complex system of distribution of labor among the sectors of the world economy through digitalized labor relations (from hiring workers to paying wages), which are coordinated by socially created institutions of market regulation and the institution of market self-regulation. Within the framework of the concept of a global digital ecosystem, it is considered with an emphasis on the specifics of three-tier (macro-, meta- and mega-) regulation and the presence of a special infrastructure (Figure 14).

According to our proposed model, the mechanism of the functioning of the global digitalized labor market is formed by:

1) the global ecosystem of employers is a network of business entities of various organizational forms that operate in five sectors of the world economy and interact through the use of digital tools. The division of the economy by sectors is as follows: primary sector – agriculture and extractive industries; secondary – manufacturing; tertiary – transport and utilities; quaternary – trade, finance, insurance and real estate; quinary – healthcare, education, recreation, governmental services and research;

2) the global ecosystem of employees is a global pool of workers with different qualification (highly skilled, skilled, low-skilled) belonging to different professional, age, racial, socio-cultural groups and performing work on a regular or non-regular basis;

3) scientific and educational space is a community of leading educational institutions, business schools, training centers, distance learning platforms, research institutions from around the world that form a digital environment for lifelong learning;

4) digital space is an environment consisting of IT infrastructure, digital interfaces, as well as digital technologies and determines digital interaction between business, employees, the scientific and educational community, a network of national, regional, international regulatory bodies.

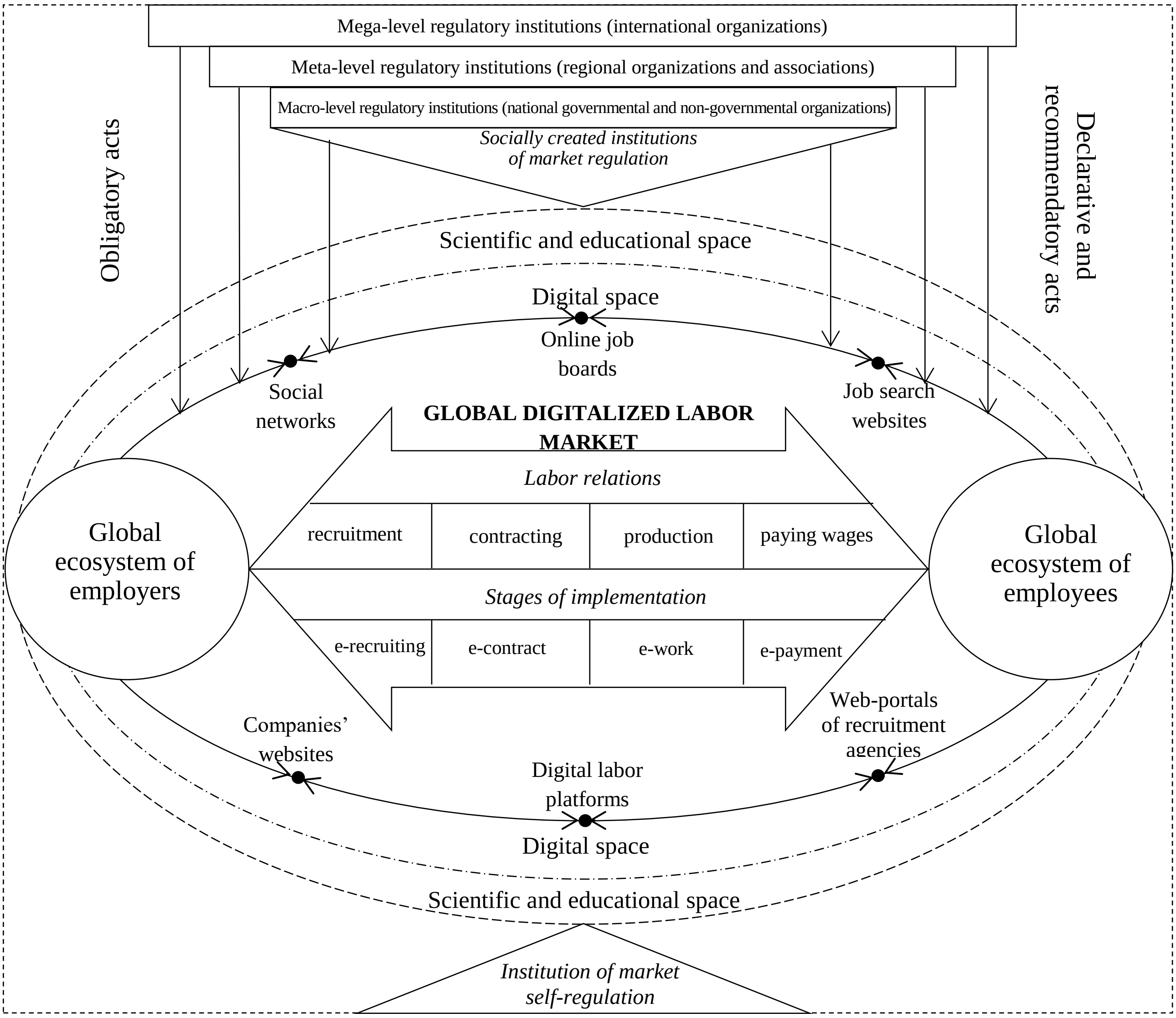


Figure 14. The mechanism of the functioning of the global digitalized labor market

Source: Developed by authors

Regulation and coordination of the digital ecosystem of the global labor market is carried out through socially created institutions of market regulation at three levels (macro-, meta- and mega-) through the development of obligatory acts (conventions, pacts, protocols) and declarative and recommendatory acts (recommendations, declarations, consulting documents).

The regulatory institution of the mega-level is the UN specialized agency – the International Labour Organization (ILO). Its main task is to promote social progress, to establish and maintain social peace between different strata of society, as well as to solve arising social problems in an evolutionary and peaceful way. Therefore, membership in the ILO requires states to monitor compliance with fundamental principles in the field of labor relations: the freedom of association and the right to collective bargaining; the prohibition of discrimination in labor relations; the elimination of forced labor; the prohibition of child labor. In order to address the challenges associated with profound changes in the world of work, the ILO Global Commission on the Future of Work was established in 2017. The main task of this organization is to develop comprehensive measures to ensure: 1) the general labor guarantee; 2) the guaranteed social protection from birth to old age; 3) the general right to lifelong learning, which gives people the opportunity to acquire professional skills and improve their qualifications; 4) the principles of gender equality. Moreover, the main task of this institution is to use the results of technological progress in the interests of ensuring decent work, including the development of an international system for digital labor platforms regulating.

The regulatory institutions of the meta-level are regional organizations and associations. The level of meta-regulation involves the coordination of aspects of social and labor relations that arise between business representatives and the labor force within geographic and geopolitical boundaries. To address the specific challenges of regional labor markets, the ILO established the International Labour Office with regional offices in Africa, Latin America and the Caribbean, the Middle East, Asia Pacific, Europe and Central Asia.

At the macro-level, the coordination of labor relations is carried out by national governments and authorities, which form the legislation that regulates the relationship between employers and employees. State regulation of the labor market is implemented as follows: 1) the approval of legislative norms governing the procedure for hiring and firing, the rights and obligations of the employer and the employee and establishing responsibility for violation and non-compliance with these norms; 2) the development and implementation of employment policy, social protection of employees who temporarily lost their jobs, lifelong learning, etc. Non-governmental organizations that provide consulting and expert services to representatives of these ecosystems are also considered macro-level regulatory institutions. Nowadays, the most influential organizations in the labor market are the national non-governmental organizations of the USA and the EU: Freelancers Union, Service Employees International Union, European Forum of Independent Professionals, etc.

The functioning of the digital ecosystem of the global labor market is ensured by the institution of market self-regulation, which is based on a mechanism for balancing the main elements of the labor market: demand in the form of the needs of companies in the labor; supply in the form of labor resources of the economically active population; labor prices in the form of wages; competition between employees for a vacancy, and between employers for the ability to attract labor in the required quantity and with the required skills. The digitalization of labor relations between an employee and an employer takes place according to the scheme “e-recruiting – e-contract – e-work – e-payment”. The main digital channels through which the mechanism of self-regulation of the labor market is indirectly carried out are digital labor platforms, online job boards, job search websites, web-portals of recruitment agencies, companies' websites, social networks.

Within the digital ecosystem of the global labor market, a global digitalized labor market is being formed. Digitalization of the labor market is a new phenomenon in the world economy, which provides for an exponential growth in the number of digital labor platforms that form a single global labor market.

The global digitalized labor market should be viewed as a global integrated digital space, within which the interaction of labor buyers and sellers is realized through functioning of the interstate mechanism of supply and demand regulation using digital labor platforms, online job boards, job search websites, web-portals of recruitment agencies, companies' websites and social networks. The relationship between the players of the global digital labor market is maintained through cross-border transactions, information exchange and modern technology.

The global digitalized labor market has the following features: 1) growth in the volume of work performed through the use of digital technologies; 2) an increase in the number of digital labor platforms (intermediaries between employees and employers); 3) growth in the total number of independent self-employed freelance professionals; 4) spread of new forms of work based on temporary employment contracts, zero-hour contracts (an employment contract under which the employer does not guarantee the employee daily employment and pays only the hours actually worked), umbrella contracts (an employment contract consisting of a number of individual contracts); 5) spread of crowdsourcing (attracting a "smart crowd" to jointly search for effective business solutions).

The formation of a single digitalized labor market gives any business access to a large number of mobile labor force with specific skills to solve urgent problems. Digitalized work involves the performance of various types of work by an employee remotely from the employer's location using digital technologies and mobile applications via digital labor platforms ("Fiverr", "Upwork", "Freelancer", "PeoplePerHour", etc.). According to the World Employment and Social Outlook 2021 (ILO, 2021), multinational corporations turn to freelance professionals through a range of digital labor platforms, which simplifies and speeds up the process of finding the required pool of highly qualified personnel.

Digital labor platforms ensure the functioning of the global labor market. These platforms reduce the time and financial resources required to find highly qualified personnel of a certain (sometimes unique) specialization and also create opportunities for the realization of knowledge, skills and abilities by independent self-employed professionals in the field in which they are competent. The digital economy is characterized by rapid growth rates and therefore there is a need to analyze the effectiveness of the functioning of digital labor platforms and the role of self-employed independent professionals working in this sector.

Nowadays, digital labor platforms are becoming efficient information and analytical centers. They can be classified in three areas: 1) platforms that allow one to find a job or employees (“LinkedIn”, “Monster.com”, “Vault.com”, “Indeed”, “Careerbuilder”, “Xing”, “Glassdoor”); 2) platforms where service providers cooperate with their customers (“Uber”, “TaskRabbit”, “Angie's List”, “Upwork”, “Amazon Home Services”); 3) platforms for talent and performance management (“Good.co”, “PayScale”, “Reviewsnap”, “Pymetrics”). According to the forecasts of the McKinsey Global Institute (Manyika et al., 2015), by 2025 digital labor platforms will provide 72 million full-time jobs, which will ensure the growth of world GDP by USD 2.7 trillion (or 2 %). Until 2025, 540 million economically active people around the world will be able to benefit from the activities of digital labor platforms. Thus, 230 million people will shorten their period of unemployment, quickly gaining new jobs; 200 million people who don’t work or work part-time will find additional work through the freelance platforms; 60 million people will have the opportunity to find a job that directly meets their skills; another 50 million people will move from informal to formal employment.

Digital labor platforms reflect the real situation in the labor market since they affect the transparency of the demand that exists for certain professional skills. This makes it possible to make guidelines for young people in choosing such a type of educational program that will clearly meet the requirements of the labor market. As a result, there is a possibility to reduce irrational spending on higher education. In different countries, where there is a mismatch between supply and demand for a number of professions, such costs are estimated by experts at USD 89 billion. Digital labor platforms ensure efficient use of labor. Small businesses or startups that are the main customers of these platforms can outsource certain types of work to self-employed professionals. This allows small and medium-sized businesses to gain access to employees with specialized skills, for example, in developing applications for mobile devices, user interface design, search engine optimization paying only for the amount of work performed. According to the McKinsey Global Institute (Manyika et al., 2015), companies that are clients of digital labor platforms have seen an increase in labor productivity by 9 % and a decrease in the cost of attracting highly qualified personnel by 7 %.

Digital labor platforms contribute to the growth of employment of the population and increase the wages of independent self-employed professionals by creating equal working conditions. In the digital economy, the uniqueness of knowledge and skills is becoming a key factor influencing the formation of wages. For example, according to the Freelance Forward 2020 Report (Upwork, 2020), 59 million American freelancers earned USD 1.2 trillion in 2020. The most common digital labor platforms as of 2021 are “Fiverr”, “Upwork”, “Freelancer.com”, “Envato Studio”, “CrewScale”, “PeoplePerHour”, “Toptal”, “Guru.com”, “DesignCrowd”, “Nexxt” (Table 4).

In addition, digital labor platforms are becoming a place for the concentration of international capital. The functioning of these platforms simplifies and accelerates the procedure of financial transactions between buyers and sellers of services through the use of modern electronic payment systems (PayPal, Skrill, Payoneer, WebMoney).

General vector and sectoral changes in the global economy are a reflection of structural changes taking place within the framework of the systemic transformation of society. The criterion for such changes is the spread of artificial intelligence and the digitalization of human activities. Thus, a new phenomenon, which is the digitalization of the labor market, is acquiring special significance in the digital economy. It has been proven that the transformation of the labor market presupposes a rapid increase in the number of digital labor platforms that form a single global labor market. In the digital economy, there has been a significant increase in the number of independent self-employed professionals who perform various types of work remotely from the employer's location using digital technologies through digital labor platforms. A number of factors accelerate the development of digital labor platforms, namely socio-demographic shifts, the growth of international trade, the spread of information and communication technologies.

Table 4

Rating of the top 10 digital labor platforms according to the "FinancesOnline.com", 2021

Rank	Digital labor platform	Type of platform	Headquarters
1	Fiverr	Freelance marketplace, online outsourcing	Israel
2	Upwork	Freelance marketplace	USA
3	Freelancer.com	Freelance marketplace	Australia
4	Envato Studio	Freelancing website	Australia
5	CrewScale	Platform for building tech teams	USA
6	PeoplePerHour	Freelance service marketplace	UK
7	Toptal	Freelance marketplace	USA
8	Guru.com	Freelance marketplace	USA
9	DesignCrowd	Online crowdsourcing platform	Australia
10	Nexxt	Cloud-based freelance platform	USA

Source: Developed by authors based on FinancesOnline.com data (2021).

The single digitalized labor market, which is being actively formed, has positive economic and socio-demographic effects on modern society. The economic effect is manifested, first of all, as a reduction in time and resources (including human and financial). In particular, business by reducing the time and funds for finding highly qualified personnel of unique specialization ensures its effectiveness. The socio-demographic effect is manifested in the realization of the intellectual potential of independent self-employed professionals, regardless of their place of residence. Moreover, the digitalization of the global labor market makes it possible to solve a number of socially significant problems, namely reducing unemployment, especially among young people, creating jobs, reducing social tensions in depressed regions around the world.

REFERENCES

1. Schwab K. (2016). The Fourth Industrial Revolution: what it means, how to respond. World Economic Forum. Retrieved from:

https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond (Last accessed: 03.05.2021)

2. Lane M., & Saint-Martin A. (2021). The impact of Artificial Intelligence on the labour market: What do we know so far? *OECD Social, Employment and Migration Working Papers*, No. 256, OECD Publishing, Paris, 60 p. DOI: https://doi.org/10.1787/7c895724-en

3. Pyshchulina O. (2020). Tsyfrova ekonomika: trendy, ryzyky ta sotsialni determinant [Digital economy: trends, risks and social determinants]. Kyiv : Tsentr Razumkova, Vydavnytstvo «Zapovit», 274 p. Retrieved from: https://razumkov.org.ua/uploads/article/2020_digitalization.pdf (Last accessed: 03.05.2021)

4. PwC (2019). 2019 AI Predictions. Six AI priorities you can't afford to ignore. Retrieved from: https://www.pwc.com/us/en/services/consulting/library /artificial-intelligence-predictions-2019.html (Last accessed: 04.05.2021)

5. WEF (2018). The Future of Jobs Report 2018. Geneva: World Economic Forum, 133 p. Retrieved from: http://www3.weforum.org/docs/ WEF_Future_of_Jobs_2018.pdf (Last accessed: 04.05.2021)

6. Lund S., Madgavkar A., Manyika J., Smit S., Ellingrud K., Meaney M., & Robinson O. (2021). The future of work after COVID-19. McKinsey Global Institute. Retrieved from: https://www.mckinsey.com/featured-insights/future-of-work/the-future-of-work-after-covid-19 (Last accessed: 04.05.2021)

7. Herweijer C., & Waughray D. (2018). Fourth Industrial Revolution for the Earth. Harnessing Artificial Intelligence for the Earth. PwC, 48 p. Retrieved from: https://www.pwc.com/gx/en/news-room/docs/ai-for-the-earth.pdf (Last accessed: 05.05.2021)

8. Farrell D., Laboissiere M., Pascal R., Segundo C., Rosenfeld J., Stürze S., & Umezawa F. (2005). The emerging global labor market. McKinsey Global Institute. Retrieved from: https://www.mckinsey.com/featured-insights/ employment-and-growth/the-emerging-global-labor-market (Last accessed: 06.05.2021)

9. Kuptsch C. (ed.) (2010). The internationalization of labour markets. Geneva : International Labour Organization, 229 p. Retrieved from: http://citeseerx.ist.psu.edu/viewdoc/download?rep=rep1&type=pdf&doi=10.1.1.18 8.961 (Last accessed: 06.05.2021)

10. Freeman B. R. (2008). The new global labor market. *Focus*, Vol. 26, № 1, 1 –6. Retrieved from: https://www.irp.wisc.edu/publications/focus /pdfs/foc261.pdf (Last accessed: 06.05.2021)

11. Beerepoot N. (2014). Creating a global labour market. The opportunities and challenges of outsourcing and reshoring. The Broker. Retrieved from: https://www.thebrokeronline.eu/creating-a-global-labour-market-d93/ (Last accessed: 06.05.2021)

12. Stoliarchuk Ya., & Poruchnyk S. (2014). Suchasna sehmentatsiia ta kliuchovi tendentsii rozvytku svitovoho rynku pratsi [Modern segmentation and key trends in the development of the world labor market]. *Ukraina: aspekty pratsi*,

7, 12–17. Retrieved from: http://nbuv.gov.ua/UJRN/Uap_2014_7_4 (Last accessed: 06.05.2021)

13. Kolot A. M. (2018). Sotsialno-trudova sfera v koordynatakh novoi ekonomiky: rozshyrennia mozhlyvostei ta novi zahrozy [Social and labor sphere in the coordinates of the new economy: expansion of opportunities and new threats]. *Sotsialno-trudova sfera v umovakh stanovlennia novoi ekonomiky: hlobalni vyklyky ta dominanty rozvytku*: materialy kruhloho stolu. Kyiv: KNEU, 7–15. Retrieved from: http://ir.kneu.edu.ua/bitstream/handle/2010/25195/KS.pdf;jsessionid=016822137C91AF36930E42F5F3BFF617?sequence=1 (Last accessed: 06.05.2021)

14. OECD (2016). New Forms of Work in the Digital Economy. *OECD Digital Economy Papers*, No. 260, OECD Publishing, Paris, 44 p. DOI: https://doi.org/10.1787/5jlwnklt820x-en

15. Tul S., & Shkurupii O. (2020). Didzhytalizatsiia svitovoho rynku pratsi [Digitalization of the world labor market]: monograph. Poltava: PUET, 302 p.

16. ILO (2021). World Employment and Social Outlook 2021: The role of digital labour platforms in transforming the world of work. Geneva: ILO, 282 p. Retrieved from: https://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/wcms_771749.pdf (Last accessed: 07.05.2021)

17. Manyika J., Lund S., Robinson K., Valentino J., & Dobbs R. (2015). A labor market that works: connecting talent with opportunity in the digital age. New York : McKinsey Global Institute, 88 p. Retrieved from: https://www.mckinsey.com/~/media/mckinsey/featured%20insights/employment%20and%20growth/connecting%20talent%20with%20opportunity%20in%20the%20digital%20age/mgi_online_talent_a_labor_market_that_works_full_report_june_2015.pdf (Last accessed: 07.05.2021)

18. Upwork (2020). Freelance Forward 2020, 89 p. Retrieved from: https://www.upwork.com/documents/freelance-forward-2020 (Last accessed: 07.05.2021)

19. FinancesOnline (2021). 20 Best Freelance Websites for Beginners and Professionals in 2021. Financesonline.com. Retrieved from: https://financesonline.com/top-20-freelance-websites-for-beginners-and-professionals/ (Last accessed: 07.05.2021)

2.2. The need for the skills of the future

Artem Ahekyan
Candidate of Physical and Mathematical Sciences, Professor
Precarpathian Institute named Mykhailo Hrushevsky of Interregional Academy of Personnel Management, Lviv, Ukraine
E-mail: pimaup_doktorant@ukr.net

Rostyslav Peleschyshyn
Candidate of Pedagogical Sciences, Director of Secondary School №54
Lviv, Ukraine
E-mail: rostislavpele@gmail.com

Zenovii Kvasnii
Candidate of Economic Sciences, Associate Professor of Management, Precarpathian Institute named after Mykhailo Hrushevsky of Interregional Academy of Personnel Management, Truskavets, Ukraine
E-mail: zenovii_kvasnii@ukr.net
ORCID ID 0000-0001-9124-1579

The world of work is in a constant state of flux. The skills needed to be successful in today's workforce differ substantially from those of the past. By the same logic, future occupations will also require completely new skills. New roles will come into being, some of which we don't yet have names for, as other functions become obsolete. The next decade is predicted to be a time of particularly intense change. The World Economic Forum-2020 predicts that we will need to reskill more than 1 billion people by 2030, as jobs are transformed by the Fourth Industrial Revolution. This will apply to current jobs as well as those yet to come into being.

Currently, a significant amount of research is devoted to changes in the labor market and the need adaptation to these changes in higher education. According to the findings McKinsey Global Institute, by 2030 work can replace 800 million jobs [1]. The WEF predicts that 42% of the core skills required to perform existing jobs will change in the next couple of years. Changes are occurring at an exponential rate, wrote Klaus Schwab, the founder and executive chair of the WEF. Also known as Industry 4.0, the defining trait of the Fourth Industrial Revolution is connectivity, with data and information being shared across platforms and media. Boundaries will be blurred between the physical, digital and even biological spheres.

Automation and machine learning will be at the heart of these changes. These will perhaps lead to the most significant changes in terms of skills required by the workforce. Old roles will be automated out, while new roles working with these automated systems will come into being. While this could vastly improve our lives, workers not in possession of the right skills are at risk of being left behind. The effects of this will be certainly be exacerbated by the coronavirus pandemic.

While many of the positive and negative effects will be in the hands of policymakers, those looking to improve their future employability would do well to identify and acquire the most desirable skills in the workplaces of the future. We are likely to see skills gaps emerging, which will create high demand for qualified workers. Below we've compiled a list of what we think some (but definitely not all!) of these future skills might be. The consensus seems to be that the jobs of the future will require a mixture of hard and soft skills.

1. Data skills

Significant advances in automation, artificial intelligence, and the simplification of access to so-called Big Data, tools, and processing methods have led to the disappearance or significant transformation of traditional jobs and the emergence of new ones that we cannot even imagine today [2]. The WEF predicts that data and AI will be one of the key drivers of future growth in the near future. We'll touch on AI below, but for now let's focus on data skills. It's almost a cliché to say we live in an age of big data. This doesn't make it any less true, however. Data is being harvested at a never-before-seen scale – used for everything from improving industrial processes to keeping shelves stacked to accurately targeting digital ads.

The scope and range of big data is only set to increase in years to come, facilitating machine learning and automation. Data is the language which will allow for the connectivity at the heart of Industry 4.0. Accordingly, those who are able to organise data collection, interpret the results, and make decisions based on these findings will be in high demand. While this will be particularly relevant in professions like business analysis or data science, data literacy will be important across all professions. Farmers, marketers, and doctors alike will need to use data to make the best decisions. Currently, there is a skills gap in terms of data literacy. Research from Accenture and Qlik shows that 74% of employees are uncomfortable working with data. This has a knock-on effect; on average, companies lose 43 hours of productivity per employee due to a lack of data literacy every year. The cost to various economies is considerable: 109billionintheUS,24 billion in Germany, and $13 billion in the UK.

Additionally, PwC research shows that while 69% of employers will demand data skills from employees by 2021, only 17% of the UK workforce can be classed as 'data literate'. Data skills, then, can be a key asset to those looking to boost their employability in the future jobs market.

Relevant careers

- Business analyst
- Data scientist
- Marketer.

2. Artificial intelligence

AI is the second half of the WEF's pairing with data. Rapid advances in AI and machine learning are one of the key drivers of the Fourth Industrial Revolution. These will change the way that we work, dealing with repetitive tasks faster and with a greater degree of precision than any human ever could; mapping out trends to predict what will happen in the future, and creating highly-personalised user experiences.

While the risk to certain job functions is significant under the current system, AI has the potential to revolutionise the way we work and live for the better. Those with the AI skills to develop and implement artificial intelligence systems will be in high demand from employers and entrepreneurs looking to revolutionise and streamline the way we work and live. While programming and analytic skills are central to the development of AI, a grasp of AI/machine learning will be highly advantageous to those in other job functions, who will be harnessing AI in their operations, and to the managers overseeing things.

Pre-coronavirus, it was predicted that ultimately AI would create more jobs than it would destroy. The current state of the global economy means that any forecasts of job creation need to be temporarily reassessed. Nevertheless, those with the skills to develop and harness artificial intelligence and machine learning will be in a good position. We will hopefully also see a trickle-down effect; the WEF has stated that AI and related technologies will boost economic growth, thus creating more jobs for everyone.

Relevant careers

- Machine learning engineer
- Business intelligence analyst
- UI designer

3. Blockchain

Blockchain is a shared, immutable ledger that simplifies the process of recording transactions and accounting for assets on a business network. An asset can be tangible (house, car, money, land) or intangible (intellectual property, patents, copyrights, branding). Almost anything of any value can be tracked and sold using the blockchain. This technology reduces risks and costs for all parties involved. Blockchain is ideal for providing such information as it offers authorized network participants instant, general and completely transparent access to information in an immutable ledger. The blockchain network allows you to track orders, payments, accounts, items, and more. And because all participants share a single source of trusted data, you can view all transaction details at any time to work with greater confidence and gain new benefits and opportunities [3].

Blockchain topped LinkedIn’s 2020 list of the most in-demand hard skills in 2020. While most people’s first association with blockchain will be Bitcoin, the technology’s potential business applications are far wider. Blockchain is defined as a decentralised public ledger. It gives a robust and reliable record of trades and transactions while cutting out traditional authorities – in the case of Bitcoin, banks. The impact of blockchain in finance is predicted to be significant. The WEF estimates that 10% of the global GDP will be stored on blockchain by 2027.

Aside from finance, blockchain could also be used in the hiring, to check credentials and employment history – MIT is already awarding digital versions of its degrees. It could be used in logistics and supply chain management to track the movement of goods and map the lifecycle of products from source material to final usage. Or it can be used in the field of copyright management, as a record of ownership for intellectual property. These are just a few examples of its potential applications. As blockchain is only beginning to impact the world outside of cryptocurrency, many job opportunities in the field will relate to the initial period of implementation and compliance.

Relevant careers

- Blockchain engineer
- Legal counsellor
- UX designer

4. Sales and marketing

Sales and marketing don't sound like particularly futuristic careers. These skills will be essential in the workplaces of the future, however, because they cannot be automated. For the time being at least, these roles require a human touch, in order to get an edge in new digital landscape [4]. Marketing campaigns often aim to create leads for your sales funnel so that your sales reps can then follow up with them and turn them into paying customers. As if that's not confusing enough, sales reps often use marketing techniques – such as special offers or free gifts – to encourage people to cross the line. Still, if you're a business owner then you need to know the difference between marketing and sales activities if you want to be successful. At the same time, you need to remember the similarities between the two – after all, both disciplines are ultimately about improving your brand image and creating connections with customers. It's not B2B or B2C, it's B2P – business-to-person.

In the current and future jobs market as mapped by the WEF, these roles currently account for the greatest share and will continue to do so in 2022, growing over the next two years. LinkedIn also include sales in their top-10 job skills of 2020, alongside buzzier skills such as cloud computing and blockchain. Marketing itself has been revolutionised by technology, offering new channels such as social media, affiliate marketing (another top LinkedIn skill), and digital content. More importantly, analytic tools allow for an unprecedented level of data collection and performance measurement. This increases the stakes, requiring marketers to up their game to stay competitive.

No matter how advanced the tools, however, human marketers will be needed to make decisions and steer campaigns. And salespeople will be needed to close deals with other human beings. The responsibility of bringing in revenue, directly or indirectly, continues to fall to these job functions.

Relevant careers

- Salesperson
- Social media manager
- Affiliate marketing manager.

5. Healthcare and nursing

The global population is ageing. In 2015, 12.3% of the world's population was aged over 60. By 2030, it is estimated that this will rise to 16.4%, and then to 21.3% by 2050. This trend will be particularly pronounced in Europe, North

America, and East Asia, where declining birth rates and increased life expectancy will change the makeup of society. Accordingly, there will be greater demand for healthcare and nursing skills in the employment market of the future. We are already seeing current and projected shortages of nurses in the UK, the US, Australia, and Japan – among others. While nursing is where we see the most pressing demand, these nations are facing shortages for nearly every kind of healthcare profession. If we measure these shortfalls next to the anticipated increase in need, we can see that nurses and other healthcare professionals will clearly in high demand, not just in the jobs market, but by humanity as a whole. No doubt the coronavirus pandemic has helped us all see this more clearly than ever before.

Relevant careers

- Nurse
- Healthcare professionals
- Medical doctors.

6. Emotional Intelligence

Emotional intelligence is one of the most frequently referenced skills in lists of what will be needed in the future jobs market – as well as the current one. It also carries personal benefits. Research has frequently shown that high emotional intelligence is one of the most reliable predictors of career success and salary levels. Emotional intelligence is the sum of a person's skills and abilities to recognize emotions, to understand the intentions, motivation and desires of other people and their own, as well as the ability to manage their emotions and the emotions of other people in order to solve practical problems [5]. The concept was first by Daniel Goleman, in his 1995 book Emotional Intelligence, which suggested there was more to intelligence than just IQ. Since then, it has been widely acknowledged and has been the subject of much scholarship and debate.

Empathy is at heart of emotional intelligence (TED speaker Brené Brown is considered by many to be the leading authority of this subject). Those in possession of emotional intelligence are alive to their own feelings and those of others, and how these relate to actions and decision-making. They show humility in giving and receiving feedback, are reliable and committed to helping others, and willing to apologise and to forgive when necessary. As we move towards a globalised society, being aware of and considerate of cultural differences has also become a part of the emotional intelligence mix.

Possessing these qualities help us to work in collaborative environments, reduce stress, and get the best results from everyone. Naturally, you can see why employers would want to hire people like this. Unfortunately, there is a skills gap in emotional intelligence. While this is negative, it does create a clear opportunity for those with a view to improving their own future employability.

Relevant careers

Emotional intelligence is necessary in any career that involves working with other people. Whether a nurse, a CFO, or a coder, emotional intelligence will greatly strengthen your career skills.

7. Creativity

In the creative industries, on according to scientists, jobs will be created at a frantic pace [6]. High growth rates creative industries (from 4.3% to 17.6% in different countries), which are twice the growth rate of the sphere services and four - the sphere of industrial production, as well as an increase in the share of employees in the creative economy (25% of the young population of the world) [7] contributed to the fact that the experts of the World Economic Forum in Davos, the creative economy is seen as a new model of economic growth, with a significant advantage «There is a relatively small initial investment in the so – called "soft" infrastructure (human capital)» [8].

Creativity is regularly identified as a key skill for the future. It's important to note that this does not apply only to 'creative' professions, but is relevant across industries and functions. Indeed, the quality of creativity is one that has increased in importance in all types of professions in recent years, says Accenture. Indeed, it is argued that creativity is more important for more careers than the often-focussed upon STEM skills. Creativity is deemed to be a particularly essential skill in the field of management and leadership and, interestingly, in science and engineering, according to this report. Accenture notes that in the latter category, the need for creativity (and socio-emotional intelligence) will increase as human-machine collaboration increases.

This is perhaps more broadly applicable. As machine learning and automation increasingly comes to take over many day-to-day functions, we will see something of a levelling effect between different organisations. The differentiating factor will be creativity.

Certainly, we've already seen the powerful influence of creativity in the world of tech entrepreneurship, where it is often the idea of how to employ technology rather than the technology itself which defines the biggest ideas (Everything from Tinder to Uber is based on GPS, for instance).

Schools will play a role in fostering creativity. Nesta calls for the integration of creativity into the curriculum – noting that in countries like Finland, Australia, and Canada are already working on this. Younger generations are digital natives, but there also needs to be a focus on employing these skills with creativity.

Creativity is an umbrella term. Underneath it, comes an array of skills considered necessary for the workplaces of the future: complex problem solving, multidisciplinary thinking, and cognitive flexibility. Education plays a crucial part in fostering creativity – not just when learning at school or university, but throughout our lives, be it through formal learning or through life experience.

Relevant careers

Like emotional intelligence, creativity will be at the core of all future professions. And, like emotional intelligence, creativity in all its guises is something that cannot be automated. We may be able to use machines to do the legwork, but they can only do what we tell them.

Conclusion: it remains up to us to see the connections, take risks, and to identify the problems that we believe need to be solved. Machines can only learn, after all, what we tell them to.

REFERENCES

1. The future of education, according to experts at Davos. URL: https://www.weforum.org/agenda/2018/01/topquotesfromdavos onthefutureofeducation/
2. Jahanian F. How higher education can adapt to the future of work. URL: https://www.weforum.org/agenda/2020/01/howcanhighereducationadapttoa$ constantlyevolvingfutureofwork
3. IBM Blockchain . URL: https://.www.ibm.com › blockchain
4. What Is The Difference Between Sales And Marketing? URL: https:// www.digitalmarketing.org
5. Smith, M.K. (2002) «Howard Gardner and multiple intelligences», *The Encyclopedia of Informal Education*, URL: https://http://www.infed.org /thinkers/gardner.htmon October 31, 2005.
6. Kharlamova G., Humenna O. Creativity will save: lessons for Ukraine. Bulletin of Taras Shevchenko National University of Kyiv. Economics. 2018. Vip. 1 (196). S. 76—84.
7. Ukraine 2030: The Doctrine of Balanced Development. Second edition / for sciences. ed. O. Zhilinska. Lviv: Kalvariia, 2017. 164 pp.
8. Florida R. Homo creativus. As a new class conquers the world. Our format, 2018. 380 p.

2.3. Experience of leading countries in terms of density of robotics for the implementation of digital technologies

Liubov Kvasnii
Ph.D., Associate Professor of Economic and Management, Ivan Franko Drohobych state pedagogical university;
Associate Professor of Economics and Entrepreneurship,
Precarpathian Institute named Mykhailo Hrushevsky of Interregional Academy of Personnel Management, Drohobych, Ukraine
E-mail:lg_k@ukr.net
ORCID ID 0000-0001-5248-544X

Oksana Vivchar
Doctor of Economic Sciences, Professor, Professor of the Department of Criminal Law and Procedure and Law Enforcement, West Ukrainian National University, Ternopil, Ukraine
E-mail: o.*vivchar*@wunu.edu.ua
ORCID ID 0000-0001-9246-2226

Viktorija Paslavska
Ph.D.,, Associate Professor of Management,
Precarpathian Institute named of Mykhailo Hrushevsky of Interregional Academy of Personnel Management, Truskavets, Ukraine;
E-mail: vika_pasl@ukr.net
ORCID ID 0000-0002-1083-1006

Liubov Malik
Ph.D., Associate Professor of Organizational Management and Administration, National Forestry University, Lviv, Ukraine
E-mail: lubamalik84@gmail.com

We observe a lot of interest in the topic of the work of business processes, especially in the banking sector. Already today, several large banks in Ukraine carry out diagnostics of processes for the possibility of work, piloting the most appropriate processes, launch virtual «employees» to operate, as well as actively develop internal examination of robotic process management. First of all, such a «virtual» employee is often repeated, routine operations, for example, in the Beck office of the Organization: displaying financial transactions in accounting systems, mail analysis, documentation of documents for predefined rules, formation and reporting, implementation of regular animals, plan-Fact analysis, search and verification of counterparties and other similar tasks.

In other European countries, the work of business processes is actively used to increase operational efficiency from about 2015, in particular in large banks, industrial groups, retail sector, telecom companies. Companies around the world are increasing their use of robots. According to the International Federation of

Robotics (IFR), the global average for industrial robots per 10,000 manufacturing workers grew from 66 in 2015 to 85 in 2017.With integration of artificial intelligence and other improvements in robotics (e.g., better machine vision, better sensors, etc.), robotics promises to see significantly improved pricing and performance over the next decade. As a potentially new general-purpose technology, a central question is whether and how robotics will impact production processes, particularly in such globally traded sectors as manufacturing. The last major technology wave, driven by information technology, was largely decentralizing in nature, enabling the geographic distribution of far-flung supply chains to the periphery in search of cheap labor. Will the next wave of technology innovation based on robotics have the opposite effect, enabling a reshoring of manufacturing to the core?

There is both considerable excitement and trepidation about the so-called «fourth industrial revolution» and its ability to power growth around the world. (This paper eschews the term «fourth industrial revolution», because it is a misleading and overly simplistic term-if anything, there have been at least six major production technology systems since the late 1700s, not four. The more accurate term is the "next production system").

While there are many important questions about the next production system, including the timing of impacts, the nature of the technologies involved, and the effects on industries, labor markets, and productivity, one critical question is how its impacts will likely differ between developed and developing economies. The short answer is that while both developed and developing economies will benefit from the next production system, developing economies will likely benefit less, in part because their lower labor costs provide less incentive to replace it with technology, and because the new production systems appear to enable shorter production runs, smaller factories, and higher productivity-all of which should enable reshoring to higher-wage nations.

As the next wave of technological innovation emerges, interest in technology's role in international affairs appears to be growing. But much of that focus is on product technology (e.g., smartphones, commercial jets, automobiles, solar panels, etc.) rather than on process technology ("machines" to improve *how* a good or service is produced) that enables automation.

Automation is a particular kind of process technology. The term "automation" was originally coined in 1945 when the engineering division of Ford Motor Company used it to describe the operations of its new transfer machines that mechanically unloaded stamping from body presses and positioned them in front of machine tools. Today, it refers to any production process that is controlled by a machine, with little or no input from an operator in order to produce, in a highly automatic way. There are many technologies that can enable a production process to be automated, and robotics is an increasingly important one. While there is no hard and fast definition of "robotics," the term generally refers to physical machines that can be programmed to perform a variety of different tasks, with some level of interaction with the environment, and limited or no input from an operator.

Robots are key tools for boosting productivity. To date, most robot adoption has occurred in manufacturing, wherein they perform a wide variety of manual tasks more efficiently and consistently than humans. But with continued innovation, robot use is spreading to other sectors, from agriculture to logistics to hospitality. Robots are getting cheaper, more flexible, and more autonomous, in part by incorporating artificial intelligence. Some robots substitute for human workers; others-collaborative robots, or "cobots," which work alongside workers-complement them. As this trend continues, robot adoption will likely be a key determinant of productivity growth and will potentially reshape global supply chains.[1]

The presence of artificial intelligence and robotics in industry is growing - fast. Globally there are now 113 installed industrial robots per 10,000 employees in the manufacturing sector, an increase from 74 just four years ago. South Korea leads the way in their use of robots, with 855 installed per 10,000 employees.

The rise of the machines has well and truly started. Data from the International Federation of Robotics reveals that the pace of industrial automation is accelerating across much of the developed world with 74 installed industrial robots per 10,000 employees globally in 2016. By 2020, that increased to 113 across the manufacturing sector. Asia now has a robot density of 118 units per 10,000 workers and that figure is 114 and 103 in Europe and the Americas, respectively. China is one of the countries recording the highest growth levels in industrial automation but nowhere has a robot density like South Korea[2].

In 2019, South Korea had 855 installed industrial robots per 10,000 employees. That is mainly due to the contiued installation of high volume robots in the electronics and electric sectors. Germany and Japan are renowned for their automotive industries and they have density levels of just around 350 per 10,000 workers. Interestingly, Japan is one of the main players in industrial robotics, accounting for over half of the global supply. In the United States, the pace of automation is slower with a density rate of 228. China is eager to expand its level of automation in the coming years and it has been targeting a place in the world's top-10 nations for robot density by 2020. It had a density rate of 25 units in 2013 and that grew to 97 by 2017. In 2019, that figure had grown quite considerably once again to 187.

The world's first ever 'robot restaurant complex' has opened in Guangdon province, China. The restaurant has more than 40 robots, capable of serving and cooking over 200 dishes. Guests make their orders with robot waiters, their food is then delivered directly to their table from a skyrail system or brought in on a tray. The restaurant is testament to China's growing robotics industry, which has a

[1] These are the countries with the highest density of robot workers. https:// www.weforum.org › 2020/09

[2]Там само

marker value of $5.4 billion[3]. A Chinese business claiming to be the world's first «robot restaurant complex» officially opened Monday in the southern Guangdong province. FOODOM Tianjiang Food Kingdom — located in Foshan's Shunde District, an area hailed as the "cradle of Cantonese cuisine" — is the sixth automated restaurant operated by Qianxi Robot Catering Group.

The label "robot restaurant complex" speaks to the restaurant's scale, range of cooking robots, and synchronicity of its system: The facility has a seating capacity of nearly 600 diners and accommodates over 40 robots capable of cooking some 200 dishes from three basic categories: Chinese (including Shunde specialities), hot pot, and fast food. Qianxi Group's other automated restaurants, though similar, don't serve such a wide range of cuisines under one roof.

Guests arriving at the pink-and-white restaurant make their menu selections with wide-eyed robot waiters. When ready, the food is delivered directly to their table from a skyrail system or brought in on a tray. Some robots, such as the burger machine, serve customers 24 hours a day. The robot restaurant complex's noodle-making robot, for example, takes up 4 square meters of floor space and can churn out 120 dishes per hour if needed. They're also safer, he said, thanks to a standardized cooking process and the absence of human-to-human contact. A complete scientific control system and the widespread use of smart equipment reduce the risk of (coronavirus) infection. This makes it safer and more hygenic.

The cooking robots "learned" how to prepare complicated Chinese dishes by imitating the actions of experienced human chefs, then had their operations improved through a lengthy trial-and-error process. "For a simple-looking dish like chicken broth cabbage, the frying temperature, frying time, the number of times it should be flipped — all of these variables need to be adjusted over the course of more than a thousand attempts". China has an enormous appetite for all things robotic. Its industrial robot sector is the largest and fastest-growing of any country in the world, growing 21% in 2019 to a market value of $5.4 billion. Factory robots are crucial to cutting production costs and maximizing workers' efficiency.

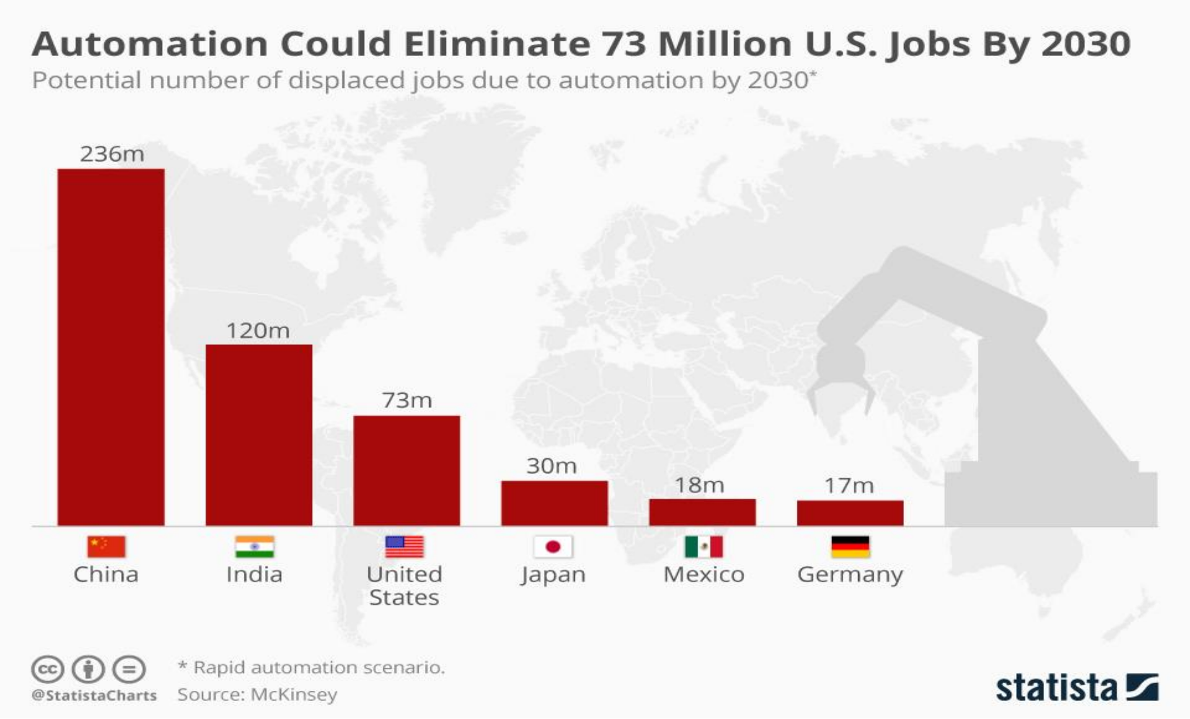
Recent years have borne witness to attempts to mechanize all manner of tasks and professions, including welcoming guests at conferences, teaching in the classroom, presenting the news on TV, and even sex. In the medical field, China has relied on robots to assist the elderly, diagnose patients, and administer acupuncture. The need to minimize human-to-human contact during the COVID-19 pandemic has given robots an elevated platform. Since January, they've been used to disinfect hospitals, serve food to sick patients, and patrol the streets. Some of these robocops can do everything from taking people's temperature and delivering public safety messages to chastising anyone caught without a face mask in public.

Please wear a mask, pay attention to personal hygiene, and avoid crowded places, such robots — even airborne drones — broadcast via loudspeaker in

[3] Welcome to China's latest 'robot restaurant'. https://www.weforum.org/agenda/2020/07/china-robots-ai-restaurant-hospitality

bustling cities. If you feel unwell, seek medical assistance promptly. In Ukraine, 20,000 employees accounted for one robot. The robotic complexes are in large factories belonging to large-scale international companies: Henkel, Philip Morris, Procter & Gamlbel, etc. Companies with Ukrainian capital are suited to work with care. If we talk about deploying industries, then in Ukraine it is possible to note metallurgy and food industry, as well as logistics and agrosphere.

An example of a comprehensive automation in the heavy industry of Ukraine can be considered an Interpaipstal plant - a single modern metallurgical plant built in independent Ukraine from scratch. This is equipped with almost everything: Special software monitor the state of equipment, and the production processes manages the MES system.The pandemic has also given niche businesses like unmanned convenience stores and automated grocery delivery services a new lease on life. During China's COVID-19 peak in February, Qianxi Group sent a Wuhan hospital a robot capable of preparing over 100 portions of clay pot rice per hour, eliminating the risk of transmission from human contact.[4] Faster productivity growth in many functions and industries that involve moving or transforming physical things will be spurred by better and cheaper robots. Robots are already driving productivity. Investment in robots contributed to 10 percent of GDP growth per capita in Organization for Economic Cooperation and Development (OECD) countries from 1993 to 2016, and there is a 0.42 correlation between a country's wage-adjusted manufacturing robot adoption (see below) and growth in productivity between 2010 and 2017.5[5]

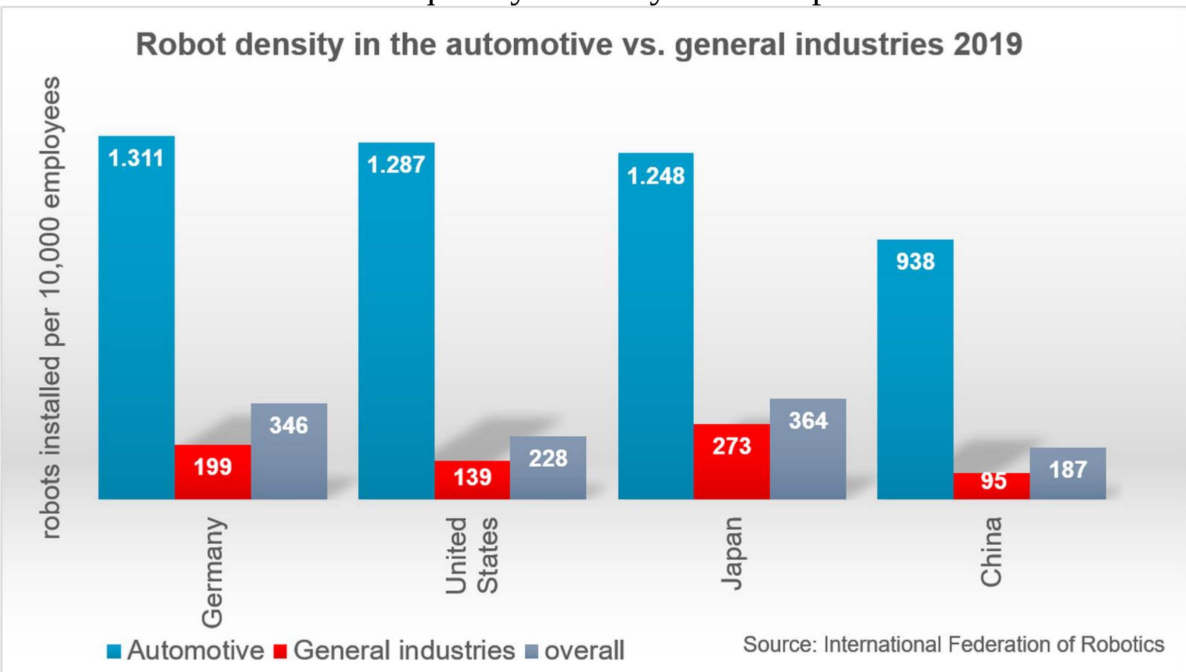


[4] International Federation of Robotics. https://www. ifr.org › service-robots › the-a.

[5] Robotics and the Future of Production and Work.https://itif.org/publications/2019/10/15/robotics-and-future-production-and-work

The robot density in the US automotive industry hit a new record of 1,287 installed units per 10,000 employees. The United States ranks seventh worldwide. The density is similar to Germany (1,311 units) and Japan (1,248 units). China is in twelfth place with 938 units.[6]

The robot for automating business processes is a program (or software) that runs on a user's computer or on a selected server. The program simulates the actions of a person by performing tasks according to certain rules. The robot interacts with any number of IT applications through the user or software interface, performs a specified set of actions according to the schedule, in the order of the queue or when there are certain conditions. Like any other program, the robot may fail. But the work is restored quickly - usually it takes up to several hours.



Automation is the key not only to post-pandemic recovery, but to post-pandemic growth and progress," says Milton Guerry, President of the International Federation of Robotics. "In the upswing after the 2008 financial crisis, companies like General Motors, Ford, Fiat-Chrysler, and Tesla invested extensively in robotics and automation. As a result, thousands of new jobs were created within the automotive industry. So many years and technological advancements later, we have the opportunity to learn from this success story and emerge even stronger than before.

Robot density in the general industry is still comparatively low with only 139 units per 10,000 employees. Overall in all surveyed countries worldwide, the potential for robot installations in the general industry is tremendous. In the United States for example, yearly orders of robots from non-automotive sectors surpassed automotive robot orders for the first time. Sales of robotic units in the US increased 7% in 2020 from 2019. Year-over-year orders in life sciences increased

[6] International Federation of Robotics. https://www. ifr.org › service-robots › the-a.

by 72%, food and consumer goods grew by 60%, and plastics and rubber saw a 62% increase.

To help educate companies about how to successfully apply robotics, AI, machine vision and related automation technologies, we've launched AUTOMATE FORWARD, a virtual show and conference taking place March 22-26," says Jeff Burnstein, President of the Association for Advancing Automation (A3). "High-profile industrial experts and over 250 automation suppliers report about cutting-edge use cases for automation and what they recommend for the automation journey of companies either just starting or expanding their automation journey.[7]

RPA technology is primarily aimed at increasing the efficiency of activity, and not to reduce jobs. Having instructed mechanical and routine work with works, employees can send their strength to solve creative, creative tasks, to develop a team, etc. New vacancies will be opened - specialists in robotic processes will be required.

Faith in the future of «smart» machines is in investors, because private capital in the field increases every year: the total funding of the ten largest agreements in 2018 more than $ 11.5 billion, which are 16 times more than the number of investments in Ten biggest deals in 2017.

The most promising directions - works for industry, unmanned, logistics systems, medical works and artificial intelligence. According to IDC forecasts, by 2022, global expenses for the purchase of robotics and unmanned aerial vehicles will reach $ 201.3 billion[8].

Conclusion: Robot adoption will likely be a critical determinant of productivity growth and has the potential to reshape global supply chains.

Improvements in automation technology such as robotics are poised to bring more automated manufacturing production work to developed countries, rather than offshore it to lower-wage countries.

As a rule, robots are used on physically difficult work: such technique allows minimizing traumatism, accelerate production processes and improve product quality. And production management systems - to control the production processes, the operation of the equipment and minimize the probability of errors through the "human factor".

Most forecasts exaggerate the impact automation will have on employment. The evidence suggests structural unemployment will not increase due to automation, and labor will receive a significant share of the benefits.

Policymakers should support – rather than resist – the development of the next production system.

---

[7] International Federation of Robotics. https://www. ifr.org › service-robots › the-a.

5 main directions of robotics development. https://www.imena.ua › blog › 5-directions-of-develop

In the next 20-30 years, more than half of professions will master work. This is not a movie scenario about the future, but substantiated calculations and forecasts of leading audit and consulting companies – EY, MCKINSEY, DELOITTE, and others. Already, such a technique performs many types of work in the automotive, food, mining and metallurgical industry. In Ukraine, the work in industry is not yet popular - the cost of an employee's work hours at the same factory is lower than the cost of labor work, but here are companies specializing in services and service, their offices already trust business processes. It is cheaper and easier than the production of production, because it does not work here, but a special program ROBOTIC PROCESS Automation (RPA). Such works write texts, check and process data, managed money, prepare and give reports, accrue salaries and perform many other routine work. And this is also a world trend. According to Market Research Future, the global process of process development will increase by 30% per year and by 2023 will reach $ 2.7 billion.

III. CHANGES IN THE FINANCIAL SERVICES MARKET UNDER THE INFLUENCE OF AI

Zoia Pestovska
PhD in Economics, Associate Professor
Associate Professor of the Department of innovation management and financial analytics
Alfred Nobel University, Dnipro
E-mail: at@duan.edu.ua
ORCID ID 0000-0001-9536-8008

3.1. Artificial intelligence in banking

One of the main causes of the 2008 financial crisis was outdated forecasting methods based on regression methods. With modern advances in artificial intelligence (AI), namely the ability to effectively use statistics for forecasting, the situation could be different. To understand how AI technologies work, consider its components (Fig. 15): cognitive science applications, robotics applications, and natural interface applications. Cognitive scientific systems are based on the analysis of the human thinking process: how the neural networks of the brain work, how a person uses stored knowledge, how people think and act rationally.

Artificial Intelligence		
↓	↓	↓
Cognitive scientific applications	Robotic applications	Natural interface applications
Expert systems Training systems Genetic algorithms Neural networks Intelligent agents	Visual perception Tactility Agility Movement Navigation	Natural languages Speech recognition Multisensor systems Virtual reality

Figure 15. Components of artificial intelligence.
Source: Developed by the authors based on Desai (2017 [1])

Cognitive scientific systems are based on expert systems and neural networks, machine learning, the agent approach (intelligent agents), and genetic algorithms. Since the introduction of intelligent agent terminology, any approach in AI has been associated with an agent, since it is assumed to represent people in the real world. An intelligent agent is a program or a component of an automated system that independently performs a task specified by the user for long periods of time. Agents perform some functions: searching for sources, requesting, checking for compliance with the search criteria and issuing a response in a user-friendly form. But the term "intelligent" does not mean that there is an intellectual component in the agent, it emphasizes the high level of control technology in comparison with simple automatic control systems (Desai, 2017 [1]).

The second aspect of the application of AI is robotics, namely the task of perception. Robots can sense their environtment using integrated sensors or computer vision. Perception is important not only for planning, but also for creating an artificial sense of self-awareness in the robot. This allows you to maintain interaction work with others in the same environment.

The third aspect of using AI is the natural-language user interface, in which linguistic phenomena (words, phrases, and sentences) act as controls for creating, selecting and modifying data in programs. Most natural language processing systems are based on formal grammar rules. The development and study of these rules is known as computational linguistics. For a full understanding of the field of AI as a science, we could show the sub-sectors of it (Fig. 16).

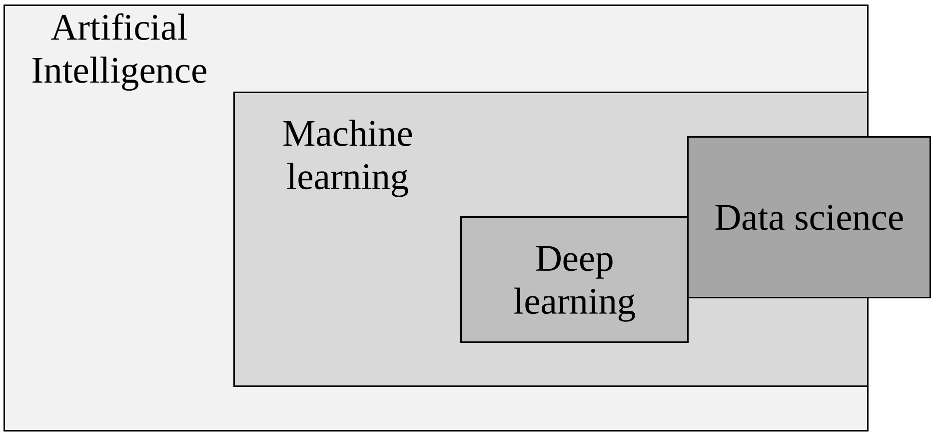


Figure 16. Sciences related to the field of artificial intelligence.
Source: Developed by the authors based on Egbuna (2018 [2])

From 2019-2020, during the COVID-19 pandemic, digital interaction trends intensified. To compete and thrive, existing banks must become AI-driven institutions and use AI technology as the basis for new offerings and customer service. For decades, banks have continually adapted technological innovations to redefine the way customers interact with them. Banks introduced ATMs in the 1960s, and electronic card payments in the 1970s. The 2000s saw widespread adoption of 24/7 online banking, and the 2010s saw the proliferation of on-the-go mobile banking. AI technologies can lead to a higher degree of automation and, when deployed after risk control, can often improve human decision making, both in terms of speed and accuracy. Machines run without breaks for lunch and sleep, and the number of errors is reduced. A robot, unlike a human, does not step on the same rake twice and is not subject to emotional outbursts. Robotization in the work of banks has led to the emergence of new specialties, for example, the operator of chat bots - an employee whose main duties are to regularly debug the software for the actual requests of regulators or clients. AI technology can dramatically improve banks' ability to achieve four key outcomes: higher margins, massive personalization, distinctive multi-channel experiences, and faster innovation cycles (Biswas, Carson, Chung, Singh, Thomas, 2020 [3]). Artificial intelligence has given the banking and financial industry a way to meet the needs of customers looking for smarter, more convenient and safer ways to access, spend, save and invest their money. AI in finance is changing the way we interact with money. AI is helping the financial industry to simplify and streamline processes ranging from lending decisions to quantitative trading and financial risk management (Schroer, 2019 [4]). There are conflicting opinions regarding its development and potential impact. Some scientists warn that there is a downside to these innovative technologies. Intuition, imagination, and strategic thinking are abilities that for a long time were considered exclusively human, but now they are not (Archer, 2021 [5]). AI refers to the ability of machines to independently perform tasks that are characteristic of human interaction with the environment (for example, recognizing and generating speech, texts, images and behavior patterns, predicting behavior based on previous data) (Raexpert, 2018 [6]). Machine learning (ML) refers to systems that can not only complete tasks, but also learn from experience. In banking, a large amount of customer data is fed into computer systems. Computers can sort, classify, and analyze this data. They can make predictions based on previous customer behavior and make decisions based on previously defined criteria. Systems can also learn from exceptions and improve over time (Istocks, 2020 [7]).

The areas of application of AI in banking can be roughly ranked from those related to customers to those related to the internal activities of the bank, and then decisions related to investment and cybersecurity will be in the middle:

1. Loan solutions and collection.
2. Personalized banking and chat bots.
3. Budgeting.
4. Retail payments and integration with digital assistants.
5. Risk management and investment.
6. Quantitative (algorithmical)trading.
7. Cybersecurity and fraud detection.
8. Video surveillance and video analytics.
9. Work with documents, reporting.
10. Regulations and rules.
11. Internal business processes, personnel management.

1. Loan solutions and collection.

In some countries having good credit helps in obtaining profitable financing options, finding a job and renting an apartment. Since so many vital things depend on our credit history, the process of approving loans and cards is more important than ever. AI-powered solutions are helping banks make smarter underwriting decisions by leveraging a variety of factors that more accurately assess traditionally underserved borrowers such as millennials (Schroer, 2019 [4]).

Whether AI is used at certain stages or throughout the entire crediting process will depend on a bank. When analyzing a borrower, it is necessary to automatically analyze his social Internet profile, obtain information from government organizations, and check documents for their validity. Then to put all the information about a borrower together and rank it by profitability, reliability, risk. Software robots help to analyze borrowers, carry out their scoring. And the credit manager only has to make a decision on reliable and up-to-date data (Markelov, Shipilov, 2020 [8]).

To communicate with debtors, banks develop collector robots. Collectors' activity is one of the most socially sensitive segment of the financial market. Now the debt collection procedure has been described in machine language by setting strict scripts for communicating with clients. And these programs are not just a robot tape recorder capable of calling a debtor and giving out a standard set of template phrases. The AI chooses the next phrase based on the analysis of the answer received, analyzes the emotions of the client, but, AI is not subject to emotions and, therefore, is spared from nervous breakdowns, and, as a result, from complaints about incorrect behavior (Markelov, Shipilov, 2020 [8]).

2. Personalized banking and chatbots.

Traditional banking is failing to keep up with today's digital savvy consumers. They need tools to help them control their budget and make adjustments to spending in real time; ready to use computer banking advice. Chatbots use AI to make personalized financial advice and natural language processing to provide instant customer service on their own (Schroer, 2019 [4]). Enhanced by AI technologies, mobile banking can immediately provide customers with tips, tricks and information. Improving customer service improves client confidence and satisfaction.

When a customer needs to verify their identity to the bank, the AI picks up PINs or uses voice recognition to authenticate client. Artificial intelligence connects and manages all interactions between services and ensures transaction security. Some UK banks allow customers wishing to open an account to send selfies to verify their identity. That is, you can open an account in minutes, without visiting a branch and without waiting during several days of manual verification (Istocks, 2020 [7]). Using natural language processing technology, chatbots in financial services respond to customer inquiries in a timely and accurate manner. For example, HDFC Bank launched the Eva chatbot and thus attracted new customers and created better conditions for existing ones.

Conversational banking allows us to ask questions and get answers in real time. Interactions persist, so bots can provide a more personalized service every time a customer connects and recommend products based on their behavior and the services the customer is already using (Istocks, 2020 [7]). Chatbots are becoming indispensable where a bank needs to inform the client about the product line or help fill in the requisites correctly, navigate the site or warn about the due date.

3. Budgeting.

Using online budgeting software such as YNAB or EveryDollar, artificial intelligence can be seen in how these systems interact with banking transactions, automatically transfer funds to specific categories, and make predictions about the financial situation (Istocks, 2020 [7]). Machine learning has made it possible to replace graphical interfaces with voice ones. Banks have a direction of voice assistants, and in corporate business they are now developing a business assistant that will help clients not only on financial issues related to banking, but also on issues related to general intelligence, business management, analytical services, for example, keeping the minutes of the meeting - with the correct accents that will be placed within this protocol. There are robots that can already talk to a person for up to seven minutes, and we will not understand that this is not a human being. However, the robot needs to be constantly listened to and improved, because people can sometimes go into completely unexpected directions of conversation.

Banks began to analyze the emotions of people during communication in order to identify negativity at different stages of communication. As it turned out, it is not so important how loud a person speaks, as what he says. You can analyze the entire volume of customer interaction, rather than selectively checking calls and chats manually (Kostylev, 2019 [9]).

4. Retail payments and integration with digital assistants.

In some countries, you can simply ask Google or Alexa to perform simple transactions, such as checking accounts or paying a bill (Istocks, 2020 [7]). Instead of using credit or debit cards to pay for purchases, many people use their mobile devices to make contactless purchases. Services such as Apple Pay and Google Pay allow users to make payments securely from mobile devices using biometric face or fingerprint scanning technologies (Istocks, 2020 [7]).

For example, when the mobile application is turned on, a client simply speaks by voice that he wants to send money to “Mom” or “Son for study”, or “Daughter to a mobile phone”, and this is enough for the payment order to be generated. Then there is only confirmation of the operation, and everything else is done by the AI (Markelov, Shipilov, 2020 [8]).

5. Risk management and investment.

Accurate forecasts are critical both for speed and for the protection of many businesses. Financial markets are increasingly turning to machine learning to learn trends, identify risks, save labor, and provide more accurate information for future planning (Schroer, 2019 [4]). AI analyzes risks, taking into account transaction and credit history, income growth, market conditions. Predictive analytics provide detailed insights into micro-actions and behaviors to determine if an investment is possible. Such tasks cannot be performed and handled by humans (Archer, 2021 [5]). With the ability to process massive amounts of data, AI is also transforming investment banking. Investors can even make voice deals in the morning (Istocks, 2020 [7]). AI has not yet reached the level of operational risk management, but it has already been introduced to the art of management in terms of "risk-**profitability**" coordinates. Some of the banks are pursuing a risky policy and thereby increase their profitability (the main thing is not to go beyond the current standards), and some banks are categorically not allowed to approach the regulatory limits of risk. Until recently, maintaining the “risk-return” balance was based on specific people or on long calculations, and now artificial intelligence provides “clues” in real time (Markelov, Shipilov, 2020 [8]).

6. Quantitative (algorithmical) trading.

Quantitative trading is the process of using large datasets to identify patterns that can be used to enter into strategic trades. AI computers can analyze large and complex datasets faster and more efficiently than humans. The resulting algorithmic trading processes automate trades and save time (Schroer, 2019 [4]). Many well-known hedge funds use AI for their own purposes. When planning and managing assets, AI can conduct algorithmic trading, concluding several hundred transactions per second, which is inaccessible to humans; the main thing is to properly debug the algorithms. Also, based on fundamental and technical analysis of securities prices (this is already big data), recommendations can be made on how to change the components of the investment portfolio (Markelov, Shipilov, 2020 [8]).

7. Cybersecurity and fraud detection.

Scaling up cybersecurity and fraud detection efforts is now a necessity for any bank or financial institution, and artificial intelligence is playing a key role in making online finance more secure (Schroer, 2019 [4]). Banks and financial intermediaries deal with huge amounts of personal data and people's money. Fraud is the most dangerous thing that can happen in this industry: one mistake can lead to incredible losses, trouble and criminal liability. AI detects suspicious activity, provides an additional layer of security and prevents fraud (Archer, 2021 [5]).

8. Video surveillance and video analytics.

CCTV security (Closed Circuit Television, a system in which video signals are transmitted between connected devices such as CCTV cameras, monitors and video recorders) and video surveillance have long been a valuable resource for solving and preventing crimes in various business conditions. For banks, video surveillance will be used to monitor individual government industries, the national corporate headquarters and critical infrastructure of buildings, as well as their perimeters, entrances, parking, ATMs, terminals.

Key issues: manually identifying suspects on video can be difficult and time-consuming, especially when there are hours of video footage to watch to understand the incident and pinpoint the suspect. AI-powered video analysis software (like VIDEO SYNOPSIS) enables banks to overcome these and other challenges (BriefCam, 2021 [10]). Using deep learning techniques, video content analysis solutions analyze video, identify emerging objects, and then extract and categorize them, indexing video metadata to make the video searchable, actionable and quantifiable. Thanks to the capabilities of video analytics, banks can: search and filter video to identify suspects based on known characteristics (gender, color of clothing, direction of movement, type of vehicle); accelerate of video viewing in order to comprehensively understand and investigate incidents; launch an alert based on face matches from the watchlist for face recognition; predetermined behaviors such as living in sensitive areas; or even actions based on counting, for example, when a certain number of objects or a simultaneous number of objects are detected in a predetermined period of time.

Bank branch video can help them understand broader behavioral trends, optimize customer service, create safer building layouts, and generate better security protocols. For financial institutions, these capabilities can save thousands of man-hours each year and improve loss prevention (Goldmeier, 2019 [11]).

9. Work with documents, reporting.

In each bank it is necessary to process of streams of paper documents: invoices, acts of work performed, acts of reconciliation, consignment notes, which must be scanned, recognized, posted to accounting registers, transactions and contracts. Robots already know how to do this, only others, since software robots always have a narrow specialty. At the same time, human participation is limited exclusively to those documents that the robot did not recognize or that the robot "doubts". Automation of routine and "normatively inevitable" operations, preparation of regulatory reporting using AI significantly frees up time either for creative work or for working with "poorly recognized" documents. Here it is necessary to mention the actions of banks on AML/FT, which manually require a lot of resources, and a lack of resources or poor-quality reporting may result in license revocation. The principle of operation remains the same: information systems and software robots prepare data for decision making, which remains with a person **(Markelov, Shipilov, 2020 [8]).**

10. Regulations and rules.

A financial institution must comply with various laws and regulations that are difficult to follow. Reports take too long and one tiny detail left out by a bank specialist can lead to complications or even serious problems. AI considers all the rules, detects deviations, analyzes the data and follows the rules exactly. AI implementation projects are difficult to start without the will of senior management, but it is impossible to continue if their need is not understood by the employees themselves. Moreover, the chain begins with the regulator, which largely contributed to the fact that banks are ahead of insurance companies in the development of digital technologies for about five years. Now that the National Bank of Ukraine regulates the insurance market, this will give a legislative impetus in this industry (Kostylev, 2019 [9]).

11. Internal business processes.

AI still helps the bank more than the client, primarily in reducing costs by automating the work of employees. Backoffice is already providing the opportunity to improve processes through machine learning. For example, it analyzes a large amount of internal data (mail, instant messengers) and determines «which stars start to burn out». As it turned out, these are often the «top» people who were most actively involved in projects, but got bogged down in routine and tired (Kostylev, 2019 [9]). If we are talking about internal business processes in a bank, then most often it concerns finalizing the flow of paper documents, uploading statements, transferring data from one system to another. In parallel, programs are actively used to assess the quality of communication with a client. Robots have learned to react not only to certain keywords, but also to analyze in general (by a number of parameters) the behavior of employees when talking with a client. And tracking customer satisfaction with a specific service was almost the first direction of robotization, and not only in the financial sector (Markelov, Shipilov, 2020 [8]). Examples of using AI in different bank services are presented in Table 5 and 6.

Table 5

Uses of AI in banking

<table>
<tr><td colspan="6">Uses of AI in banking</td></tr>
<tr><td colspan="2">Channel</td><td colspan="2">Front office</td><td>Middie office</td><td>Back office</td></tr>
<tr><td colspan="2">Size of cost savings opportunity</td><td colspan="2">$199B</td><td>$217B</td><td>$31B</td></tr>
<tr><td rowspan="2">Key use cases</td><td>More mature</td><td colspan="2">Conversaional banking</td><td>Antiraud & risk</td><td>Credit underwing</td></tr>
<tr><td>Less mature</td><td>AI biometrics technology</td><td>Personalized insights</td><td>Anti-money laundering / Know-your- customer</td><td>Smart contracts infrastructure</td></tr>
</table>

Source: Developed by the authors based on Digalaki (2021 [12])

Banks are expanding their use of AI technologies to improve customer experiences and back-office processes (Fig. 17).

<table>
<tr><td colspan="4">←Front-office Back-office→</td></tr>
<tr><td>Smile-to-play facial scanning to initiate transaction</td><td>Micro-expression analysis with virtual loan officers</td><td>Biometrics (voice, video, print) to authenticate and authorize</td><td>Machine learning to detect fraud patterns, cybersecurity attacks</td></tr>
<tr><td>Conversational bots for basic servicing requests</td><td>Humanoid robots in brances to serve customers</td><td>Machine visison and natural-language processing to scan and process documents</td><td>Real-time transaction analysis for risk monitoring</td></tr>
</table>

Figure 17. Using AI in front- and back-office processes.
Source: Developed by the authors based on Digalaki (2021 [12])

Table 6

Examples of using AI in banking

AI apps	Name	Location	How it's using AI in finance	Industry impact
Loan solutions and collection	ZestFinance	Los Angeles	ZestFinance is the maker of the Zest Automated Machine Learning (ZAML) platform, an AI-powered underwriting solution that helps companies assess borrowers with little to no credit history.	Auto lenders using ML underwriting cut losses by 23% annually, more accurately predicted risk and reduced losses by 25%.
	DataRobot	Boston	DataRobot helps financial institutions and businesses quickly build accurate predictive models that enhance decision making around issues like fraudulent credit card transactions, digital wealth management, direct marketing, blockchain, lending and more.	Alternative lending firm Crest Financial is using DataRobot's software to make more accurate underwriting decisions by predicting which customers have a higher likelihood of default.
	Scien aptic	NYC	In addition to other financial-based services, Scienaptic Systems provides an underwriting platform	Working with one major credit card company, Scienaptic boasted $151

			that gives banks and credit institutions more transparency while cutting losses. Scienaptic's Ether connects myriad unstructured and structured data, smartly transforms the data, learns from each interaction and offers contextual underwriting intelligence.	million in loss savings in just three weeks.
	Underwrite.ai	Boston	Underwrite.ai analyzes thousands of data points from credit bureau sources to assess credit risk for consumer and small business loan applicants. It acquires portfolio data and applies ML to find patterns and determine good and bad applications.	Since working with Underwriter.ai in 2015, a major online lender providing dental financing reduced its default rate from 17.8% to 5.4%.
Personalized banking, chatbots and budgeting	Kasisto	NYC	Kasisto is the creator of KAI, a conversational AI platform which helps banks reduce call center volume by providing customers with self-service options and solutions. The AI-powered chatbots also give users calculated recommendations and help with other daily financial decisions.	TD Bank Group announced plans to integrate Kasisto's technology into their mobile app, providing customers with real-time support and spending insights.
	Abe AI	Orlando, Fla	Abe AI is a virtual financial assistant that integrates with Google Home, SMS, Facebook, Amazon Alexa, web and mobile to provide customers with more convenient banking. Abe AI provides services ranging from simple knowledge and support requests to personal financial management and conversational banking.	In 2016 Abe released its smart financial chatbot for Slack. The app helps users with budgeting, savings goals and expense tracking.
	Trim	San Francisco	Trim is a money-saving assistant that connects to user accounts and analyzes spending. The smart app can cancel money-wasting subscriptions, find better options for services like insurance, and even negotiate bills.	Trim has saved $6.3 million for more than 50,000 people.
Risk managment and investient	KEnsho	Cambridge, Mass	Kensho’s software offers analytical solutions to leading financial institutions like J.P. Morgan, Bank of America, Morgan Stanley and S&P Global using a combination of cloud computing and natural language processing (NLP). The company's systems can provide answers to complex financial questions in plain English.	Traders with access to Kensho's AI-powered database after Brexit used the information to quickly predict an extended drop in British pound. In March 2018, S&P Global announced a deal to acquire Kensho for $550 mln.

	Ayasdi	Menlo Park, Calif	Ayasdi creates cloud-based and on-premise machine intelligence solutions for enterprises and organizations to solve complex challenges. For fintech companies Ayasdi is deployed to understand and manage risk, anticipate the needs of customers and aid in anti-money laundering processes.	Ayasdi is helping banks combat money laundering with its AML detection solutions. Using the company's AML solution, one major bank saw a 20% reduction in investigative volume.
Quantitative (algorithmical) trading	AlphaSense	NYC	AlphaSense is AI-powered search engine and serves clients like banks, investment firms and Fortune 500 companies. The platform utilizes natural language processing to analyze keyword searches within filings, transcripts, research and news to discover changes and trends in financial markets.	AlphaSense provides brokers and traders with access to SEC and global filings, earning call transcripts, press releases and information on both private and public companies.
	Kavout	Bellevue, Wash	Kavout uses machine learning and quantitative analysis to process huge sets of unstructured data and identify real-time patterns in financial markets. One of Kavout's solutions is the Kai Score, an AI-powered stock ranker, which analyzes massive amounts of data, such as SEC filings and price patterns, then condenses the information into a numerical rank for stocks.	Kai's "top picks portfolio" boasts a 21.9% compound annual growth rate (CAGR) since 2012, vastly outperforming the S&P 500's 13.3% CAGR.
	Alpaca	San Mateo, Calif. (U.S. office)	Alpaca combines proprietary deep learning technology and high-speed data storage to provide short and long-term forecasting applications. Alpaca’s technology identifies patterns in market price-changes and translates its findings into multi-market dashboards.	Alpaca recently partnered with financial news giant Bloomberg to provide users with its "AlpacaForecast AI Prediction Market" to predict in real-time for major markets.
Cyber security and fraud detection	Shape Security	Mountain View, Calif	Utilized by top banks in the U.S., Shape Security curbs credit application fraud, credential stuffing, scraping and gift card cracking by pinpointing fake users. Company's ML models are trained on billions of requests, allowing the software to effectively distinguish between real consumers and bots. Shape Security's Blackfish network uses AI-enabled bots to detect compromised login credentials, alerting both customers and companies to security breaches instantly.	Shape's solutions have helped one major bank protect customers from account highjacking and detected one million credential stuffing attacks in the first week of use.

	Darktrace	Cambridge, Mass	Darktrace creates cybersecurity solutions for a variety of industries and financial institutions. The ML platform analyzes network data and creates probability-based calculations, detecting suspicious activity before it can cause damage for some of the world's largest financial firms.	Global financial software firm Ipreo deployed Darktrace to protect its customers from sophisticated cyber attacks and saw immediate results in real-time threat detection and defense.
	Vectra	San Jose, Calif	Vectra is the company behind Cognito, an AI-powered cyber-threat detection and hunting solution. Vectra's platform automates threat detection, reveals hidden attackers specifically targeting financial institutions, accelerates investigations after incidents, and identifies compromised information.	Vectra helps a prominent securities exchange prevent malware attacks. Cognito immediately identified a misconfiguration in the exchange's authentication systems that would have gone unnoticed.

Source: Developed by the authors based on Schroer (2019 [4]).

There are many opportunities to leverage advanced data analytics, machine learning, and intelligent process automation. Research firm Opimas predicts that AI will have a major impact on jobs in capital markets, with more than 20,000 tech and data jobs created by 2025. As efficiency grows, its forecasts 90,000 job losses in asset management and 58,000 in securities servicing, and 45,000 in sales and trading. However, these numbers will pale in comparison to the opportunities to increase productivity and create real added value for customers (Haq, Ogle, 2018 [13]). It is believed that there are segments in the banking industry that cannot be digitized: in the corporate segment, for example, or in investment banking, there are often unique situations that only a person can figure out. Areas in which it is necessary to solve complex problems are less amenable to digitalization. The help of a specialist will always be in demand here (Krasyukov, 2021 [14]).

It is interestingly, while bankers tend to use the term «artificial intelligence», scientists themselves are very cautious about it and try not to mention it in vain. Scientists see instead of AI mainly mathematical problems and algorithms. And the main thing for them is to train personnel for solving such mathematical problems. Intelligence, according to academic science, is needed not so much artificial as human to hear business problems, understand, adequately interpret and pose mathematical problems, and then solve them.

In academichians and among technology companies, it is a popular belief that AI is, for the most part, case based analysis. Case-based (precedent) analysis is the process of determining whether an action is right or wrong by comparing the action with unambiguous paradigm cases or closely related cases that have already been analyzed. And this case analysis works well, sometimes even better than the person himself, especially in situations that are similar to those encountered before. At the same time, there is no ethics and morality with which they are trying to "load" AI in the precedent analysis. In each case, in relation to the current analysis, it is important and necessary to solve two problems. The first task is to define a similar situation as a prototype, the second task is the actual analysis based on the data of the training sample and the search for a control solution.

Thus, we got acquainted with the essence of AI, as well as with the possibilities and examples of its application in banking: lending, personalization and chatbots, budgeting, integration with digital assistants, retail payments, risk management and investment, quantitative trading, cybersecurity and fraud detection, video surveillance, working with documents, reporting, tracking regulatory documents, internal business processes, personnel management.

REFERENCES

1. *Desai R. (2017) Artificial Intelligence (AI)* [An Educational Blog]. Retrieved from: http://drrajivdesaimd.com/2017/03/23/artificial-intelligence-ai/ (Last accessed: 07.04.2021)

2. *Oluebube Egbuna (2018). Artificial Intelligence, Machine learning, deep learning and data science - What's the difference?* [Developer Circles Lagos]. Retrieved from: https://cutt.ly/RbkugRp (Last accessed: 05.04.2021)

3. *Biswas S., Carson B., Chung V., Singh S., Thomas R. (2020). AI-bank of the future: Can banks meet the AI challenge?* [McKinsey&Company]. Retrieved from: https://cutt.ly/lbkucwP (Last accessed: 04.04.2021)

4. *Schroer A. (2019). AI and the bottom line: 15 examples of artificial intelligence in finance* [Builtin]. Retrieved from: https://builtin.com/artificial-intelligence/ai-finance-banking-applications-companies (Last accessed: 07.04.2021)

5. *Archer (2021). 6 Artificial Intelligence use cases in financial* [Archer Software, Cprime]. Retrieved from: https://archer-soft.com/blog/6-artificial-intelligence-use-cases-financial-services (Last accessed: 07.04.2021)

6. Raexpert (2018). Iskusstvennyj intellekt v bankovskom sektore [Artificial intelligence in the banking sector] [*Raexpert*]. Retrieved from: https://www.raexpert.ru/researches/banks/bank_ai2018/ (Last accessed: 05.04.2021)

7. Istocks (2020). 8 sposobov ispol'zovanija bankami iskusstvennogo intellekta i mashinnogo obuchenija [8 ways banks can use AI and machine learning] [*Istocks.club*]. Retrieved from: https://cutt.ly/Sbkusra (Last accessed: 06.04.2021)

8. Markelov K., Shipilov V. (2020) Cifrovaja transformacija v bankah kak neizbezhnost' i iskusstvennyj intellekt kak sredstvo razvitija bankinga [Digital transformation in banks as an inevitability and artificial intelligence as a means of banking development] [*Bisjournal*]. Retrieved from: https://ib-bank.ru/bisjournal/post/1468 (Last accessed: 07.04.2021)

9. Kostylev I. (2019) Chetyre trenda primenenija AI v finansovom sektore [Four trends in the use of AI in the financial sector] [*Bosfera*]. Retrieved from: https://bosfera.ru/bo/chetyre-trenda-primeneniya-ai-v-finansovom-sektore (Last accessed: 05.04.2021)

10. *BriefCam (2021) Comprehensive Video Analytics platform* [BriefCam]. Retrieved from: https://www.briefcam.com/solutions/platform-overview/ (Last accessed: 06.04.2021)

11. *Goldmeier L. (2019) 4 Ways Banks Are Using Artificial Intelligence to Drive Increased Security and Business Performance* [AI and video analytics blog]. Retrieved from: https://cutt.ly/qbkukZs (Last accessed: 07.04.2021)

12. *Digalaki E. (2021) The impact of artificial intelligence in the banking sector & how AI is being used in 2021* [Businessinsider]. Retrieved from: https://www.businessinsider.com/ai-in-banking-report (Last accessed: 07.04.2021)

13. *Haq R., Ogle C. (2018) Can Banks Get Smarter? Rethinking AI in Financial Services* [Publicis Sapient]. Retrieved from: https://www.publicissapient.com.cn/insights/rethinking-ai-financial-services (Last accessed: 07.04.2021)

14. Krasyukov D. (2021) Iskusstvennyj intellekt – jeto «bomba» dlja bankovskogo biznesa [Artificial intelligence is a "bomb" for the banking business] [*Financial and business association of euroasian cooperation*]. Retrieved from: https://www.fbacs.com/articles/iskusstvennyy-intellekt-eto-bomba-dlya-bankovskogo-biznesa.html (Last accessed: 07.04.2021).

3.2. Artificial intelligence in insurance and financial technologies

The main feature of the insurance business is that customers evaluate the effectiveness of insurance products when they need to receive a refund, not when they make a purchase. Unlike other products or services, policyholders can only make judgments about the value that an insurance company provides when an insured event occurs. Therefore, the most important indicator in insurance is the assessment of customer satisfaction with the coverage of their claims (Faggella, 2020 [1]). The insurance industry operates with a lot of data like contracts, claims, invoices, financial statements, emails, medical information. Unstructured (PDF files, text documents, images, tables and videos) and structured information - data arrays suitable for further analysis - comes from the divisions to the head office.

The most suitable tool for working with large amounts of data is artificial intelligence. It measures customer engagement, insurance coverage, premium streams and claims submission, identifies patterns in documents, shapes templates, and structures information. AI potentially lives up to its promise to imitate the perception, reasoning, learning, and problem-solving of the human mind. In this evolution, insurance will move from its current state of “detect and correct” to «predict and prevent», transforming all aspects of the industry in the process (Balasubramanian, Libarikian, McElhaney, 2021 [2]). Artificial intelligence can deliver on industry expectations through machine learning and deep learning (table 7).

Table 7

Development of AI

Artificial intelligence The science and engineering of making intelligent machines			Machine learning A major approach to realizing AI			Deep learning A branch of machine learning		
1950s	1960s	1970s	1980s	1990s	2000s	2010s	2020s	
Artificial intelligence (Al)			Machine learning (ML)			Deep learning (DL)		
Intelligence exhibited by machines, whereby machines mimic cognitive functions associated with human minds; cognitive functions include all aspects of learning, perceiving, problem solving, and reasoning.			Major approach to realizing Al by learning from, and making data-driven predictions based on, data and learned experiences, ML comprises several categories, including reinforcement learning, supervised learning, and unsupervised learning.			Branch of ML in which algorithms attempt to model high-level abstractions in data. DL connects artificial, software-based calculators that approximate the function of brain neurons. Neural networks, formed by these calculators, receive, analyze, and determine inputs and are informed if determination is correct.		

Source: Developed by the authors based on (Balasubramanian, 2021 [2])

AI will replace the accustomed research methods, which include hundreds of questionnaire items that require time and resources to collect the right amount of data and validate it. The new opportunity that AI provides is beneficial for both insurance companies and customers. Providing artificial intelligence with the correct data and ensuring adequate preparation of the system is important here. Human participation is required only to control the work of artificial intelligence (Everest, 2021 [3]). The next generation of successful insurance workers must have an unique combination of technological skills, creativity and the willingness to tackle something that is not a static process, but a combination of semi-automatic and machine-supported tasks that are constantly evolving.

The areas of application of AI in insurance can be contingently divided into those related to the quality of customer service, and those that specialize in conrete types of insurance:

1. Searching for clients, communications and accepting them for insurance.
2. Personalization.
3. Omnichannel.
4. Smart contracts.
5. Affective computing.
6. Settlement of claims and pretensions.
7. Anti-fraud.
8. Medical and health insurance.
9. Vehicle insurance.
10. Real estate insurance.

1. Searching for clients, communications and accepting them for insurance.

Insurance starts with finding clients. To do this, AI finds users on the Internet who are interested in buying, for example, third party liability insurance policies for vehicle owners, and makes them a targeted offer. AI is based on search history, data from social networks and other open and closed sources available to it. It helps not only the insurance company in promoting services, but also the client, for example, in auto-filling the insurance application, if communication, for example, take place on a partner site.

Chatbots and voice assistants provide instant communication with both potential and existing customers. As they learns, technologies are increasingly recognizing the needs of policyholders, giving more accurate answers and building a correct dialogue. Such "assistants" do not get tired and do not get annoyed, do not require a salary for their work and, if necessary, process thousands of requests per day. They have beautiful voices and impeccable diction. Such optimization in the long term affects the attractiveness of insurance rates for customers.

AI helps insurance companies at the stage of scoring (a client assessment system based on numerical statistical methods) and onboarding (the process of adapting a client to a new product: tooltips and pop-ups on the site recommend certain actions). With its help, insurance companies make a reasoned decision on admitting a client for insurance and set a fair tariff. Insurers use machine learning to assess the likelihood of customer fraud at the time of purchase and subsequent monetary losses. Arguments “against” the policyholder can be, for example, the provided inaccurate data, bad credit history or information about the initiated legal claims (Samiev, 2021 [4]).

2. Personalization.

AI-powered insurance gains access to customer data through wearable devices, location-based sensors, site sensors and geographic information systems. With AI machine learning techniques, the insurance company can perform more accurate analytics in real time. Traditionally, insurers use generic models when working with clients to form their packages and prepare rates due to the lack of data and their complex analysis. The insurance company can now use AI to collect individual data in real time. Each individual case will serve as the basis for the contract, contributing to its flexibility and accuracy of rates.

Insurance products designed and priced according to the client's individual needs and lifestyles will enable clients to pay for the coverage they need. The client practically pays for his actions, forming his own statistics, he can make decisions about how his actions affect insurance coverage, insurance coverage and pricing (Zfort, 2020 [5]).

There are examples of such decisions in Ukraine. Inshurtech-company EASY PEASY has launched on the Ukrainian market an online service for buying car insurance on the principle of “pay as you go” with payment for kilometers (Avdeeva, 2020 [6]). Now, in order to insure a car under CASCO, you do not need to go to the insurance company and pay immediately for the year. The insurance can be bought on the website and replenished with casco-kilometers depending on the intensity of car use through a mobile application. It is insurance according to the ON / OFF principle. The main auto-casco product is called EASY KATKA (in computer games, “katka” is a game stage). The essence of "EASY KATKA" is that the client pays for the distance that the car can travel while under insurance coverage. It's like refueling with gasoline. The distance traveled by the car is tracked using a telematics device, this information is encrypted.

3. Omnichannel.

Omnichannel provides for the development of a self-service portal where customers and insurers can access to find answers to questions, conduct business (transactions, orders, file claims, pay bills), check status, send request to support service and download resources. This is an effective approach to increase quality of customer service (Kantarci, 2021 [7]).

4. Smart contracts.

Blockchain-based insurtech-companies are creating better risk sharing models, giving people more personalized and affordable insurance options. For example, Nexus Mutual aims to replace existing insurance models with smart contract-based mutual markets. By allowing people to share risk among larger populations, they seek to reduce insurance costs and replace the need for larger insurance companies (Kantarci, 2021 [7]).

5. Affective computing.

Affective computing, also known as emotion AI, can be used to better understand clients and respond to their mental condition. Here's how insurance companies can use this technology (Dilmegani, 2021 [8]):

- intelligent call routing: angry customers can be directed to more experienced telecom operators to satisfy these clients;

- fraud detection: insurance companies can use voice analytics to understand if a customer is lying when filing a claim.

6. Settlement of claims and pretensions.

Claims processing involves several tasks: review, investigation, correction, translation, or rejection. The process of filing a claim for reimbursement og insurance lossess is quick and hassle-free. Chatbots are used to register a claim, verify details, make sure it is not fraudulent, and submit the claim to a bank for further processing. Chatbots can use geographic and social data of customers to personalize their interactions with the company. With the help of computer vision, the chatbot can examine the evidence of the accident and estimate the amount of damage - no longer the need to send an insurance inspector to photograph and compile a report (Zfort, 2020 [5]).

7. Anti-fraud.

Various types of trespasses can be carried out both by the clients of the insurance company and by insurance company employees. Sometimes insurance agents keep money for personal use rather than sending it to the insurance company or selling policy without an insurance premium collection license.

Analyzing security sensor data could bring new opportunities for business insurance. To mitigate the damage caused by a security breach, a company can take advantage of cyber threat insurance, which covers a wide range of cyber risk losses that can unexpectedly arise from cyber attacks. Cyber insurance uses predictive analytics to identify the risk of attacks such as hacking and the use of malware (Zfort, 2020 [5]). Steps in insurance fraud detection using big data analysis (Fig. 18).

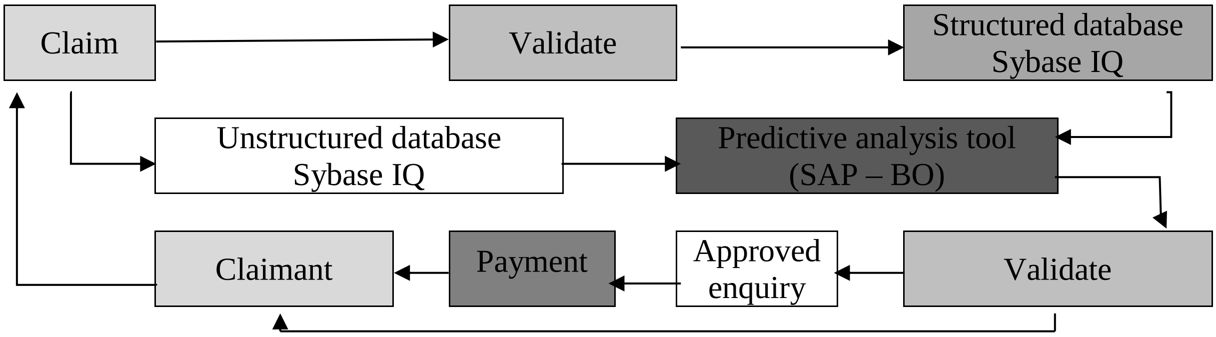


Figure 18. Steps in insurance fraud detection using big data analysis.
Source: Developed by the authors based on (Kantarci, 2021 [7])

8. Medical and healts insurance.

AI affects the cost-effectiveness of health insurance. Insurance companies are equipping their clients with new platforms that select the most appropriate coverage for the user, aimed at promoting healthy lifestyles.

AI helps sort out real medical claims from fraudulent ones. Automated matching of physician prescriptions and diagnoses in voluntary health insurance can save huge amounts of money for insurers in payments for unnecessary tests. With additional GPS data, wearable devices can track and report about compliance with the applicant's disability rehabilitation protocol. Stricter adherence will shorten the time to return to work.

Telemedicine applications have become an almost integral part of voluntary health insurance, which in real time, using fitness gadgets and data that the client enters on their own, analyzes the state of his health, and then tells the client when something is wrong with his pulse, blood pressure or other indicators, suggests changing the daily routine, adjusting physical activity, making an appointment with specialists. All of this makes it possible to individualize tariffs for regular customers. Using a combination of images and videos, multiple control points can be obtained for each user. Software can detect crow's feet around the eyes, estimate body mass index, and determine how quickly a person is aging biologically (Zfort, 2020 [5]).

9. Vehicle insurance.

By analyzing vehicle telematics data with machine learning algorithms, insurance companies use AI to create personalized risk profiles for drivers. Some insurers use the collected data to provide drivers with discounts on safe driving habits and punish dangerous behaviors such as over speeding or hard braking.

In the event of an accident, the same data helps assess damage in real time using a smartphone camera, determine the severity of the damage, estimate the cost of repairs, and analyze the impact of the accident on that driver's future insurance premiums. Machine learning mechanizms ensure this analysis is accurate because it compares the received photo with a database of photos with thousands of car accidents images. API portals can combine publicly available data with the insurer's own data to create better insurance products for customers (Zfort, 2020 [5]).

The sequence of actions that is launched when an insured event occurs is important. For example, if an airbag sensor is triggered in an insured car, the control panel of the insurance company automatically calls the ambulance team, sends an emergency commissioner to help the client, support specialists call him to reassure and help. If necessary, a tow truck will be called, which will take the car to where the client can pick it up. This is possible only when using complex algorithms that take into account hundreds of parameters: from the distance of the client himself to the loading of the dealership, where the car will be sent for repair (Krajnik, 2020 [9]).

Many companies implement analysis of losses that look like fraudulent ones in the presence of subtle links between the participants in the accident, vehicles or insurance contracts. AI involvement can minimize or eliminate illegal claims, resulting in lower rates for bona fide policyholders. AI empowers insurance companies to reduce costs and to be less dependent on investigators.

One of the tasks of AI is to identify subtle relationships between unprofitableness and hidden factors. AI is used to build tariff models and regulate the cost of a policy in relation to a specific client. For example, in auto insurance, AI applies coefficients that take into account the age and experience of the driver, his accident-free past, place of residence, season, traffic situation. Also taken into account are the state of the market, the level of wages in the region, the forecast of customer churn. Based on an instant analysis of both linear and non-linear relationships, a real personalization of the tariff takes place (Samiev, 2021 [4]).

10. Real estate insurance.

AI can provide home insurance options in 15 minutes to 60 seconds for each home individually, with smart home controls and emergency assistance as needed.

Internet of things (IoT) and AI take into account plants, topography, and even how easily firefighters can get involved when needed. New models assess disaster hazards, property condition and past customer claims records. IoT humidity sensors can monitor home plumbing. The system not only alerts the homeowner, but can also cut off the flow of water in broken pipes (Zfort, 2020 [5]).

The rapid spread of AI in insurance in Ukraine is hindered by the small volume of the insurance market, which entails insufficient data required for machine learning systems to develop correctly. In addition, large-scale implementation of such systems requires a significant investment of capital for development and support, as well as time for training AI based on real data and building the necessary infrastructure. Insurance clients also need to be ready for new technologies and overcome their fear of personal data leaks (Krajnik, 2020 [9]). The colossal amount of rules, combined with the confidential information of thousands of users, is forcing the insurance industry to be cautious when adopting new technologies (Makadia, 2020 [10]).

A 2015 KPMG report predicts that radically safer vehicles, including driverless technologies, will shrink the auto insurance industry by a whopping 60% over the next 25 years. It is worth considering that auto insurance takes an over 40% part of the insurance industry as a whole (Faggella, 2020 [1]).

The Internet of Things is changing insurance in the same way that data science is changing finance: moving analysis from a proxy data (proxy is representative, authorized, intermediary) to source data. Whereas financial models used to rely on a statistical sample of past results to predict future results, today data science allows predictions based on real events in real time, using large datasets rather than samples to make the best assumptions. Whereas insurance companies used to rely on risk pools built using statistical sampling, today IoT sensors allow insurance companies to estimate coverage based on real events in real time using data associated with individuals rather than sample data associated with groups. I.e., we are moving from proxy data (about categories) to raw data (about individuals). That is, whether the asset is a stock portfolio or a 2009 Honda Civic, a bond, or a cargo ship, the change in the way an asset is predicted is determined by the type of data that technology has to offer analysts. Many consumers have shown a willingness to transfer facial data and even biometrics for cheaper products. BioBeats and Fitsense are two health insurance wearable data startups with a focus on personalizing employee health plans (Faggella, 2020 [1]).

Possibilities for insurers of direct access to customer data through IoT (Rutkowski, 2018 [11]):

- wearable or personal devices;
- sensors on objects like personal and commercial vehicles and containers;
- location-based sensors in factories, warehouses, offices and homes: "smart" thermostats, alarms and cameras;
- geographic information, systems and satellites providing geophysical, topographic, climatological and hydrological data.

The main problems of insurance companies are summarized in Fig. 19.

The greatest concerns that loom over the insurance sector today					
↓	↓	↓	↓	↓	↓
Subdued premium rate	Mild interest rates	Shifting consumer behavior	Slow economic grows	Need for regulations and technological innovations	Blazing market competition

Figure 19. The biggest fears in the insurance sector today.
Source: Developed by the authors based on (Makadia, 2020 [10])

Artificial intelligence could help banks and insurance companies deliver service with efficiency and quality by facilitating the following activities (Fig. 20).

AI could help banks and insurance companies deliver service by facilitating the following					
↓	↓	↓	↓	↓	↓
Risk tolerance calculation and assessment for trading desks	Claims analysis, asset management, risk calculation, and prevention	Consistent optimization of customer investments and insurance coverage	Transaction analysis for banks and financial organizations	Selection of better investments based on preferences, risks and spending pattern	Better customer service

Figure 20. Artificial intelligence opportunities in insurance.

Source: Developed by the authors based on (Makadia, 2020 [10])

Many insurance companies have already implemented (Samiev, 2021 [4]):

- a mobile application for the settlement of claims for insurance of property of individuals (filing an application, conducting a remote inspection, checking the validity, confirming the client's application with a digital signature, paying compensation);
- settlement of insurance claims through WhatsApp (we can report an insured event under Casco or property insurance of individuals, send a photo of documents, get advice, find out the decision-making time frame and get a referral for repairs);
- digital assistant (the role of an online concierge with automated customer calls: contacts customers and informs them about the need to pay regular installments; the robot is trained in speech recognition, which allows it to understand the customer and advise him on the product);
- a project to automate business processes for the sale of insurance products and interaction with customers based on a microservice architecture;
- service product for bank card holders;
- usability of insurance products in a mobile bank;
- individual online scoring for mortgage life insurance (insurance of loss of the collateral and personal insurance of the borrower with the possibility of issuing / buying a policy on the website);
- automation of VHI (voluntary health insurance) business processes based on Diasoft Insurance Medical (optimization of application processing, ensuring the scalability of VHI business, creation of a unified information environment for VHI contracts).

In the modern financial sector, several other technologies are used besides Insurtech - those that have been considered in relation to insurance (CFI, 2020 [12]):

1. Algorithmic trading.

Algorithmic trading involves the use of algorithms to make the best trading decisions. Traders typically create mathematical models that track business news (fundamental analysis) and trading activity (technical analysis) in real time to discover any factors that could cause a security to rise or fall. The model comes with a predefined set of instructions for various parameters (time, price, quantity) for placing trades without the active participation of the trader.

Unlike human traders, algorithmic trading can analyze large amounts of data simultaneously and therefore execute thousands of trades every day.

In addition, algorithmic trading does not make trading decisions based on emotion, which is a common limitation among human traders whose judgment can be influenced by emotion or personal aspirations. This technology is used by hedge fund managers and financial institutions to automate trading activities.

2. Data protection.

Fraud is a serious problem for financial companies and causes billions of dollars in losses every year. Usually, financial companies store a large amount of their data on the network, and this increases the risk of a security breach. In the past, fraud detection systems were designed around a set of rules that today's fraudsters could easily circumvent. Therefore, today most companies use machine learning to detect and combat fraudulent financial transactions. Machine learning works by scanning large datasets to detect unique activities or anomalies and flagging them for further investigation by security teams.

AI works by comparing a transaction with other data points, such as customer account history, IP address, location, to determine if a flagged transaction is consistent with the behavior of the account owner. Depending on the nature of the transaction, the system may automatically reject the withdrawal or purchase until the person makes a decision.

3. Portfolio management (Robo-advisors).

Robo-consultants are online applications built using machine learning that provide automated financial advice to investors. The applications use algorithms to build a financial portfolio in line with the investor's goals and risk tolerance. Robo advisors require low account minimums and are usually cheaper than human portfolio managers. When using robotic advisors, investors must enter their investment or savings goal into the system, and the system will automatically determine the best investment opportunities with the maximum return. For example, an investor who is 30 years old and has a savings goal of $ 500,000 by the time of retirement can enter those goals into the app. The application then allocates investments across different financial instruments and asset classes (stocks, bonds, real estate) to achieve the investor's long-term goals. The app optimizes the investor's goals according to market trends in real time to find the best diversification strategy.

4. Underwriting of loans.

In the banking and insurance industry, companies gain access to millions of consumer data that can be used in machine learning to simplify the underwriting process (services provided by financial institutions that guarantee payments in the event of financial losses; underwriting in the stock market is guiding the process of issuing securities securities and their distribution; underwriting in banking is the procedure for assessing the likelihood of loan repayment by the bank, as well as the optimal structuring of the transaction based on the results of risk examination;

underwriting in insurance is the process of analyzing the risks offered for insurance, making a decision on risk insurance and determining the tariff rate and conditions adequate to the risk insurance).

Data scientists can train algorithms on how to analyze millions of consumer data (age, income, occupation and credit behavior of a consumer, foreclosure history) to match records, look for unique exceptions, and decide if a consumer is eligible for a loan or insurance (CFI, 2020 [12]).

5. Crowdfunding.

In the past, borrowers had to go to the bank and submit a lot of documents for a loan, which was (and still is) extremely troublesome. But fintech crowdfunding platforms (e.g., Patreon, GoFundMe) have emerged to bring borrowers and investors together in an alternative space to traditional banking. Now, if your idea is promising, you can directly attract investors by receiving money from various sources to start your business without financial obstacles (FireLabs, 2020 [13]).

6. Blockchain and cryptocurrency.

Probably the most famous application of artificial intelligence in finance, blockchain and cryptocurrency is now ruling the world of decentralized alternative banking. Global crypto exchanges (such as Coinbase) allow users to exchange cryptoassets for money and vice versa; new smart blockchain services (such as BlockVerify) help users avoid fraud by ensuring the integrity of blockchain data and transactions (FireLabs, 2020 [13]).

In addition to the above general and insurance-specific obstacles to the early and widespread adoption of AI, there are also ethical issues.

The EU Parliament and the European Council agreed on the General Data Protection Regulation (GDPR) in December 2015 (OECD, 2020 [14]). It applies to firms that process personal data from persons residing in the EU, regardless of whether their services are free or paid, whether the firm is based in the EU or not. This was an update to the Data Protection Directive that entered into force in 1995. According to the GDPR, fines can be up to € 20 million or 4% of the global annual turnover (whichever is greater) if the firm's actions result in information loss or data leak. It entered into force in member countries from May 2018.

The GDPR requires that personal information be deleted without undue delay when the data is no longer required in relation to the purpose for which it was collected. The use of the data should also be limited when the quality of the data is disputed by the data subject. The firm must keep accurate records of the consent of the data subject to use his data for primary and any secondary purposes.

Ethics Guidelines for Trustworthy AI: High-Level Expert Group on Artificial Intelligence (AI HLEG) (OECD, 2020 [14]) is a set of 7 key requirements that AI systems must meet in order to be considered trustworthy:

- human participation and oversight: AI systems should empower people by allowing them to make informed decisions and protecting their fundamental rights; at the same time, there is a need to ensure adequate oversight mechanisms that can be achieved through person-in-the-loop and person-in-a-team approaches;

- technical reliability and safety: AI systems must be robust and safe, provide a contingency plan in case something goes wrong, and also be accurate, reliable and reproducible; it is the only way to ensure that unintended harm is minimized and prevented;
- confidentiality and data management: in addition to ensuring full respect for confidentiality and data protection, it is also necessary to ensure adequate data management mechanisms, taking into account the quality and integrity of the data and ensuring legitimate access to the data;
- transparency: business models of data, systems and AI must be transparent; traceability mechanisms can help. Moreover, AI systems and their solutions should be explained in a manner understandable to stakeholders; people should be aware that they are interacting with an artificial intelligence system, and should be informed about the capabilities and limitations of the system;
- diversity, non-discrimination and fairness: bias should be avoided as it can have many negative consequences, from the marginalization of vulnerable groups to the exacerbation of prejudice and discrimination. By promoting diversity, artificial intelligence systems must be accessible to all and involve relevant stakeholders throughout their life cycle;
- social and environmental well-being: artificial intelligence systems should benefit all people, including future generations, therefore, it is necessary to ensure their sustainability and environmental friendliness. Moreover, they must take into account the environment, including other living things;
- accountability: mechanisms need to be put in place to ensure responsibility and accountability of AI systems and their results. Audit capability, which allows you to evaluate algorithms, data, and design processes, plays a key role in this, especially in mission-critical applications. Moreover, adequate and affordable reimbursement must be provided.

Consider the main trends in the development of the financial sector (Biswas, Carson, Chung, Singh, Thomas, 2020 [15]):

1. Customer expectations are growing as digital banking spreads.

In the first few months of the COVID-19 pandemic, the use of online banking and mobile banking channels in various countries increased by about 20-50 percent and is expected to remain at this higher level after the pandemic dies down. As consumers increasingly use digital banking, they are beginning to expect more, especially when compared to the standards they are accustomed to from leading internet companies. Meanwhile, these digital experience leaders are constantly raising the bar on personalization to the point where they sometimes anticipate customer needs and offer tailor-made services at the right time through the right channel.

2. The use of advanced artificial intelligence technologies by leading financial institutions is growing steadily.

Nearly 60% of companies have implemented at least one AI capability. The most commonly used artificial intelligence technologies are: automation of robotic processes (36%) for structured operational tasks; virtual assistants or conversational interfaces (32%) for customer service departments; machine learning methods (25%) to detect fraud and support underwriting and risk management.

3. Digital ecosystems are depriving traditional financial services of intermediaries.

By providing access to a diverse set of services through a common hotspot, digital ecosystems have changed the way consumers discover, value, and purchase goods and services. For example, WeChat users in China can use the same app for not only messaging but also booking a taxi, ordering food, scheduling a massage, playing games, sending money to a contact, and accessing a personal credit line. Non-banking businesses and "super applications" are adopting financial services and products, providing an engaging experience for customers and disrupting traditional methods of sourcing banking products and services. As a result, banks will need to rethink how they participate in digital ecosystems and apply AI to harness the full power of data available from these new sources.

4. Tech giants are moving to financial services as the next addition to their core business models.

Globally, leading tech giants have achieved outstanding market advantages: a large and motivated customer network; datasets to better and more accurately understand individual customers; natural strengths in the development and scaling of innovative technologies (including AI); access to cheap capital. The big tech players are already entrenched in financial services (payments, lending and insurance), and they may soon try to use their advantages to expand their presence and scale.

REFERENCES

1. *Faggella D. (2020) Artificial Intelligence in Insurance – Three Trends That Matter* [Emerj]. Retrieved from: https://emerj.com/ai-sector-overviews/artificial-intelligence-in-insurance-trends/ (Last accessed: 07.04.2021)

2. *Balasubramanian R., Libarikian A., McElhaney D. (2021) Insurance 2030 - The impact of AI on the future of insurance* [Mckinsey]. Retrieved from: https://www.mckinsey.com/industries/financial-services/our-insights/insurance-2030-the-impact-of-ai-on-the-future-of-insurance (Last accessed: 07.04.2021)

3. Everest (2021) II v strahovanii: tri samyh vostrebovannyh navyka intellektual'nyh sistem [AI in Insurance: The Three Most In-Demand Intelligent Systems Skills] [*Everest Innovation integrator*]. Retrieved from: https://www.everest.ua/ru/yy-v-strahovanyy-try-samyh-vostrebovannyh-navyka-yntellektualnyh-system/ (Last accessed: 07.04.2021)

4. Samiev P. (2021) Zastrahuj menja, robot: chto mozhet II v strahovanii [Insure me, robot: what AI can do in insurance] [*Financial sector Banking Review*]. Retrieved from: https://bosfera.ru/bo/zastrahuy-menya-robot-chto-mozhet-ii-v-strahovanii (Last accessed: 07.04.2021)

5. Zfort (2020) Budushhee iskusstvennogo intellekta v strahovanii [The future of artificial intelligence in insurance] [*Zfort blog Zfort Group*]. Retrieved from: https://www.zfort.com.ua/blog/budushee-iskusstvennogo-intellekta-v-strakhovanii

6. Avdeeva M. (2020) «Ne pizi — strahujsja Easy!» My sdelaem vse, chtoby ljudi poljubili pokupat' strahovki! ["Do not pizi - secure Easy!" We will do our best to make people love buying insurance!] [*Forinsurer*]. Retrieved from: https://forinsurer.com/public/20/12/03/4915 (Last accessed: 07.04.2021)

7. *Kantarci A. (2021). Top 6 Digital Transformation Applications in Insurance in 2021* [AIMultiple]. Retrieved from: https://research.aimultiple.com /digital-transformation-insurance/ (Last accessed: 07.04.2021)

8. *Dilmegani C. (2021) [8]. 9 AI Insurance Applications/ Use Cases in 2021: In-depth guide* [AIMultiple]. Retrieved from: https://research.aimultiple.com /ai-insurance/ (Last accessed: 07.04.2021)

9. Krajnik A. (2020) Iskusstvennyj intellekt v strahovanii: chem on mozhet byt' polezen [Artificial intelligence in insurance: how it can be useful] [*Hightech.plus*]. Retrieved from: https://hightech.plus/2020/09/22/iskusstvennii-intellekt-v-strahovanii-chem-on-mozhet-bit-polezen (Last accessed: 07.04.2021)

10. *Makadia M. (2020) How Artificial Intelligence is Transforming the Insurance Space* [Customerthink]. Retrieved from: https://customerthink.com/ how-artificial-intelligence-is-transforming-the-insurance-space/ (Last accessed: 07.04.2021)

11. *Rutkowski M.K. (2018) How IoT data can impact insurance and the wider financial sector* [Ernst&Young]. Retrieved from: https://www.ey.com/en_gl/ consulting/how-iot-data-can-impact-insurance-and-the-wider-financial-sector (Last accessed: 07.04.2021)

12. *CFI (2020). What is Machine Learning (in Finance)?* [Corporatefinanceinstitute]. Retrieved from: https://cutt.ly/DbcTxqC (Last accessed: 07.04.2021)

13. *FireLabs (2020) How AI Solutions Reshape the Financial Sector* [Fire Labs Team]. Retrieved from: https://4irelabs.com/articles/ai-in-finance/ (Last accessed: 07.04.2021)

14. *OECD (2020) The Impact of Big Data and Artificial Intelligence (AI) in the Insurance Sector* [Organisation for Economic Co-operation and Development]. Retrieved from: www.oecd.org/finance/Impact-Big-Data-AI-in-the-Insurance-Sector.htm (Last accessed: 07.04.2021)

15. *Biswas S., Carson B., Chung V., Singh S., Thomas R. (2020). AI-bank of the future: Can banks meet the AI challenge?* [McKinsey&Company]. Retrieved from: https://cutt.ly/5bcTQS3 (Last accessed: 07.04.2021).

3.3. Use of artificial intelligence by financial institutions to increase business security and efficiency

With the growth of automation and the transition to cloud storage, cybercrime is the biggest threat to business continuity and reputation. Traditional solutions, such as firewalls and antivirus, are no longer sufficient to ensure reliable information security as cyberattacks become more sophisticated. And here are some interesting solutions, such as BDO Carbon SOC and BDO Deep Reconnaissance. The purpose of the SOC (Security Operation Center) is to detect, analyze and respond to incidents in the field of cybersecurity, using a combination of technological solutions, modern processes and a highly qualified team of cybersecurity specialists (BDO, 2020 [1]). Factors of financial institution readiness for digital transformation: readiness of infrastructure; readiness of business processes; staff readiness; product and sales readiness. What is needed primarily for transformation: professional software; electronic document management; cybersecurity.

There are seven components of cyberattacks: - monitoring (intelligence): attackers try to get information about the object; - preparation of the necessary tools to attack the object; - delivery of attack tools inside the organization (phishing attacks); - exploitation of vulnerabilities within the organization; - installation; - capture control; - actions for program purposes. Consider the example of ImmuniWeb, how to monitor the attack surface (ImmuniWeb, 2021 [2]). ImmuniWeb Discovery determines place of a company in Internet by the name of this company: how many servers, websites, API (Application Programming Interface), mobile applications, code repositories, CDN (Content delivery network are servers with specialized software that speed up content delivery end users, servers are located around the world so that the response time to site visitors was minimal) and public clouds are exposed to the network, as well as in DarkNet (Shadow network, is a hidden, anonymous network, a system of unrelated virtual tunnels that transmits data in encrypted form, in which IP addresses are not publicly available, so users can communicate without much fear and government intervention).

Other ImmuniWeb products provide application penetration testing:

- ImmuniWeb On-Demand is a one-time web application penetration test or API with zero false positives SLA (Service Level Agreement) is the company's approach to the organization of IT processes, according to ITIL (IT InfrastructureLibrary) SLA is a mini-agreement that sets the quality of IT services), unlimited patch checks and full integration of DevSecOps (Development, Security, IT Operations, Application Delivery - is built-in security, not security that acts as a perimeter around applications and data);

- ImmuniWeb MobileSuite is similar to On-Demand, but for mobile applications and their API points;

- ImmuniWeb Continuous monitors applications 24/7 and detects new or changed code. As soon as there are even minor changes that may affect the security or integrity of the program, experts immediately test it, providing customers with timely and cost-effective penetration testing.

The IT infrastructure is becoming so intertwined that it is virtually impossible to provide clarity to who has access to your data or why and how they process that data. In practice, organizations of all sizes are now trying to provide holistic visibility, while most data leaks and intrusions are due to incomplete visibility and a vague view of cyber risks.

Aspects of anti-hacking of payment systems are inseparable from the concept of cybersecurity. Cybersecurity involves the protection of personal information, namely the detection, avoidance or response to attacks. Standard "ISO / IEC 27032: 2012 Information technology / Security techniques / Guidelines for cybersecurity" provides a clear understanding of the relationship between cybersecurity and network security, application security, Internet security and critical information infrastructure security (Evseev, Korol, Kots, 2015 [3]).

Recently, the NBU did not dwell on the simplest issues of information security, such as password length requirements. The requirements are so serious that their implementation is comparable to the procedure for obtaining a PCI DSS (Payment Card Industry Data Security Standard) certificate. This is documentation with a list of criteria that the service must meet if it manages such things as the card number, its validity period and CVV-code. The PCI SSC (Payment Card Industry Security Standards Council, formed by the five largest payment systems) creates the rules of «safe play» that companies wishing to obtain the «PCI-DSS Certificate» must follow. It is necessary to pass such certification every year (Mehmood, 2018 [4]). The cost to implement all the requirements of this standard can be millions of hryvnia and even millions of dollars for individual financial institutions.

For example, the PCI DSS standard requires that networks be laid with a cable not lower than «category 5e», and for a certain branch of the bank will have to completely relocate the network. In addition, each bank must prepare and maintain detailed diagrams of all communications and maintain a cable log. So, sometimes it is cheaper to close a branch than to bring it in line with the new regulations. Banks will also have to comply with malware protection and authentication requirements when users access sensitive data, i.e. upgrade their IT systems with additional expensive equipment, replace obsolete software and train staff to work with new ones (Karmanny, Kovzhoga, Lutsenko, 2019 [5]). Blockchain technology with all its advantages (decentralization, full transparency, confidentiality, protection from unauthorized access, compromise implementation) can be aimed at solving existing problems of cybersecurity of banks (Yarovenko, Kovach, 2019 [6]).

The main disadvantages of banking information systems are their centralization and opacity. In such systems, as in most corporate, all the basic data is in one place. In order to completely capture the system or critically hit it, it is enough to successfully attack its central data server. Having gained access to the central data register, the attacker gets the opportunity to easily perform all possible manipulations with the system. This problem is solved by blockchain technology by creating numerous copies of distributed data registers, which are placed in different nodes of the system. Under such conditions, the failure of one registry cannot lead to the collapse of the entire system (Bahou, 2018 [7]). The opacity of banking information systems creates favorable conditions for fraud by bank employees. In a blockchain-based information system, no employee would be able to make changes to the system without being noticed, and all his manipulations with the system would be permanently recorded and stored in each copy of the data register on each node. If we compare the capabilities of AI technology and blockchains, we can say that they can't replace each other, because they are aimed at solving different problems.

Banks have traditionally used a rules-based approach to manage the risks of fraud, money laundering, and sanctions. This rules-based approach is also referred to as a risk-based or risk-scoring approach: companies undertake a formal money-laundering risk assessment and then document the risk scenarios they are exposed to based on their customers, products, and business lines. Companies submit pre-determined scenarios to the regulators for approval and the AML process must follow the approved processes. The traditional risk-based approach could be costly, as simple pre-determined scenarios could give rise to false positives or negatives. For example, if a scenario is to red flag politically exposed persons (PEPs) from a high-risk country, all PEPs from that country would be subject to further scrutiny and documentation even though there are no other transaction or activity based data that support such a risk assessment. With the help of AI, banks can run two approaches in parallel: one based on an intelligence-based approach using big data and another that uses AI's capabilities to recognise patterns. The data is usually based on transactions and also features detailed information on the customers and their business or personal activities – so each bank prefers to use its own dataset. Blockchain, a distributed ledger system that allows the anonymisation of transaction-level information, could enable banks to maintain their competitive positions and protect customer data privacy while also contributing to industry-wide efforts to combat fraud and money-laundering (Chan, Chow, Wong, Dimakis, Nayler, Bermudes, Raman, Lam, Baker, 2019 [8]).

For the bank's treasury, compliance with regulatory requirements is a huge daily problem. With anti-money laundering (AML) reforms, scrutiny of cryptocurrencies, and growing demand for real-time payments, regulations are constantly multiplying. Treasuries are turning to Regulation as a service (RaaS) technology, which standardizes reporting, automates document processing, and deploys AI technologies to find patterns and create reusable blocks and patterns. Investing in this new technology frees up valuable resources and reduces paperwork (Lewis, 2021 [9]).

Environmental, social and corporate governance (ESG) has become the most important set of guidelines. Criteria such as the business's carbon footprint, supply chain standards, and even the ability to recycle product packaging affect an organization's ESG rating. Ignoring how the company's performance is consistent with the ESG is a mistake for investors. Investors are putting pressure on the Treasury to work with companies that promote ESG. Therefore, in order to collect data from several sources in a single ESG file, AI is also required (Lewis, 2021 [9]). Changing consumer preferences and monetary habits are forcing banks to reconsider outdated business models. Banking as a service (BaaS) has become the main way for banks to overcome the limitations of the growth of their traditional methods of work. Banks provide access to authorized third-party companies. They turn their intellectual property into paid services, licensing the main functions (underwriting, money transfers, currency exchange, crediting of non-banking brands). Directions for banks to use the AI capabilities to improve the efficiency of their activities (Everest, 2021 [10]):

1. Data standardization.

Banking systems are required to adhere to common standards of conduct, including customer registration. The modern process of data management in banks can be divided into three components: database management systems, modeling of existing data and ETL-processes (Extract, Transform, Load; extraction of data from external sources, conversion and cleaning according to the bank's business model, download in a cloud or other storage). At each stage you need specialized tools such as SQL Server, Teradata, Informatica. Companies like Paxata and Trifacta, for example, adapt data specifically for machine learning tools.

2. Use of ready tools.

High-level data processing tools are now available from companies such as IBM, Microsoft, Google and Amazon. US banking structures use mainly tools for analysis like Microstrategy, Qlik, Tableau, for machine learning - Heat, for external interfaces - Google Studio, for internal - Google BigQuery.

3. Testing the effectiveness of processes.

When data processing tools begin to show the first results, the financial company needs to conduct A/B testing (Split testing, a research method, the essence of which is that the control group of elements is compared with a set of test groups in which one or more indicators were changed to find out which of the changes improve the target) to verify accuracy and achieve a high level of reliability. For example, if any information is used to extrapolate trends (predict how a process will affect a bank's operations in the future) or to predict customer behavior, the specialist should check each of the variables in the regression analysis and the results of the existing data set. Such AI services are provided to banks by RapidMiner and Feature Labs.

4. Work with internal resources.

Before releasing an AI product for direct communication with customers, bank should learn to use intelligent services for data analysis, such as counting for the outflow of users or counting the number of new customers. For example, company SharpIQ works with US banks and uses current data to forecast the number of SBA (US Small Business agency) lenders. As a result of such calculations, the number of loan applicants has doubled. Directions for improving the financial performance of companies based on implemented digital solutions (Chubatyuk, 2020 [11]):

1. Overall efficiency.

Integrated digital tools allow to form and launch a single mechanism of effective work of the company due to its immersion in the digital environment. Therefore, negative external factors do not have a significant impact on its activities and do not offset the financial goals. For example, the modernized digital infrastructure has helped the insurance giant Guardian Life to reduce costs, provide maximum flexibility in all operations and accelerate interaction with market participants like partners, customers, suppliers, potential new employees. The company has moved more than 200 of its applications to the public cloud, closing the latest data center without a loss. The solution has significantly facilitated and accelerated the transition of the entire company to a more efficient process of developing new products and improving existing ones, as the tasks are most clearly distributed between employees and top management.

2. Total revenue growth.

Digital transformation is evolving not so much through new technology capabilities, but through customer inquiries about the quality of service, the desire to get something fundamentally new through progressive methods. Sometimes it takes very little to get a large-scale result. For example, the Chipotle fast food chain demonstrated one of the best practices to increase revenue and customer satisfaction with timely integrated digital tools: the company updated its mobile application on the eve of the crisis so that users can personalize their orders as quickly and conveniently as possible, which successfully copes with the priorities of people in food, its payment and delivery methods. As a result, Chipotle's digital sales increased by more than 100% in the first year of use.

3. General improvement of service quality.

Many digital technologies, in particular data processing software, lead indirectly to increased sales by optimizing resources, transforming financial transactions, reducing production costs through process automation. They are designed to improve the quality of the product / service itself, allowing them to adapt to the needs of both existing and potential customers. E.g., Rolls-Royce successfully uses software that analyzes the data of its jet engines to increase their fuel efficiency. Based on this capability, the company can operate with forecasts for fuel costs of its airline customers. This allowed Rolls-Royce to form and develop its own business model, in which jet engines can not be sold directly, as before (a complex cost process due to constant fluctuations in fuel prices in the market), and, based on real prospects for fuel pricing, earn on their rent. Real-time data analysis allows Rolls-Royce to benefit more by charging for spare parts as well as repair services.

4. Overall customer satisfaction.

The client fears the crisis no less than the business that holds on to him. By improving the quality of customer service, businesses increase their competitiveness by using digital channels of communication, testing, promotion and implementation. For example, major clothing brands use special software in their online services to constantly analyze consumer preferences and reactions to innovation. Industrial enterprises use special software to model the demand for certain products before investing in the launch of a separate production line for its manufacture. Pharmaceutical companies use special software to analyze the activity of consumption of a particular drug and the reaction to it, based on the collected feedback and real medical indicators. One well-chosen integrated solution is often required to obtain the desired result.

5. General focus on growth and innovation.

The main advantage of digital transformation is sales growth, the ability to respond to business needs and customer satisfaction. For companies with a lower level of digital maturity the benefits is in lower costs and increased efficiency in the reduction mode. For example, more mature respondents often cited the sale of new products or services as the main advantage of digital transformation for their innovative functions. Organizations with a low level of maturity expressed uncertainty about the launch of new products and services in principle. Over time, the group of insecure found themselves in a losing situation against their brave competitors. Table 8 shows which of the following business results have the greatest potential for achievement through the use of AI.

Table 8

The greatest potential business outcomes to be chieved through the use of AI

Areas of using AI	%
Fraud detection	77
Reduction of risk	70
Customer retention	68
Staying in compliance	57
Success in existing markets	37
Success in new markets	31
Staff retention	20

Source: Developed by the authors based on (FireLabs, 2020 [12])

Thus, to meet growing customer expectations and overcome competitive threats, financial companies must provide intelligent offerings and expertise (action recommendations, forecasting and automation of key solutions or tasks), personalized services (relevant and timely, based on a detailed understanding of past customer behavior and context) and be multi-channel (covering physical and online contexts on multiple devices and providing the same experience) and combine financial capabilities with other products and services (Biswas, Carson, Chung, Singh, Thomas, 2020 [13]). Fig. 21 shows how a bank can attract retail customers during the day. Fig. 22 shows an example of the banking experience of a small business owner or treasurer of a medium-sized enterprise.

How AI transforms banking for a retail customer										
Name: Arina		Age: 25 years		Occupation: Working profeccinal						
1. Seamless integration with nonbanking apps	→	2. Facial recog-nition for fricti-onless payment	→	3. Analytics-backed personalized offers	→	4. Personalized money-management solutions	→	5. Aggregated overview of daily activities	→	6. Savings and investment recommendations
↓		↓		↓		↓		↓		↓
Bank app recognizes Arina's spending patterns and suggests coffee at nearly cafes		Arina uses smile-to-pay initiate payment		Arina gets 2% off on health insurance premiums based on her gym activity and sleep habits		App offers money-management and saving solutions, prioritizes card payments		Arina receives end-of-day overview of her activities, with augmented reality, and reminders to pay bills		Arina receives integrated portfolio view and a set of actions with the potential to augment returns

Fig. 21. How a bank can attract retail customers during the day.

Source: Developed by the authors based on (Biswas, Carson, Chung, Singh, Thomas, 2020 [13])

How AI transforms banking for a small- or medium-size-enterprise customer										
Name: Yevgen		Age: 42 years		Occupation: Treasurer of a small manufacturing unit						
1. Customised lending solutions	→	2. Micro-expression analysis to review loan applications	→	3. Seamless inventore and receivables management	→	4. SME platform to source suppliers and buyers	→	5. Beyond-banking support services	→	6. Servised by an AI-powered virtual adviser
↓		↓		↓		↓		↓		↓
Bank is integrated with client business management systems Yevgen gets loan offer based on company projected cash flows		Yevgen answers short question-naire; app scans his facial movements Firm is credited with funds after application approval		App suggests items to reorder, gives visual reports on receivables management Yevgen receives customized solutions for invoice discounting, factoring, etc.		Yevgen is assisted in sourcing and selecting the right vendors and partners		Yevgen gets prefilled tax documents to review and approve; files with a single click		An AI-powered virtual adviser resolves queries Yevgen seeks profess-sional advice on a lending offer

Fig. 22. An example of the banking experience of a small business owner or treasurer of a medium-sized enterprise.

Source: Developed by the authors based on (Biswas, Carson, Chung, Singh, Thomas, 2020 [13])

The AI-focused Bank of the Future will also have the speed and maneuverability that digital companies have today. It will quickly innovate, launch new features in days or weeks instead of months. To become a priority-oriented organization, a bank must optimize the stack of its value creation capabilities (Fig. 23).

AI-bank of the future				
	Profitability	Personalization at scale	Omnichannel experience	Speed and innovation
Reimagined engagement	1. Intelligent products, tools, experiences for customers and employees	2. Within-bank channels and Journys (e.g., web, apps, mobile, smart devices, branches, internet of things	3. Beyond-bank channels and journeys (e.g., ecosystems, partners, distributors)	4. Smart service and operations engagement for customers and moblle
		5. Digital marketing		

AI-powered decision making	6. Advanced analytics	Customer acquisition	Credit decision making	Monitoring and collections	Retention and cross-selling, upselling	Servicing and engagement		
	7. AI capablities	Natural language processing	Voice-script analysis	Virtual agents bots	Com-puter vision	Facial recog-nition	Block chain	Robo-tics	Beha-vioral analytics

Core technology and data	8. Core technology and data	A. Tech-forward strategy (in-house build of differential capabilities vs buying offerings; in-house talent plan)				
		B. Data-management for AI world	C. Modern API architecture	D. Intelligent infrastructure (AI operations command, hybrid cloud setup)	E. Hollowing the core (core modernization)	F. Cyber-security and control tiers
Operating model	9. Platform operating model	A. Autonomous business + tech team				
		B. Agile way of working	C. Remote collaboration	D. Modern talent strategy (hiring, residing)	E. Culture and capabilities	
		10. Value capture				

Fig. 23. Future bank based on artificial intelligence.

Source: Developed by the authors based on (Biswas, Carson, Chung, Singh, Thomas, 2020 [13])

The level of basic technologies and data provides a wider use of the cloud and the reduction of outdated technologies (Table 9).

Table 9

The core-technology-and-data layer accommodates increasing use of the cloud and reduction of legacy technology

Capabilities	Our perspective
Tech-forward strategy	Build differentiating capabilities in-house by augmenting the internal skill base; carefully weigh options to buy, build, or compose modular architecture through best-of-breed solutions
Data management for AI world	Upgrade data management and underlying architecture to support machine-learning use cases at scale by leveraging cloud, streaming data, and real-time analytics
Modern API's architecture	Leverage modern cloud-native tooling to enable a scalable API platform supporting complex orchestrations while creating experience-enhancing integrations across the ecosystem
Intelligent infrastructure	Implement infrastructure as code across on-premises and cloud environments; increase platform resiliency by adopting AlOps to support deep diagnostics,

	auto-recoverability, and auto-scale
Hollowing infrastructure	Distribute transaction processing across the enterprise stack; selectively identify components that can be externalized to drive broader reuse, standardization, and efficiency
Cybersecurity and control tiers	Implement robust cybersecurity in the hybrid infrastructure; secure data and appiications through zero-trust design principles and centralized command-and-control centers

Source: Developed by the authors based on (Biswas, Carson, Chung, Singh, Thomas, 2020 [13])

The AI-focused Bank of the Future will require a new operational model, as working groups within the bank continue to operate separately, often without agreeing on goals and priorities (Biswas, Carson, Chung, Singh, Thomas, 2020 [13]). The operational model of the platform provides for cross-functional business groups and technology groups, organized as a series of platforms within the bank. Each team in the platform controls its own assets (e.g, technology solutions, data, infrastructure), budgets, key performance indicators and talents. In turn, the team provides a family of products or services to the bank's end customers or other platforms within the bank. The bank can get three archetypes of platform teams: business platforms (groups focused on customers or partners who are engaged in achieving business results in the field of consumer and corporate lending and transaction banking); corporate platforms (provide specialized capabilities and common services for standardization throughout the organization in the areas of debt collection, utilities, human resources and finance); support platforms (allow enterprise and business platforms to provide end-to-end technical features such as cybersecurity and cloud architecture).

This is what a new generation banking platform looks like (Fig. 24).The transformation of business models is primarily the provision of financial services not in the bank's offices, but where and when such a service is required by the client. This can be a purely financial service (bank transfer) or part of a comprehensive service (buying a car on credit or paying for housing). The essence of digital transformation is the transition from document-centric activity to data-centricity. Now most banks focus on financial documents (payment orders, loan agreements, guarantees). The main asset of a digital organization is its data. Data-centricity involves accounting not only for numbers (accounts, entries, documents), but also for their semantic meaning, i.e. there must be unity of form and content (Markelov, Shipilov, (2020 [15]).

There are two approaches to the development of AI. The first, traditional, is a repetition of human capabilities. The second is the creation of an original machine AI. With the traditional approach, it is necessary to translate human abilities into program code. Here the main task is the recognition and processing of graphic and sound images, because the bulk of information about the outside world a person receives through sight and hearing. Man is freed from routine actions for creativity and analysis. The main thing here is not writing algorithms, but the ability to see and correctly set the applied problem. The second approach is innovative. It is more risky, because work with AI will begin at some stage to learn and teach their own kind, and man in this case becomes an extra link in the chain of evolution (Markelov, Shipilov, (2020 [15]). At the junction of both approaches, we can talk about creating a universal AI, however, with great caution. It must solve a wide range of problems, but operate only in closed environments, where there are certain rules of conduct and a finite set of states. That is, universal AI can be measured not by the ability to achieve complex goals in a wide range of environmental variability, but by the effectiveness of skills acquisition. We can also talk about narrow AI, which is used for narrow applications. The narrower the task, the more effective AI solutions can be. E.g., document recognition is a narrow AI (Markelov, Shipilov, (2020 [15]). There are some aspects of AI that require caution and special attention (FireLabs, 2020 [12]):

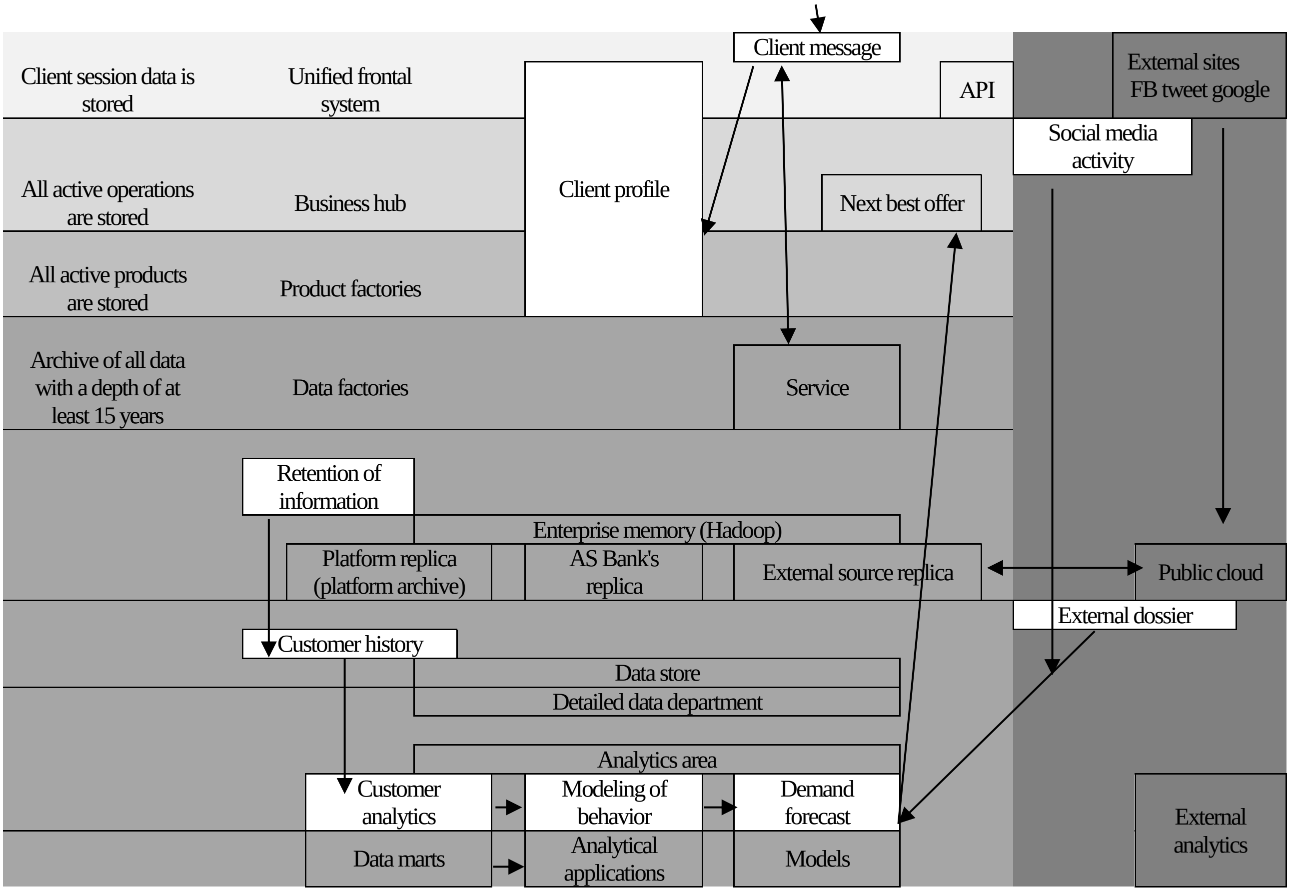


Fig. 24. New generation of banking platform
Source: Developed by the authors based on (Tadviser, 2020 [14])

1. High cost of implementation.

Despite the fact that the introduction of AI promises significant cost reductions, its integration is initially expensive. Some financial companies are unable to adopt innovative technologies, remaining on the verge of progress, while their competitors are moving forward and capturing their market share.

2. Limiting the reproduction of human intelligence.

No AI system will ever come close to human productivity, because machines are doomed to remain machines. It is better to realistically assess the limits of AI. Evidence of AI inconsistency is an example of IBM Project Debater technology that can participate in various discussions. This technology was used to create a project that included about a thousand abstracts and scientific articles by students and young scientists. On the one hand, the result showed that AI is not able to make moral decisions, because morality is a unique ability and trait of man. Therefore, if AI is widely used, it can be dangerous (Markelov, Shipilov, (2020 [15]).

3. Limited performance improvement.

No matter how long artificial intelligence systems learn, they still cannot exceed the human learning potential because their capabilities are limited by the amount of historical data they receive.

4. Poor creativity.

Artificial intelligence systems are completely devoid of a unique human trait - creativity. Thus, they can perform some tasks accurately and quickly, but they cannot make unusual, extraordinary decisions.

5. The threat of unemployment.

A common fear associated with the mass introduction of AI is the threat of unemployment. This is true for the low-skilled workforce around the world, as automation can replace manual operations. Cars do not sleep or eat; the employer does not have to pay taxes for them or pay for their leave. In the long run, automation based on artificial intelligence will really reduce the cost of manual labor.

To overcome the challenges that limit the deployment of artificial intelligence technologies across the organization, financial companies must take a holistic approach. To become AI leaders, it is necessary to invest in the transformation of capabilities at all four levels: the level of interaction, the level of decision-making based on AI, the level of basic technology and data, the operational model (Biswas, Carson, Chung, Singh, Thomas, 2020 [13]). When these interdependent levels work in unison, they allow customers to provide a multi-channel experience, support large-scale personalization, and manage fast-paced innovation cycles that are critical to staying competitive. Each level must play a unique role, because insufficient investment in one level creates a weak chain link that can harm the whole company.

REFERENCES

1. BDO (2020) Shtuchnij intelekt dlja zahistu vashogo biznesu [Artificial intelligence to protect your business] [*BDO*] Retrieved from: https://cutt.ly/xbEjo3r (Last accessed: 09.04.2021)

2. ImmuniWeb (2021) ImmuniWeb® AI Platform [*ImmuniWeb*®] Retrieved from: https://www.immuniweb.com/ (Last accessed: 09.04.2021)

3. Evseev S.P., Korol O.G., Kots G.P. (2015) Analiz zakonodavchoї bazi v sistemi upravlinnja bankivs'koju bezpekoju [Analysis of the legal framework in the banking security management system]. *Eastern European Journal of Advanced Technologies*, 5/3 (77). 48–59.

4. *Mehmood A. (2018) An Introduction to PCI DSS (Payment Card Industry Data Security Standard)* [Cryptomathic – global provider of secure server solutions to businesses]. Retrieved from: https://cutt.ly/9bEkUDY (Last accessed: 09.04.2021)

5. Karmanny E.V., Kovzhoga S.O., Lutsenko E.M. (2019) Organizacijno-pravovi aspekti protidiї zlomu platizhnih sistem u suchasnih umovah didzhitalizaciї [Organizational and legal aspects of counteracting the hacking of payment systems in modern conditions of digitalization]. *Criminal Threats in the Security Sector: Effective Response Practices: Panel Discussion Papers*, 39-49. https://doi.org/10.37320/2415-3583/12.36. Retrieved from: https://cutt.ly/JbEhOxb (Last accessed: 09.04.2021)

6. Yarovenko G.M., Kovach V.O. (2019) Perspektivi zastosuvannja tehnologiї blokchejn u sistemah zabezpechennja kiberbezpeki bankiv [Prospects for the application of blockchain technology in cybersecurity systems of banks]. *Criminal Threats in the Security Sector: Effective Response Practices*: Panel Discussion Papers, 151-161. DOI: https://doi.org/10.37320/2415-3583/12.36. Retrieved from: https://cutt.ly/vbEhZ70 (Last accessed: 09.04.2021)

7. *Bahou A.J. (2018) Blockchain and Applications in Information Security* [Information Systems Security Association]. Retrieved from: https://cutt.ly/LbEhMHn (Last accessed: 09.04.2021)

8. *Chan C., Chow C., Wong J., Dimakis N., Nayler D., Bermudes J., Raman J., Lam R., Baker M. (2019). Artificial intelligence applications in financial services* [Oliverwyman]. Retrieved from: https://cutt.ly/RbEkAIt (Last accessed: 09.04.2021)

9. *Lewis L. (2021). 3 Big Tech Trends in Treasury Management [Processmaker]*. Retrieved from: https://www.processmaker.com/blog/3-big-tech-trends-in-treasury-management/ (Last accessed: 09.04.2021)

10. Everest (2021) Jak bankivs'ki ustanovi vikoristovujut' shtuchnij intelekt u svoïj dijal'nosti [How banking institutions use artificial intelligence in their activities] [*Everest Innovation integrator*]. Retrieved from: https://cutt.ly/ebEkGCy (Last accessed: 09.04.2021)

11. Chubatyuk Yu. (2020) Svidoma «Cifrova zrilist'» i finansovi pokazniki: u chomu smilivi procvitajut', a nevpevneni – prograjut' [Conscious "Digital Maturity" and financial indicators: in what the brave prosper, and the insecure - lose] [*Everest*]. Retrieved from: https://cutt.ly/0bEh3gH (Last accessed: 09.04.2021)

12. *FireLabs (2020) How AI Solutions Reshape the Financial Sector* [Fire Labs Team]. Retrieved from: https://4irelabs.com/articles/ai-in-finance/ (Last accessed: 09.04.2021)

13. *Biswas S., Carson B., Chung V., Singh S., Thomas R. (2020). AI-bank of the future: Can banks meet the AI challenge?* [McKinsey&Company]. Retrieved from: https://cutt.ly/VbEjrwE (Last accessed: 09.04.2021)
14. Tadviser (2020) Iskusstvennyj intellekt v bankah [Artificial intelligence in banks] [*Tadviser*]. Retrieved from: https://cutt.ly/mbEh6vN (Last accessed: 09.04.2021)
15. Markelov K., Shipilov V. (2020) Cifrovaja transformacija v bankah kak neizbezhnost' i iskusstvennyj intellekt kak sredstvo razvitija bankinga [Digital transformation in banks as an inevitability and artificial intelligence as a means of banking development] [*Bisjournal*]. Retrieved from: https://ib-bank.ru/bisjournal/post/1468 (Last accessed: 09.04.2021)

3.4. Artificial intelligence technologies in crisis management of banks

The global financial landscape is shifting towards banking as a service, driven largely by the tech-savvy generations' preference for seamless, simple and comprehensive platform banking operations. Understanding the unique needs and aspirations of the target audience - millennials - and coordinating with them the actions of the bank's management is the basis for avoiding crises in the bank in the coming years due to a drop in competitiveness. Millennials won't queue up to fill out piles of questionnaires. They'll just complain on Facebook about their bad experience and go to another bank. Millennials know how to spread information. If they like the service of a particular bank, that bank can expect an influx of clients.

Let us outline the reasons why the digital culture, opportunities and strategy in banking technologies are much less developed than in the media, retail or logistics (Oleksiuk, 2017 [1]):

1. Outdated systems.

Banks must understand and reorganize their corporate systems before they can innovate. The huge IT departments of financial institutions often maintain sophisticated retail banking technology software that is built on outdated technology and is difficult to modernize.

2. Organizational issues.

The large number of employees in most banks is a barrier to digital mobilization. And each bank is just one component in a huge system that is too cumbersome to quickly adapt to market changes.

3. Strict regulation.

Banks have to deal with ever-increasing regulatory requirements, and this is quite costly for them.

4. Customer preferences.

Not everyone needs a progressive digital approach to their funds. Ironically, the simple pursuit of a certain level of human interaction still exists. Because of such a lag in the banking business, we can apply anti-crisis management methods, because it can be viewed not only as overcoming an existing crisis, but also as a constant diagnosis, neutralization and prevention of crisis phenomena.

Anti-crisis management of a bank is a system of measures to prevent, identification and overcoming of the negative consequences of internal imbalances and the crisis state of the bank with minimal losses (expenses) through integration and due to the synergy of the system, situational, functional, process, project, risk-oriented, behavioral approaches, which allows not only to solve existing problems, but also to strengthen the bank's development potential. The implementation of the anti-crisis strategy is carried out through the appropriate methods, means, tools and technologies (Table 10).

Table 10

Traditional and innovative approaches to anti-crisis management of the bank

Methods, tools, technologies	Anti-crisis management stages		
	Prevention of crises	Identification and overcoming the crisis	Post-crisis recovery / growth
Traditional			
Analytical tools for forecasting and planning (stress testing, going concern plan, system of early diagnosis of crisis phenomena, organization of risk management)	+		
Organizational and management tools (cost optimization, outsourcing, benchmarking, centralization of some management functions)	+	+	
Ways to balance the assets and liabilities of the bank (prolongation of deposits; liabilities restructuring; maturity limitation; loyalty programs)		+	
Tools for dealing with problem assets (restructuring of loan debt; recovery of collateral in court; write-off from reserves; sale to collectors; transfer to the asset management company)		+	+
Methods of recapitalization (increase of authorized capital; sale or merger; attraction of subordinated capital; conversion of debt instruments into capital)		+	
Innovative			
Financial analytics systems (digital data management platforms)	+		+
E-commerce and marketing systems (digital platforms and interoperability systems, CRM systems)	+		+
Digital platforms for the resource base formation (crowdfunding, crowdinvesting)	+		+
Digital technologies (artificial intelligence, Big Data, mobile technologies, cloud computing, Internet of Things, blockchain, machine learning)	+		+

Source: Developed by the authors based on (Panteleeva, 2019 [2])

A crisis is an event that has already happened, as opposed to a risk which is a possible future event. If a risk event in the case of an occurrence could cause significant losses, such risk should be considered a potential threat. In the case of a high probability of the threat, it is considered real. Variants of the characteristics at which the risk can be classified as a threat are given in table 11.

Table 11

Criteria for assigning risk to threat

Risk characteristics		Attribution of risk to threat
Probability	Negative consequences (losses)	
High	Significant	The real threat
High	Insignificant	Risk is not a threat
Not high	Significant	Potential threat
Not high	Insignificant	Risk is not a threat

Source: Developed by the authors based on (Korvat, Burlaka, 2017 [3])

The criteria for classifying a risk as a threat (Table 11) make it possible to distinguish between: - the risk of a crisis as an unlikely possible event (potential threat of a crisis); - a real threat of a crisis when the probability of a crisis is high; - a real crisis as an event that has occurred.

This classification is consistent with the distribution of crisis management into anticipatory, preventive and reactive. In addition, it explains the relationship between crisis management and risk management and the economic security system. As you can see, artificial intelligence is still considered an innovative method of anti-crisis management (Table 1) and can be used rather to prevent a crisis or (if there is a carefully developed strategy) at the stage of post-crisis recovery. The anti-crisis strategy is the rationale and selection of promising approaches related to the innovative development of the bank, the identification of growing segments of the banking services market, cost optimization and diversification of activities. Approaches, the implementation of which would allow the bank not only to strengthen its financial stability, but also to strengthen its competitive position and confidence in it, are becoming a priority.

Therefore, artificial intelligence is one of the key factors in transforming the banking industry, saving time, increasing revenues, identifying risks and fraud, and increasing customer value (Archer, 2020 [4]). Artificial intelligence in banking risk management can reduce operational, regulatory and compliance costs, and can be used for model risk management (backtesting and model validation) and stress testing, which is required by European and US prudential regulators. The very first known financial crisis occurred in 33 AD in the Roman Empire under Tiberius. And since then, most financial crises have come from weakening lending standards and stock market crashes. By examining historical data on financial crises, predictive AI can help financial institutions improve their lending standards and invest wisely in stocks (Naveen, 2020 [5]).

Since the banks of each country are linked into a single system and the problems of each of them in one way or another affect its stability as a whole, we will consider the use of AI at the level of central banks, using the example of the actively discussed "BoB" (the Bank of England Bot, Bot of the Bank of England) (Danielsson, Macrae, Uthemann, 2020 [6]). BoB can help with many central bank tasks such as information gathering, data analysis, forecasting, risk management, supervision, monetary policy analysis, liquidity crisis response. There are also some concerns about the use of AI in central banks for regulation:

1. Procyclicality.

Perhaps BoB will prioritize better methodologies and standardized processes, imposing an increasingly homogeneous view of the world on market participants. This amplifies the pro-cyclical impact of banks' own artificial intelligence systems, which pursue the same goal: to maximize profits while respecting constraints. Everyone will see risk the same way, and AI banks will want to buy / sell the same assets. Procyclicality will bring short-term stability and high returns, but at the expense of increased systemic risk.

2. Unknown-unknowns.

System-type vulnerabilities, as a rule, arise at the boundaries of areas of responsibility. The current AI learns from events that have happened (known-knowns). BoB can be trained in simulated (known-unknowns) scenarios. However, the financial system is infinitely complex. Every action taken by the authorities and the private sector changes the system, which is explained by Goodhart's Law (1975): "When an economic indicator becomes a target function for economic policy, the old empirical laws using this indicator are no longer valid". That is exactly the unknown-unknowns cause crises.

3. Trust.

Excessive confidence in BoB can undermine contingency planning and preventive regulation, and create a false safety sense that could possibly lead to a crisis. How do we know BoB does the right thing. A person does not need to be told that he cannot get rid of his own kind. People just know it is an integral part of their humanity. AI has no humanity. If it is to act autonomously, people must first solve its problems. BoB will face times when it makes critical decisions in a way that no other person does. People can adjust their goals. AI can't. Trust in human decision making comes from a shared understanding of values and a shared understanding of the environment. BoB has no values, only goals.

4. System optimization.

BoB will have to deal with "intruders": those who take on unacceptably high risks, those who create instability for profit, those whose main goal is to damage the financial system. Here BoB is at a disadvantage compared to violators. He must control the entire system, and they only need to identify local loopholes and therefore they will always have the advantage. The AI's goals determine its actions, which makes BoB predictable. The standard defense is that the AI will randomly react to interactions with humans or another AI, limiting their ability to play with it. This mimics the natural defenses that humans provide - they create randomness, nuance, and interpretation that vary from person to person and from time to time. There are some reasons why such countermeasures will not work in practice for

BoB: - randomized responses must be programmed into the AI of the central bank, which is unacceptable, since the rules and supervision must be transparent and fair; - randomization requires AI designers to specify a distribution for BoB actions, and this distribution can be reconstructed as regulated organizations abide by repetitive decisions.

Thus, artificial intelligence will be useful for central banks at the microprudential level because it will reduce costs and increase efficiency, help in responding to the crisis, improve the flow of information to monetary policy committees, but at the macroprudential level it cannot be completely trusted, and maybe an emergency switch will be needed here.

As we deal with the aftermath of a pandemic, banks will need to re-evaluate their resistance to all aspects of risk. The increased capital and liquidity reserves that banks have been holding in compliance with regulatory requirements since the global financial crisis have served them well, even if managing liquidity and market risk was inevitably very challenging during the peak of volatility associated with COVID-19. Many corporate clients actively used their existing revolving credit facilities to bolster their cash and liquidity at the onset of the crisis. Banks had to reconsider their approaches to lending. This was the end of some types of lending - loans secured by home equity, for example - and an accelerated assessment of portfolio risks, relief for clients (Kpmg, 2020 [7]). The impact of COVID-19 was so rapid, widespread and interconnected that banking models of liquidity, market and credit risk could not adequately reflect them. In many cases, banks have had to apply quality judgments (expert estimations) in conjunction with the results of their models. Loan portfolios needed to be revalued due to the emergence of such problem sectors as air travel, leisure and corporate real estate.

For example, the Lloyds Banking Group is leveraging artificial intelligence to tackle crisis management challenges, including staff and customer restrictions due to social distancing and quarantine measures, as calls to call centers increase. Using AI, Lloyds can identify calls from priority customers, for example, those who work for the NHS (National Health Service of England) or are over 70 years old, and place them at the top of the queue. And a suite of AI-powered features built into its mobile banking app is designed to help Lloyds, Halifax and Bank of Scotland customers with payment change notifications and the ability to track expenses (Motsi-Omoijiade, 2020 [8]).

Lloyds has developed an advanced artificial intelligence-based fraud detection system called the “Rat”. Launched in 2019, the system uses a combination of biometric data (including voice recognition) and software that can determine in real time whether a client's computer has been remotely accessed. “Rat”'s machine learning algorithms track suspicious patterns by analyzing a huge number of data points, revealing new fraudulent methods. Advanced data, analytics, and artificial intelligence are becoming the backbone of estimation. Advanced data analytics capabilities will be critical, including cloud-based AI and predictive modeling techniques that combine internal and external data to deliver truly robust insights. One of the key lessons from COVID-19 is that internal data alone is not enough.

Operational risk management and robust cybersecurity will be crucial. More systems could be migrated to the cloud, and the use of low-code systems that can be easily and quickly built on top of existing infrastructure will also proliferate. In a more digital environment, maintaining and constantly updating cyber defenses will be imperative. Banks will also need to ensure that robust compliance controls are in place and adapt their internal controls for a large proportion of their remote employees. With the world entering a period of probable recession, credit default rates will continue to rise, while bank profitability will be threatened. Some banks will suffer from declining market capitalization and may be acquired by stronger ones. Anti-crisis management in banks now and in the future should include (Kpmg, 2020 [7]):

1. Investment in technology and data.

Better data availability and quality, advanced artificial intelligence and machine learning analytics, and faster reporting.

2. Credit risk management.

Loan portfolios need to be managed on a disaggregated basis, i.e., evaluate not only the industry as a whole, but also individual corporate and private clients, and predict their cash flows and risks after COVID-19.

3. New models of operational risk and resistance to surprises.

Banks have proven their resilience in the midst of COVID-19 and must be able to handle whatever the future brings. With further lockdowns, operations should be able to flexibly switch between physical and virtual channels. Cybersecurity and customer data protection must come first. A four-step process for achieving data ownership consists of: - contextual estimation: data should be used based on need and context, not just because it is available for use; - data storage: issues related to location, security and access to data; - risk assessment: it is necessary to assess the vulnerability of the data in advance; - risk mitigation plan: based on the assessment, effective and reliable measures must be taken to minimize any future risks.

4. Mindfulness for growth opportunities, not only to risk mitigation.

Dynamic predictive models to better understand customers and their associated risks can also provide opportunities for competitive advantage and growth. In addition to the above, the mechanism of anti-crisis management of the banking sector should have the following properties: mobility and dynamism in the use of resources, changes, implementation of innovative programs; implementation of target-oriented approaches in technology development and decision-making; taking into account the time factor in anti-crisis management processes; increased attention to the processes of development of management decisions and the choice of alternatives for the implementation of activities; use of anti-crisis quality criteria in the development and implementation of solutions (NBU, 2004 [9]). In modern banks, there are divisions that can predict and even reduce the risk of crises: the risk management department and the internal audit service (Table 12) (NBU, 2016 [10]).

Table 12

Delineation of functions of risk management department and internal audit department

Criterion	Risk management	Internal audit
The nature of control	Internal component of the object of control	Independence from the object
Control tools	Deviation analysis, internal methods, instructions, provisions, the principle of four eyes*	Revision, stocktaking (inventory)
Frequency of control	Continuously	As needed
Control period	It is considered that the information provided is reliable	Past period
Reliability of information	Information and methodological support of management decisions, coordination	The accuracy of the information is checked
Corporative management	Debugging and maintaining functionality	Checking the effectiveness of management
Risk management	Debugging and maintaining functionality in risky conditions	Checking the quality and effectiveness of the risk management system

*The principle of four eyes (Two-man rule) is the rule according to which for signing of the legally and/or financially important document (for example, the contract) or decision-making (for example, the business plan) there is needed signature (approval) not of one person, but of several people who are in the leadership of a company (top-managers or even owners).

Source: Developed by the authors based on (Stechishin, 2016 [11])

It can be concluded that now artificial intelligence is not yet sufficiently applicable for decision-making in crisis management. In the short term, people are still making and implementing decisions. Because AI training is time-consuming and data-intensive, banks and financial companies can be encouraged to start collecting crisis data to be able to use AI in decision-making in the near future based on the detection of deviations. In crisis management, artificial intelligence can be used as part of a team approach in the medium term (Table 13).

Table 13

Short-, medium-, and long-term perspective of AI on decision-making in crisis management

Perspective of AI on decision-making in crisis management		
Short-term	Medium-term	Long-term
- Simple binary decisions - Human as decision-maker - Semi autonomous AI for decision-making - More and more complex and decision-sensitive judgment - Data gathering for crises	- AI for decision-making in organizational daily run: more available data - Abnormality detection for pre-crisis stage - Team approach: human as the final instance, AI as additional intelligence - Training of AI for crisis - Change from semi-autonomous to autonomous AI agents	- Understandable machine learning systems - Effective decision-making by AI agents - Application on crisis management: “right arm of human” - Industrial revolution, will be everywhere …- Strong AI?

Source: Developed by the authors based on (Noizet, Weber, 2018 [12])

The system of threats and solutions in anti-crisis management, data sources, promising technologies, future directions, pitfalls and problems of anti-crisis analytics are presented in Table 14.

Table 14

Taxonomy* of crisis analytics

Elements of crisis analytics				
1. Data sources	2. Challenge (problems, features)	3. Pitfalls (traps)	4. Future directions	5. Enabling technologies
Data exhaust Online activity Sensors Small data / MyData Public data Crowdsourced data	Volume Variety Velocity Veracity Vagueness Volunteers Validity Values Visualization Verification Virality Privacy	Overestimation Noisy data False data	Reability Real-time analytics Multimodal informatics Disaster tolerance Context awareness	Mobile phones The internet AI and ML Crowdsourcing Neo-geography Visual analytics Open Data

*Taxonomy is the result of the classification and grouping of complex systems in the form of a hierarchical structure. The elements and groups of objects of the subsystem selected for research are called taxon. Taxonomy can be viewed as a form of knowledge representation; comes from the Greek taxi (order, agreement) and nomos (law, science).

Source: Developed by the authors based on (Qadir, Ali, Rasool, Zwitter, Sathiaseelan, Crowcroft, 2016 [13])

Some of the phenomena presented in table 5 need clarifications.

1. Sources of big crisis data.

Exhaustion of data is information that is collected passively using digital technologies. Our lives with the ubiquity of digital devices are increasingly online and leave a traceable digital footprint. An important example of data depletion is call detail records (CDRs), which are created by mobile companies to collect various details related to any call made through their network. It also includes transaction data (bank statements, credit card history) and usage data (access logs). A promising use of data exhaustion in anti-crisis analytics is the use of mobile money transactions, but so far such data is rarely shared publicly due to privacy concerns.

Small data and personal data, as opposed to big data, which revolves around the analysis of filtered and aggregated data (since the sampling and analysis units are very different, for example, the sampling unit is at the individual level, and the unit of analysis may be at the country level), even having large datasets work with a unit of analysis of the same coverage as the sampling unit. Personal data ("MyData") can help optimize the lives of individuals (in terms of health, productivity, for example, the startup Open mHealth, the small data laboratory at Cornell Institute of Technology and at the United Nations University (Small Data Lab - UNU; The Small Data Lab at Cornell Tech)).

2. Complexities of Big Crisis Data Analytics.

Technical problems associated with the processing of conventional big data: volume (large amounts of data that cannot be processed on a single computer or using traditional database tools); variety (data in many formats: structured, semi-structured and (mostly) unstructured; speed (data streaming, response times from milliseconds to seconds); reliability (uncertainty that the data is true or consistent with reality, as people tend to exaggerate in conditions of severe stress), data noise (false rumors, outdated or corrupted data), determination of the representativeness of the data, since the need for reliable statistical analysis is not eliminated due to the large amount of data, sometimes data that was not recorded is more important than what was recorded) (Gupta, Kumaraguru, Castillo, Meier, McFarland, 2014 [14]). In the case of big crisis data (such as social media), complications are added: fuzziness (working with natural language and language diversity problem); virality (understanding of cascading crisis information); voluntariness (motivation and coordination of digital volunteers); validity (mitigating social media biases and mistakes); values (ensuring confidentiality and ethical use of crisis data); visualization (how to best visualize big crisis data such as crisis maps) (Gao, Barbier, Goolsby, 2011 [15]).

Let's take a closer look at some of these challenges. Values. The big crisis data analyst community should use humanitarian principles that are binding on UN agencies, or adopt similar ones:

- humanity: data collection can be strictly regulated by the principle of “need to know”, that is, there should be quite a lot of deviations from the trend towards collecting and storing data in the hope that future data analytics will help to better understand conflicts and disasters;
- neutrality;
- impartiality: when collecting data, it is necessary to be free from bias towards certain types of data and be careful not to increase the vulnerability of groups by emphasizing differences;
- independence: vulnerable groups should not be allowed to become targets for individual services from which service providers want to profit and increase sales (for example, by offering refugees discounts on international roaming for mobile phones or using the Internet), i.e. such methods of exploitation who benefit from the vulnerability of people in need are incompatible with the principle of independence.

Volunteers. Supporting a target group of volunteers, for example, in crowdsourcing, is difficult beyond a certain period of time, since volunteers have other needs such as work, families, sport, and hobby. It is also difficult to maintain the quality of crowdsourced data. To address these challenges and motivate, it is sometimes suggested to use game-based approaches to “gamify” crowdsourcing (O’Leary, 2015 [16]).

3. Traps (pitfalls). The digital gap.

The digital gap is associated with the uneven diffusion of technology around the world. The result of this gap could harm countries that lack infrastructure, economic accessibility and data shortages. The uneven nature of big data in terms of volume, speed, reliability, and variety introduces bias that can lead to ineffective data analysis (O'Leary, 2015 [16]).

4. Future directions.

Data quickly becomes obsolete due to a dynamically changing environment. In many cases, different crises have many cascading stages in which one problem can cause other problems. In such scenarios, real-time analytics can help prioritize the most urgent issues before any further damage is done. It is also important to ensure proper authentication, authorization and accounting.

Predictive / context-sensitive crisis analytics powered by artificial intelligence. Much of the work on crisis analytics has focused on retrospective, including work on descriptive analytics (to answer "what happened or is happening?") or diagnostic analytics (to answer "why did this happen?"). Relatively little work has focused on forward-looking analytics such as predictive analytics (to answer "what will happen?") and prescriptive analytics (to answer "how can we do this?") (Elhauge, (2010 [17]). The problem is the presence of unique events in the data that do not correlate strongly with past events, and since the fields of machine learning and data mining mainly make decisions based on past events, which could potentially lead to false positives.

With advances in artificial intelligence and the ubiquitous availability of the Internet and GPS for smartphones, it is possible (provided that legal and policy issues can be appropriately addressed) to disseminate context-sensitive, personalized information about the crisis to crisis-prone or crisis-stricken (for example, using AI for automated processing and SMS for distribution) (Friedman, Rubin, Brown, Buntin, Corn, Etheredge, Gunter, Musen, Platt, Stead, 2014 [18]). Multimodal big crisis data information. Big crisis data includes both very big data and a large number of data sources (which can provide different types of data). This highlights the dangers of siled big crisis data analytics. To gain a better understanding of the reality of a crisis, it is necessary to reconcile and combine the various different forms of crisis information (e.g. text, images, speech, video, maps, crowdsourced and official reports). This area of multimodal big crisis data analytics defines the real boundaries of research in big crisis data analysis and promises to be a fertile area for future research in the general field of crisis informatics.

5. Enabling technologies.

Mobile phones, Internet, AI and ML, crowdsourcing, neo-geography, visual analytics, Open Data – some of them we use in our everyday life, and other ones we discussed in previous material. That is, even if big data can provide answers to the most important questions, in order to take full advantage of big crisis data, it is necessary to work in many different directions.

REFERENCES

1. *Oleksiuk A. (2017)* Trick or Treat: How Companies are Responding to Banking Technology Trends [Intellias]. Retrieved from: https://www.intellias.com/responding-to-technological-changes-in-banking/ (Last accessed: 14.04.2021)

2. Panteleeva N.M. (2019) Tehnologiї shtuchnogo intelektu v antikrizovomu upravlinni bankom [Technologies of artificial intelligence in anti-crisis bank management] [*Economic Sciences Series, Issue 33*]. DOI: 10.32999/ksu2307-8030/2019-33-38. Retrieved from: http://webcache.googleusercontent.com/search?q=cache:GJvdpAZZz04J:ej.journal.kspu.edu/index.php/ej/article/download/145/140/+&cd=15&hl=ru&ct=clnk&gl=ua (Last accessed: 14.04.2021)

3. Korvat O.V., Burlaka G.O. (2017) Instrumenti ta tehnologiї antikrizovogo upravlinnja v strahovij kompaniї [Crisis management tools and technologies in an insurance company] [*Money, finance and credit. Issue 14, pp. 287-292*]. Retrieved from: http://repository.hneu.edu.ua/handle/123456789/19478 (Last accessed: 14.04.2021)

4. *Archer (2020) How AI is changing the risk management?* [Archer-soft]. Retrieved from: https://archer-soft.com/blog/how-ai-changing-risk-management (Last accessed: 14.04.2021)

5. *Naveen J. (2020) Can artificial intelligence prevent the next financial crisis?* [Bbntimes]. Retrieved from: https://www.bbntimes.com/technology/can-artificial-intelligence-prevent-the-next-financial-crisis (Last accessed: 14.04.2021)

6. *Danielsson J., Macrae R., Uthemann A. (2020) Artificial intelligence as a central banker* [VoxeuCepr]. Retrieved from: https://voxeu.org/article/artificial-intelligence-central-banker (Last accessed: 15.04.2021)

7. *Kpmg (2020) A new risk management playbook for banks* [Kpmg]. Retrieved from: https://home.kpmg/xx/en/home/insights/2020/07/a-new-risk-management-playbook-for-banks.html (Last accessed: 15.04.2021)

8. *Immaculate Motsi-Omoijiade I (2020) How AI is helping banks meet the challenges of COVID-19* [Birmingham Business School Blog]. Retrieved from: https://blog.bham.ac.uk/business-school/2020/05/15/ai-and-the-challenges-of-covid-19/ (Last accessed: 15.04.2021)

9. NBU (2004) Metodichni rekomendaciї shhodo organizaciї ta funkcionuvannja sistemi rizik-menedzhmentu v bankah Ukraїni: polozhennja, zatverdzhene postanovoju Pravlinnja NBU vid 02.08.2004 r. № 361 [Methodical recommendations on the organization and functioning of the risk management system in the banks of Ukraine: the provision approved by the resolution of the Board of the NBU, 02.08.2004 № 361] [*NBU*] Retrieved from: https://zakon.rada.gov.ua/laws/show/v0361500-04#Text (Last accessed: 16.04.2021)

10. NBU (2016) Pro organizaciju vnutrishn'ogo auditu v komercijnih bankah Ukraїni: polozhennja, zatverdzhene postanovoju Pravlinnja Nacional'nogo banku Ukraїni vid 10.05.2016 № 311 [On the organization of internal audit in commercial banks of Ukraine: the provision approved by the resolution of the Board of the National Bank of Ukraine, 10.05.2016 № 311] [*NBU*]. Retrieved from: https://zakon.rada.gov.ua/laws/show/v0311500-16#Text (Last accessed: 16.04.2021)

11. Stechishin T.B. (2016) Social'na vidpovidal'nist' jak instrument antikrizovogo upravlinnja bankivs'koju sistemoju Ukraїni [Social responsibility as

an instrument of anti-crisis management of the banking system of Ukraine] [*Young Science, TNEU, № 24, pp. 111-120*]. Retrieved from: http://dspace.wunu.edu.ua/handle/316497/3544 (Last accessed: 15.04.2021)

12. *Noizet G., Weber P. (2018) Artificial Intelligence / An approach for decision-making in crisis management* [Diva-portal]. Retrieved from: https://www.diva-portal.org/smash/record.jsf?pid=diva2%3A1232369&dswid=-280 (Last accessed: 15.04.2021)

13. *Qadir J., Ali A., Rasool R., Zwitter A., Sathiaseelan A., Crowcroft J. (2016) Crisis analytics: big data-driven crisis response* [Journal of International Humanitarian Action, №1]. DOI 10.1186/s41018-016-0013-9. Retrieved from: https://jhumanitarianaction.springeropen.com/articles/10.1186/s41018-016-0013-9 (Last accessed: 16.04.2021)

14. *Gupta A., Kumaraguru P., Castillo C., Meier P., McFarland D. (2014) Tweetcred: real-time credibility assessment of content on twitter* [Social Informatics: 6th International Conference, Barcelona, Spain, November 11-13, pp. 228-243]. DOI: 10.1007/978-3-319-13734-6_16. Retrieved from: https://link.springer.com/chapter/10.1007/978-3-319-13734-6_16 (Last accessed: 16.04.2021)

15. *Gao H., Barbier G., Goolsby R. (2011) Harnessing the crowdsourcing power of social media for disaster relief* [Cyber-Pysical-Social Systems, IEEE Computer Society, Los Alamitos, USA.] DOI: 10.1109 / MIS.2011.52. Retrieved from: https://preventviolentextremism.info/sites/default/files/Harnessing% 20the %20Crowdsourcing%20Power%20of%20Social%20Media%20for%20Disaster%20Relief.pdf (Last accessed: 16.04.2021)

16. *O'Leary D.E. (2015) Big data and privacy: Emerging issues* [Intell Syst IEEE 30(6):92–96. Open mHealth]. DOI: 10.1109/MIS.2015.110. Retrieved from: http://www.openmhealth.org/ (Last accessed: 16.04.2021)

17. *Elhauge E. (2010) The fragmentation of U.S. Health Care: causes and solutions* [Oxford University Press, New York. Oxford Scholarship Online]. DOI: 10.1093/acprof:oso/9780195390131.001.0001. Retrieved from: https://oxford.universitypressscholarship.com/view/10.1093/acprof:oso/9780195390131.001.0001/acprof-9780195390131 (Last accessed: 16.04.2021)

18. *Friedman C., Rubin J., Brown J., Buntin M., Corn M., Etheredge L., Gunter C., Musen M., Platt R., Stead W. (2014) Toward a science of learning systems: a research agenda for the high-functioning learning health system* [Journal of the American Medical Informatics Association. TheOxford University Press]. DOI: 10.1136/amiajnl-2014-002977. Retrieved from: https://pubmed.ncbi.nlm.nih.gov/25342177/ (Last accessed: 16.04.2021)

IV. ARTIFICIAL INTELLIGENCE AND THE FUTURE OF HEALTHCARE

4.1. New systems of medical diagnostics

Yurii Shulzhyk
Ph.D., Associate Professor of Management, Deputy Director for Research, Precarpathian Institute named of Mykhailo Hrushevsky of Interregional Academy of Personnel Management, Truskavets, Ukraine;
E-mail: pimaup_ doctorant@ukr.net
ORCID ID 0000-0003-1699-054X

Vladimir Mural
Ph.D. in Economics, Professor of the International Personnel Academy, Deputy Institution of the Lviv Regional Council "Sambir Professional Medical College", Sambir, Ukraine
E-mail: v.mural@i.ua

Oksana Kvasnii
Ph.D. in Economics, Lecturer, State Higher Educational Institution "Mechanical and Technological College", Drohobych, Ukraine
E-mail:ukrnet91@ukr.net
ORCID ID0000-0001-8881-9165

Since primeval times, man has attempted to explain natural phenomena using models. In the past. four decades, a new kind of modeler, the medical informatician, has developed and proliferated a new kind of model, the medical diagnostic decision support (MDDS) system. Modeling remains an inexact science. Ptolemy, in the Almagest, placed the earth at the center of the universe, and still could explain why the sun would rise in the east each morning. MDDS systems incorporate inexact models of the incompletely understood and exceptionally complex process of medical diagnosis. Yet mankind, using imperfect models, has built machines that fly, and cured many diseases. Because MDDS systems augment the natural capabilities of human diagnosticians, it is likely they will be employed productively.

Experimental studies of human mental activity processes showed that 85% of the time goes to create conditions for its own mental work, ODOs are reduced to finding the necessary information, printing, building schedules and other stationery work, which, in principle, can perform various technical devices. The work of a medical researcher or practitioner, this conclusion can be applied. An instrument that improves the activities of medical workers in the field of information processing, management and planning is the medical information system (Miss).

1.Definition, goals, Miss tasks

Medical diagnosis is the process of determining which disease or condition explains a person's symptoms and signs. It is most often referred to as diagnosis with the medical context being implicit. The information required for diagnosis is typically collected from a history and physical examination of the person seeking medical care. Often, one or more diagnostic procedures, such as medical tests, are also done during the process. Sometimes posthumous diagnosis is considered a kind of medical diagnosis.

Diagnosis is often challenging, because many signs and symptoms are nonspecific. For example, redness of the skin (erythema), by itself, is a sign of many disorders and thus does not tell the healthcare professional what is wrong. Thus differential diagnosis, in which several possible explanations are compared and contrasted, must be performed. This involves the correlation of various pieces of information followed by the recognition and differentiation of patterns. Occasionally the process is made easy by a sign or symptom (or a group of several) that is pathognomonic. Diagnosis is a major component of the procedure of a doctor's visit. From the point of view of statistics, the diagnostic procedure involves classification tests.

Consider two approaches to the definition of Miss. In the broadest sense, under the medical information system understand the form of organization of activities in medicine and healthcare, which unites medicals, and mathematicians, engineers, technicians with a complex of technical means and provides collection, storage, processing and issuance of medical information of various profiles in the process. solving certain tasks of medicine and health [1].

In the narrow sense, the medical information system is called a complex of technical means and mathematical provision, intended for collection, analysis of medical and biological information and issuance of results in a user-friendly.

The creation of a medical information system pursues several purposes:

• improving the quality of medical workers' activity and. health care institutions;

• by organizing the perfect (corresponds to the level of technical means) of the processing of medical information, including by improving management and planning processes;

• facilitation of medical workers, elimination of labor-intensive and low-efficient manual processes and analysis of medical data;

• ensuring effective exchange of information with other information systems.

Most common tasks in clinical facilities:

• objectification of interpretation of research results (according to some data, falsely positive or mistakenly negative, clinically insufficient or misinterpreted results of X-ray, electrocardiological and laboratory studies lead in 31% of cases to false diagnosis);

• automation of information processing at the stage of preliminary work of medical staff to determine the diagnosis and development of treatment tactics;

• automation of laboratory studies: biochemical, electrophysiological, X-ray radiological and others;

• creation of data (banks) databases: accumulation of information about each patient for further analysis of the material, the organization of processing of this information with relevant mathematical support (including systems for managing databases - DBMS);

• creation of knowledge bases: accumulation of expert knowledge in the field of medicine and health required for the development of expert diagnostics, treatment and rehabilitation, promotion, examination, planning and management;

• organize the flow of information within the institution (the task of organizational management, tasks of personnel, logistics, statistical reports, assessment of activities of hospitals by some in-depth indicators, etc.) [2].

Almost all of the listed tasks can be effectively solved with the use of expert systems - one of the progressive directions of modern computer technologies, which is substantially based on the idea of creating artificial intelligence (AI).

A diagnosis, in the sense of diagnostic procedure, can be regarded as an attempt at classification of an individual's condition into separate and distinct categories that allow medical decisions about treatment and prognosis to be made. Subsequently, a diagnostic opinion is often described in terms of a disease or other condition. (In the case of a wrong diagnosis, however, the individual's actual disease or condition is not the same as the individual's diagnosis.)

A diagnostic procedure may be performed by various healthcare professionals such as a dentist, podiatrist, optometrist, nurse ractitioner, healthcare scientist or physician assistant.

A diagnostic procedure (as well as the opinion reached thereby) does not necessarily involve elucidation of the etiology of the diseases or conditions of interest, that is, what caused the disease or condition. Such elucidation can be useful to optimize treatment, further specify the prognosis or prevent recurrence of the disease or condition in the future.

The initial task is to detect a medical indication to perform a diagnostic procedure. Indications include:

- Detection of any deviation from what is known to be normal, such as can be described in terms of, for example, anatomy (the structure of the human body), physiology (how the body works), pathology (what can go wrong with the anatomy and physiology), psychology (thought and behavior) and human homeostasis (regarding mechanisms to keep body systems in balance). Knowledge of what is normal and measuring of the patient's current condition against those norms can assist in determining the patient's particular departure from homeostasis and the degree of departure, which in turn can assist in quantifying the indication for further diagnostic processing.
- A complaint expressed by a patient.
- The fact that a patient has sought a diagnostician can itself be an indication to perform a diagnostic procedure. For example, in a doctor's visit, the physician may already start performing a diagnostic procedure by watching the gait of the patient from the waiting room to the doctor's office even before she or he has started to present any complaints.

Even during an already ongoing diagnostic procedure, there can be an indication to perform another, separate, diagnostic procedure for another, potentially concomitant, disease or condition. This may occur as a result of an incidental finding of a sign unrelated to the parameter of interest, such as can occur in comprehensive tests such as radiological studies like magnetic resonance imaging or blood test panels that also include blood tests that are not relevant for the ongoing diagnosis.

2.Classification of Miss

The classification of Miss is carried out using various classification signs. Depending on the degree of automation of the processes of collecting and processing information, Miss are divided into automated and automatic. In automated systems, part of operations for collecting and processing information is performed by a person. Automatic systems involve a complete exclusion of a person from the processes of collecting and processing information.

Depending on the type of information base, Miss are divided into systems that operate with data and knowledge. The second type systems are called expert systems - firstly, their functioning is essentially based on knowledge received from experts, and secondly, their results. Functioning in a well-known sense are close results of functioning of experts [3].

Depending on the type of decreased tasks, Miss can be divided into three groups:

• Information reference - automated search systems, measuring systems;

• Information and logical diagnostic systems that are predictive, monitoring systems (monitoring systems);

• Management - automated control systems.

Table 15.

Differential diagnosis of hemorrhagic and ischemic stroke (for Mysyuk N.S.)

Signs	Stroke hemorrhagic	Stroke ischemic
Holders	Is less characteristic	Characteristic
Sudden development	Characteristic	Is less characteristic
Slow development	Uncharacterially	Characteristic
Loss of consciousness	Characteristic	Is less characteristic
Pallor face	Uncharacterially	Characteristic
Hyperemia	Characteristic	Uncharacterially
Arterial hypotension	Uncharacterially	Characteristic
Arterial hypertension	Characteristic	Uncharacterially
Hyperthermia	Characteristic	Uncharacterially
Meningism	Characteristic	Uncharacterially
Blood in Liquor	Characteristic	Uncharacterially
Blood in Liquor is not	Uncharacterially	Characteristic

Information information system is capable of making certain conversion of information and form a reference document. The information logical system is intended to convert information stored in its memory in such a way that you can get new information. In management systems, a fundamentally new function is implemented - the development of control impacts. The most widespread in medical institutions received information and search engines (STIs), which, depending on the nature of the information stored, are divided into documentary and factual. Using this kind of tables can be formed, so-called, "medical memory" - a table, where in the columns indicates the name of the disease, in the rows - the name of the symptoms, and at the intersection site - the value of the frequency of birth of this symptom in this disease (an example of such a Medical memory can serve as a table 15.

There are Ts.Factographic SHS contain information arrays of actual data. Analogues of such systems are "paper" directories, catalogs, technical passports. In computer nose actual data usually. Stored in databases (databases) and are tables, in columns of which are listed different characteristics of objects, and in rows, descriptions (values of characteristics) of these objects are listed.

Documentary STIs operate information in the form of documents - Examples of such systems may be a bibliographic card station, cardboard and paintings / other card indexes. By performing a search, documentary IPS issues. or documents numbers or their headers or addresses of finding the desired documents. In this case, the assessment of the information contained in the documents found gives a person [4].

Diagnostic, systems to a certain extent are reminiscent of the IPS, they can be considered as "complex" IPSs that solve complex "(in terms of mathematical processing of information) of the diagnostic problem - the search for the name of the predicted disease according to the given names of the observed symptoms. Diagnostic systems are usually built in such a way that the computer puts forward a number of plausible diagnostic variants: the task of a doctor - choose the correct diagnosis. Computational diagnostics This involves the exclusion of a doctor from the field of diagnostic activity, its main task - the creation of new, more accurate and perfect methods for deciding on the basis of mathematical methods and computing.

To a collection and processing of information to a certain extent, an IPS, information and measuring and diagnostic systems can be used, and in this sense, they are an integral part of control systems [5]. Managing systems implement the collection of information about the management object, information processing, data transmission to the management body, the formation of a control decision, the issuance of control impact on the control object. To a collection and processing of information to a certain extent, IPSs, information and diagnostic systems can be used - in this sense, they are an integral part of control systems.

The method of differential diagnosis is based on finding as many candidate diseases or conditions as possible that can possibly cause the signs or symptoms, followed by a process of elimination or at least of rendering the entries more or less probable by further medical tests and other processing, aiming to reach the point where only one candidate disease or condition remains as probable. The final result may also remain a list of possible conditions, ranked in order of probability or severity. Such a list is often generated by computer-aided diagnosis systems.

The resultant diagnostic opinion by this method can be regarded more or less as a diagnosis of exclusion. Even if it does not result in a single probable disease or condition, it can at least rule out any imminently life-threatening conditions.
Unless the provider is certain of the condition present, further medical tests, such as medical imaging, are performed or scheduled in part to confirm or disprove the diagnosis but also to document the patient's status and keep the patient's medical history up to date. If unexpected findings are made during this process, the initial hypothesis may be ruled out and the provider must then consider other hypotheses.

3. Principles of Miss Development

Development of Miss - Complex work of specialists in the field of medicine and health, system engineering and computer technology. In this case, different groups of specialists perform various functions.

The functions of medicine and health specialists include [6]:

- wording of the goal (goals) and basic tasks of the system;

• Development of the nomenclature of methods of treatment, diagnoses, complications, signs (indicators), research methods

• development of information models (model of illness, institution, network of medical and prophylactic institutions);

• determination of system information streams;

• creation of standardized documents.

The development of any medical information system should rely on some of the principles of building systems in general (the study and formulation of these principles is carried out by system engineering, which is also referred to as "the theory of large systems", "the theory of complex systems").

The principle of formulating the objective of the system is that the purpose of the construction and use of a particular system must be clearly formulated, the entire sequence of tasks and conditions that will lead to the achievement of the goal. The principle of new tasks is that most of the new tasks that are solved by the system would be fundamentally impracticable or ineffective when solving without miss. Following this principle, the development of Miss should lead to an increase in the effectiveness of solving the task.

The principle of a comprehensive (systemic) approach involves a thorough harmonization of solved tasks and a set of technical means. Components of Miss must satisfy a certain set of requirements (accuracy of equipment, methods for presenting data, types of computing devices, etc.) that provide the most rational solution to tasks. The principle of typing of design decisions is to use a positive experience accumulated in developing analogues that have been successful by practice. The principle of continuous development of the system means that in the Miss project, the possibilities of modernization of the system should be provided in order to increase its efficiency. The principle of automation of document circulation involves the use of unified documents - standardized illness history, conclusions. Compliance with this principle sharply increases the efficiency of the system, facilitates the implementation of non-automated manual operations remaining, data collection.

The principle of a single and flexible information base implies the effectiveness of operating data stored in information arrays - this principle is implemented using databases and mathematical provision, which allows to effectively operate these bases (DBBD). The principle of completion of tasks and workers, programs is implemented by creating packages of applications (PPPs) that combine tasks for basic solutions and interdependent information. The principle of resource savings in the introduction, storage and output means means that these operations must be organized in such a way as to minimize the time and efforts of the service personnel on their implementation.

The organization of information is substantially used in Miss who solve the issue of information received from various information channels. As an example, we can give widespread miss monitoring, designed to work in dialogue with medical staff serving intensive care chambers, surgical operating and resuscitation blocks. Such Miss are the bedside monitors that work autonomously or in a complex with a central post of nurses that have a display and a special recorder for printout information and implement the following features:

• control over the state of patients in several dozen chambers;
• the possibility of introducing information to the history of the disease;
• Control over the state of ECG, blood pressure, respiration, temperature, electroencephalogram.

A variety of systems of this kind is a microprocessor domestic and remote monitoring system, a key link of which is "Electronic Combine" - a specialized computer that occupies an intermediate place in functional capabilities between well-known telephone (AVN) and personal computers.

Table 16.

Characteristics of features

Name of signs	Discriminant coefficients	Significance of signs	Diagnostic indices
X1	***a*** i	X11 X12 X13 …	*A1X1*1 *A 1 X 1 2* ***a₁x*** 13
X2	***a₂***	X21 X22 …	a2 X21 a 2 X22 …
			$Z=\sum a_i x_i$

$$a_i=\frac{Xi(Y1)-xi(Y2)}{\delta 2},$$

where
$X_i(Y_1)$ - is the conditional average value of the symptom X, in the disease Y_2
δ^2 - total dispersion of the symptom X_i with both diseases.

4. Systems of artificial intelligence in medicine

The formation of the industries of intellectual systems at the end of-70s, the early 80s is due to [7]: • successes in the field of computer technologies, which led to the massive implementation of computing machines and robots in solving designing and management tasks; • a high level of competition in the development of computer technologies.

Successes in the field of computer technology are well known - the embodiment can serve them; Mass-twisting small over dimensions, inexpensive and together with. the rather powerful desktop and portable computers.

The rapid development of the market of personal computers has led to a high level of competition not only between individual manufacturers, but also between national development programs. The initiator was a fifth generation computer program, followed by a strategic computer program of the United States (1983), National Programs of England, France, Germany, Interstate Western European project ESPRIT. The countries of the social system also adopted a comprehensive program scientifically: the technical progress of the member countries by 2000, one of the priority positions of which was the creation of a new generation super-computer with a speed of more than 10 billion operations per second using the principles of artificial intelligence.

The NanoZoomer Series is a family of whole slide scanners that convert glass slides into high-resolution digital data by high-speed scanning.

The NanoZoomer comes with a variety of functions such as image acquisition of fluorescence samples and multilayer acquisition. Scanned data can be viewed on a PC monitor by using the dedicated viewer software, and patented navigation map technique* delivers slide viewing environment just as if operating a microscope.

Following products are CE marked under EU's In Vitro Diagnostics Directive (IVDD) for in vitro diagnostic use:
NanoZoomer S360, NanoZoomer S210, NanoZoomer S60, NanoZoomer-SQ including optional software e.g. NDP.view2 (U12388-21), NDP.view2 plus (U12388-22) and NDP.serve3 software (U13173-21, -22, -23).

In China, following products are registered for in vitro diagnostic use: NanoZoomer S360, NanoZoomer S210, NanoZoomer S60 and NanoZoomer-SQ.

In Canada, NanoZoomer S360 (C13220-31) has Medical Device License (License № 97957).

In Russia, following products are registered as medical device: NanoZoomer S360, NanoZoomer S210, NanoZoomer S60 and NanoZoomer-SQ.

In Israel, following products are registered as medical device: NanoZoomer S360, NanoZoomer S210, NanoZoomer S60 and NanoZoomer-SQ.

In the US, Japan and other countries, NanoZoomer is for research use only and is not permitted to use for clinical diagnostic purposes.

Features:

Scanning speed 20× mode (15 mm × 15 mm): approx. 30 s
Scanning speed 40× mode (15 mm × 15 mm): approx. 30 s
Max. 360 slides.

FDSS/µCELL Functional Drug Screening System: C13299

Compact body
Simple-to-use operation
Compact and low cost drug screening system for laboratory use. It accommodates 384 and 96 microplates with simultaneous dispensing.

FDSS7000EX Functional Drug Screening System

HTS
Cell-based assay
Drug screening system for HTS cell-based assay that use microplates of 1536, 384 and 96. It analyzes kinetics of various cells such as floating and attached.
Drug screening system
The FDSS (Functional Drug Screening System) series are designed for cell-based assays in the drug discovery field.

Immunochromato Reader (Lateral flow reader)

The Immunochromato Reader (Lateral flow reader) quickly and quantitatively measures the color intensities of red, blue and fluorescence based immunochromatographic lateral flow reagents. It is an optimal tool for research and development work and quality control of lateral flow reagent kits.

Interfaces between automated systems are at times as important as the man-machine interface. Fundamental questions, such as the definition of diseases and of findings, limit our ability to combine data from the literature, from clinical databanks, from hospital information systems, and from individual experts' experiences in order to create MDDS systems. Similar problems exist when trying to match the records from a given case (collected manually or taken from an electronic medical record) with a computer-based diagnostic system. A diagnostic system may embody definitions for patient descriptors that differ from those of the physician who evaluated the patient, even though the words used may be identical [8].

Conclusion

It is relatively safe to predict that specialized focused MDDS systems will proliferate, and a sizable number of them will find widespread application. As new medical devices are developed and older devices automated, MDDS software that enhances the performance of the device, or that helps users to interpret the output, of the device, will become essential. Computerized ECG analysis, automated arterial blood gas nterpretation, automated protein electrophoresis reports, and automated differential blood cell counters are but a few examples of such success at the present time.

In summary, the future of MDDS systems appears to be bright. The number of researchers in the field is growing. The diversity of MDDS systems is increasing. The number of commercial enterprises interested in MDDS systems is expanding. Rapid improvements in computer technology continue to be made. A growing demand for cost-effective clinical information management and the desire for better health care are sweeping the Ukraine . All these factors will ensure that new and productive MDDS applications be developed, evaluated, and used.

REFERENCES

1. Medical Diagnostic Systems – NIST. URL: www.nist.gov › document
2. Medical diagnostic decision support systems--past, present ... URL: www.ncbi.nlm.nih.gov
3. Reichertz P. Diagnostik und Automation. Med Monatsschr. 1965 Aug;19(8): 344–347.
4. Buck CR, Jr, Reese GR, Lindberg DA. A general technique for computer processing of coded patient diagnoses. Mo Med. 1966 Apr;63(4):276–passim.
5. Slack WV, Hicks GP, Reed CE, Van Cura LJ. A computer-based medical-history system. N Engl J Med. 1966 Jan 27;274(4):194–198.
6. Gremy F, Joly H. Le problème de l'aide diagnostique par les calculateurs électroniques. Rev Fr Etud Clin Biol. 1967 Apr;12(4):322–329.
7. Gorry GA, Barnett GO. Experience with a model of sequential diagnosis. Comput Biomed Res. 1968 May;1(5):490–507.
8. Masarie FE Jr, Miller RA, Bouhaddou O, Giuse NB, Warner HR. An interlingua for electronic interchange of medical information: using frames to map between clinical vocabularies. Comput Biomed Res. 1991;24: 379-400.

4.2. Labour and Social Protection problems in circumstances of Artificial Intelligence's growing into Public Healthcare Sector

Viktoriia Viennikova
Research Assistant of Labour Law Department
Yaroslav Mydrui National Law University
E-mail: viktoryven@gmail.com
ORCID ID 0000-0003-1925-8127

Ilya Kolosov
Philosophy Doctor in Law,
Lawyer of Private Entity "Kolosov V.A."
E-mail: kolosov07121987@mail.ru
ORCID ID 0000-0002-8856-9634

Introduction and Aims. Last decades attested that research interested in field of IT and hi-tech increasingly grows which effected by impact of these phenomena on routine and social development. However, ethic and academic responsibilities lead to properly investigation whether or not Intelligence progress affects on Human activities consequently results unemployment, social uninsured, instability and so on and so forth.

Contemporary computers and Artificial Intelligence were started since 1950-th from Alan Turing's contribution. The "Turing test" was based on the fact that the intelligent behavior of a computer is the ability to achieve human level performance in cognition related tasks [1]. Consequently puts forward the problem of human's cognition "acceptance" and "value" in compare with "perfect" Artificial Intelligence. Nevertheless, the problems of evaluation, feels, emotions et cetera provoke the philosophy's discussion about their coexistence and furthermore development. Peculiarly significance aforesaid discussion has become in field of Public Healthcare Sector, i.e. this one related closely with Insurance for the Poor and Near Poor and other mandatory contributory schemes, a tax-funded health care fee-waiver programmes, considered as a social assistance programme for households.

Over the last decade, research on aforesaid field has increasingly demonstrated the need of summarizing essential scientific doctrine and systematization knowledge obtained from variety of world countries, Public Healthcare Sector improved by AI-intervention with consequently social risks. Phenomenon of Artificial Intelligence's impact on social ethics and stability has been explored by many researches. Notwithstanding, proposed paragraph targeted to explanation of labour and social protection law problems and disadvantages appeared and ways of their overcome.

Methods. Proposed paper has contributed in acknowledgement to formal and compares methods as special and deduction, analysis ad synthesis as common, which led to obtain a new data and background for discussion and further investigations from contemporary scientific viewpoint. Furthermore references were obtained by cross-referencing the key articles in field researched.

Results & Discussion. Dzobo, Adotey et al. constituted that historically, the term "artificial intelligence" dates to 1956 when it was first used in a conference at Dartmouth College in the US. Since then, the development of artificial intelligence has in part been shaped by the field of neuroscience. By understanding the human brain, scientists have attempted to build new intelligent machines capable of performing complex tasks akin to humans. Indeed, future research into artificial intelligence will continue to benefit from the study of the human brain. While the development of artificial intelligence algorithms has been fast paced, the actual use of most artificial intelligence (AI) algorithms in biomedical engineering and clinical practice is still markedly below its conceivably broader potentials. This is partly because for any algorithm to be incorporated into existing workflows it has to stand the test of scientific validation, clinical and personal utility, application context, and is equitable as well. In this context, there is much to be gained by combining AI and human intelligence (HI) [2].

Ramesh et al. maintained that the proficiency of artificial intelligent techniques has been explored in almost every field of medicine. Artificial neural network was the most commonly used analytical tool whilst other artificial intelligent techniques such as fuzzy expert systems, evolutionary computation and hybrid intelligent systems have all been used in different clinical settings [3].

Sniecinski and Seghatchian argue that Artificial Intelligence (AI) reflects the intelligence exhibited by machines and software. It is a highly desirable academic field of many current fields of studies. Leading AI researchers describe the field as "the study and design of intelligent agents". McCarthy invented this term in 1955 and defined it as "the science and engineering of making intelligent machines". The central goals of AI research are reasoning, knowledge, planning, learning, natural language processing (communication), perception and the ability to move and manipulate objects. In fact the multidisplinary AI field is considered to be rather interdisciplinary covering numerous number of sciences and professions, including computer science, psychology, linguistics, philosophy and neurosciences. The field was founded on the claim that a central intellectual property of humans, intelligence-the sapience of Homo Sapiens "can be so precisely described that a machine can be made to simulate it". This raises philosophical issues about the nature of the mind and the ethics of creating artificial beings endowed with human-like intelligence. Artificial Intelligence has been the subject of tremendous optimism but has also suffered stunning setbacks [4].

Amisha, Malik et al. with reference to Mintz, Brodie, Hamlet, Tremblay, Clark et al. discussed that AI is growing into the public health sector and is going to have a major impact on every aspect of primary care. AI-enabled computer applications will help primary care physicians to better identify patients who require extra attention and provide personalized protocols for each individual. Primary care physicians can use AI to take their notes, analyze their discussions with patients, and enter required information directly into EHR systems. These applications will collect and analyze patient data and present it to primary care physicians alongside insight into patient's medical needs.

Scholars presented, that a study conducted in 2016 found that physicians spent 27% of their office day on direct clinical face time with their patients and spent 49,2% of their office day on electronic hospital records and desk work. When in the examination room with patients, physicians spent 52,9% of their time on EHR and other work. In conclusion, the physicians who used documentation support such as dictation assistance or medical scribe services engaged in more direct face time with patients than those who did not use these services. In addition, increased AI usage in medicine not only reduces manual labor and frees up the primary care physician's time but also increases productivity, precision, and efficacy.

From author’s opinion, searching and developing pharmaceutical agents against a specific disease via clinical trials take years and cost a gazillion dollars. To quote a recent example, AI was used to screen existing medications, which could be used to fight against the emerging Ebola virus menace which would have taken years to process otherwise. With the help of AI, we would be able to embrace the new concept of “precision medicine.”

Authors argued that some studies have been documented where AI systems were able to outperform dermatologists in correctly classifying suspicious skin lesions. This because AI systems can learn more from successive cases and can be exposed to multiple cases within minutes, which far outnumber the cases a clinician could evaluate in one mortal lifetime. AI-based decision-making approaches bring used in situations where experts often disagree, such as identifying pulmonary tuberculosis on chest radiographs.

This new era of AI-augmented practice, in respect to author's opinion, has an equal number of skeptics as proponents. The increased utilization of technology has reduced the number of job opportunities, which many doctors in the making and practicing doctors are concerned about. Analytically and logically machines may be able to translate human behavior, but certain human traits such as critical thinking, interpersonal and communication skills, emotional intelligence, and creativity cannot be honed by the machines.

Authors showed, that in 2016, the Digital Mammography DREAM Challenge was done where several networks of computers were connected, and the goal was to establish an AI-based algorithm by reviewing 640,000 digital mammograms. The best which was achieved was a specificity of 0.81, sensitivity of 0.80, area under receiver operator curve was 0.87, which is roughly approximated to bottom 10% radiologists. In conclusion, AI has potential, but it is unlikely that AI will replace doctors out rightly. AI would be an integral part of medicine in the future. Hence, it is important to train the new generation of medical trainees regarding the concepts and applicability of AI and how to function efficiently in a workspace alongside machines for better productivity along with cultivating soft skills like empathy in them.

Scholars constituted that AI-importance determined primary care physicians get well versed with the future AI advances and the new unknown territory the world of medicine is heading toward. The goal should be to strike a delicate mutually beneficial balance between effective use of automation and AI and the human strengths and judgment of trained primary care physicians. This is essential because AI completely replacing humans in the field of medicine is a concern which might otherwise hamper the benefits which can be derived from it [5].

Gómez-González provided implication that ethical and social aspects to be considered for the analysis of Artificial Intelligence and AI-mediated applications in Medicine and Healthcare are summarized. They can be considered as divided into three partially overlapping sets (Groups G1, G2 and G3).

The First Group (G1) includes topics currently under analysis, as raised by other areas of prior development of AI applications (e.g. social networks, online commerce, automation in factories, autonomous vehicles), such as:

— Data privacy, integrity and anonymity, legal responsibility and accountability, and other general aspects of the relationship of humans with (at least partially autonomous) machines [see also Second Group G2].

— The effects on medical professionals and on their relationships to both patients and employers, quality control and monitoring of workers. These effects include the need for professional updates, training and qualification, and the effects on employment (lost jobs, new jobs, deep changes in some medical specialties, the risk that some of them may even disappear).

— Security and reliability.

— Metrics of performance, improved health outcomes and clinical pathways, reduction of medical errors, personalized medicine and psychosocial outcomes. It is important to note that current AI systems are good – even outperforming humans – at ‘narrow’, specific tasks (e.g. locating certain elements or patterns in images) while (still) failing in global, overview analysis.

— The existence of a ‘human-in-the-loop’ with or without the ability to override the system, and the questions that arise if there is no time/possibility for human intervention in a critical – even life or death – situation.

The Second Group (G2) includes topics – some of which may also be under analysis in other areas – of particular relevance for Medicine and Healthcare, such as:

— Explainability and interpretability of the systems. These concepts refer to being able to explain the ‘reasoning process’ of AI systems to a human operator. It is currently required by legislation but the evolution of AI technology leads to systems too complex to be understood by a human. Since they may give better results than humans (at least, in certain tasks), should we accept the results given by AI systems without being able to understand how they (‘the machines’) came to them?

— Trust and reliability. If ‘a machine’ performs better than a human, what to do when they give conflicting opinions?

— Data quality. The generation of suitable databases and repositories of medical data and information for learning and development of AI systems.

— Data security. The social impact of malicious data alterations can be particularly severe since certain health issues (e.g. toxic consumption history, genetic disposition to diseases) may be manipulated to blackmail or discredit individuals and groups, for instance in processes related to employment and profiling.

Moreover, AI applications in Medicine and Healthcare author define a business environment in which economic figures roar to the order of millions, making them a desirable target for illicit, adversarial attacks. As in any other computer services, there are risks of hacking and data theft but, in addition, those of malicious manipulation of the algorithms and data used to train the systems. Alterations in how a system learns may produce changes in diagnosis and prescriptions, affecting billing and insurances, and even ‘small’ changes on images and data sets can alter such important outcomes as the benignancy or malignancy of lesions.

Author provided implication, that inserting or removing only a ‘critical’ element in an image (e.g. a malignant nodule, a crack in a bone) requires only a few pixels and it is much easier to make than already existing ‘fake’ photographs and videos. Such manipulations can be used in many malicious applications, from fraud to insurances to massive sabotage of diagnostic processes.

— Additionally, increased security risks appear when 'physical devices' are involved, such as companion robots assisting persons with disabilities or the elderly, or surgical robotic systems.

— Bias and fairness: Do AI systems have biases or are they fair with different (e.g. ethnic, gender, age) groups in diagnosis, prognosis and treatments? Do they receive proper, balanced data for training? Are results valid?

— The social impact of 'erroneous data for learning' can be very high. System may not give any warning but processing results may be incorrect.

— Empathy, including shared decisions and ('the machines') helping humans to make difficult decisions.

— Citizen (taxpayer) opinion and involvement in a 'patient-centric' model. Questions include the common-good in public-funded research, informed consent, citizen science, the 'reduced asymmetry' in information between the patient and the doctor, and citizen-generated (genetic, etc.) tests without a doctor prescribing them and analyzing their results.

— Test, benchmarking. There is a clear need for updated testing and evaluation procedures. This is a key issue in which relevant changes are required.

— Regulation, and the legal aspects related to liability and malfunction. There are no (updated, international) regulatory standard for most types of AI applications. Who is legally accountable if the system fails? The 'original' human designer? The programmer? The person who provided the training cases for the AI system to learn? The physician/human operator who used the system? The AI system itself?

— Affordability and socio-economic impact. Global figures and market of AI in Medicine and Healthcare forecast very relevant, positive impact for the coming years. However, the economic analysis must include the social points related to health systems, the industries and the patients, as such technologies also risk evolving into a significant factor of inequality.

— Information for the public and professionals about the real efficacy of AI-mediated treatments and clinical tools, especially against severe diseases of deep social interest – such as cancer – as compared to the many 'announcements' of 'spectacular (initial) results' which, are not later proven to be particularly useful in routine clinical use.

— The availability of trustworthy, open-access information – warranted by public services – is essential to reduce the risks of 'fake-based' medicine and to protect citizens from 'digital health scammers',

— and, of course, as related to the issue of human-in-the-loop, the question of whether (or not) harnessing AI systems under human control on life and death decisions. Should we allow 'a machine' to take such decisions (on us, on a relative)? To this point, it should be considered that there is an ongoing (although partially silent) social debate – even at a 2019 Meeting in the United Nations – about the development of other types of machines with the ability to make decisions with regards to human life, the already mentioned lethal autonomous weapons systems (LAWS). Their objectives are clearly the opposite of medical devices, and the popular name of ‘killer robots’ prevent them from being included in medical literature, but the fundamental idea to discuss is the same: will ‘a machine’ take the ultimate decision to keep or end a human life?

The Third Group (G3) includes certain aspects barely -or not included at all in analysis of AI applications in Medicine and Healthcare, such as:

— Humanization of care, allowing for more time with the patient that improves clinical outcomes and relieves high stress levels (burnout, suicide rates) of physicians. However, AI systems still lack the (much needed) ability of a physical (contact) examination of the patient.

— Social engineering, profiling based on merged medical, health and social data. This issue questions the use of such merged information for the preventive detection of events of clinical significance (e.g. suicide) and for commercial uses (e.g. tailored marketing, insurance, health care coverage or employment). A significant topic is the potential genetic screening of (the whole, groups of) population (detailed below).

— The availability of (unsupervised, unreliable) multiple data, genetic tests for anyone, with the risk of ‘patient-generated’ medicine.

— Limits to data use? Post-mortem data inheritance? Should there be any limit to the use of very personal information (e.g. from Extended Personalized Medicine)? What happens when a person dies? Should personal data (e.g. genetic data) remain available for use by AI systems? Should there be a post-mortem limit? Can personal (medical, biological) data be inherited? By a relative or by a public institution? For commercial use? What happens if data are of high scientific value (e.g. belonging to a person with a rare disease)? Or with the potential of being directly used to treat a disease?

— The expanding availability of crowd-sourcing of algorithms and processing power. The free sharing of expertise, know-how, and experience define a debate of ‘solidarity’ vs risks of malicious use.

— Reading and decoding brain signals. The hope for the severely impaired may be turned into ‘mind reading’ technologies challenging privacy at its basics.

— Interactions with neural processes, which can be applied to help in neurological, mental diseases and, potentially, to interfere with free will.

— Gene editing as an enabler for self-experimentation in humans, with the risk of unexpected results and the potential for change of the genetic heritage.

— Gene editing ‘to design’ humans and human-animal embryos. With the (already documented) risk of unexpected results in newborns and the unknowns derived from the creation of new types of human-animal beings (‘chimera’).

— The two sides of technology. With the (relatively) easy weaponization of many of the mentioned AI and AI-mediated technologies and the corresponding high risk of bioterrorism.

— Whole-brain computerized emulation and 'head transplant', challenging the quest for immortality and the very definition of life.

— The search for artificial life forms (explicitly declared for military purposes), questioning the definitions of life (natural, artificial) and death.

— The balance of benefits versus risks and pitfalls and the very fundamental question of whether there should be (or not) limits to research and development? Many AI systems and AI-mediated applications show an intrinsic 'mix' of positive, negative, and controversial aspects depending on their specific implementations, and that, according to published information, their readiness levels vary from commercially available to very early, conceptual designs. The scientific and ethical criteria for the analysis of AI applications in Medicine and Healthcare also need a thorough review and updating. Current approach to test medical products and drugs is based on randomized, controlled trials on large sets of cases in which statistically significant changes are evaluated. However, the new paradigm of Personalized Medicine tailors diagnosis and treatments of very specific features - on a genetic level- of each individual. Innovative procedures should be developed to allow for valid evaluation processes within affordable limits of time and costs, and many questions arise:

— How can those treatments be rigorously tested? Which are the time and cost required to find 'enough cases' to 'generate scientific evidence'?

— How should AI systems be benchmarked? Should they be compared to a (possibly error-prone) human doctor or 'against' another 'machine'?

— Should there always be the possibility of a human-in-the-loop with the ability to override the AI system? Even if the human makes more errors than machines (in certain tasks)? Bottom-line of this set of considerations is that regulations and legislation clearly lag the technology, and that both technical and ethical debates should take place. Common ethical guidelines for the evaluation of technologies mostly date from the pre-digital era. Nowadays, which should be the figures of merit to consider? How should they be updated? Which are the roles of the public and the policy makers?

In general, scholar argued, that there are many publications and studies about the technical features of AI systems in Medicine and Health, their (increasing) performance figures and metrics, and comparisons to human users and operators. The incorporation of AI-based technologies into the medical practice will produce substantial changes in (all) areas of Medicine and Healthcare, from the medical, scientific and technical grounds to workflow, clinical pathways and management, and to the relationship with the patients and the health systems and providers. Certain medical specialties, particularly those related to image and data analysis and interpretation (e.g. Radiology, Pathology, Dermatology, and the different branches of Surgery, Forensics, Epidemiology, Public Health and others), will experience profound transformations (some of which have already started) due to the adoption of new tools with expanding capabilities and increasing autonomy. There are (professional) voices in the debate arguing that some specialties will even disappear and jobs will be lost. Other jobs (e.g. related to genetic counseling, medical data scientists and engineers) will arise. Initial (technical) results in certain areas of application (diagnosis, surgical robotics, precision medicine) are not as spectacular as predicted, some of them even really disappointing and contradictory to the previous public announcements. Nevertheless, technology is advancing, technical challenges are being addressed, and systems improved.

Author estimates, that very significant changes are happening in the role of the individuals in relation to their Healthcare and, particularly, in the relationship between the patient and the doctor in Medicine. These changes can be seen as an evolution to new paradigms of 'individual involvement' in health care and of 'patient empowerment' in medicine, and this evolution is fostered by AI and AI-mediated technologies through three main aspects:

— The availability of online information, evolving from disperse, unstructured descriptions of symptoms and medicaments to interactive platforms offering healthcare advice to diagnosis and even schemes for disease treatment, and of personal biometric and physiological data from sensors and IoT devices.

— The easy connections to a multitude of individuals or groups of persons with similar interests, diseases or treatments, all across the globe, in any language.

— The increasing access to the individual's genetic data without the need of a physician ordering such analysis. Only a drop of saliva and prices on the order of a hundred euros are required to have your own genome (at least partially) analyzed and searched for alterations which are potentially related to diseases. The evolution of individual behavior in relation to Medicine and Health Care presents a novel array of many advantages, pitfalls and un-addressed concerns. The overall access to many types of data has an important effect in the relationship between the patient and the doctor, namely the reduction of the 'asymmetry in information' between them and the evolution towards a 'patient-centric' model. This new situation started with the generalized availability of information on online platforms of the internet and it has evolved with AI technologies for data mining and advanced – easier – user interaction. Suddenly, patients could ask 'the Google Doctor' about anything, from symptoms to the 22 side effects of treatments to advices for healthy lifestyle and then visit the real physician's office with a list of 'informed' questions, requests and even complaints. Anyone can even have a (digital) 'personal medical coach'.

In the following years, it has become evident that there is no 'a priory' guarantee of the quality – even of the certainty – of the information found on internet searches. Very valuable resources can be mixed with completely erroneous – even maliciously misleading – material and a certain level of knowledge is required to find and understand the information of real interest for any case. In addition, to evaluate the clinical situation of a patient and potential treatment options there is also a clear need of the 'integrated analysis', of the 'global vision' provided by a qualified, trained, real doctor. The evolution of technology has expanded AI systems, starting from 'basic' – but very effective – symptom checkers to increasingly autonomous 'digital doctors'.

Reporter provides a detailed state of the art of the current and near-future applications of Artificial Intelligence in Medicine and Healthcare. From these provisions, the author proposes a categorization of these application in terms of their potential benefits, risks, and availability level. Additionally, it also presents the emerging social debate on some related topics, and analyses the ethical and social impact of these technologies and the way they may change human behavior, transforming the roles of doctors and patients [6].

Briganti and Monie, with reference to authors' implications, maintained that one of the core challenges of the application of AI in medicine in the next years will be the clinical validation of the core concepts and tools recently developed. Although many studies have already introduced the utility of AI with clear opportunities based on promising results, several well recognized and frequently reported limitations of AI studies are likely to complicate such validation. We will hereby address three of such limitations, as well as provide possible ways to overcome them.

Firstly, the majority of studies comparing efficiency of AI vs. clinicians are found to have unreliable design and known to lack primary replication, i.e., the validation of the algorithms developed in samples coming from other sources than the one used to train algorithms. This difficulty could be overcome in the open science era as open data and open methods are bound to receive more and more attention as best practices in research. However, transitioning to open science could prove difficult for medical AI companies that develop software as a core business.

Secondary, studies reporting AI application in clinical practice are known to be limited because of retrospective designs and sample sizes; such designs potentially include selection and spectrum bias, i.e., models are developed to optimally fit a given data set (this phenomenon is also known as overfitting), but do not replicate the same results in other datasets. Continuous reevaluation and calibration after the adoption of algorithms that are suspected of overfitting should be necessary to adapt software to the fluctuation of patient demographics. Furthermore, there is a growing consensus as of the need of development of algorithms designed to fit larger communities while taking into account subgroups.

Thirdly, only few studies are known to compare AI and clinicians based on same data sets; even in that scenario, critiques have been made pointing at lower diagnostic accuracy rate than expected in specialty doctors. Opposing AI and clinicians is, although well represented in the scientific literature, probably not the best way to tackle the issue of performance in medical expertise: several studies are now approaching the interaction between clinicians and algorithms as the combination of human and artificial intelligence outperforms either alone.

Medical technology is one of the most promising markets of the 21st century, with an estimated market value rapidly approaching a thousand billion dollars in 2019. An increasing percentage of the revenue is due to the retail of medical devices (such as heart monitoring devices) to a younger population, which is not the primary target consumer profile (because health problems such as atrial fibrillation are less likely to appear). Because of this phenomenon, the Internet of Things (IoT) is redefining the concept of healthy individual as a combination of the quantified self (personal indicators coded in the Smartphone or wearable) and series of lifestyle wearable-provided parameters (activity monitoring, weight control, etc.).

Furthermore, in the last couple of years several wearable companies have been concluding important deals with either insurance companies or governments to organize a large-scale distribution of these products: this kind of initiatives is mainly aimed to induce lifestyle change in large populations. While western countries are continuing to evolve toward health systems centered on the patient's individual responsibility toward its own health and well-being, the ethical implications of ongoing medical monitoring with medical devices through the Internet of things are frequently discussed. For instance, ongoing monitoring and privacy violations have the potential to increase stigma around chronically ill or more disadvantaged citizens and possibly penalize those citizens that are unable to adopt new standards of healthy lifestyle, for instance by reducing access to health insurance and care; little to no debate has been focused on these potential and crucial pitfalls in health policy making.

In this techno-political framework, the issue of data protection and ownership becomes more and more crucial, although more than two decades old. Several attitudes toward data ownership are described in the literature: although some works argue for common ownership of patients data to profit personalized medicine approaches, consensus is shifting toward patient ownership, as it has positive effects on patient engagement as well as may improve information sharing if a data use agreement between the patient and healthcare professionals is developed.

Several universities have started to create new medical curriculum, including a doctor-engineering, to answer the need of educating future medical leaders to the challenges of artificial intelligence in medicine. Such curricula see a stronger approach to the hard sciences (such as physics and mathematics), and the addition of computational sciences, coding, algorithmics, and mechatronic engineering. These “augmented doctors” would count on both a clinical experience and digital expertise to solve modern health problems, participate in defining digital strategies for healthcare institutions, manage the digital transition, educate patients and peers.

Society as well as healthcare institutions could benefit from these professionals as a safety net for any processes including AI in medicine but also as a drive of innovation and research. Aside from basic medical education, there is a need for implementation of ongoing educational programs regarding digital medicine and targeting graduated physicians, so as to allow retraining in this growing field. In most cutting-edge hospitals around the world, such experts are charged with the mission of Chief Medical Information Officer (CMIO).

As reported by several studies, electronic health records can be an important administrative burden and a source of burnout, phenomenon increasingly present in physicians, both in training and trained. Although artificial intelligence solutions such as Natural Language Processing are becoming more and more capable of helping the physician deliver complete medical records, further solutions are needed to solve the issue of the increasing time allocated to indirect patient care.

Ambient clinical intelligence (ACI) is understood as a sensitive, adaptive and responsive digital environment surrounding the physician and the patient and capable of, for instance, analyzing the interview and automatically fill the patient's electronic health records. Several projects are underway to develop an ACI, which would be a crucial application of artificial intelligence in medicine and much needed to solve modern problems with the physician workforce.

One of the great barriers to the adoption of intelligent medical technologies in physicians is the fear of a dehumanization of medicine. This is mainly due to the increasing administrative burden imposed on physicians. However, modern technology such as ACI and Natural Language processing are bound to solve the issue of administrative burden and will help clinicians focus more on the patient.

As recently discussed in the literature doctors will most likely not be replaced by artificial intelligence: smart medical technologies exist as such as support to the physician in order to improve patient management. As recent studies have indicated, however, comparisons frequently occur between artificial intelligence solutions and physicians, as if the two counterparts were in competition. Future studies should focus on the comparison between physicians using artificial intelligence solutions with physicians without the aid of such applications, and extend those comparisons to translational clinical trials; only then will artificial intelligence be accepted as complementary to physicians. Healthcare professionals stand nowadays in a privileged position, to be able to welcome the digital evolution and be the main drivers of change, although a major revision of medical education is needed to provide future leaders with the competences to do so.

The implementation of artificial intelligence in clinical practice is a promising area of development, that rapidly evolves together with the other modern fields of precision medicine, genomics and teleconsultation. While scientific progress should remain rigorous and transparent in developing new solutions to improve modern healthcare, health policies should now be focused on tackling the ethical and financial issues associated with this cornerstone of the evolution of medicine [7].

Artificial Intelligence in Medicine leads to publish original articles from a wide variety of interdisciplinary perspectives concerning the theory and practice of artificial intelligence (AI) in medicine, medically-oriented human biology, and health care. Artificial intelligence in medicinemay be characterized as the scientific discipline pertaining to research studies, projects, and applications that aim at supporting decision-based medical tasks through knowledge- and/or data-intensive computer-based solutions that ultimately support and improve the performance of a human care provider. Artificial Intelligence in Medicine considers for publication manuscripts that have both: Potential high impact in some medical or healthcare domain; Strong novelty of method and theory related to AI and computer science techniques. Artificial Intelligence in Medicine papers must refer to real-world medical domains, considered and discussed at the proper depth, from both the technical and the medical points of view. The inclusion of a clinical assessment of the usefulness and potential impact of the submitted work is strongly recommended. Artificial Intelligence in Medicine is looking for novelty in the methodological and/or theoretical content of submitted papers. Such kind of novelty has to be mainly acknowledged in the area of AI and Computer Science.

Methodological papers deal with the proposal of some strategy and related methods to solve some scientific issues in specific domains. They must show, usually through an experimental evaluation, how the proposed methodology can be applied to medicine, medicallyoriented human biology, and health care, respectively.

They have also to provide a comparison with other proposals, and explicitly discuss elements of novelty. Theoretical papers focus on more fundamental, general and formal topics of AI and must show the novel expected effects of the proposed solution in some medical or healthcare field. Following the information explosion brought by the diffusion of Internet, social networks, cloud computing, and big-data platforms, Artificial Intelligence in Medicine has broadened its perspective. Particular attention is given to novel research work pertaining to: AI-based clinical decision making; Medical knowledge engineering; Knowledge-based and agentbased systems; Computational intelligence in bio - and clinical medicine; Intelligent and processaware information systems in healthcare and medicine; Natural language processing in medicine; data analytics and mining for biomedical decision support; New computational platforms and models for biomedicine; Intelligent exploitation of heterogeneous data sources aimed at supporting decisionbased and data-intensive clinical tasks; Intelligent devices and instruments; Automated reasoning and meta-reasoning in medicine; Machine learning in medicine, medically-oriented human biology, and healthcare; AI and data science in medicine, medically-oriented human biology, and healthcare; AIbased modeling and management of healthcare pathways and clinical guidelines; Models and systems for AI-based population health; AI in medical and healthcare education; Methodological, philosophical, ethical, and social issues of AI in healthcare, medically-oriented human biology, and medicine [8].

Conclusions and Recommendations. In general, this survey evidently highlighted, that in majority of countries studied the Artificial Intelligence in Medicine impact on society similarly challenges and presumably risks are acknowledged. There is some contradiction in implications about these one between scholars, but changes and improving growth of Artificial Intelligence and consequently risks for humanity has accepted undoubtedly.

As reported, aforesaid risks and challenges divided into five groups:

- Ethic, bioethics, Gene;
- Moral, Sensitive, Estimative;
- Psychological and humanization;

- Employment, Social Protective

and, conversely

- Economic.

Assumed these, has provided implication about need of new legal framework creation for Doctors' and Professions' Employment Protection, Patients Rights Bill, based on principles of *cooperation* and *coexistence* between Human and Artificial Intelligence.

Has stated, that in Ukraine there are need of properly and widespread scientific discussion in aforesaid field for improvement and modernization of native system of Medical, Labour and Social Protection Law.

Has emphasized that most problems of Artificial Intelligence growth in may overcome in respect to principles of scientific responsibility. Consequently, it led to furthermore investigations in field of simultaneously Artificial & Humane "improvements" for growth of effectiveness and safety level of scientific progress.

Moreover, furthermore surveys have to be devoted on, from the one hand, contributions of safety growth of Artificial Intelligence in Human activities, simultaneously, whether or not Intelligence progress affects on Human activities consequently results unemployment, social uninsured, instability, from the other hand.

REFERENCES:

1. Mintz Y, Brodie R. Introduction to artificial intelligence in medicine. *Minim Invasive Therapy Allied Technologies*. 2019;28:73–81.

2. Dzobo K., Adotey S., Thomford N., Dzobo W. Integrating Artificial and Human Intelligence: A Partnership for Responsible Innovation in Biomedical Engineering and Medicine. *OMICS*. 2020 May; 24(5):247-263. doi: 10.1089/omi.2019.0038.

3. Ramesh A., Kambhampati C., Monson J. R. T., Drew P. J. Artificial intelligence in medicine. *Annals of the Royal College of Surgeons of England*. 2004 Sep; 86(5):334-8. doi: 10.1308/147870804290.

4. Sniecinski I., Seghatchian J. Artificial intelligence: A joint narrative on potential use in pediatric stem and immune cell therapies and regenerative medicine. *Transfus Apher Sci*. 2018 Jun;57(3):422-424. doi: 10.1016/j.transci.2018.05.004.

5. Amisha, Malik P, Pathania M, Rathaur VK. Overview of artificial intelligence in medicine. *J Family Med Prim Care*. 2019 Jul;8(7):2328-2331. doi: 10.4103/jfmpc.jfmpc_440_19.

6. Gómez-González, E. and Gómez, E., Artificial Intelligence in Medicine and Healthcare: applications, availability and societal impact, EUR 30197 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-18454-6, doi:10.2760/047666, JRC120214

7. Briganti G., Moine O. Artificial Intelligence in Medicine: Today and Tomorrow. *Frontiers in Medicine*, 05 February 2020. Retrieved from https://doi.org/10.3389/fmed.2020.00027 (Last accessed: 16.03.2021).

8. ARTIFICIAL INTELLIGENCE IN MEDICINE. Retrieved from https://www.elsevier.com/wps/find/journaldescription.cws_home/505627?generatepdf=true (Last accessed: 16.03.2021).

V. THE IMPACT OF AI TECHNOLOGIES ON THE MODERNIZATION OF TRANSPORT INFRASTRUCTURE

5.1 Artificial intelligence in industry 4.0 logistics and SUPPLY CHAINS

Elena Pryiatelchuk
Doctor of Economics
Associate Professor at the Department of International Business
Taras Shevchenko National University of Kyiv
E-mail: pryyatelchuk@gmail.com

Aleksey Stupnytskyy
PhD (Economics)
Professor at the Department of International Business
Taras Shevchenko National University of Kyiv
E-mail: a.stupnitsky@ukr.net

Ivan Shved
Postgraduate student of the Department of International Business
Taras Shevchenko National University of Kyiv
E-mail: durrer@ukr.net

Modern system software with elements of artificial intelligence (AI) has penetrated almost any field, becoming widespread and high-demand due to growing volumes of data, increasing computing power of computers and intensifying performance of algorithms. The logistics infrastructure of Industry 4.0 is no exception – AI technology is used from the automotive industry to air transport and telecommunications. It reveals potential opportunities for logistics business development, attracts new investments and facilitates changes in existing business processes. According to Stanford University '*AI Index Report 2021'* and IDC's *IDC 'Future Scape: Worldwide Digital Transformation 2021'*, investment in AI technology grew 40% in 2020, reaching $67.9 billion and its sales are expected to be approximately $106 billion by 2025. ($8.1 billion in 2018) at an annual growth rate of 15.5% *(CAGR)* [1].

Digital logistics in Industry 4.0 currently includes:

- Artificial Intelligence, AI;
- Big Data;
- Machine learning;
- Internet of Things (IoT).

They are a new approach to the management of logistics infrastructure and Supply Chain 4.0 for the efficient distribution of materials, products and services from enterprises to customers (B2C) and from enterprises to enterprises (B2B).

The main applications of AI in logistics are:

1. AI and demand forecasting One of the greatest benefits of using AI in logistics is its ability to predict demand, optimize shipping routes, and manage networks. AI using *Big Data* makes forecasting systematic and builds on a long-term perspective, including trends based on different variables, such as weather, exchange rates, real-time sales and expected in a specific region, the number and types of delivery vehicles, the need for servicing or a specific service. Analysis and processing of structured and unstructured data using software and AI allows you to ‘intelligently’ combine them for effective use in implementation of logistics operations.

2. AI and ‘last mile’ delivery (expedited delivery of goods to the buyer) The AI transforms the routine actions of a logistics operator on selection of necessary delivery channels, packaging, and message to the client about the delivery time into an instant solution, by managing various data points and appointing an executor, as well as predicting the time required for the order to reach the client. The predictive capabilities of AI ensure that information is segmented to select the fastest route to the customer.

3. AI and intelligent warehousing The ‘smart’ warehouse of the online store *Ocado Andover* (UK) is completely controlled by AI-based robots, and its efficient work involves moving, sorting and packing goods of more than 65 thousand orders (or about 3.5 million food products) every week. 40% of the space inside cargo remains empty because of bulky packaging. This motivates rethinking of packaging issues, optimising processes and materials, using ‘smart’ containers during transportation of goods, and developing environmentally friendly delivery formats. *Amazon Kiva Robots* collect and distribute goods to different warehouses within 5 minutes. In the near future, AI robots will be integrated into all Amazon warehouses to create more efficient sorting [2].

4. AI and emergencies Recent developments in AI technologies indicate that AI can not only help prepare for emergency situations, but also can predict the best method for dealing with crisis situations, accumulate experience of corrective measures in order to avoid further emergency. While human factors will remain significant in the near future due to the complexity of the logistics infrastructure, AI data-driven environment models as a solid foundation for business planning will enable better strategies in the future.

Expert systems on AI- based technologies in logistics industry allow:

a) identify / concretise and disseminate experience in management decisions;

b) ensure the integrity of the logistic question / answer formulation to address analytical and operational problems;

c) solve problems in automation of logistics processes using AI (selection and identification of carriers taking into account stocks in warehouses, design of international marketing systems, linking local and global logistics tasks).

‘Intelligent Automation’ is a term that combines intelligent automation of business processes using a combination of AI and robotic processes. However, *RPA (robotic process automation)* is not the equivalent of AI, which is able to learn and gain insights from unstructured data. *RPA* operates only on the basis of pre-written clear rules (it cannot learn anything on its own and somehow develop itself). In fact, robots automate easy tasks and make large amounts of data available to AI, which learns to adapt to processes and improves them based on data obtained from *RPA* [3].

The components of automation tasks using AI in logistics are:

1. Deep learning and neural network.

2. Cognitive computing (data analysis – *Data Science* – data extraction, search for patterns in data, forecast).

3. Computer vision (CV) – object identification and classification, content description and intelligent image and video processing, gesture and handwriting recognition.

4. Working with natural language (NLP) and speech technologies (recognition and automatic translation of texts, speech generation, etc.).

Modern mathematical algorithms of AI-based expert systems designed to solve transport problems and to work with data are adaptive, that is:

1) they themselves recognize all the necessary parameters in the process of work;

2) they simulate traffic flows and optimize routes;

3) they calculate the fare;

4) they carry out solutions of inverse problems when it is required to understand the reasons that have generated certain consequences.

Most large logistics companies and retail chains using AI technologies use typical expert systems consisting of three components:

a) *knowledge bases*, which are based on initial data and logical schemes and store the practice of decisions made (series of decisions like "if ..., then ...") and key criteria used when choosing a carrier for certain goods;

b) *an inference mechanism* that provides a search in the knowledge base for exactly those rules and algorithms that are suitable for making a particular decision, identifies rules that are suitable for a particular case, and establishes a sequence for their assessment;

c) *a user interface* that facilitates interaction between decision-makers and expert systems, ‘translates’ important questions for them into ordinary language and interprets their answers, provides an opportunity to develop the knowledge base through additional information.

AI-based expert systems have already proven their ability to improve the productivity and quality of logistics operations, transform data and information into useful knowledge, find and share rare experiences and skills, and manage knowledge as a vital resource for competitiveness. In fact, optimization of logistics is based on the *decomposition principle* – a large task is divided into many small ones, which are then linked together with the help of a special coordinating task.

In 2018, DHL, a leading logistics operator in the express delivery market, and IBM presented a study on Artificial Intelligence in Logistics, which assessed the potential and cost of using AI in logistics, benefits of developing a new class of logistics assets and intelligently supported operating systems. It has been proven that, *first*, the increased use of applications through interactive communication (virtual assistant with speech recognition) improves customer engagement through introduction of the ability to deliver goods before the customer orders them. *Second*, AI technologies simplify production line operation and production processes through image recognition and dialogue functions. *Third*, AI changes the entire operating logistics model from reactive to predictable and proactive, which provides better results at optimal costs (at back and front office levels) and allows shifting the focus of employees involved in logistics to more important tasks. *Four*, AI technologies allow the use of an advanced recognition system to track shipments and asset status, lead to complete autonomy of the delivery process at all stages, and predict fluctuations in the volume of global shipments before they occur [4].

Currently, the introduction of AI into the logistics industry is taking place in the following areas.

1. ***Effectiveness of data management and customer service*** One of the main benefits of introducing AI into the logistics industry is the ability to provide better customer service (especially to consumers who use online ordering). Nowadays, with the growing number of e-commerce businesses, all logistics companies have cloud databases that provide instant access to customer and order data. The efficiency of managing the day-to-day activities of a logistics company is determined by availability, costs, transportation, staffing, suppliers and monitoring flows and resources in order to ensure the quality of customer service.

2. ***Improving labour safety for employees*** Occupational safety is paramount to any business, regardless of its size or industry. In the logistics industry, it is no longer so much about minimising payments and compensation for injuries, but about legal and moral obligation of companies to provide their employees with a safe work space. This ultimately leads to increasing productivity, satisfaction and loyalty of employees, relieving employees of dangerous work procedures and enhancing work efficiency in general. For example, a packaging and palletising robot can eliminate any risk of injury while performing industrial tasks, which saves employees' time and relieves them of the stress caused by repetition.

3. ***Improving the accuracy of supply chain processing*** With the help of AI, logistics companies can more effectively manage all processes in the supply chain with a proactive logistics system that not only contributes to faster delivery, but also provides the ability to determine if there is an increase (or decrease) in demand from their customers, and adjust the volume of production in order to reflect the trend. AI improves the process of managing and analysing massive amounts of data as spreadsheets and other abandonware are no longer effective in data management. Real-time tracking process based on proactive logistics results in fewer human errors, lost or misplaced orders.

4. ***Reducing costs*** The introduction of AI and automation in the field of logistics has a huge impact on cost reduction, as it reduces the number of errors in decision-making by logistics operators. Thus, large loads containing hundreds of orders that are lost or mishandled require huge costs to locate them, change the route and correct the situation. Under these conditions, AI not only allows better data management (due to the accuracy of all processes), but also by automating it, reduces the need for the number of employees, which leads to cost savings.

The use of AI creates proactive logistics. Despite its advantages (viewed by a logistics manager), AI is relatively useless if it cannot add value to support more efficient decision-making by a company to organise fast and cost-effective DTD deliveries *('door-to-door')*. *Proactive logistics* requires:

a) making decisions within a broader information exchange system in the logistics industry;

b) internal investment in digital transformation (from 5G for warehouses to container and order tracking technologies);

c) intensifying work with digital integration partners for supply chains to ensure interoperability between systems;

d) high level of 'informational' trust.

According to Ericsson, which surveyed 2,000 logistics professionals in China, Germany, Sweden and the United States in 2020, more than 60% of logistics companies will use AI and big data to deliver goods before orders arrive in the next five years (at the stages of forecasting demand and forming stocks). And 1/3 stated that the inability to quickly exchange relevant information between buyers and suppliers is the main obstacle to the development of their business [5].

A decade ago, logistics companies used simple customer analytics and marketing campaign optimisation. Restructuring of the traditional logistics business today is taking into account new needs: digital twins, systems for predicting failures and remote diagnostics, computer vision for quality control, etc. are being introduced. For example, *Hyper CI* systems allow building a 'map' of customer behaviour in real time – finding interests and predicting tendencies to buy or abandon a product, automatically react, building a 'customer path' step by step. The increase in the efficiency of using AI as decision-making models is perceived by logistics managers as a signal to use two **possibilities for implementing AI**:

- *interpret models* (human control and explanation of models at each stage of the decision process);
- *embed models in business processes* for automated decision-making and modernisation of all points of interaction in supply chains, creating an effective cycle of digital interaction with the client, processing and transporting orders (including the 'last mile' delivery).

At the same time, companies that rapidly implement and scale new AI technologies, as well as quickly train personnel, gain a competitive advantage in the market. On the one hand, preventive logistics contributes to a change in warehouse networks – local distributing warehouses are becoming more common than the delivery of orders from a centralised warehouse (shortening customer service times and the ability to predict and flexibly respond to changes in demand). On the other hand, the current size of retail chains and the scale of e-commerce players require the introduction of AI models and machine learning tools for retailers based on the complexity of doing business, distribution characteristics, the number of regions of presence, and differences in consumer behaviour in different regions.

The global AI market for logistics is categorised by component, technology, end-user category, and region.

A. *By components*, the AI market in logistics is segmented into software (interoperability, processing of large amounts of data and their protection, and confidentiality), services (professional and managed) and platforms (interaction and creation of flexibility to effectively manage various business functions).

B. *By technology*, the AI market is divided into machine learning (ML) and deep learning (65% of the market), as well as natural language processing (frontier and cloud analysis engines).

C. *According to end users*, the global AI market in logistics is segmented into elements used in supply chains: robotic warehousing, virtual operational assistants, warehouse process managers, identification mechanisms and automatic diagnostics of images of goods and cargo, etc.

D. *By region*, the AI market is subdivided into North America (accounting for almost 39% of the market), Europe, the Middle East and Africa, Latin America, and the Asia-Pacific region.

The main AI players in the logistics market are *Google* (USA), *IBM* (USA), *Microsoft* (USA), *Oracle* (USA), *Salesforce* (USA), *Kairos* (USA), Hitachi (Japan), *SAP* (Germany), *Anagog* (Israel), *Autoplant Systems Pvt. Ltd.* (India), which are implementing numerous organic and inorganic growth strategies, are entering into agreements with logistics companies to introduce new logistics products and AI technologies, as well as mergers and acquisitions to further expand their presence in the global market.

In conditions when digital ecosystems based on *Big Data* make reliable forecasts and save costs, the role of a company's logistics manager is shifting to algorithms. Logistics companies use two types of AI at present.

The first helps employees to better solve current tasks, which allows them to optimise the number of vehicles for transporting cargo, to reduce their operating costs and delivery time. So, based on *Big Data*, the AI program analyzes all previous transportation that the company has performed, loading the entire array of information into the system (from road conditions to weather and news), thus preventing situations when “something goes wrong”. At the same time, the sources of big data in digital logistics are:

• automated control systems for warehouse, transport, purchases, sales, and personnel;

• *RFID*-tags (they mark vehicles, warehouse equipment, products in order to ‘digitize’ movement of goods and quickly identify goods in the warehouse, controlling its movement along the entire supply chain);

• results of routing of freight flows.

The second type of AI not only analyses, but also independently makes decisions (for example, unmanned concept tractors developed by many leading manufacturers from *Tesla* to *Volvo* and *Mercedes*).

AI technologies in logistics supply chains Digital logistics services require predictable and intelligently supported operations, introduction of AI technologies in the supply chain combined with traditional and digital logistics, and new models of interaction with customers. Today, in *Supply Chain 4.0* logistics, real-life situations are actively simulated on the principles of AI, planning is integrated into a general system of autonomous resource potential management for solving both applied and global problems.

In recent years, the use of AI in supply chain management has grown exponentially across the global economy, driven by higher demand for data transparency and traceability, and the need to improve customer service. In terms of AI adoption in supply chains (as of early 2020) the leading industries are telecommunications (26%), high tech (23%), healthcare (21%), professional services (19%), transport and logistics (18%). *PwC* predicts that the introduction of AI technologies will increase global GDP by 14% by 2030 [6].

AI technologies are being used in logistics supply chains to solve the following problems [7]:

- calculation of the optimal route;
- risk assessment to determine the cost of cargo insurance;
- forecasting the optimal loading of transport;
- building differentiated logistics supply chains;
- visual control of safety at the warehouse;
- the use of unmanned vehicles and delivery robots.
- **The main data for AI technologies when analyzing the efficiency of logistics operations are:**
- location of production, distribution warehouses and points of sale;
- movement of warehouse stocks;
- quantity, delivery routes and technical characteristics of transport;
- sales volumes in retail outlets, schedules and volumes of deliveries from contractors, temporary "windows" for product delivery to stores;
- traffic situation, meteorological conditions, etc.

3PL operators of *FMCG* companies with large transport and warehouse flows within the global digital ecosystem (in connection with distributors) determine:

a) the reasons for the delay in delivery;
b) the efficiency of resource optimisation based on analysis of delivery time (pooling, joint cross-docking with clients, etc.); Today,
c) patterns and measures to reduce costs and improve service;
d) levels of modelling business processes and logistics operations.

The networked nature of the logistics industry and the large volume of day-to-day data (accounting, finance, human resources, legal support, and information technology) used by companies provide a natural basis for realizing the power of AI to save time, reduce costs, and increase productivity while taking on routine operations. Currently, a large number of specialized companies offer users all kinds of software, computer equipment for its application, as well as modern AI technologies used for supply chain management and *Big Data* analysis in logistics (retail chains, maintenance of warehouse complexes and inventory management, development of autonomous transport funds). They include the following systems:

a) analysis of a large number of orders in online stores to determine the greatest consumer demand and forecast trade trends in the future;

b) integrated enterprise management information (enterprise resource planning, *ERP*);

c) warehouse management with address storage (*WMS*);

d) control of automated technical means and unmanned aerial vehicles;

e) Transport Management System (*TMS*) to determine the most efficient transport routes and analyse performance;

f) managing the cycle of the current state of the vehicle to proactively calculate maintenance times and minimize the risk of breakdowns.

The use of new AI technologies in supply chains is a way to maintain the competitiveness of the logistics business, the purpose of which is:

a) analysis of a large array of internal / external data of the logistics environment;

b) search and formulation of proposals for making decisions regarding process planning at the right time and in the right place;

c) creation of a system of 'smart alerts'.

The system of 'smart alerts' includes AI-based software and predicts both arrival / departure times of vehicles depending on traffic conditions and container repair requirements based on damage detection of *GPS* trackers, and insurance claims based on climate sensors and other variables. At the same time, all calculations and proposals are automatically performed, and the logistics operator intervenes only if necessary, taking into account unforeseen factors, providing additional feedback for training AI. The system also helps optimise the use of empty containers in the container shipping industry and automatically calculates:
how many unloaded containers need to be loaded at each port;

how to distribute the optimal containers for each customer order;

when they are returned at the right time, in the right place and in the right condition in order to pass them on to the next client;

targets for maintenance, unloading and sorting of goods.

For example, AI-based software optimizes route dispatch and manages freight traffic based on actual and projected orders. As a result, this concept demonstrates the potential to reduce idle kilometers of transportation by 10% and provides carriers with predictions of final destinations in 90% of cases. For example, its application contributed to the fact that one of the leading shipping lines achieved 20% savings by reducing the cost of transshipment of unloaded containers (storage and transportation), as well as a 10% reduction in the number of containers used [8].

Modelling the *Supply Chain* at the micro (the process of receipt / shipment of goods in the warehouse) and macro (the entire supply chain from the supplier to the store), in contrast to forecasting, occurs by changing the influence of sales volumes on the warehouse load to maximize the use of warehouse space, equipment and personnel. In turn, AI technology allows:

firstly, to measure the behaviour of the environment and ensure calculation of the model, bringing the result closer to real time;

secondly, centrally manage all the company's warehouses (central and regional);

thirdly, to find areas for improvement of processes, fix ‘bottlenecks’ and calculate the load of each warehouse (for 12 hours in advance);

fourth, use mobile devices (including data collection terminals) as platforms to control access to video recording systems, *RFID* tags and *GPS* sensors (including the minute-by-minute digitization of the working time of junior warehouse personnel and drivers, which they spend on each task). According to calculations, the economic effect from their use is on average 15% [9].

Using AI technologies to optimise supply chains To avoid critical supply chain disruptions, logistics companies use the ***ABC* operating model**:

A. A complete picture of the entire logistics ecosystem.
B. Accurate forecasting of supply and demand.
C. Optimal planning of logistics and delivery.

The implementation of the *ABC* operating model in the logistics industry allows the use of AI technologies both inside the company (back office) and in the external environment (front office), which helps to move from reactive actions to proactive operations with smart forecasting. Today, the operating model of the TNC supply chain consists of many links (suppliers of components and raw materials, manufacturers, logistics firms, distributors, warehouses, carriers, retail chains, etc.) and is a transnational network. All links of the *Supply Chain* exchange information, and the efficiency of the business of all participants in the supply chain depends on the speed of this exchange and the quality of the transmitted data. AI finds such interdependencies that the employee cannot build, because there is no direct connection between the data, and their volumes are huge (the criterion of predictability of logistics is determined by facts, and not by the subjective judgment of the individual). When planning the work of a logistics operator, weather and road conditions are entered into the software algorithm in real time to continuously optimise the calculation of the best transportation route. At the same time, ***AI technologies allow***:

❖ determine the required number of vehicles to fulfill orders received from customers, calculate transportation costs, revenues and profits;

❖ create comfortable driving conditions through identification of road signs and markings, response to weather and traffic situations;

❖ manage autonomous freight vehicles (through devices designed to monitor the condition and ammortization of components and assemblies in real time, depending on the state of the vehicle, and not on the mileage);

❖ process data from other vehicles and infrastructure facilities, taking into account the risks of breakdowns on the way and forecasting the timing of maintenance;
❖ perform an automatic analysis of the fundamental documents of transport companies (registration certificates, extracts from the *K-bis* trade register, transport licenses, and social security certificates) and check their reliability by comparing them with the national database.

For example, the company *HERE*, which develops mapping platforms, has created software that allows predicting hazards on the road by analyzing images from front cameras, smartphones or video recorders. Thanks to the introduction of the new *GedVerifier* technology by the companies of the *GedTrans* logistics group (developed by the *S2PWeb* innovation laboratory), up to 14 thousand documents per month no longer need to be manually processed, and the time of the process itself has been reduced by 8 times [10].

AI technologies enable logistics companies to:
First, to accurately alert about supply problems and, accordingly, take the necessary (preventive / corrective) steps in advance. For example, the largest French company *Carrefour Group* has been using the *SAS Viya* analytical platform based on AI technology since 2019 to build a more efficient supply chain. Its implementation ensures collection and processing of data received from stores (including online stores) and from warehouses, increases the accuracy of forecasting, reduces the risks of overstocking, shortage of inventory, write-off volumes of expired products, which ultimately allows you to build an effective multichannel distribution and optimization of warehouse stocks.

Today, the *Carrefour Group* is a multinational network with more than 12 thousand stores in more than 30 countries, serving 105 million customers, and the group employs more than 380 thousand employees worldwide. With revenues of €92.4 billion in 2020, the group is a global leader in the *food for all* sector, offering quality food every day at affordable prices [11].

Second, to realise cost savings and improve business processes. For example, independent research firm *Tractica* estimates that by the end of 2021, sales of warehouse and logistics robots with AI will reach $22.4 billion. *United Parcel Service (UPS)* saves about 10 million gallons of fuel annually thanks to *Big Data* analysis combined with AI.

Third, to introduce smart contracts into supply chains with more efficient transactions in large networks with a huge number of stores in different regions and an enormous data flow.

Key AI applications for supply chain optimization are:

I. ***Improving end-to-end visibility and response time*** AI technologies provide the ability to collect and analyse real-time data from multiple connected devices and systems (including *SCM, ERP* and *CRM* systems) to provide information to logistics decision-makers. Using these solutions, the purchasing centre gains insight into the supply chain, supply delays / disruption issues (whether internal or external) and takes action to minimize negative impacts in the supply chain.

II. *Precise forecasting* Introduction of AI technologies allows logistics companies to collect information from different contractors, customers and their own function centres (including inventory and products) and use it for accurate predictions in real time. This improves the planning of operations in supply chains, increase their efficiency through automation, frees managers from making 'routine' decisions in order to focus on developing strategies at a higher level.

Using hybrid AI technology, a German company *INFORM* combines operation analysis, machine learning and electronic control systems for machine operation using computer algorithms, which provides results that significantly exceed both traditional control algorithms and algorithms based on pure data. Its software aims to optimize the operation of seaports, inland and intermodal terminals, distribution centres and delivery operators. The *Agile Optimization* platform provides affiliates with a new management strategy based on rapid, interactive decision making. This type of optimization is especially useful if you need to perform a complex transport operation, avoiding crashes and eliminating the lack of time [12].

III. *Effective planning of supply chains and production* AI tools and solutions help to balance the 'gaps' of supply and demand, and effectively plan production and *SCM* strategies on the one hand. On the other hand, it is necessary to objectively assess the needs of the market and manage production accordingly in order to avoid overproduction or shortages of the product, which can lead to losses. For example, shipping operators can use the *Marine Traffic* platform to obtain real-time ship position information and the estimated time of arrival (*ETA*) of each ship based on satellite data.

IV. *Supplier Selection and Supplier Relationship Management* AI solutions are used to provide customized advice on supplier relationship management. Today, the availability of relevant, reliable and regular information about potential or existing suppliers is a significant competitive advantage in the context of its use to build mutually beneficial commercial relationships.

Revision of partnerships with suppliers and other players in the logistics market, adjustment of terms and obligations under contracts, a thorough analysis of the use of working capital and liquidity is associated, *firstly*, with the transition to a client business model in an increasingly competitive environment through development of new competencies: "client – manager – logistic architect". *Secondly*, with creation of a logistics ecosystem that connects 'traditional' and innovative services, taking into account the developments of competitors and customer requirements (digital interaction with customers, automatic order confirmation, securing cars, and online tracking). *Thirdly*, with generation of anti-crisis projects: in the event of unfavourable conditions, a proactive response to changes is used – an instant refusal to work with unprofitable products, cost reduction, and redistribution of resources [13].

V. *Logistics routes optimization* AI technologies enable logistics decision-makers to analyze existing routes, identify bottlenecks and identify efficient routes which reduce both time and total cost of warehousing and shipping. At the same time, AI-powered data processing tools help to capture the details associated with the movement of goods in real time, and correctly estimate the delivery time. For example, the complex process choosing an optimal carrier (sorting hundreds or thousands of routes and schedules) is performed by an operator within 10 minutes and more, whereas the AI-based process is carried out in a matter of seconds.

VI. *Optimization of the transport fleet* Nowadays, the optimization of the transport fleet is one of the significant advantages of AI in transport logistics. With that, AI solves the following tasks:

- distributing orders by cars and building optimal routes in real time – so that delivery to the point of sale is as economical as possible;
- traffic congestion forecasting – the system accumulates the average speed of movement on each road section every 15 minutes during the day and builds the best route options.

For example, the *Yandex.Routing* platform indicates that AI builds a delivery model to several thousand points in 15 minutes, and the efficiency of using 200 transport units increases by 15-20% (taking into account time 'windows' for unloading goods, carrying capacity and cost of using vehicles, travel routes in the city centre due to legal restrictions, potentially changing traffic situations during the day, etc.). The *Route-to-Market* modelling system allows building an optimal *End-to-End* strategy based on a huge amount of input data, including data on changes in demand, market volatility, and growing share of trading clients. That is, due to the advantages of big data analytics and routing algorithms, the offloading of vehicles for the client is reduced by an average of 30 minutes.

VII. *Warehouse management efficiency* The use of AI technologies in the field of warehouse logistics allows t:

a) reducing both excessive stock and undersupply through accelerated analysis of large data sets;

b) eliminating errors that may appear when the analysis is performed manually;

c) optimizing forklift management, sorting and inventory management using autonomous ground vehicles.

The main directions of changes in warehouse logistics under the influence of AI technology introduction are:

1. Voice technologies and personnel management in warehouse complexes (Pick-by-Voice) Today, the classic warehouse management system (*WMS*) is being replaced *by Pick-by-Light, Pick-by-Voice* and *Pick-by-Vision* systems by transforming warehouse management using AI. The most versatile and promising is the *Pick-by-Voice* system, which is actively used in the warehouse infrastructure of the USA and EU countries. It allows, *firstly*, organizing voice control of warehouse operations without paper and electronic documents; *secondly*, freeing collectors' eyes and hands for maximum concentration on warehouse operations; *third*, reducing the error rate and increasing labour productivity.

Voice-activated warehouse management systems have significantly changed the way the companies that use them operate at all levels. Thanks to the use of this technology, firms improve the most important indicators of their activities –

productivity growth is 35%, order fulfillment accuracy is 99.99%, the number of sick leaves and staff training time is reduced by 50%. So, AI-based software:

❖ not so much informs (the direct responsibility of language assistants), but analyzes the incoming information on the arrival of goods and shipments, including the definition of unpredictable ‘peaks’ of workload and the optimal distribution of personnel for distribution centre managers of a logistics company;

❖ not so much indicates the location of goods in the warehouse, but rather suggest / form the most optimal path to the location of the cell and subsequently place it most successfully based on the demand and product proximity (this takes into account such factors as temperature, illumination, shelf life, etc.).

2. Management of warehouse performance based on data Currently, software has been developed and implemented using AI technology for logistics centres. It manages warehouse personnel and managers, based on the set parameters, monitors the production process and the responsibilities of employees in real time, finds ways to improve the efficiency of personnel (a leading company in this area is *Hitachi*). In fact, AI:

a) provides adequate work assignments based on the data sets collected daily in corporate business systems and verifies them in logistics tasks;

b) changes work tasks and orders in real time to improve control automation, basing decisions on large amounts of information;

c) automatically analyses the result of applying new approaches, selects the processes with the best performance and applies them in the next work schedule;

d) identifies risks and plans the allocation of key resources (be it capital or time resources), providing promising smart prediction (a completely new level of knowledge for making management decisions) and taking into account the subjectivity of the manager's perception with a large variability of decisions;

e) reduces the role of guesswork and intuition, which affects the efficiency of allocation of human resources in the context of competence of employees-managers in a particular area and in accordance with their projects.

The growth in online sales has led to an increase in both the number of warehouses for *IoT* stores due to new and more diverse product lines, and the needs of end customers for faster delivery (‘same day’ with high demand, transparency and traceability). *DHL* has come up with an AI-based *IDEA* algorithm integrated into the existing IT infrastructure that dramatically improves warehouse picking and reduces costs. For example, it leads to a reduction in the distance travelled by warehouse employees by 50% and an increase in the productivity of individual offices of logistics centres by 30% [14].

3. Improving employee mobility using AI technologies Employee mobility does not mean the speed of their movement, but the speed of assimilation of certain knowledge and support for the increased mobility of human talents, both inside and outside the organization. Each employee is not a ‘hot plug’ (like a USB flash drive), they need time to become productive in a new role, to build the necessary cause-and-effect relationships in a new area of knowledge. In this regard, AI makes this adaptation period much faster and more effective in the context of not so much the use of a ‘package of knowledge’ and understanding the essence of one's work from a ‘bunch’ of files for reading, but rather the ‘key’ platforms on which it will work.

So, the analytical component of adaptive AI implies the ability of a new employee to answer questions regarding operations that were performed in the past, for example: *“Show me a tag cloud from my predecessor's working hours? What did he spend most of his time on? How has his work evolved over the past 12 months?”* This saves them weeks, or even months, since already during the first hours of work from the moment of taking on a new role they will be able, firstly, to apply this knowledge in practice, and secondly move from the project to project or connect to it at various stages on the basis of flexible cross-functionality.

Modern large transport and logistics companies such as *Acteos*, *Akanea*, *Infor*, *Manhattan Associates*, *OMP / GPI Xyric and Cofisift / Xyric* are both software developers for AI technologies and consultants on their further use. And although the world's leading database operators (*SAP, Microsoft Oracle, IBM*, etc.) have integrated AI into their commercial offerings, it is specialized logistics companies that develop, update and improve AI-based software algorithms. This allows:

- automated decision-making when carrying out necessary operations;
- operating automatic stackers (*AGV*) or warehouse drones;
- analyse the situation and determine the minimum number of employees required for the full operation of the warehouse;
- effectively use autonomous logistics robots that combine AI with stereoscopic cameras, create and store a map of the surrounding area, safely bypass employees, stationary obstacles and other handling equipment.

In early 2020, Stanford University (USA) released the results of a study according to which, for more than seven years, the computing power of AI has been ahead of **Moore's Law,** according to which the processor speed doubles every 18 months, which means that developers can expect a doubling of application performance during this time frame with the same equipment cost. These results, prepared by a consortium of companies *McKinsey & Company, Google, PwC, OpenAI, Genpact and AI21Labs*, show that AI computing power is growing faster than traditional processors, and the tipping point (when the speed of AI development began to outstrip Moore's Law) was 2012.

In early 2021, the largest logistics operator and leader in the contract logistics market, *DHL*, released the fifth edition of the *Logistics Trend Radar*, a kind of seismograph for identifying future trends in the *Supply Chain* industry. It identifies 29 key trends that will affect it in the medium term and, in particular, states that “the *COVID-19* pandemic has led to dynamic changes in the digital logistics of the workspace and has brought the digitalization of the industry closer by several years” [15].

In the future, the tendency to reduce the need for logisticians performing operational functions (suppliers, dispatchers, shipping specialists, warehouse managers, etc.) will accelerate – automated warehouse operations, unmanned stackers and transporters instead of loaders and pickers. In the next 5-7 years, such a profession as a freight forwarder may become a rudiment due to the emergence of electronic Internet services that connect the cargo owner with agents, carriers, terminals, insurance companies and select delivery schemes. AI technologies will significantly affect **the list of professions in logistics**: such specialties as a cross-logistics operator, a BTS coordinator, a designer of intermodal transport hubs and smart roads, a transport network security engineer, an architect of intelligent control systems will be in demand. It is the latter that will have the highest value of multi-competent knowledge in the fields of IT technologies, procurement and warehouse, transport, production and distribution logistics, mathematical analysis and management of AI- based production processes.

REFERENCES

1. How Analytics and AI are Changing the Future: 8 Trends for 2021. (In Russian Как аналитика и ИИ меняют будущее: 8 трендов на 2021 год. – URL: https://ai.cnews.ru/articles/2021-01-31_kak_analitika_i_iskusstvennyj_intellekt

2. 8 Ways Artificial Intelligence Will Change Logistics (In Russian 8 способов, как Искусственный Интеллект изменит логистику). – URL: https://fialan.ua/news/vagno-znat/logistica-ai/

3. Artificial Intelligence in Logistics. (In Russian Искусственный интеллект в логистике). – URL: https://retailservices24.ru/blog/iskusstvenniy-intellect-v-logistike-1#pochemu-logistika

4. Artificial Intelligence in Logistics. A Collaborative Report by DHL and IBM on Implications and Use Cases for the Logistics Industry. 2018. – URL: http://www.globalhha.com/doclib/data/upload/doc_con/5e50c53c5bf67.pdf

5. The Future of Logistics is Predictive. Here's how. – URL: https://www.ericsson.com/en/blog/2020/11/future-of-logistics-is-predictive

6. Artificial Intelligence in the Field of Logistics. (In Russian Искусственный интеллект в сфере логистики). – URL: https://tg777.ru/info/iskusstvennyy-intellekt-v-logistike/

7. Revolutionizing: How the Cargo Industry Is Using the Internet of Things and Artificial Intelligence. (In Russian Совершая революцию: как грузовая отрасль использует Интернет вещей и искусственный интеллект). - URL: http://vestnik-glonass.ru/news/tech/sovershaya-revolyutsiyu-kak-gruzovaya-otrasl-ispolzuet-internet-veshchey-i-iskusstvennyy-intellekt/

8. Eremina L.V. Improving the efficiency of logistics planning through the use of artificial intelligence / L.V. Eremina, A. Yu. Mamoiko, A.S. Papikyan. - // *Technics. Technologies. Engineering.* (In Russian Еремина Л.В. Повышение эффективности логистического планирования за счет использования искусственного интеллекта / Л.В. Еремина, А.Ю. Мамойко, А.С. Папикян. — // *Техника. Технологии. Инженерия*). — 2019. — № 4 (14). — С. 1-7. — URL: https://moluch.ru/th/8/archive/142/4404/

9. The Chain of Events: how Artificial Intelligence Revolutionized Logistics (In Russian Цепь событий: как искусственный интеллект совершил революцию в логистике). – URL: ttps://trends.rbc.ru/trends/industry/5f19c0139a794784f1e06bd8

10. Artificial Intelligence in Logistics and Freight Transportation. (In Russian Искусственный интеллект в логистике и грузовых перевозках). – URL: https://logist.today/dnevnik_logista/2019-12-22/iskusstvennyj-intellekt-v-logistike-i-gruzovyh-perevozkah/

11. Carrefour Optimizes Logistics with the SAS Viya Platform. (In Russian Carrefour оптимизирует логистику с помощью платформы SAS Viya). – URL: https://www.sas.com/ru_ru/news/press-releases/2019/january/carrefour-optimizes-logistics-with-sas-viya.html

12. INFORM: Case of Success of Artificial Intelligence Technology in Logistics. (In Russian INFORM: кейс успеха технологии искусственного интеллекта в логистике). – URL: https://www.everest.ua/ru/inform-kejs-uspeha-tehnologyy-yskusstvennogo-yntellekta-v-logystyke/

13. Logistics 2020-2021: Life after the Pandemic. (In Russian Логистика 2020-2021: жизнь после пандемии). – URL: https://telsgroup.ru/media_center/tels_in_the_press/5235/

14. Artificial Intelligence in Action – DHL's Algorithm Improves the Efficiency of Electronic Order Fulfillment. (In Russian Искусственный интеллект в действии – алгоритм DHL повышает эффективность электронного исполнения заказов). – URL: https://ewlog.com.ua/blog/Iskusstvennyiy-intellekt-v-logistike

15. Artificial Intelligence, Robotics, Quantum Computing, Sustainability and Global Volatility – DHL's New Logistics Trends Radar on the Trends that will Shape Logistics in the Future. (In Russian Искусственный интеллект, робототехника, квантовые вычисления, устойчивое развитие и глобальная волатильность – новый «Радар логистических трендов» DHL о тенденциях, которые будут формировать логистику в будущем). – URL: https://logistics.ru/logistika-scm/iskusstvennyy-intellekt-robototekhnika-kvantovye-vychisleniya-ustoychivoe-razvitie-i

5.2. Models of artificial intelligence of optimization and formation of logistics routes

Olena Chukurna
[1]Doctor of Economics sciences, Professor of marketing department,
Odessa State Polytechnic University,
ORCID: 0000-0001-9285-7068,
E-mail: elenachukurna@gmail.com

Liubov Bovnegra
[2]Candidate of technical sciences, Private professor , Head of Department information technology design in mechanical engineering, Odessa State Polytechnic University, *ORCID:* 0000-0003-0429-2816,
E-mail: dlv5@ukr.net

Vitalii Dobrovolskyi
[3]Master of Logistics systems engineering, Odessa State Polytechnic University, *ORCID:* https://orcid.org/0000-0002-9388-9528,
E-mail: dobrovit05@gmail.com

The rapid development of logistics, which was associated with the integration processes in the European Union and the spread of globalization, contributed to the actualization of the development of logistics models for traffic optimization. Ukraine's integration into the EU has raised the issue of creating competitive logistics systems and infrastructure that can solve the problems of forming logistics routes for the transportation of goods.

Social progress in the European Union has reached such a level that it is necessary to create strict conditions for liberalization and harmonization of the transport market, especially in the field of commercial aspects, tariff policy, infrastructure development, information support, border crossings, speed of movement of goods and passengers, compliance environmental safety, requirements for the safety of cargo and vehicles, service both in terms of maintenance and technological maintenance, and in terms of working conditions and recreation of participants in the transport process. Within the framework of the European Common Transport Policy, five main priority areas have been formulated, which are aimed at creating a single market for transport services, but these areas meet the conditions of EU countries, which already have first-class road, rail, water and intermodal, border and customs routes complexes, service points, cargo and passenger terminals, traffic control systems and other devices and facilities that ensure the reliable operation of transport. For Ukraine, where many such issues are unresolved, the number of such priority areas should be expanded. All these aspects of the country's logistics complex and the problems of its integration into the EU logistics system need to be addressed, using mathematical models and methods to optimize the route of transportation of goods. Solving such problems requires a theoretical justification of models and methods of optimizing the route of transportation is relevant.

The mathematical apparatus used to solve the optimization of logistics routes usually uses standard approaches that are based more on economic methods. In this study, in order to solve the problem of optimizing the transportation of goods in logistics, a theoretical and methodological justification of models that have a mathematical solution using the problem of a traveling salesman. The proposed approach is based on the method of setting the problem of the traveling salesman and its solution using the method of branches and boundaries and genetic algorithms. The first method allows you to build a matrix of optimal logistics routes, the second method is based on reproduction and the most optimal characteristics obtained by crossing the most suitable for solving the problem, data, and spread them throughout the search for the optimal solution. The method of genetic algorithms today has limited application, but in the conditions of «Industry 4.0», it will be widely used. This is due to the use of artificial intelligence in the processing of large databases, the work of which in some systems is based on genetic algorithms. In general, the development of the fourth industrial revolution contributed to the emergence of fundamentally new quantum computers capable of processing large arrays of data, the principle of information processing in which is based on qubits. That allows to process metadata, thus the method of genetic algorithms is the most effective for work with large databases.

According to the method of genetic algorithms, the whole new population of acceptable solutions is reproduced by selecting the best representatives of the previous generation, crossing them and obtaining many new variations. This new generation will contain a higher ratio of characteristics that have the best members of the previous generation. As a result, the best characteristics are distributed throughout the population. In this way, the highest quality characteristics of the group are generated, which apply to all its elements or subjects. These models will have software and can be used to solve economic problems in transport logistics on a wide information base. In addition, the method of genetic algorithms makes it possible to use metadata to model optimal transport routes with a high level of probability of the results. Consider these two models to solve the problem of the salesman, which allows you to form the optimal route for transporting goods.

Mathematical formulation of the salesman's problem. In addition to transport and logistics systems, the salesman's task is widely used in automated design, testing and fabrication of integrated circuits, production of printed circuit boards, laser cutting of plastics and metals, protein structure research, embroidery, welding and continuous drawing and other industries. Consider it for the applied aspect of transportation in logistics systems. It can be formed as follows: the salesman must visit a number of cities, the distances between which are known. The salesman chooses the shortest ring route, which begins and ends in the city of his residence, and he must visit the desired city once and only once.

Consider the problem of the salesman on the example of the transport system. The transport network has $(n + 1)$ a point. Known distances between points $c_{ij}, i, j = 0, n$. Leaving the starting point (he is assigned the number 0), the salesman must visit all other points only once and return to point 0. The task of the salesman finds the answer to the question: in what order you need to go around the points to keep the total distance? This approach is most effective for use in the development of ring routes in transport logistics.

The salesman problem can be formulated as an integer linear programming problem. We introduce variables. $x_{ij}, i = \overline{0,n},\ j = \overline{0,n};\ i \neq j,$ that have the following meaning:

$$x_{ij} = \begin{cases} 1, if\ the\ salesman\ after\ point\ i\ gets\ to\ point\ j, \\ 0, otherwise. \end{cases}$$

Also introduce variablesu_i, u_j $(i, j = \overline{1,n})$, which will allow to formulate the condition of connectivity of the route of the salesman: to exclude disintegration of a route into subcyclets Then the mathematical model of the problem takes the form:

$$\sum_{i=0}^{n} \sum_{\substack{j=0, \\ j\neq i}}^{n} c_{ij}x_{ij}, \to min_{x_{ij}\in\Omega} \quad (2.1) \qquad \textbf{(1)}$$

$$\Omega: \sum_{\substack{j=0, \\ j\neq i}}^{n} x_{ij} \to 1, i = \overline{0,n} \quad (2.2) \qquad \textbf{(2)}$$

$$\sum_{\substack{j=0, \\ j\neq i}}^{n} x_{ij} \to 1, j = \overline{0,n} \quad (2.3) \qquad \textbf{(3)}$$

$$u_i - u_j + nx_{ij} \leq n - 1, i, j = \overline{1 \dots n}, (2.4) \qquad \textbf{(4)}$$

$$u_i, u_j = int, j, i = \overline{1 \dots n}.\ (2.5) \qquad \textbf{(5)}$$

$$x_{ij} + x_{ji} \leq 1, i, j = \overline{0 \dots n}, i \neq j. (2.6) \qquad \textbf{(6)}$$

Formula (1) defines the objective function as the total length of the salesman's route. Condition (2) states that the salesman enters each point only once, condition (3) - that the salesman leaves each point only once. Restriction (4) requires that any salesman route consist of one cycle. The system of equations (5) limits the range of admissible values of additional variables to integers (positive or negative). The last restriction (6) excludes the return of the salesman to the point where he has already visited. Consider the mathematical formulation of the problem of a salesman on the example.

The salesman has to go around five points. When leaving point 0, the traveler must visit all other points only once and return to point 0. It is necessary to find out in what order to go around the points so that the total distance traveled was minimal. The distances between the points are given in the form of a matrix::

$$C = [c_{ij}] = \begin{bmatrix} 0 & 12 & 4 & 9 & 10 \\ 12 & 0 & 11 & 6 & 8 \\ 4 & 11 & 0 & 3 & 5 \\ 9 & 6 & 13 & 0 & 7 \\ 10 & 8 & 5 & 7 & 0 \end{bmatrix}.$$

The formulation of this problem using formulas (1) - (6) is as follows. The objective function for these conditions will look like this:

$$y = 12x_{01} + 4x_{02} + 9x_{03} + 10x_{04} + 12x_{10} + 11x_{12} + 6x_{13} + 8x_{14} + 4x_{20} + 11x_{21} + 13x_{23} + 5x_{24} + 9x_{30} + 6x_{31} + 13x_{32} + 7x_{34} + 10x_{40} + 8x_{41} + 5x_{42} + 7x_{43} \to min_{x_{ij} \subset \Omega}$$

With the following restrictions:

$$\Omega: \quad f_0 = x_{01} + x_{02} + x_{03} + x_{04} = 1$$

$$f_1 = x_{10} + x_{12} + x_{13} + x_{14} = 1$$

$$f_2 = x_{20} + x_{21} + x_{23} + x_{24} = 1$$

$$f_3 = x_{30} + x_{31} + x_{32} + x_{34} = 1$$

$$f_4 = x_{40} + x_{41} + x_{42} + x_{43} = 1$$

$$f_5 = x_{10} + x_{20} + x_{30} + x_{40} = 1$$

$$f_6 = x_{01} + x_{21} + x_{31} + x_{41} = 1$$

$$f_7 = x_{02} + x_{12} + x_{32} + x_{42} = 1$$

$$f_8 = x_{03} + x_{13} + x_{23} + x_{43} = 1$$

$$f_9 = x_{04} + x_{14} + x_{24} + x_{34} = 1$$

$$u_i - u_j + 4x_{ij} \leq 3, \qquad i,j = \overline{1,4}, i \neq j$$

$$u_i, u_j = int, j, i = \overline{1,4}$$

$$x_{ij} + x_{ji} \leq 1, i,j = \overline{0 \dots 4}, i \neq j.$$

Solving the problem of a salesman by the method of branches and boundaries. Consider a complete symmetric oriented graph (X,U), $X = \{0,1,\dots,n\}$ – set of vertices; U – set of arcs. Each arc (i, j) of the graph is assigned a number σ_{ij} arc length. You need to find a contour that passes through each vertex only once (Hamiltonian contour), which has the shortest length. Under the length of the contour we mean the value equal to the sum of the lengths of the arcs σ_{ij}. This will be the route of the traveling salesman.

First, for the set of all Hamiltonian contours R is determined by some estimate from below (lower limit) $\varphi_{(R)}$ contour length. Then the set of all Hamiltonian contours is divided into two subsets. The first subset consists of Hamiltonian contours that include a definite arc (i,j). Let us denote this set $\{(i,j)\}$. The second set consists of Hamiltonian contours that do not include this arc. Let's mark it$\left(\overline{\{(\iota,\jmath)\}}\right)$. For each of the subsets $\{(i,j)\}$ i $\left(\overline{\{(\iota,\jmath)\}}\right)$ the lower limit of the length of Hamiltonian contours is determined $\varphi_{(i,j)}$ i $\varphi_{\overline{(\iota,\jmath)}}$. Each new boundary is not less than the lower boundary of the whole set of Hamiltonian contours $\varphi_{(R)}$.

Among the two subsets of the contours of the subsets $\{(i,j)\}$ i $\left(\overline{\{(\iota,\jmath)\}}\right)$ a subset with a smaller lower bound is selected. This subset is again divided into two subsets. For newly created subsets, there is a lower bound. The process of splitting subsets similarly continues until a subset containing a single Hamiltonian contour is selected. The relationship of subsets obtained as a result of partitioning is depicted as a tree, the vertices of which are attributed to the lower limits.

Having obtained the Hamiltonian contour, the torn branches of the tree are viewed and the lower limits of the sets corresponding to the torn branches are compared with the length of the obtained Hamiltonian contour (record). If the lower limits of the subsets corresponding to the broken branches are smaller than the record, then these branches develop according to the same rule. As a result of the development of branches, new Hamiltonian contours can be obtained. In this case, the record is taken to be equal to the smallest of the lengths of the Hamiltonian contours. The solution of the problem is considered complete if the lower limits of these branches are not less than the record. The contour with the shortest length is selected as the optimal contour. The calculation of the lower limits is based on the following property. If you find the length of the optimal contour with the distance matrix A, and then subtract some number a from the elements of some row or column of matrix A and solve the problem with the new matrix again, the contour will not change and its length will decrease by this number a. Changing all the elements of a row or column to the same number does not affect the optimal solution of the problem. If the subtraction operation is performed for other rows and columns, the length of the optimal contour with a modified matrix will differ from the length of the optimal contour with the original matrix by the sum of numbers subtracted from the elements of rows and columns. Therefore, to determine the lower bound of the set of all Hamiltonian contours, it is necessary to find in each row of the matrix A:

$$\alpha_i = min_{1\leq i\leq n}\{a_{ij}\} \qquad \textbf{(7)}$$

Then it is necessary to subtract this value from all elements of this line (operation of reduction of a matrix of distances on lines). As a result of reduction of a matrix in each its line there will be at least one zero (the received matrix A *). Then in the matrix, arranged in rows, we find the smallest element:

$$\beta_j = min_{1\leq j\leq n}\{a^*_{ij}\} \qquad \textbf{(8)}$$

in each column of the matrix A * (operation of compiling the matrix of distances by columns), α_i, β_j – summary constants. The fully composite matrix contains at least one zero in each row and each column.

Because the length of the optimal contour L_1 in the problem with a completely reduced matrix differs from the length of the optimal contour L in the problem with an unreduced matrix by the sum of the summation constants:

$$\gamma = \sum_{i=1}^{n} \alpha_i + \sum_{j=1}^{n} \beta_j, \tag{9}$$

then $L = L_1 + \gamma$

In a fully composite matrix, all elements are non-negative, so $L_1 > 0,\ \gamma$ can be chosen as the lower limit of the Hamiltonian contour, ie assume that $\varphi_{(R)} = \gamma$.

Consider the method of choosing an arc (i, j), inclusion or non-inclusion of which in a contour divides a set of Hamiltonian contours into subsets$\{(i, j)\}$ i $\left(\overline{\{(\iota, \jmath)\}}\right)$. Exclusion of an arc (i, j) from a Hamiltonian contour is carried out by replacement of the corresponding element of a matrix of distances on ∞. As a result of the exclusion, it is possible to perform additional reduction in the matrix and improve the limit.

The inclusion of the arc (i, j) in the Hamiltonian contour allows to reduce the size of the matrix by deleting the i-th row and j-th column. In addition, when the arc (i, j) is included in the Hamiltonian contour, it is possible to form a non-Hamiltonian contour, ie a contour passing through part of the vertices. Therefore, in order to prevent the formation of such a circuit, it is necessary to exclude from consideration one of the arcs. In the simplest case, when including the arc (i, j) in Hamiltonians, the contour must be excluded from consideration of the arc (j, i). After this operation, you need to perform the operation of additional reduction of the matrix and improve the lower limit. It is most probable that the optimal contour will include arcs, which in the given matrix correspond to zero elements. Therefore, the choice must be made as follows. An element in a consolidated matrix $\alpha_{ij} = 0$ conditionally replaced by ∞. Thus, the arc (i, j) will be excluded from the Hamiltonian circuit.

To determine the sum of the summation constants of the resulting matrix, you must add the smallest element α_i i-th line with the minimum element β_j j-th column, because the remaining rows and columns contain at least one zero element. Denote the sum of the constants of the reduction of the matrix with the arc excluded (i, j) through:

$$\gamma_{(\overline{\iota,\jmath})} = \alpha_i + \beta_j. \tag{10}$$

A similar calculation is performed for all other zero elements of the given matrix, conditionally replacing them on ∞.

First of all, we will exclude from the contour the arc (i, j) for which the sum of the summation constants $\gamma_{(\overline{\iota,J})}$ is the largest, because in this case the sharpest change in the estimate will occur.

Algorithm for solving the salesman problem by the method of branches and boundaries:

1. Reduce the matrix of distances in rows and columns. Find the lower limit of all Hamiltonian contours:

$$\varphi_{(R)} = \gamma = \sum_{i=1}^{n} \alpha_i + \sum_{j=1}^{n} \beta_j. \quad \textbf{(11)}$$

2. Replace each zero in the consolidated matrix conditionally with ∞ and find the sum of the summation constants $\gamma_{(\overline{\iota,J})} = \alpha_i + \beta_j$ Value $\gamma_{(\overline{\iota,J})}$ write in the corresponding rows and columns of the consolidated matrix next to the zeros.

3. Exclude the arc (i, j) for which the sum of the summation constants $\gamma_{(\overline{\iota,J})}$ is the largest (except for the arc $(i,\ j)$ is achieved by replacing the corresponding element of the matrix with ∞). As a result, a subset of Hamiltonian contours will be formed $\left(\overline{\{(\iota,J)\}}\right)$.

4. Reduce the resulting matrix of distances and determine the lower limit $\varphi_{(\overline{\iota,J})}$ subsets of contours $\left(\overline{\{(\iota,J)\}}\right)$.

5. Include the arc (i, j) in the circuit, which is reduced to the exclusion from the matrix obtained after the execution of paragraph 2, the i-th row and the j-th column. Replace one of the elements of the resulting matrix with ∞ to prevent the formation of a non-Hamiltonian contour.

6. Give the resulting distance matrix and determine the lower limit $\varphi_{(i,j)}$ subsets of contours $\{(i,j)\}$.

7. Check the dimension of the abbreviated matrix. If the abbreviated matrix has a dimension of 2 × 2, then go to step 9.

8. Compare the lower limits of subsets of contours $\varphi_{(\overline{\iota,J})}$ i $\varphi_{(i,j)}$ and go to step 2. If $\varphi_{(\overline{\iota,J})} < \varphi_{(i,j)}$, then the subset is subject to division $(\overline{\iota,J})$, otherwise - a subset $\{(i,j)\}$.

9. Determine the Hamiltonian contour and its length.

10. Compare the length of the resulting contour with the lower limits of the broken branches. If the length of the contour does not exceed the lower limits of the torn branches of the decision tree, then the optimal Hamiltonian contour is obtained. If the length of the obtained Hamiltonian contour is greater than the limit of some branches, then, following the algorithm, we develop these branches until we obtain a contour with a shorter length or make sure that it does not exist (Fig. 25).

Solving the traveling salesman's problem using genetic algorithms. Unlike evolution that occurs in nature, the genetic algorithm only models those processes in the population that are essential for development. Its most adapted members are able to "reproduce" offspring with other members of the population, which leads to the emergence of new individuals, combining some characteristics inherited from their parents. Less adapted individuals are less likely to be able to reproduce offspring, so that the properties they possessed will gradually disappear from the population in the process of evolution.

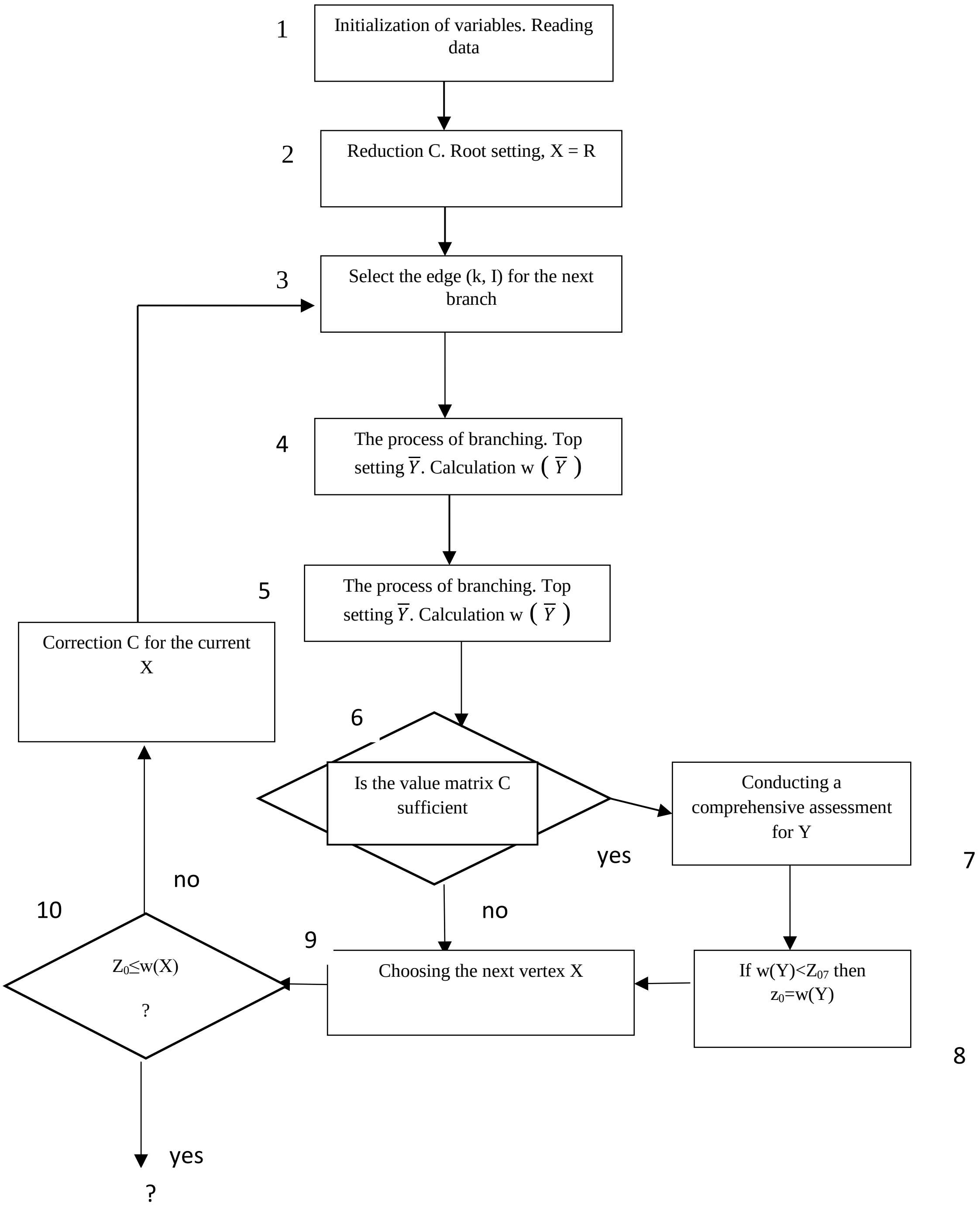


Figure 25. Block diagram of the algorithm for solving the problem of a salesman by the method of branches and boundaries

Thus, the whole new population of acceptable solutions is reproduced by selecting the best representatives of the previous generation, crossing them and obtaining many new individuals. This new generation will contain a higher ratio of characteristics that have good members of the previous generation. Crossing the most adapted members leads to the fact that the most promising areas of the search space are explored. Eventually, the population will converge to the optimal solution. There are many ways to implement the idea of biological evolution within the genetic algorithm. The scheme of the classical genetic algorithm is shown in Fig. 26. Consider the use of genetic algorithms on the example of the classic traveling salesman problem. The problem, as mentioned earlier, belongs to the class of NP-complete problems, ie the operating time of the algorithm, the decisive task of the salesman, significantly depends on the size of the input data, ie the number of cities. All effective (reduce the full search) methods of solving the problem of the salesman - heuristic methods. Most heuristic methods are not the most effective route.

In order for the problem to be solved with the help of genetic algorithms, it is necessary to find out what exactly is the solution of this problem, to encode the solution in the form of a chromosome and to make the function of adaptation for such chromosomes. Only then can this problem be solved by means of genetic algorithms. Find out what can be considered a solution to the problem of a salesman.

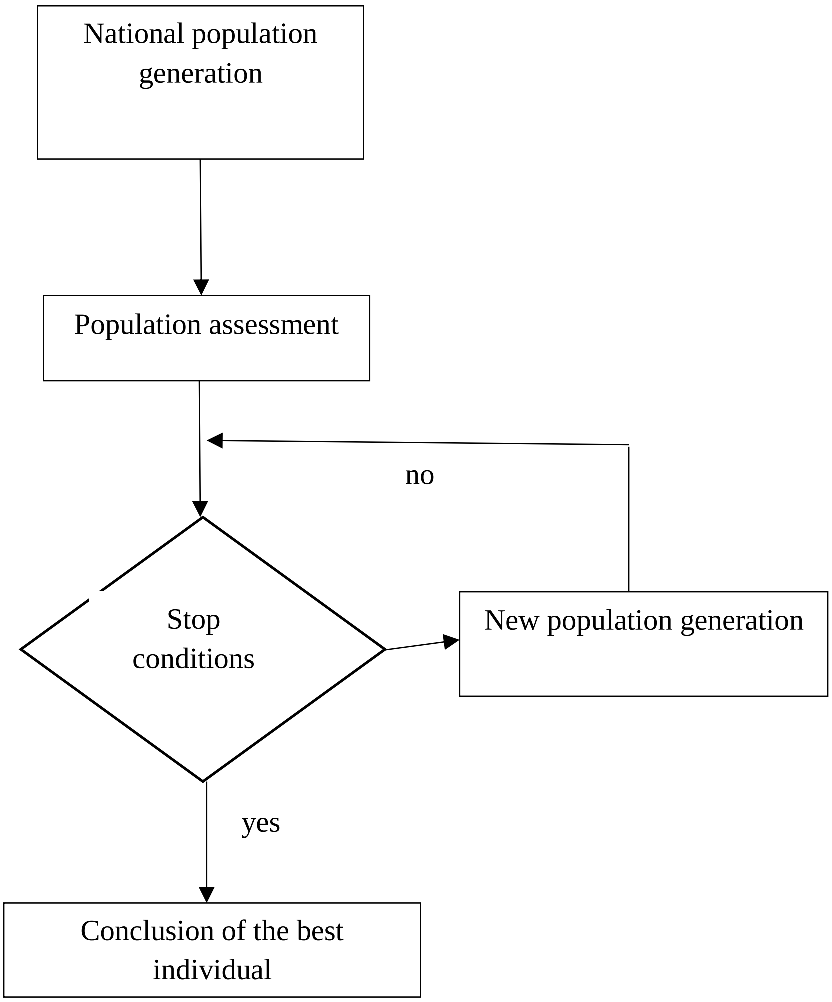


Figure 26 Robot diagram of a classic genetic algorithm

Obviously, any solution will be any route between cities that satisfies the following conditions: it crosses everything without exception of the city and not one does not cross more than once. You can encode such a route in the form of a sequence of city numbers, starting from the very first, at the end of the sequence the number of the penultimate city, as the route is closed and the last will be the city from which it began. Obviously, it will not repeat the values in this sequence. Suppose for simplicity of example the number of cities N = 8.
Code cities from 1 to 8. Then the same path will look like:

1	6	2	5	4	8	3	7

Now we need to present the solution in the form of a chromosome. Above we have already encoded the solution in the form of a sequence of city numbers, now it remains to recode its chromosome. For certainty, we assume that we encode a chromosome in the form of a bit vector. Obviously, the length of the gene in bits on the chromosome will be equal to:

$$L = \log_2 N \quad \textbf{(12)}$$

For the given example L = $\log_2 8$ = 3. That is for coding of one gene 3 bits will be required. The sequence is encoded using binary encoding:

000	101	001	100	011	111	010	110
1	6	2	5	4	8	3	7

However, in presenting the decision in this way, we did not take into account several significant factors:

- at random generation of initial population the chromosome in which values of genes will be repeated can arise: 000 000 010 011 100 101 110 010.

- Chromosomes with repetitive genes can give a crossover or mutation.

There are several ways to address this lack of coding, but they all lead to excessive consumption of computing resources, because you need to further check the chromosomes. One way is to check for duplicate values within the fitness function, and when you encounter them, replace them with values that are not on the chromosome. The second way is not to check anything, but to assign such chromosomes a very low value of the fitness function, but in this case the genetic algorithm begins to work extremely inefficiently. Generally speaking, the question of coding solutions into a gene sequence is very important for genetic algorithms. The quality of the algorithm depends on how successful it is. The most important, and mandatory, requirement for coding - the chromosome must clearly represent some solution, so that it is not possible to interpret the same chromosome differently. It is desirable that the chromosomes occupy as few bits as possible, be shorter. Simplicity of coding is also an important condition. The speed of work depends on it. After coding, a genetic algorithm with the desired parameters is started.

Detailed description and detailed diagram of the class of genetic algorithm. It should be noted that the task of a salesman is a task of the bridging type, which means that for certain input parameters of the problem the number of solutions can go to infinity. Therefore, it makes sense to use a genetic algorithm to solve problems of this type. The problem is encoded so that its solution can be represented as an array of information-like chromosome composition. This array is often called the «chromosome». Randomly in the array creates a number of initial elements of "persons", or the initial population. Individuals are evaluated using the adaptation function, as a result of which each person is assigned a certain value of adaptation, which determines the possibility of survival of the person. After that, using the obtained values of fitness, the persons admitted to crossbreeding (selection) are selected. "Genetic operators" are applied to individuals (in most cases they are a crossover operator and a mutation operator, thus creating the next generation of individuals.

Next-generation individuals are also evaluated using genetic operators and selection and mutation are performed. This simulates an evolutionary process that lasts several life cycles (generations) until the criterion of stopping the algorithm is met. Such parameters in the program are: finding a global or suboptimal solution; exhaustion of the number of generations devoted to evolution; exhaustion of time given for evolution. As for the types of data used in the program, they have an integer value, so the corresponding structures in the program implementation are also integers (Fig. 27).

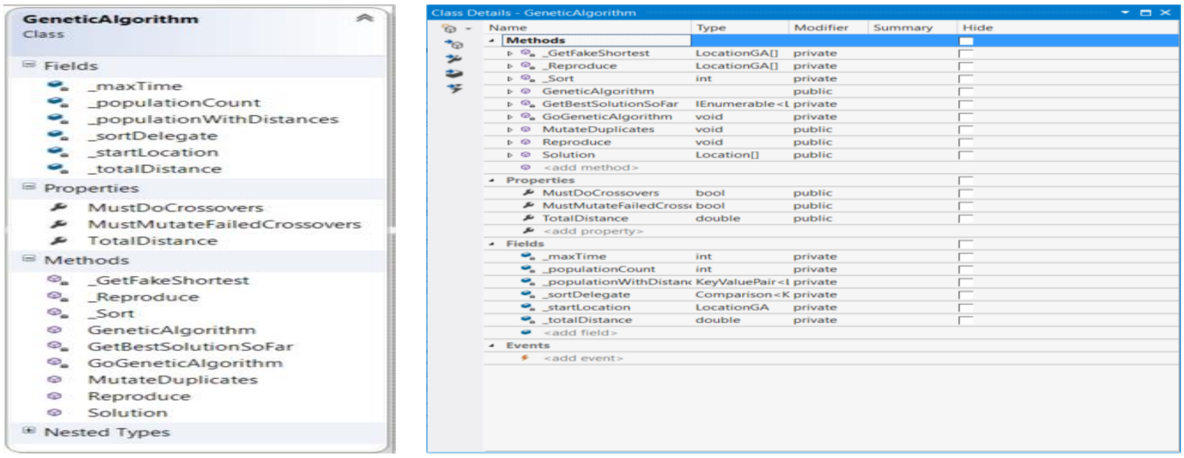
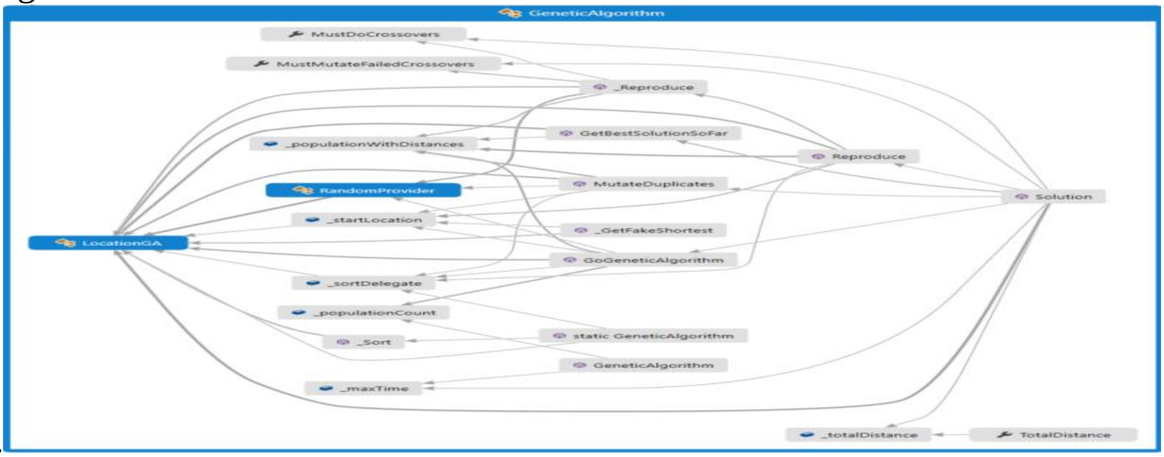


Figure 27. Display of different types of structures in the software implementation of the genetic algorithm

Stages of the genetic algorithm

We present the general scheme of the basic genetic algorithm as an iterative process consisting of several stages: 1) generation of the initial population; 2) the creation of offspring: a) the choice of parental couple and the implementation of crossbreeding; b) making mutational changes in the population; 3) selection and formation of a new generation; 4) if the condition of stop is not fulfilled - transition to item 2.

The diagram of interdependencies of functions and methods of a class is shown in fig. 28.



.

Figure 28. Diagram of interdependencies of functions and methods of the class of genetic algorithm

REFERENCES

1. Basima H. (2011) Evaluating the effectiveness of mutation operators on the behavior of genetic algorithms to non- deterministic polynomial problems / Hani F. Hasan Basima, Saleh M. Saleh Moutaz // Informatica. № 35. p. 513–518
2. Zvonkov V. B., Popov A. M. (2013) COMPARATIVE INVESTIGATION OF CLASSICAL OPTIMIZATION METHODS AND GENETIC ALGORITHMS / Vestnik Siberian State Aerospace University. № 4(50). 2013. p. 23-27
3. Ikotun A. M. (2011) The effectiveness of genetic algorithm in solving simultaneous equations / A. M. Ikotun, N. O. Lawal, P. A. Adelokun // International journal of computer applications. V.14. № 8. February 2011. p.38–41
4. Krykavsky E.V. (2004) Do teorii optymizatsii logistychnych vytrat / Krykavsky E.V., Dovbakh N.A., Kostyuk A.S., Shevtsiv L.Y. // Visnyk Sumskogo derzhovnogo universytetu. Seria Ekonomika. №5 (64). p. 142-154/
5. Oklander M., Yashkina O., Yashkin D. (2019) Minimization of transportation risks in logistics by choosing a cargo delivery route with the minimal projected number of road accident / Eastern-European Journal of Eenterprise Technologies. Vol. 5, № 3 (101). P. 57–69. URL: http://journals.uran.ua/eejet/article/view/181612
6. Rybak V.A. (2015) APPLICATION OF GENETIC ALGORITHMS TO SOLVE THE PROBLEMS OF OPTIMIZING ENVIRONMENTAL QUALITY / SYSTEM ANALYSIS AND APPLIED INFORMATICS. № 2. p. 65-70

7. Setlak G. (2002) Solving multicriteria optimization problems using genetic algorithms / System Research & Information Technologies, 2002, №.3. p. 32-42

5.3 Artificial intelligence and the world market of self-driving vehicles

Elena Pryiatelchuk
Doctor of Economics
Associate Professor at the Department of International Business
Taras Shevchenko National University of Kyiv
E-mail: pryyatelchuk@gmail.com

Aleksey Stupnytskyy
PhD (Economics)
Professor at the Department of International Business
Taras Shevchenko National University of Kyiv
E-mail: a.stupnitsky@ukr.net

Ivan Shved
Postgraduate student of the Department of International Business
Taras Shevchenko National University of Kyiv
E-mail: durrer@ukr.net

The development of modern Industry 4.0 essentially depends on further improvement of vehicles and transportation systems, which should ensure increasing population mobility, efficiency of freight and passenger transportation, road safety, comfort of drivers and transport users, and a decrease in the environmental load. One of the priority areas in solving these problems is creation of ground autonomous vehicles (AV). The USA, Germany, Japan, China, Great Britain, Sweden, France, and Korea are currently carrying out the most active work on creation of self-driving vehicles.

The AV development occurs in 3 main areas:

- *consumer* (private car, taxi, city car transport network);
- *industrial* (specialized equipment);
- *military* (combat vehicles of various missions).

The AV functions include:

- *introduction and expansion* of functionality of various driver assistance systems (now standardly equipped for cars of all classes);
- creation of AV control systems (which are currently at the stage of testing prototypes, including operational ones).

The main advantages of AV using are:

- the ability to transport goods in hazardous areas, or during natural and man-made disasters or military operations;

- time and cost reduction for transportation of goods and passengers;
- more efficient use of road capacity due to centralized traffic management;
- reduction of fuel consumption, vehicle emission into the atmosphere;
- saving time spent on centralized management of the transport system;
- increasing the use of cars for people with disabilities;
- improvement of transport and environmental safety, minimization of road accidents and the number of casualties in them;
- increasing the comfort of passengers.

The main directions of the AV market dynamics are:

- number of foreign patents and published patent applications for ground-based AV and driver assistance systems;
- AI-based software for calculation of routes used to download on vehicles;
- *FaceID* recognition systems for vehicle users;
- robo cars that deliver orders to customers;
- express delivery using drones.

AV market development format Mass implemented AV is an object built into the general information environment which either supplies the vehicle control module with information for making a decision, or an immediate solution for a centralized system that controls the traffic flow. At the same time, the traffic area and the transport itself should be equipped with all sorts of sensors and scanning devices that transmit huge amounts of data to the information system.

Stimulating factors for the development of the AV market are:

1. *Economic Effect* It is that the costs of logistics companies are expected to decrease and productivity – to increase. The costs of this process will be a reduction of professional drivers in the labour market of jobs, but this reduction will take place gradually – as the levels (classes) of autonomy are introduced. For international transportation, AV technologies, on the one hand, will help to solve the problem of the growing shortage of qualified driver personnel, and on the other hand, stimulate the growth of demand for AV operators. With implemented AV mass use, large logistics operators who have funds for the purchase and maintenance of such a fleet of vehicles will gain additional competitive advantages.

2. *Organisational Optimisation* In an urban environment, the synergy of AI technologies and general AV information system will help optimise traffic flows, reducing downtime and accelerating average travel speeds.

3. *Security* The AV safety is a rather controversial issue at the initial stage, however, with the development of AI technologies and automated systems, the total number of accidents and fatalities on the roads will undoubtedly reduce. The fact that an AV with the possibility of remote shutdown is more controllable by road services is an additional argument.

The AV market development based on AI technologies is turning into an **independent segment** of modern transport infrastructure of an innovative type. The following data testify to the accelerated development of the AV segment of the market. In 2020, investments in the development of new medical drugs using AI solutions and research in the field of molecular medicine amounted to over $13.8 billion. (4.5 times more than in 2019). Companies developing AV are third in the list – $4.5 billion, while about 40% of the cost of software for cognitive platforms and AI technologies falls on analysis tools , organisation, access and provision of logistics services based on structured and unstructured information [1]. According to the US National Venture Capital Association, in 2020, venture capital funds such as *Plug and Play Ventures*, *Accel and Lightspeed Ventures* invested $18.4 billion in the development of start-ups that specialise in, among other things, AV. The global research firms *P&S Market Research* and *Market Research Future* estimate that by 2023 the global *CAGR* will be 12-14.5%. The rapid growth of this market is driven by the many benefits that AI can provide to AV, including improved efficiency, pedestrian and driver safety, and cost savings [2].

The main sectors of the AV market are:

1) self-driving passenger vehicles;
2) autonomous cargo vehicles;
3) ‘fast delivery’ drones;
4) air winged capsule taxi.

Currently, most of the world's leading automotive companies are implementing AV projects in an effort to make self-driving cars flawless and safe for passengers.

An autonomous vehicle is a vehicle equipped with an automatic control system (autopilot) that can move without human intervention. An *autopilot* as a device or hardware and software complex leading a vehicle along a certain assigned trajectory is used to control aircraft (due to the fact that the flight most often takes place in a space that does not contain a large number of obstacles), as well as to control rail transport vehicles. However, modern autopilot allows you to automate all stages of movement of any other vehicle, including a car.

The general principles of operation for all unmanned vehicles are approximately the same and include the following elements: GPS-navigator, radar, lidar (creates a 3D map of the area), satellite navigation system, inertia sensors, position and parking sensors, and video cameras. These elements are combined into a new generation ***ITS* system** with a wide range of capabilities for solving the following tasks [3]:

- control and management of parking lots (including payment);
- analysis and processing of traffic information (inner perimeter);
- management of cargo transportation;
- traffic control (external perimeter).

One of the main applications of the *ITS* system is to assist the vehicle driver using cloud-based decentralised databases. Information is provided about hazardous areas, precipitation, traction, visibility, wind, etc. Due to cooperative awareness, the vehicle receives both a warning about danger and a the risk of collision at an intersection, breakdown of electric lighting, wrong road, road works, changing the traffic signal, etc.

The basic components of autonomous AV are external cameras and radar equipment – information exchange between vehicles using [4]:

❖ ***V2V*-systems** (vehicle-to-vehicle), which: a) provide safe driving due to communication between vehicles at intersections with poor visibility, b) warn drivers of the danger of a frontal, side or rear collision (exchange of coordinates and values of speeds between cars in order to avoid any collision), c) notify about a vehicle malfunction, d) provide traffic regulations;

❖ ***V2I*-systems** (vehicle-to-infrastracture), which: a) provide the transmission of information (signal) from roadside equipment (sensors) to the car through radio communication, b) duplicate information to other approaching cars; c) create an up-to-date digital road map to ensure safe and efficient road traffic.

In 2019, Cornell University (USA) developed a first-of-its-kind model of platoons for self-driven vehicles and smart intersections to control their traffic and intersections. The goal is to increase the capacity of city streets (creation of intelligent infrastructure to optimise traffic) and reduce traffic jams and accidents (fast and safe passage through intersections). The test results showed that this model increased the traffic capacity of vehicles on city streets by up to 138% compared to the operation of conventional traffic lights. Based on the fact that mathematical errors associated with this model are possible, which can lead to malfunctions or even accidents, the authors of the model developed a formula that takes into account the likelihood of failures and adds a time gap with optimal time between the traffic of platoons of unmanned vehicles [5].

Conventional cars have zero level of automation and have no automation at all (complete manual control), and the fifth – highest level – implies that the system controls the car as well as an experienced drivers do (a completely self-driving car). The *SAE International* (International Professional Association of Automotive Engineers) levels determine how ready a system is to give control of a car to AI software and an on-board computer. ***SAE levels*** are currently being applied by automakers, national regulators, engineers and investors. According to the *SAE International* classification, driver assistance systems today are divided into 5 classes of autonomy (including cars with ABS and cruise control) [6]:

• ***Level 1*** (‘hands on’, ‘driver assistance’) – the driver and the system together control the vehicle, the vehicle is equipped with adaptive cruise control and steering or braking control;

• ***Level 2*** (‘hands off’, ‘partial automation’) – the system fully controls movement / braking, the driver monitors the ride and is ready to intervene at any time if the system cannot respond correctly and control itself;

• ***Level 3*** (‘eyes off’, ‘conditional automation’) – the role of the driver is “backup”: the driver does not need an immediate response, but is able to intervene within a time limit determined by the manufacturer;

• ***Level 4*** (‘mind off’, ‘wide automation’) – the system takes full control, the driver does not need constant attention, fully automatic driving is carried out only in some spatial areas (geofences) or in some situations (today most developers are trying to create systems of this particular level).

• ***Level 5*** (‘steering wheel optional’, ‘full automation’) – no human intervention, full automation (there is no steering wheel in front of the driver). According to the Autonomous Vehicle Technology Report 2020, there is no working technology of the 5th level of autonomy in the world yet and experts do not expect such technology to appear in the medium term.

In early 2021, *Ford* announced more than doubling its self-driving and EV investments from $11.5 billion to $29 billion by 2025, with the majority of vehicles being either electric or hybrid with self-driving functionality (semi- and fully self-driving cars with 4 and 5autonomy level). To further digitise the business, *Ford* will partner with *Google* to integrate Android software into its millions of vehicles from 2023. *General Motors* is also investing $27 billion in self-driving cars by 2025, *Volkswagen* plans to sell 100% self-driving cars in 2025-2030, and *Daimler AG* presented a new model *Mercedes-Benz S-Class* in 2020, the owners of which in Germany will be able to use the functions of the level 3 autopilot already in 2021.

The most complex in ground-based AV is the ***Mobility as a Service*** system (MaaS), the constituent elements of which are:

I. Navigation and orientation system which ensures determination of the AV position;

II. A machine vision system that forms a view of the environment;

III. Identification system providing recognition of other vehicles, obstacles on the route, road markings, road signs, and traffic light readings;

IV. Information and control system responsible for building a route, making emergency decisions depending on the surrounding traffic situation and generating control signals.

MaaS is a unified information system where all types of transport, payment and services are integrated. Today the world MaaS market is one of the most promisingwithout clear leaders on it. According to the forecast, the market volume will be about 1 trillion dollars by 2030 and it will grow by 28% per year on average. Now, the main income of carmakers consists of sales and services, but the forecast is that by 2030 about 80% of revenue will be formed from the purchase of digital services on board while in motion. *MaaS* is an objective trend in the development of mobility, a way to solve the problem in the segment of personal and public transport in the context of transition from the concept of ownership to the concept of private-public transport. Self-driving *DRT*s (or Uber-buses) are predicted to appear by 2025, combining taxi and public transport services, and the passenger will be delivered directly to the door, and not disembarked at stops [7].

The software (SW) in the AV traffic control system includes **two levels**:

❖ ***lower***, responsible for interaction with sensors and actuators;

❖ ***upper***, directly responsible for implementation of the algorithm for controlling the AV movement.

Experience in the development, production and operation of driver assistance systems (*Advanced Driver Assistance System, ADAS*) forms the AV basis, which are currently being actively integrated into the AV traffic control systems. ***The main components of ADAS*** are:

✓ telecommunication devices and systems;

✓ technologies for AV managing;

- ✓ additional systems and means to improve road safety;
- ✓ systems of transmission and exchange of information between vehicles;
- ✓ systems of transmission and exchange of information between vehicles and the infrastructure of intelligent transport systems.

The modern BPS system is a symbiosis of technology, intellectual resources and artificial intelligence (AI) technologies that simplify the operation of production lines and the process of delivering goods using image recognition and a dialogue interface.

Uncertainties in the AV market development It is assumed that access to the mass use of unmanned technologies in the AV market in the field of cargo transportation is possible within 10 years, but there are still 'open-end' questions [8]:

I. ***Terms of development of reliable AV models and the beginning of their serial production*** Today, these technologies are at the testing stage to make corrective decisions, taking into account the technological and economic risks associated with the AV conveyor production.

II. ***The amount of investment by transport companies in the purchase of unmanned vehicles*** To date, there are no valid calculations regarding the amount of funds required for the purchase and maintenance of the AV fleet, and an objective calculation is possible only after a relatively accurate forecast under item I.

III. ***Training of a sufficient number of technical personnel who will serve the AV fleet*** Although today educational institutions are already starting to open courses for specialists in AV servicing, they are more focused on basic theoretical training (their number, skill set and professional competencies have not yet been determined by the market).

IV. ***Digital road infrastructure readiness*** Accurate and readable in any weather conditions road markings, technologies for completing road objects with sensors, cameras, etc., which must work in a unified and reliable data exchange system (including those based on AI) are still at the stage of development, testing, unification and linking with organisation of their management.

V. ***Legal regulation*** The public inquiry is acute: "Who will take responsibilities in the event of an accident: manufacturer, owner, or management operator?" Without settling this legal aspect, the society will not allow the development of the AV introduction on public roads.

With both legal and technical constraints impeding active AV use today, autonomous vehicle IT developers are experimenting with logistics platforms to create AI-powered digital offerings and software as part of robust global logistics networks **to optimize AV**.

Optimisation problems require special algorithms (computational raster algorithms) to simplify computational analytics solutions. Examples of such algorithms are:

a) ***genetic algorithm*** *(GA)* which is based on the evolutionary biological concept of 'survival adaptability' and is used as a tool in urban networks;

b) ***Simulated Annealing*** *(SA)* ***algorithm*** which is formed on the basis of modelling the metal annealing process;

c) ***Artificial Immune System*** is based on the human immune system *(AIS).*

Intelligent computational analytics of these systems are capable of displaying uncertainty, imprecision and vague concepts. Therefore, these methods are used for problems of optimisation of traffic and control in transport [9]:

- automation of accident detection and forecast of future traffic conditions;
- road planning and public transport scheduling;
- definition and classification of road risks, traffic congestion;
- analysis of travel demand and pedestrian behaviour;
- forecast of gas and pollutant emissions into the atmosphere.

The problem associated with dynamic traffic situations and events is solved when choosing the shortest a justified and adaptable routing path. An optimisation method based on the *Fuzzy Logic Model (FLM)* and *Logistic Regression Model (LRM)*, as well as a dynamic approach to determining the shortest route through formation of *multi-criteria and multi scenarios,* is currently used.

As the volume of AV data is increasing rapidly, the complexity of managing transport chains and transport networks is also growing, and therefore, it is almost impossible to make optimal choices using manual planning or simple data analysis methods. In this regard, AI solutions can maintain (or even take over) control over people to effectively manage large amounts of data and make decisions in complex situations (in real time).

The main factors of uncertainty in the AV use are [10]:

- Lack of personification of liability for damage;
- Loss of the ability to drive the car independently;
- Degree of software reliability;
- Lack of driving experience for drivers in a critical situation;
- Loss of jobs by people whose jobs involve driving vehicles;
- Loss of privacy;
- The ethical question of the most acceptable number of potential victims in an imminent collision.

Data from autonomous vehicles can be stored both directly on board (if they need to be processed promptly), and in the cloud, which is more suitable for in-depth analysis. Data routing depends on their function: data that the driver needs immediately, or information from motion sensors and location information from a ***GPS system***. At the same time, it should be borne in mind that, *firstly*, even minimal delays in the transmission of information are critical for AV during their mass use (the delay in information about changes in the movement of one car, for example, about braking, will not allow to adequately correct the actions of the cars around it)... *Secondly*, a prerequisite is a developed **'smart' road infrastructure** (traffic lights, road markings, road signs, etc.) [11].

In *Wi-Fi* coverage, sending data to the cloud is economically feasible and technically simple, but if the car is in motion, the only option available may be a

4G / 5G connection (and the cost of data transmission over a cellular network can be high). The expansion of the coverage area with 5G technology allows AV:

❖ To reduce the time it takes to receive the data collected by the vehicle, due to which the vehicle will be able to react almost instantly to sudden changes in traffic or weather conditions;

❖ AI-based software to become the main catalyst for the further development of connected and autonomous cars, giving them the ability to almost instantly communicate with each other, as well as with buildings and infrastructure (V2V, V2I);

❖ Accelerate the development of digital services for drivers and passengers, which will increase the enjoyment of the trip, and, accordingly, will increase the potential profit for the providers of these services.

High-precision maps are a fundamental element in addition to *detection and tracking of moving objects (DATMO)* and *simultaneous localisation cameras (SLAM)* to orient the vehicle in its environment. This is necessary so that the autonomous vehicle knows exactly where it is and what happens next on the road outside the zone of current physical visibility. Only in this case, AV will be able to build not a reactive, but a proactive driving strategy based on AI and map services updated in real time [12]. The latter focus on:

- people and objects, including road users, vehicles, cargo, sorting belts and infrastructure;
- processes and systems, including supply chains, transport hubs, traffic, policies and regulations.

Only with an integrated ecosystem approach that takes into account these two elements, as well as technological elements (sensation, thinking, action), can AI be used effectively.

According to the *National Highway Traffic Safety Administration (NHTSA)* of the US Department of Transportation, 94% of car accidents are usually caused by human error. Today, *NHTSA* is focused on three areas:

1) technical AV characteristics which ensure the reduced number of road accidents and fatalities;

2) drafting new legal regulations (legal documents, official regulations, reporting and disclosure forms) as safety standards for automated driving systems;

3) development of cartographic services and computer systems for processing ‘living’ language. It uses analytics from *SAS* (occupies 30.8% of the global market for advanced analytics) based on *natural language processing (NLP)* technologies, which are based on deep machine learning algorithms and AI technologies (as a key priority).

Today, about 1.25 million people die in road accidents in the world every year. (more than 3.4 thousand people on average every day) and from 20 to 50 million people are injured or disabled every year (*ASIRT* statistics). According to the test results, the autopilot gets into an accident 10 times less often (in one period of time, for example, 1000 driving hours) than a regular driver. Leading robotaxi company Waymo (a subsidiary of Google parent company

Alphabet) has conducted a study of real fatal car accidents that have occurred over the past 10 years in the state of Arizona (USA) and simulated the behaviour of its robocars in similar situations. The results showed that the company's self-driving cars ‘avoided or mitigated’ 96% of accidents and reduced the likelihood of serious injury to people by 13-15 times **[13].**

Autonomous cargo vehicles (self-driving trucks) with automatic control use similar technologies to control their AI system for autonomous driving. However, the development of this AV market segment has a number of *features*:

✓ the weight of a truck is significantly greater than that of a passenger car, and it takes more time to stop it, therefore, there is less opportunity to prevent accidents;

✓ unlike cars, the use of parking assistance, cruise control, lane-level steering and hands-free steering technologies is limited for trucks (especially heavy vehicles);

✓ fully autonomous trucks are used in restricted areas where their movement is limited to predefined geographic areas (mines, warehouses, military bases, etc.).

•In general, trucks on highways are still driven by human drivers, although they are gradually adopting Level 1, 2 and 3 autonomous driving functions (emergency braking, lane departure warning and collision avoidance). Companies such as *Peloton, Continental, TomTom* are currently experimenting with:

• autonomous and semi-autonomous systems which include fully autonomous trucks for limited geography and semi-autonomous trucks for highways;

•“convoy of vehicles” technologies to improve fuel efficiency (creation of a convoy reduces aerodynamic drag by combining vehicles into a group);

•“add-on” telematics systems as part of the autonomous driving package (forward-looking cameras, system displays, driver controls, *GPS / DSRC / Wi-Fi* antennas and collision avoidance radar systems).

Although column technology reduces carbon emissions, operating costs are still high (equipment costs and annual / monthly payments to the service provider are high). According to the Future Bridge forecast, in the next 5-10 years, an increase is expected in the combination of semi-autonomous and autonomous trucks due to cheaper technologies, lower delivery costs, simplified vehicle monitoring and the emergence of new players and business models in the logistics market [14].

Traffic congestion is a significant traffic problem, despite the fact that sensors and cameras built in everywhere on freeways collect a lot of traffic information. It is big data analytics and AI-based technologies that send these data to the cloud, where it is analysed and processed, traffic patterns are determined and traffic forecast is carried out. AI technologies are also being used not only to reduce unwanted traffic, but also to provide notification of the shortest route to a destination, improve road safety and reduce waiting times.

Today, a large-scale joint project Elon Musk’s Hyperloop together with the Virgin company is one of the directions of solving the issue of ‘congestion’ on the roads. This is an unmanned passenger-cargo ‘vacuum’ capsule train, powered by solar energy on the principle of pneumatic mail and moving along an elevated or underground pipeline at a speed of 480 to 1220 km/h with an interval of half a minute. The project, worth $7.5 billion and with a payback period of 20 years, is planned to be implemented in 2022. Passengers will not need to adjust to the schedule, the average ticket price will be $20, and in passenger-cargo capsules it will be possible to travel with their cars. Agreements have already been concluded on the construction of Hyperloop in Dubai (UAE) and Chinese Tongzhen, and tunnels are being built between Washington and Baltimore, as well as between New York and Washington [15].

Another major issue is the delays in the air travel industry, which bring the annual $39 billion costs to airlines and airports in the United States according to a study by scientists from Californian Berkeley University. Along with financial losses, flight delays negatively affect the passenger experience of the flight, leading to a decrease in the image of transport companies and an increase in customer churn. Using ‘data lake’ technology and computer vision, modern AI technologies offer passengers an exceptional experience, reducing passenger waiting times and making their journey more enjoyable. AI technologies use computer vision systems to constantly monitor aircraft (hidden patterns about other opportunities that can cause flight delays and cancellations). This eliminates unplanned downtime, and separate AI and machine learning components process real-time aircraft data, historical records, and weather information. These data can be sent to passengers, which can help them plan their schedule accordingly.

AV market and social problems It is already clear that the introduction of self-driving vehicles is accompanied by uncertainty in their impact on the car-sharing market, but more importantly, in how the public formulates opinions about the benefits and problems. We are talking about the social and environmental sustainability of a complex socio-technical system (joint optimisation of both technical and social subsystems in the context of multimodal mobility of alternative vehicles) [16]. Moreover, linking driverless cars and public transport, even in their automated formats of the future, can be a tricky alliance due to their traditionally conflicting roles. They will need to work together and create synergies instead of competing for space and priorities. Achieving the optimal mix and *Transit Oriented Development (TOD)*, using AI as first and last mile solutions should be the ideal scenario for urban development as a strategy.

In 2019, Loughborough's Marcus Enoch, a professor at the British Technical University, published a forecast for public transport development in 25 years, which takes into account the prospects for the expansion of the use of big data and unmanned technologies. Four scenarios are proposed: 1) public buses and *Uber* taxis and microtransportation (bicycles, small electric vehicles and hoverboards to overcome the ‘last mile’ to the destination); 2) self-driving trains, buses, private cars and ‘air’ taxis, which account for about a quarter of all trips; 3) efficient transportation systems (no private cars) based on online services and fully integrated planning platforms; 4) development of public (urban) transport through a network of unmanned podcars (capsules), which will provide ¾ of all passenger trips, and in cities the car park will be reduced by 60%, and exhaust gases – by 80% [17**].**

While the forecast predicts a rapid increase in the number of AVs, sales of self-driving cars are still extremely low. This is determined by two factors [18]:

- *firstly,* until January 2021, no country in the world has adopted regulations allowing the legal operation of production-ready autonomous vehicles, so manufacturers are not ready to finance the development of models that cannot enter the market in the foreseeable future;
- *secondly,* the cost of sensor equipment is a limiting factor, and although by 2026 the cost of sensors needed to ensure autonomous driving will decrease by 25% compared to 2020, their price will remain quite high. This means that over the next decade, autonomous features will only be available for premium vehicles and vehicles owned by large fleets.

The Institute of Electrical and Electronics Engineers forecasts that by 2025 there will be 22 million self-driving cars in the world, and by 2040 this figure will be 33 million, and autonomous AVs will make up 75% of all cars on the road. The driverless taxi fleet will have a 50% utilization rate over a 24-hour shift, double the rate of *Uber* and *Lyft* today. According to forecasts, by 2030 the market for unmanned taxis will exceed 2 trillion dollars (revenue from the production of cars and tires, revenue from the construction of charging stations for electric vehicles and the sale of electricity, the supply of software and elements of AI technologies that they need). *Goldman Sachs* investment bank has published a forecast that in 2030 the market for mobile taxi services (such as *Uber* and *Lyft*) will increase 8 times to $285 billion, and if in 2019 such services accounted for 1/3 of the entire global taxi market, by 2030 they will exceed traditional taxi services by 5 times [19; 20].

Indeed, synergies between automation, connectivity, electrification and sharing can greatly multiply the benefits of self-driving cars. However, for policy and planning for their mass production, the areas of smooth transition need to be optimized: technology, legislation, work ethics, road infrastructure, road safety, cybersecurity and privacy, and customer trust. Even if adequate answers are given in all of the above critical areas, the future car park will be practically homogeneous no earlier than 2050 and only at sufficiently low prices for AV (in particular, self-driving cars).

Cumulative assessments of *KPMG International* (‘*AVRI* Autonomous Transport Readiness Index – 2019’ – countries' readiness to implement AV technologies and ‘Readiness to Change Index’ – the state of technological infrastructure for the AV use), the World Economic Forum (‘Logistics Performance Index’) and the Global Association of Mobile Operators (GSMA) (Mobile Network Infrastructure Development) indicate the following. The first 10 places in the rating (28 indicators for 30 countries) were taken by countries (sequentially: the Netherlands, Singapore, Norway, the USA, Finland, Sweden, South Korea, the United Arab Emirates, the United Kingdom and Denmark), which are constantly leading the AV market. If the Netherlands occupies a leading position in implementation of unmanned technologies in the cargo transportation segment (convoys of 100 unmanned trucks along the Amsterdam-Antwerp and Rotterdam-Ruhr routes) and in implementation of state transport policy among the EU countries, Singapore's success is associated with the ability to attract investments of the world's leading technology companies, the construction of the first ‘city of the future’ for testing AV (including traffic lights, bus stops, skyscrapers and even installations for simulating climatic precipitation) [21]. Ukraine was not included in the rating, but in 2018 Infocom LTD presented the first test copy of an unmanned vehicle ZAZ Lanos, equipped with a Pilotdrive navigation platform and a software system of its own production [22].

Tempora mutantur et nos mutamur in illis (Times change, and we change with them) – AI technologies have adapted so quickly in the AV market that the pace of their development is not adequate to the flexibility of perception of the consequences in the near future. That is, despite the growth of their spheres, a number of significant issues of a socio-psychological nature arise.

❖ Are they completely safe technologies?

❖ How many jobs will be eliminated and what professional restructuring is possible if AI is widely used in the AV market?

❖ What are the moral and ethical aspects of the use of technology, that is, the issues of ethical and moral responsibility of machines using AI?

And these questions are far from idle. *Firstly*, for example, if an AI controlled self-driving car is out of order, and hitting people is inevitable, where should it be directed – at two elderly people or a group of children? In such a situation, even a person cannot make the right decision, but how will the AI AV react and who will take responsibility for the mistake in using AI? *Secondly*, AI AVs need to collect a large amount of data to form a model, but they are not able to think and be creative, as a person is, but can only recognize. Therefore, the question remains open: will the AI be higher than the human, will it be able to replace it and is it fair to base all activities on the economic forecasts of machines?

REFERENCES

1. A Fresh Approach to Logistics Forecasting in 2021. McKinsey & Company. – URL: https://www.mckinsey.com/industries/travel-logistics-and-infrastructure/our-insights/a-fresh-approach-to-logistics-forecasting-in-2021

2. Abduljabbar R., Dia, H., Liyanage S., Bagloee S.A. Applications of Artificial Intelligence in Transport: An Overview. *Sustainability,* 2019, No *11*(1). – P. 187-189.

3. Wadhwa V., Salkever A. The Driver in the Driverless Car: How Our Technology Choices Will Shape the Future / Ecco-Illustrated edition, 2018, 368 p.

4. Schwartz S. No One at the Wheel: Driverless Cars and the Road of the Future / Public Affairs, 2018, 272 p.

5. Drone Squads and Smart Intersections will more than Halve Traffic Congestion (In Russian Взводы беспилотов и умные перекрестки более чем вдвое уменьшат пробки на дорогах). – URL: https://bespilot.com/news/562-smart-intersections

6. Who Drives? Robotics Digest (In Russian Кто водит? Дайджест по робототехнике). – URL: https://robotics.innopolis.university/wp-content/uploads/2020/09/Dajdzhest.pdf

7. Lushina I. Mix of General and Private. Unmanned Transport as an Inevitable Future (In Russian Лушина И. Микс общего и частного. Беспилотный транспорт как неизбежное будущее). – URL: https://www.dp.ru/a/2019/05/22/Miks_obshhego_i_chastnogo

8. Torchinsky J. Robot, Take the Wheel: The Road to Autonomous Cars and the Lost Art of Driving / Apollo Publishers, 2019, 244 p.

9. Rusul Abduljabbar R., Dia H., Liyanage S., Bagloee S.A. Applications of Artificial Intelligence in Transport: An Overview – URL: file:///C:/Users/user/AppData/Local/Temp/sustainability-11-00189.pdf

10. Logistics of the Future: Unmanned Transportation and Automation (In Russian Логистика будущего: беспилотные перевозки и автоматизация). – URL: https://www.praedium.ru/about/media/logistika_buduschego_bespilotnye_perevozki_i_avtomatizaciya-2/

11. Lipson H., Kurman M. Driverless: Intelligent Cars and the Road Ahead / The MIT Press, 2016, 314 p.

12. Abduljabbar R., Dia, H., Liyanage S., Bagloee S.A. Applications of Artificial Intelligence in Transport: an Overview. *Sustainability,* 2019, No *11*(1), p. 187-189.

13. Waymo Study Shows Drones Can Prevent Most Fatal Accidents (In Russian Исследование Waymo показало, что беспилотники смогут предотвратить большинство смертельных аварий). – URL: https://bespilot.com/news/1075-waymo-study

14. Future Bridge Unveils Top Five Technology Trends for 2021. – URL: https://www.foodanddrinktechnology.com/news/35971/futurebridge-unveils-top-five-technology-trends-for-2021/

15. Transport of the Future: 15 Interesting Facts about Elon Musk's Hyperloop (In Russian Транспорт будущего: 15 интересных фактов о Hyperloop Илона Маска). – URL: https://bespilot.com/news/540-hyperloop

16. The Future of Mobility: How Transport Technologies and Social Trends Affect the Development of the New Business Ecosystem (In Russian Будущее мобильности: Как транспортные технологии и социальные тенденции влияют на развитие новой бизнес-экосистемы). Delloite University Press. – URL: https://www2.deloitte.com/content/dam/Deloitte/ru/Documents/manufacturing/russian/future-of-mobility-rus.pdf

17. Enoch C. Four Visions for the Future of Public Transport – URL: https://theconversation.com/four-visions-for-the-future-of-public-transport-125443

18. Dolgiy P. S. Unmanned Vehicle Management / P. S. Dolgiy, G. I. Nemykin, G. F. Dumitrash (In Russian Долгий П. С. Беспилотное управление транспортными средствами / П. С. Долгий, Г. И. Немыкин, Г. Ф. Думитраш). // *Young Scientist*, 2019, № 8.2 (246.2). – С. 13-15. – URL: https://moluch.ru/archive/246/56674/

19. KPMG International. Countries' Readiness Index for Autonomous Transport – 2019 (In Russian Индекс готовности стран к использованию

автономного транспорта – 2019. – URL: https://assets.kpmg/content/dam/kpmg/ru/pdf/2019/02/ru-ru-autonomous-vehicles-readiness-index-2019.pdf;

20. Start-ups. Powering New Era of Industrial Robotics – URL: https://www.roboticsbusinessreview.com/opinion/start-ups-powering-new-era-of-industrial-robotics/

21. KPMG International. Countries' Readiness Index for Autonomous Transport – 2020 – URL: https://assets.kpmg/content/dam/kpmg/ru/pdf/2020/08/ru-ru-autonomous-vehicles-readiness-index-2020.pdf

22. The First Unmanned Lanos has been Assembled in Zaporozhye (In Russian В Запорожье собрали первый беспилотный Lanos). – URL: https://vesti.ua/strana/283317-v-zaporozhe-sobrali-pervyj-bespilotnyj-lano

VI. ARTIFICIAL INTELLIGENCE IN INDUSTRY AND ENERGY

6.1. «Smart» industry

Alfiia Antonova
PhD, Assistant professor
Department of Information Technology and Cybersecurity
Odessa National Academy of Food Technologies
E-mail: allaantonova62@gmail.com
ORCID: 0000-0003-3599-0983

Tatyana Snigur
Assistant of Department of Information Technology and Cybersecurity
Odessa National Academy of Food Technologies
E-mail:snigurochka.t@gmail.com
ORCID: 0000-0003-3636-0051

For centuries, the plant has been considered the epitome of automation, so workers were often judged on the same metrics as machines. Is it any wonder that in industry there was a difficult relationship between people and machines and the worker felt that he was in a losing position. And not without reason. Since 2000, the US industry has lost five million workplaces, with half of them were cut due to increased productivity and automation of production [1].

However, the situation is not as straightforward as it might seem at first glance. As mentioned, the second wave of business transformation focused on automating existing processes, and it was during this period that many people lost the competition to machines. On the contrary, the third wave involves the implementation of completely reimagined adaptive business processes designed to ensure human-machine interaction. At this stage, thanks to artificial intelligence, a human partly returns to production; for example, workplaces on assembly lines have fundamentally changed in the nature and meaning of the operations performed, their number is growing. Artificial intelligence adds value to engineers and managers. Thanks to artificial intelligence, completely new specialties and new opportunities arise for people employed at all stages of production.

In an era of AI-driven business transformation, the irony is that we are seeing a resurgence of human labor in factories and industrial plants. Everyone, from an assembly line worker to a maintenance technician to a robotics engineer and an operations manager, is experiencing how the concept of work is changing under the influence of artificial intelligence. Artificial intelligence frees up time, creativity and resources, preventing humans from doing the work of robots. This means that with the help of artificial intelligence, a human will be able to work more creatively and more efficiently, which will increase productivity and reduce costs. In the long term, it is of paramount importance that companies are rethinking their business processes: completely new professions are opening up for people and new ways of doing business are emerging.

Let's not rush things. Before you start transforming your business processes, job responsibilities and business models, you need to answer the following questions: What tasks do humans do best, and which ones do machines do best? Are there jobs and tasks that will gradually move to robots, since they are better at performing routine operations and processing data than humans? However, the transformation of labor is not unilateral. In this chapter, we will talk about companies that have already solved the problem of integrating man and machine in production, in the operation of equipment. These pioneers recruit both humans and artificial intelligence machines to work, providing them with the jobs that they fit best and thereby benefit from it [2].

In the middle of the 20th century, concepts about the possibility of self-learning of computer programs appeared, including the model of an artificial neural network proposed by the American neurophysiologist Frank Rosenblatt, capable of taking into account previous experience and improving it when solving problems. The enthusiastic expectations, however, quickly gave way to disappointment due to the meager capabilities of the computer technology of that time, which was not capable of complex calculations. And only by the beginning of the XXI century, with the emergence of huge databases and powerful processors capable of processing this data, recent science fiction has become a reality, and artificial intelligence (AI) has quite successfully replaced humans in many industries and areas [3].

How can artificial intelligence benefit manufacturers? The most important opportunity that AI will provide to manufacturers is its ability to correct course based on historical data and make decisions based on the options available. For example, a production line produces a product, but an important quality parameter begins to deviate from the established limits. Nowadays, most processes require some kind of human intervention to make changes to the process. Sometimes this can be done automatically on a single machine, but usually it cannot be done on multiple machines as part of a manufacturing process.

We are used to being alerted to a problem, but we have to use skills and human interaction, and sometimes memory to predict if a problem happens. It relies on someone remembering that event "A" can lead to problem "B", which is theoretically okay if they also remember what solution is required! It is in this context that we need to consider the skills that are best suited to apply this beneficial technological advance [4].

Artificial Intelligence applications in Industry

At manufacturing enterprises AI can be applied at almost all levels [5]:

– at the design level:

a) to improve the efficiency of new product development,

b) to automate the selection and evaluation of suppliers,

c) when analyzing the requirements for spare parts and details.

– at the production level:

a) to improve business processes,

b) in the automation of production lines, to reduce the number of errors, to simplify the production process through the use of image recognition functions and a dialog interface.

– at the logistics level:

a) to improve the planning of vehicle routes,

b) to reduce the delivery time of raw materials,

c) to improve interaction with customers and suppliers through interactive communication,

d) to track items and the delivery process at all stages,

e) in the long term - to predict fluctuations in shipments before they happen.

– at the promotion level:

a) to predict the volume of support and maintenance services,

b) when managing pricing.

Development stages of artificial intelligence

Human-machine interaction is a critical aspect of the transformation process of business and manufacturing processes. The path of this interaction turned out to be thorny. Initially, artificial intelligence was greeted with great enthusiasm, but expectations were not met: disappointment was soon followed by noticeable progress, which led to a second wave of excitement and new disappointments. These two recessions have come to be called the two "winters" of artificial intelligence.

Work on artificial intelligence began in the 1950s, and research progress has been extremely uneven over the following decades. By the 1970s, funding was almost phased out, that period is called the "first winter" of artificial intelligence. Then, for several years in the 1980s, researchers were able to achieve excellent results in the development of so-called expert systems - computer programs capable of analyzing and drawing conclusions. They allowed the machine to make the simplest judgments, and not to work according to a strict, predetermined algorithm. At the same time, the revolution of personal computers was gaining momentum, all attention turned to them, they became more and more accessible to the common man. Funding for artificial intelligence has declined again, and the "second winter" of artificial intelligence has come. This situation persisted until the early 2000s.

The advent of artificial intelligence has contributed to the transformation of assembly lines. Engineers at the Fraunhofer Institute for Logistics (Fraunhofer IML) have been testing inline sensors for a long time to create self-adjusting assembly lines in car factories. In essence, the conveyor itself can modify some operations of the technological process, changing additional modules and equipment to create cars to order. Thus, engineers design not just a conveyor on which one standard model is assembled, but a conveyor that can be reconfigured on its own. Andreas Nettstreter, who coordinates strategic initiatives at IML, notes:

"If one workstation fails or breaks down, its functions can easily be transferred to other stations on the conveyor" [1].

Workers on the assembly line tackle more complex tasks that robots cannot, and process engineers do not need to reconfigure the line with every performance change or breakdown. They can devote time to more creative tasks, such as how to make machines work even more efficiently.

Data monitoring

What starts with smart manipulators spreads throughout the plant and even beyond. Technologies based on artificial intelligence in manufacturing and, more broadly, in industry liberate humans. For example, artificial intelligence has changed the maintenance sphere. Sophisticated AI systems predict an impending breakdown in advance, which means that staff spends less time on routine checks and diagnostics and more time on repairs.

Artificial intelligence for accelerated machine adoption

Sight Machine, a San Francisco-based startup, uses analytics and machine learning to help customers to reduce downtime when new equipment is launched in the workshops. Thus, in one case, it was possible to reduce the downtime inevitable when introducing new robotic systems by 50%. When all fixed assets were put into operation, productivity increased by 25%. Thanks to the new technology, production efficiency has increased, and engineers and maintenance technicians have been able to focus on other, more significant tasks [1]. General Electric monitors the performance of equipment supplied to customers. For this, the Predix platform, equipped with artificial intelligence, is used. It is based on the concept of a “digital twin,” whereby all assets inside and outside the plant — from the bolt to the conveyor belt and to the turbine blade — are simulated and monitored on a computer. Predix collects and analyzes a huge amount of data; this data can be used to rethink business processes in three fundamental ways:

- **Rethinking maintenance**. General Electric collects statistics from all points where its equipment is installed, and uses machine learning technology to predict the timing of failure of certain parts (depending on their current state).

In the past, service technicians have replaced parts according to the manufacturer's recommendations. So, car candles had to be changed after 120,000 kilometers. Now they can be replaced as they wear out. Forecasting based on artificial intelligence saves time and money, while increasing the interest of repairmen in their work [1].

- **Rethinking product development**. Additional data facilitate R&D (НИОКР). General Electric installs sensors on the most stressed turbine parts to track changes in them. In the operating temperature range, the sensors literally burn out, but they manage to collect information about the turbine warming up. This helps to understand better the thermodynamics of the materials used in the manufacture of turbines and to optimize operating conditions. Thanks to the sensors, engineers have at their disposal the most detailed information that sheds light on the operation of certain systems.

- **Rethinking exploitation.** General Electric can create digital twins based on field data collected from operating objects such as jet engines. During virtual flights, the aircraft is exposed to low and high temperatures, dust, rain and even bird attacks. The company monitors tens of thousands of wind turbines, and their digital counterparts make it possible to adjust their work in real time. The analysis of these data allowed us to draw a very important conclusion: depending on the direction of the wind, it makes sense to reduce the rotation speed of the leading turbine in comparison with the calculated one. This example demonstrates that the digital twin model is not only applicable to a single unit, but also optimizes the operation of an entire wind farm. According to General Electric, digital twins can increase wind power production by 20%, which is equivalent to $ 100 million over the life of a 100 megawatt wind farm [1].

Prerequisites and opportunities for the use of artificial intelligence in industry

If a few years ago the topic of artificial intelligence aroused skepticism and mistrust among industrial enterprises, the emergence of new market requirements, the growth of government influence and the development of new technologies radically changed the situation. The question is what exactly can be attributed to the field of artificial intelligence, especially in industry, since the topic is vast, but at the same time controversial from the point of view of applied application.

Today the terms “digitalization”, (“digitalization”), “machine learning”, “artificial intelligence” are pronounced from the tribunes, are actively discussed in the media, are covered on state and commercial channels, and are promoted in the mass consciousness. Since the terminology is not yet fully established, discrepancies often arise, leading to misunderstanding of various sides. Most often this applies to the phrase "artificial intelligence", which is perceived by everyone in their own way, even after trying to appeal to such authorities as Turing, McCarthy or Kurzweil.

The industry is more and more subject to certain standards and completely transparent logic. First, you need to understand that in most cases, artificial intelligence in discrete and continuous production is understood as machine learning - a class of methods for solving problems based on precedents and for searching for patterns in historical data of production systems. And in the modern world, a person should not be responsible for developing recommendations on optimal technological modes and forecasting a resource - supporters of digitalization recommend shifting these tasks onto the shoulders of intelligent systems.

Machine learning in industry. Applications

What urgent tasks can be solved at the stages of development, production and operation using machine learning? Firstly, these are tasks that a human cannot cope with. This can be work in hard-to-reach places, in hazardous chemical production, in permafrost conditions or in increased radiation. Secondly, these are tasks where "natural intelligence" is applicable, but ineffective: predicting critical malfunctions, preventing sudden equipment failure, condition-based maintenance, predicting the remaining equipment resource. These are, in fact, those areas where a human can perform work, but in the conditions of a huge amount of information, this becomes almost impossible. Moreover, a human is not always able to sort correctly data and to resolve contradictions. And the machine can perform these tasks according to predefined algorithms. It is possible to obtain the required amount of data in industry only with an integrated approach: a combination of a system model based on physical processes and machine learning algorithms [5].

Self-learning manipulator

At the Tokyo factory, the third shift begins - and the finest hour of robotic manipulators, which can learn new skills overnight begins. The manipulator is equipped with a video camera and machine learning software, and these rotating limbs can, without assistance, determine the most efficient ways to assemble parts, and then transfer them down the conveyor. Such operations do not require additional programming.

Robotic manipulators are used in factories, for example, for applying hot glue, for installing windshields, for leveling the edges of metal after it has been cut. They are pre-programmed to perform a specific task, and when it changes, the robots have to be reprogrammed. The new robotic arms, developed by Fanuc in partnership with software maker Preferred Networks (both based in Japan), can learn independently using one of the machine learning methods - deep reinforcement learning. Demonstrates a successful result to the robot, and it independently learns to achieve it by trial and error method.

According to Shohei Hido, a senior researcher at Preferred Networks, it takes a robot eight hours to successfully complete a task 90% of the time. Almost the same amount of time would be spent for an engineer to program the robot, and since the robotic arm can learn on its own, the programmer frees up time for more complex tasks, in particular those where it is required to make judgments, evaluate and interpret the results. Having mastered a new skill, the robot can share the acquired knowledge with other robots connected to the network. Thus, eight manipulators working together for an hour can learn the same amount of skills as one manipulator working on a task for eight hours. This process Hideo calls "distributed learning": "You can imagine a thousand factory robots exchanging information."

Now imagine people working side by side with robots. Self-learning industrial robots are excellent at handling routine repetitive operations as well as tough work. But in any enterprise there will always be tasks that are too difficult for robots - for example, connecting numerous small wires or working with moving or inconvenient to grip objects. All this still needs a human.

So, can humans and robots work together successfully? History does not provide a clear answer. Robots, moving quickly and sharply, can be useful and effective, but at the same time dangerous to humans. They are often placed behind protective barriers, but this typical separation of robots and humans promises to disappear over time. So-called cobots from companies like Rethink Robotics, founded by one of the pioneers of robotics and artificial intelligence, Rodney

Brooks, are equipped with sensors that allow them to distinguish objects and avoid collisions with humans. If a robot is relatively nimble, it interacts well with a human. In factories equipped with devices from Rethink Robotics and similar companies, work is often split between humans and robots, working side by side, with tasks selected to suit their capabilities best.

Artificial intelligence in a factory

For a century, factory workshops have been the main training ground for robotization. Here you can find everything - from smart conveyor belts to robotic manipulators and operating systems with elements of artificial intelligence; the plant "grows smarter" day by day. Hitachi uses artificial intelligence to analyze big data and routine tasks of human workers, transmitting this information to robots, which, in their turn, provide instructions to employees to meet changing demand in real time and continually improve the manufacturing process.

As part of a pilot project, the company achieved an eight percent increase in labor productivity in logistics. Siemens uses a group of 3D-printed robots which resemble spiders. Using artificial intelligence, these robots communicate with each other and assemble in a Siemens laboratory in Princeton, NJ. Each robot is equipped with computer vision sensors and laser scanners, all of which are connected to the production chain “on the fly”. In Inertia Switch, robots, thanks to artificial intelligence systems and touch sensors, can work together with humans. The company uses Universal Robotics robots that can learn on the go and switch between tasks flexibly. Thus, they become excellent helpers for human workers in the shop [1].

Artificial intelligence and technical and technological development of robots

While the second winter of artificial intelligence lasted, Rodney Brooks criticized one of the fundamental ideas on which artificial intelligence research has long been based. It is about the comprehension of the surrounding world by robots based on the use of predetermined sets of symbols and the relationships between them [1]. He argued for a much more reliable approach: instead of cataloging the world around us in advance and then representing it in the form of symbols, why not to study the environment using sensors? "The world is the best model of itself," he wrote in a famous 1990 article titled "Elephants Don't Play Chess." Brooks subsequently formed iRobot, which developed the Roomba robot vacuum, and founded Rethink Robotics. iRobot has produced the most autonomous robots in the world to date; more than 10 million were sold between 2002 and 2013.

Today, Brooks's interpretation of artificial intelligence is relevant in both research and manufacturing. Rethink Robotics demonstrated the capabilities of a robotic arm equipped with built-in sensors and motion control algorithms that help the robot “sense” and correct its actions in real time. The manipulator has elastic drives and joints that can return to their original position; thus, it can deflect on contact, extinguishing energy. Therefore, even if it collides with an object (or human), the impact will be noticeably weaker (compared to a conventional robotic arm). What happens when the "iron hands" are able to independently study, as, for example, in Fanuc? Or if the manipulator is more accurate and precise, as in the

Rethink machines? Workers on assembly lines will be able to work together with self-learning robotic arms. Let's say a human is busy assembling a car and needs to fix the dashboard. The robot can lift it and set it up, and the worker will correct its actions and secure the panel without fear of being hit on the head by a bulky machine. Artificial intelligence helps both robots and humans to show their strengths, so that the entire workflow on the assembly line is transformed [6].

Let's look at a few examples of the use of AI in industry

Equipment diagnostics during operation

For industries that traditionally operate equipment (mills, pumps, electric motors, heat exchangers), it is important to have constant feedback from the operating product to assess the behavior of the object in real time, predict possible emergency situations, and prevent sudden equipment failure. In these cases, it is necessary to analyze a large amount of data to extract information from the systematically collected information. But in industry there is often not enough information received from actually operating objects, so the database needs to be supplemented with the results of full-scale and virtual experiments, using engineering analysis technologies based on numerical modeling, carrying out regular calibration to improve the quality of the forecast.

As a result, we get a model based on historical data, supplemented by the results of virtual experiments, so that the information is sufficient for high-quality training. This helps to explain the trends identified during the analysis, as well as to predict the emergence of new aspects and even to classify or segment data based on patterns of behavior, which are almost impossible to identify using traditional "human" methods. Machine learning algorithms in this case can be applied in a variety of ways. For example, in the case of technical diagnostics of equipment, when it is enough to report only the state of the object (serviceable / defective), you can apply the teaching method with a teacher (binary classification: the object is serviceable / the object is defective).

Optimization of operating modes of equipment and technological processes

The reduction of unplanned downtime and an increase in the service life of the equipment and, as a result, an increase in the quality of products and a decrease in the costs of the enterprise as a whole depend on the correctly selected modes of operation of the product. The operator can be helped by a system that selects the most optimal scenarios for technological processes and predicts deviations in equipment operation based on statistical models and engineering analysis. Here you can use a machine learning algorithm based on building a decision tree, where for each level a variable is determined that generates the least entropy. The algorithm unfolds the combinatorial tree and traverses it looking for the best option. The first step is to create a tree containing all possible plans. Then, using intelligent algorithms, those branches are sequentially cut off, which correspond to unrealistic plans or plans that violate decisions or lead to a non-optimal solution.

Also, for optimization problems in industry, you can apply the Stochastic Gradient Descent (SGD) method to minimize the function, taking small steps towards the steepest decrease in the function.

Service as per condition. Predictive maintenance

The transition to maintenance on condition allows to increase the service life of the equipment and its turnaround period, as well as the identification of defects due to data supplied in real time. Information about the current state of components and assemblies and the forecast of the residual life allow us to form recommendations for the maintenance and repair of equipment, to ensure the timely delivery of spare parts. You can determine in advance that something is wrong with the machine and decide on preventive maintenance.

Internal modeling algorithms can be used here: any complex adaptive system is able to create internal environmental models that allow predicting future events and changes for their successful adaptation. Aggregated machine learning methods are also suitable to compensate for the shortcomings of some algorithms with the help of others (Bayesian classifier, support vector machines, decision trees).

Visual recognition of defects. Computer vision

Machine vision is a collection of technologies that allows computers not only to process images as a mass of data, but to perceive and interpret them in a human-like manner. It is becoming more and more popular in the industry, since such methods can automate and significantly improve the process for which visual control is needed.

An example is a moving conveyor with ore, where it is necessary to quickly and accurately detect visual defects during product quality control. The main task is to localize and classify defects using the selected algorithms. One of the key methods in this case is deep learning. To train "deep" networks, properly formed training samples of sufficiently large sizes are required, the quality of which is determined by the completeness and consistency of the input data. At the same time, the implementation of a reproducible process is provided, which makes it possible to obtain stable output data suitable for making a decision on the presence of defects, based on general ideas about the quality of products.

Continuous production

For example, when smelting steel, it is necessary to accumulate history in order to predict the output characteristics based on the current smelting conditions. Or, using machine learning to determine the initial alloy composition and melt parameters to achieve a given quality. This will reduce the cost of raw materials, optimize the composition of elements, predict the quality of the output product, and optimally manage the smelting process. At the same time, you need to understand that there cannot be two identical heats of steel. The challenge of machine learning is to analyze a huge number of parameters in order to optimize the composition and number of input elements and operating parameters to obtain quality according to technical requirements. Here, as in the case of visual defect recognition, neural networks are used.

The machine is given a fairly large set of precedents (objects, situations), each of which is associated with certain scenarios for the development of events. In the information received, the machine finds patterns, thanks to which it subsequently gets the opportunity to predict the consequences of certain events, evaluate various hypothetical scenarios and make optimal decisions after analyzing alternative options.

A neural network should not require manual entry of rules - after training, it behaves like an expert in its subject area. At the same time, intelligent systems need knowledge control tools that can resolve possible contradictions, eliminate redundancy and generalize concepts. To do this, in any case, you need human help.

Flexible energy management. Improving energy efficiency

Machine learning technologies can reduce the operating time of equipment in high-intensity mode, reduce excess inventory, timely predict equipment wear and remaining life, reduce waste, and also reduce energy consumption costs by taking into account the state of the external environment.

Increasingly, soft computing is used to effectively manage energy consumption - this is a set of tools and methods that allow solving problems of high complexity by processing incomplete and inaccurate information: evolutionary algorithms, self-organizing growing neural networks, fuzzy logic. These are the tasks for which the experts were unable to find an optimal solution. Soft computing allows you to quickly find suboptimal, but good enough, solutions to problems of this type.

Equipment and process digital twins

So, industrial production and operation generate a large number of variables, so it becomes clear that there is a huge need for an intelligent system capable of making decisions taking into account all the above factors and on the basis of fuzzy parameters. Experts believe that to create digital twins, it is worth combining technologies such as systems modeling based on physical processes and machine learning. The digital twin is a complex dynamic model that in real time and with high accuracy reproduces the state and operating parameters of equipment and technological processes under existing conditions.

Most companies that have used machine learning to solve production problems are faced with a lack of data. Therefore, there is an urgent need to supplement the information with the results of real or virtual experiments using engineering analysis technologies based on modeling physical processes. At the same time, the model must correspond to real operating conditions and be constantly updated with knowledge about the operating facility. It is important to achieve a high quality forecast for making the right decision. Periodic calibration is performed to ensure that the digital twin matches the real equipment.

Since it is not possible to immediately identify all faults in a working model, it is important to correctly model " what-if " conditions to predict and identify the most critical issues from a security and business perspective. The system is focused on a large number of assessments, but it is necessary to choose the best one. On the other hand, a human cannot use all the information about a working product at once - it must be systematized and filtered. The digital twin offers a decision support system and recommendations for operators using machine learning algorithms based on both historical and simulated data.

Experts believe that the factor of success in this case is a combined approach to solving production problems using modern technologies and implementation techniques based on deep industry expertise [7].

Barriers to the use of artificial intelligence in industry and how to eliminate them

Examples of industrial implementations take into account the specifics of a particular industry and its business processes. While technology is still rarely used, companies are looking at AI-powered solutions over the next two years. 70% of global companies have a digital transformation strategy, 80% of companies are already investing in predictive services, 70% are focusing on supply chain optimization and logistics, 81% of US enterprises use real-time equipment monitoring.

Despite serious intentions, heavy industry faces management and decision-making challenges. Companies are often trapped in traditional division of interests. Business management is rarely done with the involvement of the IT department. More often than not, directors and executives focus exclusively on finance. This situation is strikingly different from that which is seen in IT-driven sectors such as retail, finance or internet companies.

Engaging business units in AI projects is critical to generating return on investment. The positive financial results of the project depend not only on the correctly chosen scenarios, but also on the support of the management. The market could grow even faster, even taking into consideration the low base effect. The following aspects will positively influence the growth rate:

- Fashion for digital transformation of industrial companies;
-The presence of niche players with expertise in the field of artificial intelligence and experience in implementing such solutions;
- Positive results of the implementation of pilot projects and proven statistically significant economic effects;
- Initiatives for the full implementation of already completed pilot projects;
- Availability of government programs to support initiatives in this area;
- Professional maturity of personnel and enterprises for digitalization.

As long as the reluctance to change is not reflected in business performance, enterprises also continue to operate at a good pace. Some minor improvements could well be achieved using traditional methods. Full-scale AI adoption is not a one-time event. The lag effect in this process appears slowly, but it will be more difficult to catch up if the lag occurs at the stage of collecting the so-called big data.

Specificity of heavy industry

In most cases, the use of AI in industry boils down to increasing employee productivity, increasing the efficiency of key technological processes, and improving quality control. The most significant potential for using AI is concentrated in highly specialized scenarios: forecasting and making recommendations, creating systems for recognizing patterns in data and identifying anomalies in a technological process and analyzing a video stream.

The scale and complexity of production means that industrialists are focused only on the tasks of their industry. AI requires deep knowledge of both business processes and an understanding of the specifics of industrial AI. This is why industrial companies do not often resort to consulting services in this area, even though there is a shortage of specialists. In addition, insufficiently effective pricing strategies and business models lead to the creation of highly specialized tools, rather than ready-made industrial solutions with the potential to scale.

In manufacturing companies, digital advisors are already able to advise on the optimal process parameters for maximum productivity. Their recommendations are based on historical data and predictive models to eliminate human errors and improve process efficiency. In the future, it is also necessary to take into account the peculiarities of the interaction between human and machine, because production is a place where people and machines are concentrated.

Once the decision has been made to deploy AI applications, a detailed methodology for conducting experiments needs to be developed. An enterprise's sensitivity to cost and the lack of AI experts with the right skills in most enterprises can complicate the implementation process. One proven and viable solution to the problem is working with experienced large IT companies. The lack of the required data can be compensated for by cross-industry data exchange. Companies are wary of sharing information, seeing this as a risk of losing competitive advantage and trying to protect their intellectual property. The industry has yet to realize how large datasets can be useful to everyone involved, while maintaining confidentiality and contractual obligations.

Due to a lack of experience, customers often have overestimated expectations regarding the capabilities of computer vision systems, their cost, and the payback period. Therefore, in order to test approaches and gain experience in implementing such solutions, it is recommended to start implementation with a small project. Education and investment in training is a key part of such projects.

Organizations should start by developing strategies and roadmaps for AI adoption. AI-based digital solutions are an essential part of digital transformation, they must be implemented by the business unit in close collaboration with the IT department, in which it is the business department that determines the desired result. The IT department, in turn, must be responsible for the required approaches and technologies. Usually, the initiative to implement such projects comes from the top down, and there is a need for a strong leader, often in the person of the CEO or digital transformation director, who acts as a link between IT and production within the company and between the optimized processes and the technologies suitable for this. The challenge in implementing AI is to help machine learning models become part of business and production processes [8].

AI in industrial refrigerator production

Industry has traditionally lagged behind the "lighter" areas of business, and so far only a few large projects involving AI are in the manufacturing sector. That is, the corresponding technologies are used here in supporting roles. So far, few decide to integrate AI directly into the production process, primarily because of the price of the issue: the cost of implementation turns out to be very significant, and imperfect technologies can result in serious losses. Therefore, it is often more about remote control of processes, where technology is given only relative independence. For example, recently the American Caterpillar presented a project for remote control of special equipment in mining mines and quarries, where the work of drivers is associated with an increased risk. Instead, operators will monitor the work of bulldozers and trucks, in the future from a distance of up to several thousand kilometers, and in an emergency they will be able to stop the equipment. Although this will already be an extreme case, since the transport is equipped with AI systems that recognize obstacles and allow them to avoid collisions with humans and other equipment.

More confidence in artificial intelligence was demonstrated by the South Korean LG Electronics, which plans to build a kitchen equipment plant worth $ 525 million. It is assumed that all stages of production from manufacturing and purchasing of components to quality control of finished products should be controlled by a single system based on AI and which will also constantly optimize the production process. The plant will occupy an area of 336 thousand square meters and by 2023 it will produce up to 3 million units of products per year. The world leader in the number of implementations of artificial intelligence and machine learning technologies, according to Jet Infosystems and TAdviser, is the USA. They are followed by the UK, which uses AI primarily in large investment banks, and India, which supplies these technologies to foreign customers.

AI in steel making

One of the implemented projects for the use of AI in industry is the introduction of artificial intelligence technologies for steel production in the oxygen converter workshop of the Magnitogorsk Iron and Steel Works. Since the remelted scrap is usually heterogeneous in composition, in order to bring the steel to the required standard, it is necessary to introduce ferroalloys and other special additives into it during the melting process. The service developed by Yandex Data Factory receives data on the initial composition and weight of the charge (the initial mixture of materials loaded into the melting furnace) and, taking into account the target parameters of the finished steel, gives the operator in real time the appropriate instructions on the use of additives. The consumption of the latter in the course of experimental smelting using new technologies decreased by 5%, and taking into account the rather high cost of ferroalloys, metallurgists expect to save up to 23 million rubles per month.

The pioneers are already implementing AI solutions in heavy industry and are conducting many experiments in this area. AI startup in the field of AI is Tulip Interfaces, a spin-off from Massachusetts Institute of Technology, offers an IIoT platform with specific intelligent applications over. Fanuc Corporation, a leading manufacturer of industrial automation equipment, uses artificial intelligence technology to reduce the learning curve for robots. Mining company Freeport-McMoran has successfully tested AI technologies in its smart quarry in Arizona, USA. It plans to increase copper production by 90 kt with minimal capital investment. AI technologies are quite mature, but they continue to actively develop. Data analytics tools help company analysts extract knowledge from a wide variety of information sources. The commitments to using AI launche a flywheel of data accumulation that drives the process of improving enterprise processes.

Examples include products that use predictive analytics in the discrete industry. Analyzing data from computer numerically controlled (CNC) metalworking machines, company Zifra solves the problem of detecting anomalies in the technological parameters of the machine [8]. In addition, possible causes of the anomaly are identified and tool wear on machine tools is predicted to alert users to the optimum time to replace them. Timely identification of anomalies and the need to replace tools allows operators and process engineers in production to quickly make decisions, which reduces the risk of product and equipment rejects, downtime and maintenance costs.

In the oil and gas industry

In the oil and gas industry, several projects with the participation of AI are being implemented at once. One of them, "Cognitive Geologist", involves the creation of a self-learning model of a geological object. The fact is that key decisions on field development have to be made at an early stage of development, and a mistake made at the beginning of the process is almost impossible to correct in the future. Geologists collect data bit by bit in order to get a reliable picture of the structure of the subsoil and to answer the main question: how profitable will production be? It takes a year or two, while the confidence in the correctness of the answer still does not exceed 60%. The Cognitive Geologist will mathematically process the underlying information, evaluate the likelihood of correct answers, and provide recommendations on development methods or the need for additional research. According to the calculations of specialists, the time of interpretation of geological data due to the work of AI will be reduced by six times, and the amount of useful information extracted from them will increase by 30%.

Another project involves the use of AI when drilling complex wells. A typical example: oilmen, based on a geological model, need to get into a reservoir only two to three meters thick at a depth of several kilometers and drill a well along it for a kilometer, promptly responding to changes in the configuration of the productive horizon, which are monitored using sensors installed on the drilling tool. However, the sensors are located 17 meters from the bit, so the specialists who remotely monitor the situation from the GeoNavigator Drilling Control Center learn about the well exit from the productive horizon with a delay of 20-30 minutes. During this time, the drilling trajectory can move away from the three-meter formation by a fair distance [7].

The solution to the problem was found in a trainable model, which in real time will draw conclusions about changes in conditions at the farthest point of the well based on parameters such as load on the drilling tool, resistance, temperature, vibration and ROP. This will allow GeoNavigator specialists to promptly correct the drilling trajectory and refine the geological model of the field, while generating additional data for further training of the “smart” drill. In the future, a mathematical model of drilling will make it possible to proactively predict possible emergency situations using indirect data, to establish optimal operating modes of equipment and even to determine the productivity of a formation in real time, while assessing the economic efficiency of drilling a particular horizon.

Another example is virtual flow metering software solutions - measuring the flow of liquid, gas and steam in industrial systems - based on artificial intelligence in the oil and gas industry and process industries. The disadvantages of measuring devices used today include low sampling frequency and high cost. The virtual flow meter provides an accurate estimate (up to 95%) of the pumping volume of gas and liquid, which significantly increases control over production productivity.

In oil fields, the metering systems in operation today are reliable sources of well production data, but the frequency of measurements using these devices ranges from once a day to once a week, a month or even several months. There are multiphase meters on the market, they can provide real-time production estimates, but their purchase and maintenance is not cost-effective for many fields. The activity of the entire oil production enterprise is directly dependent on production, which makes the use of virtual flow meters with the issuance of production indicators in real time and the subsequent reduction of the material balance especially relevant. For oilmen, the introduction of a virtual flow meter based on artificial intelligence makes it possible to increase oil recovery through the most complete set of production data and update the reservoir model, as well as significantly reduce capital costs for purchasing physical flow meters and operating costs for their maintenance, increase and maintain production through operational identification of shortfalls and losses. At the moment, the cost of a virtual flow meter is ten times lower than hardware counterparts.

AI-based virtual flow meters require a lot of historical data from temperature, pressure and other sensors. As with other AI solutions, regulated, controlled data collection and storage is a key success factor for implementation. The AI learns as new data becomes available to improve the accuracy of virtual flow metering. Examples of successful projects and increased business revenue through the use of AI technologies will be convincing arguments in favor of introducing new projects.

Despite the fact that many projects with AI, especially in industry, are still experimental in nature, analysts are confident in the grandiose prospects of this direction. Jet Infosystems and TAdviser in their materials predict the growth of the market for artificial intelligence and machine learning on a global scale, according to a recent forecast by PwC, the use of AI by 2030 will ensure the growth of world GDP by 14%, or $ 15.7 trillion. And a business that ignores these technologies today risks being simply uncompetitive tomorrow. Moreover, according to the forecasts of individual futurists, in the region of 2030–2050, a breakthrough is expected in the field of creating "strong" artificial intelligence, which is definitely in no way inferior to the human one [8].

Conclusion

The Turing test has not yet been passed. A superintelligence capable of learning as a person, acquiring new knowledge and solving previously unheard-of tasks, which would not be inferior in intelligence to most people, and in many things would even surpass it, has not yet been created. But already the technologies of the fourth industrial revolution are inviting modern enterprises to focus on an integrated approach.

The use of statistical methods in production and at the operational stage is a dead-end branch of development. The symbiosis of machine learning and numerical modeling algorithms is a completely contingent decision. Yes, there are risks, but they can be mitigated with strong industry expertise and best-in-class technologies. The system only generates recommendations - the decision is still left to the human. Perhaps, in a very short time, artificial intelligence will be able to solve new creative problems, but today the technological tandem of man and machine looks the most realistic.

REFERENCES

1. Paul R. Dougherty, H. James Wilson. Human + machine. Reimagining work in the age of AI. Harvard business review press. Boston, Massaghusetts, 2018.-304 p. ISBN 978-5-00146-159-3
2. “Rozumniy” ceh. Shtuchniy intellect v promislovosti, logistiki I distribucii. (2018). Accenture Global Solutions. From: https://www.accenture.com /_acnmedia/PDF-107/Accenture-Human-Machine-CH1-Low-Res.pdf
3. Pochti-kak-lyudi-iskusstvennyy-intellekt-na-zavodakh-i-mestorozhdeniyakh. from: http://sas.com/pochti-kak-lyudi-iskusstvennyy-intellekt-na-zavodakh-i-mestorozhdeniyakh/
4. Sharon Blyfield & Nicholas Nixon. (18 November 2020). Artificial Intelligence and its impact on skills. From: https://www.fenews.co.uk/featured-article/57872-artificial-intelligence-and-its-impact-on-skills
5. Zastosuvannya shtuchnogo intelektu v promislovosti. (22.03.2019) from: https://www.it.ua/knowledge-base/technology-innovation/artificial-intelligence
6. Correll N. “How Investing in Robots Actually Helps Human Jobs”, Time, April 2, 2017, from: http://time.com/4721687/investing-robots-help-human-jobs/
7. Tiulpa D. Zastosuvanniya shtuchnogo intellektu v promislovosti. Peredumovi I mojlivosti. «SAPR i grafika» №1, 2020. 26-30 c.

8. Liapina K., Izmaylov I. Bariyeri zastosuvanniya shtuchnogo intellektu v promislovosti I sposobi ih usunenniya. Compamiya «Cifra». from: https://vc.net/offline/144773-barery-primeneniya-iskusstvennogo-intellekta-v-promyshlennosti-i-sposoby-ih-ustraneniya (Last accessed: 24.07. 2020)

6.2. European Smart Energy Policy[9]

Iryna Marekha
Candidate of Economic Sciences, Senior Lecturer of the Department
of International Economic Relations
Sumy State University
E-mail: ukr_irina@ukr.net
ORCID 0000-0002-9905-7706

The intensive use of artificial intelligence and communication technologies in power systems in the European Union has led to the creation of a concept called the “smart energy”. The development of this concept in power networks leads to optimal network control, optimal use of equipment, increased quality and reliability of power supply, facilitation of the integration of renewable energy sources, optimal planning of the transmission and distribution systems, the development of the use of distributed generation and reduced system’s costs [1]. The role of smart grid in renewable energy sector was actively discussed in the paper [2]. The importance of creating energy hubs based on smart energy concept was declared in the paper [3] and [4]. The scholars mentioned above contributed significantly to the exploration and development of smart energy concept on a global level. In this chapter, we propose to concentrate primarily on the unique smart energy policy of the European countries.

Smart grids. The following statistics represent the projected market value of the global smart grid market in 2017 with a forecast until 2023, broken down by region. In 2023, the European smart grid market is expected to reach 15.4 billion U.S. dollars. It is the second position after the North American smart grid market.

A smart grid is an electricity network that can intelligently integrate the behavior and actions of all its users to ensure a sustainable, economic and secure electricity supply. As a tool that provides much-needed flexibility, smart grids offer potential benefits to the entire electricity value chain (generators, TSOs, DSOs, suppliers and consumers) and to society as a whole. Smart grids will enable DSOs to monitor the electricity flowing within their grids. On the basis of collected data, they will be able to adjust to changing conditions by automatically reconfiguring the network and/or by taking control of connected demand and

[9] This work was supported by the Ministry of Education and Science of Ukraine (Project No. 0119U100766 «The optimization model of smart and secure energy grids building: an innovative technologies of enterprises and regions ecologisation»).

distributed generation. While smart grids equip DSOs with new tools to keep the system highly reliable and affordable, they will also create new opportunities for customers and service providers. The smart grids possess a lot of benefits which include [6]:

1. Maintaining system security and quality of supply.
2. Integrating more variable renewable generation (for instance, through dynamic line-rating, later also through the flexibility offered e.g. by electric vehicles and storage).
3. Reducing costs of renewable integration compared to conventional investment.
4. Providing new incentives for customers to mitigate increases in their electricity bills by actively managing their electricity consumption.
5. Reducing the frequency of outages and costs of avoiding them.
6. Making more efficient use of the existing infrastructure to produce, transport and consume electricity, resulting in less need for new lines.
7. Enabling a massive penetration of electric vehicles and flexible recharging.
8. Optimize the use of energy resources and increase overall energy savings.

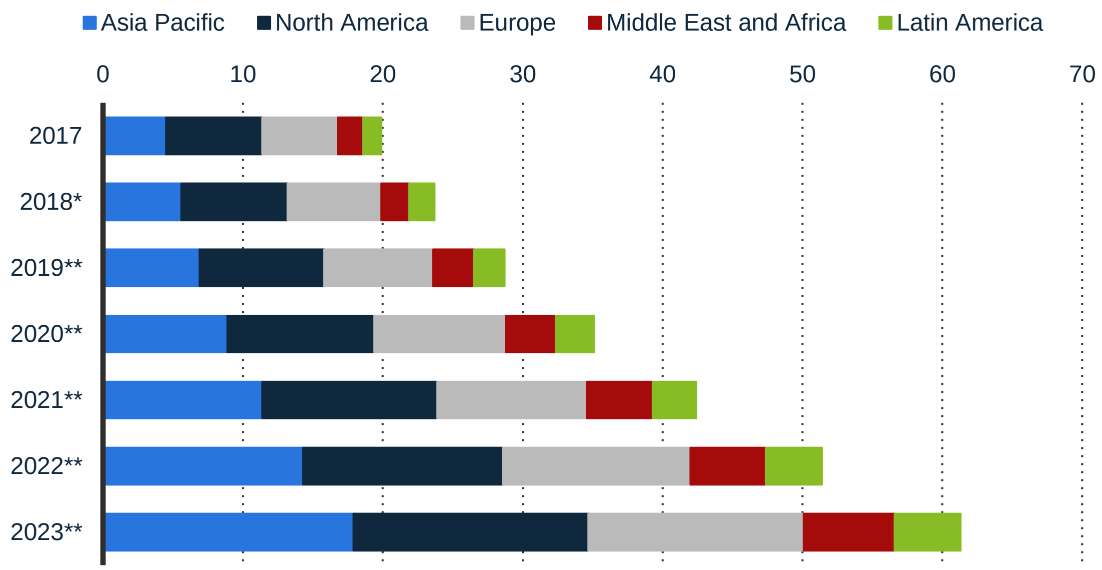


Figure 29. Market Value of Smart Grids Worldwide, by region
Source: data from statistical databank [5]

Smart grids imply a huge cultural change in the way electricity is distributed, touching upon issues from long-term network planning to real-time network operation. DSOs, currently responsible for transporting electricity from the transmission system to customers (excluding supply), will be at the heart of the new, intelligent electricity system. They will increasingly move beyond their traditional role of "building and connecting" towards "connecting and managing", and will become enablers for producers, service providers and customers to meet on an open market place. While smart grids will benefit all parts of the electricity value chain, DSOs will bear the lion's share of the initial investments to encourage development of commercial solutions. Such solutions cannot develop before the introduction of smart grid functionalities that will provide all actors with swift, transparent and accurate information and help to maintain network stability [6].

The International Energy Agency has estimated the investment needs in Europe's distribution grid at 480 bn euros by 2035 [7]. Yet DSO investments in smart technologies are currently being hampered by two things: sub-optimal rates of return and regulatory instability. Regulators tend to take a narrow view when evaluating the cost efficiency of investments, penalizing DSOs for extra expenditure.

Smart grids will not be rolled out in a single swoop. Instead, their implementation is an incremental and continuous step-by-step learning process, characterized by different starting points throughout Europe. Smart grids are not an instant revolution, but a steady evolution which has to include the customer as well as energy suppliers and producers. There is a great need for more awareness about what the deployment of smart grids will include, in particular with a view to identifying the most important steps for policymakers and industry.

Implementing smart grids requires 10 steps to be taken, many of which are closely interrelated and will develop simultaneously rather than in isolation. Let's analyze briefly each step in the common strategy of smart grid implementation using the following strategic document [6].

Step 1 "Providing regulatory incentives for innovative grid investments". Smart grids benefit everybody. But DSOs will bear most of the costs and risks of rapidly introducing new technologies on a large scale because traditional methods of regulation do not always provide the right incentives for investments in innovation. For many regulated companies therefore, their current return on investment is lower than their cost of capital. Regulators should thus allow enough commercial space for investment in future technologies that can improve the networks. They should introduce a stable long-term regulatory framework that will provide network operators with a reasonable rate of return for cost-efficient grid investments as well as incentives to increase efficiency, foster market integration and ensure security of supply. At the same time, a clear line needs to be drawn to distinguish which business should be regulated and which should be market-driven. Smart metering deployment and grid automation, for instance, must be tariff-financed.

Step 2 "Developing market models". Smart grids will be a platform for new business models. Analyzing different market model scenarios is crucial in order to demonstrate the benefits of smart grids for different parts of the value chain. There should be no prescriptions for any specific market design and no one-size-fits-all approach. Nevertheless, a clear decision is needed on what should be regulated and what should be left to the market, in order to incentivize development of smart grid solutions. A well-functioning division of work between regulated and commercial players, and well-functioning interaction between market players should be ensured, not least by defining the roles, responsibilities and interfaces among individual actors (customers, DSOs and suppliers/aggregators). In addition, all market model options should provide a framework for development of demand response programmes to ensure a customer-focused demand response market that can provide customers with a range of products which suit their preferences. In this context, DSOs should become market facilitators and enablers of active demand. DSOs will also become information hubs. They must play a central role in collecting smart metering and other network data and making the data available to third parties. With these data, suppliers will be able to provide customers with innovative products and services. DSOs will liaise with customers when necessary to agree on load management measures in cases where the distribution grid's reliability needs to be guaranteed.

Step 3 "Setting standards and ensuring data protection & privacy". Standards will provide a cost-efficient solution for market actors. They will enable interoperability, avoiding the high compliance costs of divergent national approaches that could otherwise hold back the large-scale implementation of smart grid functionalities. Different types of standards need to be defined. Technical standards for communicating and collecting data need to be developed in order to integrate the various communication technologies and electrical architectures of the smart grid solution. To facilitate the large-scale deployment of e-mobility, a standardized charging interface will be necessary to ensure interoperability and connectivity between electricity supply points and the charging infrastructure for electric vehicles. Standardized communication and data protocols will enable DSOs to improve the transfer of verified customer data to service providers. Finally, an assessment of data risks is required: resolving any data privacy and security issues is indispensable to ensuring customers' confidence. European network codes, as foreseen by the EU's Third Energy Package, should take into account innovative solutions when introducing requirements that are considered relevant at EU level.

Step 4 "Testing through demonstration projects & sharing knowledge". "Smart" technology is already available, but testing it through pilot and large-scale demonstration projects is needed in order to gain practical "in-the-field" experience prior to its massive deployment. Involving customers and market operators in demonstration projects is crucial. The pilots and demonstrations will provide continuous input to adjusting regulatory, market and technical solutions in such a way as to support the efficient balancing of the network and customer participation. Funding of smart grid demonstration projects, as proposed within the European Electricity Grid Initiative, is especially vital. Projects' 'smartness' level needs to be qualitatively and quantitatively assessed, taking into account potential energy savings, demand reduction, deployment of centralized generation and payback periods. Measuring results by indicative key performance indicators (KPIs) should provide a clear understanding of the development, and provide a catalyst to encourage investments by public European funds. Additionally, a knowledge sharing platform should offer TSOs, DSOs, policymakers and grid users a comprehensive overview of progress, results and needs of smart grids projects throughout Europe and should help to maximize the efficiency of investing in R&D.

Step 5 “Rolling out smart metering – informed customers”. A smart meter is an essential device that integrates data collection and communication within smart grids. Thus, many smart grid functionalities cannot be deployed without smart metering. Supplemented by in-home displays and portal solutions, smart meters contribute to higher customer awareness. Using open standards, smart meters will enable dynamic pricing, in turn incentivizing customers’ involvement. In doing so, they will catalyze the development of retail markets and enable enlarged business models like network operation and asset management. Later on, they will be integrated with home appliances and home automation networks. The roll-out of smart meters is a continuous process which is subject to national cost-benefit analysis. Some countries (e.g. Sweden and Italy) have already invested in installing certain smart functionalities such as remote reading of electricity meters. Nevertheless, meters installed by DSOs should only cover functionalities that are essential for optimal grid operation. They should be fully tariff-financed. Tariff-financing should also include the data and information systems required for DSOs to make meter data available for market use, i.e. IT-systems to collect, validate and transmit data effectively. Commercial parties will then introduce more customized services which could be added by those consumers who are interested. For example, the roll-out of in-home displays and home automation is a market function.

Step 6 “Monitoring and controlling the grid & distributed generation”. Remote monitoring and automatic fault detection at the level of medium and low voltage networks are currently the exception, but throughout the next decade, network operators will invest to make their grids smarter. While conventional grid development will continue, additional communication systems will have to be installed. These, in combination with smart meters, will provide DSOs with real-time information about distributed generation and load on the grid. Automation will ensure quality of supply (voltage, frequency, etc.) and minimize negative implications for grid users, for instance by reducing the duration of outages. Besides locating faults, newly installed detectors along the lines and substation devices should also provide, in cases of simple disturbances without damages, “self-healing” capabilities. All processes during normal system operation, emergency situations as well as restoration following faults should be automated. Innovative changes in tools used in control rooms should also be implemented.

Step 7 “Moving to integrated local & central balancing of all generation”. Until now, DSOs have distributed power on a top-down basis. This will change as more and more capacities will be connected to the distribution grid, which will have to accommodate vast amounts of distributed generation and new load types such as electric vehicles, heating and cooling. Higher shares of distributed energy sources will lead to increased variations in voltage. In order to “keep the system running” and to maintain service quality and reliability, bi-directional flows will need to be continuously monitored and managed. In addition to smart network technologies, enhancing the distribution network's resilience to variable intake will require smart processes for a dynamic network operation. In order to manage the distribution system and to contribute to the stability of the transmission grid, there is a clear need for DSOs to take on additional system obligations. Preferably DSOs will support balancing of load and generation. They should be allowed to dispatch distributed generation or ask network users to contribute to voltage regulation. At the same time, they might be required to contribute to the security of the transmission system by temporarily taking some of their connected users off the system, and – exclusively in cases of emergency – to operate partial networks in an island mode. TSOs, acting as overall electricity system operators, will remain responsible for ensuring a secure, reliable and efficient electricity system. A clear definition of roles and responsibilities between DSOs and TSOs as well as a structured and organized exchange of information will be necessary.

Step 8 "Aggregating distributed energy sources". Today, small-sized distributed generation units often cannot directly interact with the market and the TSOs. Aggregating units will make distributed energy sources (photovoltaics, wind, CHP and later also electric vehicles) more visible to TSOs and DSOs as local system managers, helping them to balance the system at acceptable cost and better coordinate defense schemes in transmission and distribution grids. Distributed energy resources can be aggregated into virtual power plants (VPPs), thus creating a provisional interface to exploit technical and economic synergies. Such a multi-fuel and multi-owned power station system could provide various ancillary services (e.g. balancing power and power-frequency control) as an alternative to large centralized power plants. This could also increase liquidity of reserve markets. In this context, DSOs should work as information hubs and perform a reliable and swift change of supplier. They could also become ancillary services providers, which will lead to an optimized operation of distribution networks.

Step 9 "Integrating large-scale e-mobility, heating, cooling and storage". Load management is one of the main justifications for smart grids with their objective of managing existing resources in such a way as to meet user needs in the most cost-effective manner. Electric vehicles (EVs) will be preferably charged in times when the demand is low and supply abundant, e.g. from wind and sun. At the same time, their batteries will be used as storage facilities for the grid in periods when the production of variable renewable sources is high. On the other hand, a significant penetration of EVs will result in higher power demand and un-forecast mobility in connecting to the grid. Customers' expectations of easy and convenient access to charging stations will have to be reconciled with the capacity of the local electricity grid to deliver the electricity without overloading the distribution grid. Active demand management, intelligent electricity grids and meters are thus indispensable for the efficient integration of EVs into the electricity system. Potential synergies with variable renewables have to be harnessed. Charging programmes on the basis of market and load signals will contribute to balancing power supply and demand and lower intraday price volatility. With the rising influx of variable renewables, other forms of flexible storage will also need to be developed and implemented. In addition, the potential of heating and cooling applications needs to be evaluated.

Step 10 “Moving to real customer participation in the power market”. Real active demand response will only become an inherent part of electricity retail markets once price regulation has been removed and customers have smart meters and additional interactive tools at their disposal. More accurate and frequent consumption data will enable suppliers to offer a wide range of services to customers. Dynamic pricing and time-of-use tariffs will incentivize customers to show more interest in their consumption patterns and modify their energy usage. Flexible power price structures and tailored contracts should incentivize peak loads at times with a surplus of renewable power generation, and reduction of loads at times with low levels of renewable power generation. The aggregators of load reduction will sell this load reduction on the wholesale market. Without reducing customers’ comfort, the net reduction in load moderated by DSOs will be sufficient to ensure security of supply and reduce costs as a result of more accurate planning of grid capacity and reduced need for reserve capacity. Customers will also become actively involved in the decentralized energy system as ‘prosumers’ who sell back their own electricity.

Modernizing Europe’s electricity system is crucial for Europe’s energy policy ambitions. Indeed, the European electricity industry will have a key role to play in supporting these ambitions. The European Union has set three targets for 2020 [6]:

1. It aims to reduce its CO2 emissions by 20%.
2. It strives to achieve a 20% share of renewable energy sources (RES) in overall energy consumption.
3. It tries be 20% more energy efficient.

These 2020 goals translate into significant CO2 reductions for the electricity industry and an increased RES (renewable energy sources) share in electricity consumption from today’s 18% to some 34%. By 2050, the European Union plans to achieve an effectively carbon-neutral power portfolio, in which the share of electricity from RES will amount to more than 50% [6].

Smart and digital grids are enablers of the European strategy toward a low-carbon energy future. Their deployment requires that significant investments are mobilized. What is for consumers in this digital grid revolution? Why market players should invest resources on technologies and solutions for renewed power system configurations? Who are the beneficiaries of smart electricity system developments? How winners and losers can be anticipated in the changing regulatory framework? What are the instruments and methodologies to capture all the possible benefits and costs? In order to gauge the implications of the anticipated paradigm shift for the electricity system, new reference architectures and assessment methodologies shall be developed to properly capture the interactions between the different actors and technologies to value and allocate the costs and benefits of such transformation. A fair allocation of (predominantly) shorter term costs and (generally) longer term benefits among different players is a precondition for reducing uncertainties and incentivize investments. Specific provisions in the Third Energy Package foster smart meter deployment wherever benefits outweigh costs. The 2016 Clean Energy Package proposal goes beyond this and states that all consumers should be entitled to request a smart meter from their suppliers [8]. Against this background, over the last seven years, the European Commission made efforts towards identifying, defining and applying assessment strategies and approaches for optimal decision-making on smart electricity systems. More in detail, it informed the policy decision making through the following studies and products [8]:

1. Guidelines for cost-benefit analysis of smart grid projects. The European Commission developed a comprehensive assessment framework of smart grid projects centered on a cost-benefit analysis.

2. Guidelines for cost-benefit analysis of smart metering infrastructure. The EU aims to replace at least 80% of electricity meters with smart meters by 2020 wherever it is cost-effective to do so. To measure cost effectiveness, EU countries conducted cost-benefit analyses based on guidelines we contributed to develop.

3. Examples of applications to smart electricity projects and demonstrators. The European Commission applied its assessment approach to smart grid pilots and larger scale projects (e.g. covering the whole city of Rome).

4. Comparison of international assessment approaches and frameworks. In particular, the EU partnered with US, Chinese and Brazilian actors to find synergies and differences in the evaluation methodologies and identify strengths and weaknesses.

5. Analyses on smart grid projects of common interest. The EU developed a multi-criteria assessment framework including: a) a checklist to verify that project proposals meet the requirements set out by the Regulation; b) a techno-economic assessment based on Key Performance Indicators able to capture the key features of each project; c) a Cost Benefit Analysis of each project.

The increasing share of variable renewable energy sources will prove challenging to the electricity system’s stability, security and reliability. Already today, these challenges are making themselves felt in several European regions. By 2020, intermittent RES such as wind and solar are expected to represent 17% of the EU’s total electricity consumption. On the one hand, this figure will include large-scale renewable generation sources such as offshore wind farms, whose development will require substantial investments in the transmission grid. On the other hand, distribution networks will need to accommodate an increasing number of small-scale sources. In France, for example, 900 MW of variable RES are already connected to the distribution grid; in Germany the figure is about 50 GW. At the same time, electrification of transport will be needed to further decarbonize the economy. For a significant deployment of electric vehicles by 2050, Europe needs to target a 10% share of electric vehicles by 2020. These vehicles will need to be charged through the electrical system. Together with the electrification of heating and cooling, they will further contribute to the projected growth in electricity demand. As a result, the assumption that the demand for electricity dictates the amount of electricity produced no longer holds. Power will not only flow in one direction from the power system to the consumer, but increasingly from the customer to the power system as well [6].

Smart meters. Smart metering offers consumers, suppliers, network operators, generators and regulators a wide range of useful tools and services enabling ultimately a smarter energy world. The volume of the EU's smart metering market with a forecast for 2023 is represented in the Fig. 30.

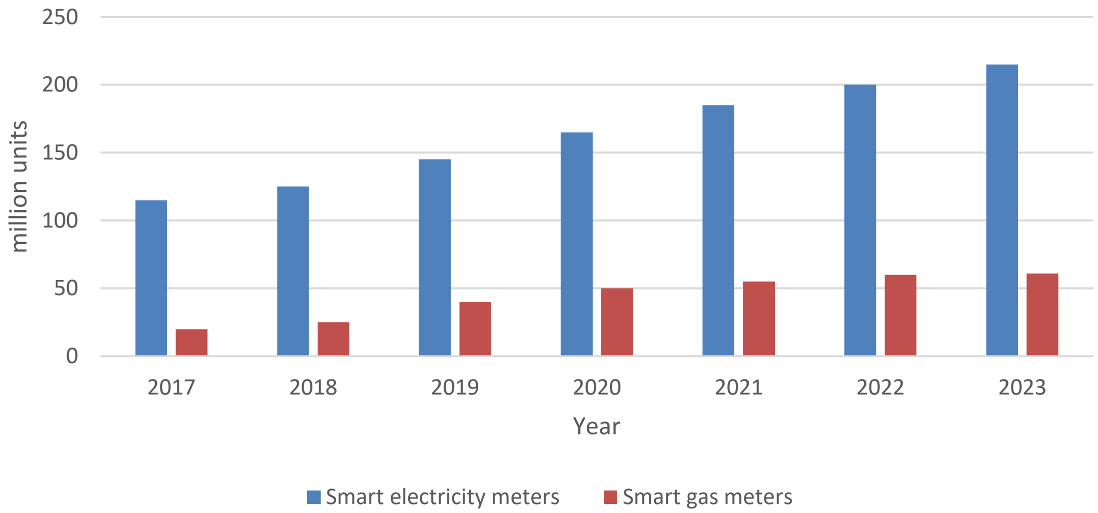


Figure 30. Installed Base of Smart Electricity Meters and Smart Gas Meters in the European Union

Source: data from [9]

Smart metering technologies consist of several different technical components which may vary according to the specific market conditions in different Member States, but the majority include the following features [10]:

1. Accurate measurement and transmission of electricity, gas, water or heat consumption data.

2. Provision of a two-way information gateway and communication infrastructure between the meters and relevant parties and their systems, for:

- raising awareness and empowering the consumer through delivery of actual consumption data;
- improving Customer Relationship Management (CRM) and services, including automated billing/invoicing based on detailed metering data;
- managing energy networks/grids better by shifting or reducing energy consumption, e.g. through Demand Side Management (DSM);
- enabling new energy services for improving energy-efficiency;
- encouraging decentralized, micro-generation of energy, thus transforming the consumer into a energy producer ("Prosumer").

Smart metering systems feature a number of innovations: digital technology, communications, control and better operation of networks. Smart metering technologies will change the way that metering works completely. They provide customers with much more information on how they use energy and enable those customers to reduce their usage. The advantages of implementing smart metering technologies are as follows [10]:

1. The advantages for consumers:
   - consumers can be informed remotely (historical data) or locally (real-time data) on energy costs and carbon emissions;
   - energy consumption of household gas, electrical and water equipment can be displayed on the appliance or on displays;
   - multi tariff functions can be added to allow demand response techniques;
   - allows electrical appliances to be automatically controlled;
   - allows the consumer to reduce costs by increasing energy consumption during off-peak cheaper tariff periods.
2. The advantages for utilities:
   - gain first-class data;
   - influence the energy consumption of their users;
   - improve profitability of the technology once Smart Metering is also used for gas, water and heat readings;
   - a reduction in 'costs to serve';
   - open gateways for the delivery of energy services;
   - assistance in the development of liberalized energy market;
   - help for revenue protection;
   - monitoring of the generation from building renewables;
   - support in demand response techniques;
   - more effective grid management;
   - a new communication channel to customers.
3. The advantages for EU and national governments:
   - prove to be THE tool to entice consumers to manage their consumption better and reduce usage leading the way to improved service levels through richer billing information;
   - be a key weapon in the fight on climate change;
   - help governments implement liberalization of energy markets;
   - allow the full realization of the Energy Services Directive.

The key components of smart metering technologies are represented in the Table 17.

Table 17.

Key Smart Metering Characteristics

Characteristics	Description
Smart grids	Smart meters are the cornerstones of Smart grids. They give accurate insight in the quality of power supply and any disturbances in electricity networks. Fraud and leakages can be detected easily, so the cost of economical energy losses decreases. They support the European efforts for efficient use of energy and getting climate changes under control.
Consumers/ Prosumers	Provide more and better information on their energy consumption and generation (real-time feedback, correct billing, on-line data); dynamic

	tariffs, such as TimeofUse; demand response programmes; easy supplier switching; an increasing number of consumers are becoming energy producers (selling energy generated locally).
Smart homes	Provide an interface for smart homes devices; allow for comprehensive home energy management; enable buildings communications systems with knock on effects for controlling heating, lighting, ventilation and appliance use.
Renewables and distributed generation	Better integrate the growing number of embedded renewable generators, such as wind and photovoltaic; measure exported power when the customers use less power than they generate; measure the output of the generator and supply this data to the energy company (complete picture of the generator's performance); manage fleets of embedded generators as though they were a single large plant – so-called virtual power plants.
Electric vehicles	Efficiently managed when charged or used as a power storage and source; information on how and when to charge or give energy back to the network independently of the location or time.

Source: data from [10]

Smart metering technologies facilitate electricity security in the European Union. Energy security occupies a prominent place in most of the EU's energy policy action areas: supply security is one the five mutually reinforcing dimensions of the EU's Energy Union strategy; the proposal for a European Energy Security Strategy includes short and long-term energy security measures targeting critical energy infrastructure; the EU internal energy market is expected to be integrated and resilient; the promotion of energy efficiency and domestic energy production, would foster the reduction of energy import dependency. Among all forms of energy, electricity seems bound to play an increasingly central role, particularly in Europe. More and more shares of EU's energy are expected to be converted into electricity, particularly in the transport, heating and services demand sectors. Depending on the scenarios, the electricity in the EU's final energy consumption - which roughly represented one fifth in 2012 - is anticipated to grow from one fourth in 2030 to one third or above in 2050 [11]. In this relation, deployment of smart metering technologies are of primary concern in the European countries.

The European countries are the active implementers of smart energy initiatives. Their environmental concern can be explained by the necessity of guaranteeing energy security for the united Europe. The European smart energy initiatives include smart grid initiatives, smart metering initiatives, and smart city initiatives. The European countries introduced a 30-year strategic energy technology plan in 2006 for the development of a smart electricity system. By now, the European countries combine successfully theory and practice of smart energy policy. From adopting numerous legislative acts and directives – to practical implementation of the suggested concepts. Smart energy technologies based on the use of artificial intelligence determine the future security of the European Union countries.

REFERENCES

1. Mohammadi, M., Noorollahi, Y., Mohammadi-Ivatloo, B., Yousefi, H. (2017). Energy Hub: From A Model To A Concept – A Review. Renewable and Sustainable Energy Reviews, 80, 1512–1527.

2. Hossain, M., Madlool, N., Rahim, N., Selvaraj, J., Pandey, A., Khan, A.F. (2016). Role of Smart Grid in Renewable Energy: An Overview. Renewable and Sustainable Energy Reviews, 60, 1168–1184.

3. Geidl, M., Koeppel, G., Favre-Perrod, P., Klockl,B., Andersson, G., Frohlich, K. (2007). Energy Hubs For The Future. IEEE Power and Energy Magazine, 5, 24-30.

4. Mohammadi, M., Noorollahi, Y., Mohammadi-Ivatloo, B. (2018). An Introduction to Smart Energy Systems And Definition of Smart Energy Hubs. Operation, Planning, and Analysis of Energy Storage Systems in Smart Energy Hubs. (pp. 1–21). Springer, Cham.

5. Official website of STATISTA. Retrieved July 25, 2020, from https://www.statista.com/

6. EURELECTRIC (2010). 10 Steps to Smart Grids (Rep.). Retrieved July 20, 2020, from EURELECTRIC website https://www3.eurelectric.org/media/26140/broch.10steps _lr-2011-030-0304-01-e.pd

7. World Energy Outlook (2010). Retrieved July 15, 2020, from OECD website http://www.oecd.org/berlin/46389140.pdf

8. Smart grid costs, benefits and impacts. Retrieved June 24, 2020, from https://ses.jrc.ec.europa.eu/smart-grid-costs-benefits-and-impacts

9. Smart Metering in Europe. Retrieved July 3, 2020, from http://www.berginsight.com/ReportPDF/ProductSheet/bi-sm14-ps.pdf

10. Official website of ESMIG. Retrieved June 20, 2019, from https://esmig.eu/page/smart-metering-technologies

11. Electricity Security In The EU: Features and Prospects. Retrieved July 24, 2019, from https://ses.jrc.ec.europa.eu/electricity-security

VII. MANAGEMENT ASPECTS OF THE USE OF ARTIFICIAL INTELLIGENCE

7.1. Conducting investment research and trading using artificial intelligence

Larysa Hryshyna
PhD in Economics,
Head of department of Economics and Organization
Admiral Makarov National University of Shipbuilding of Mykolayiv
E-mail: grishinappi@gmail.com
ORCID ID 0000-0002-3099-1453

Liliya Filipishyna
Doctor of Sciences (Economics),
Professor of department of Economics and Organization
Admiral Makarov National University of Shipbuilding of Mykolayiv
E-mail: ontariofilpi@ukr.net
ORCID ID 0000-0001-9552-1367

Iryna Zhuvahina
PhD in Economics,
Dean of the Faculty of Engineering and Economics
Admiral Makarov National University of Shipbuilding of Mykolayiv
E-mail: irene.zhuvagina@gmail.com
ORCID ID 0000-0002-6701-7750

One of the priority factors of the current stage of development of the world economy is the progressive development of the information society, the strengthening of digitalization, the comprehensive penetration of artificial intelligence. Today, all industries are covered by the introduction of information and communication technologies, the use of various programs and networks, which allows processing a huge digital flow of information, without which it is impossible to imagine the functioning of modern investment, innovation, production and service. The special conditions of the global COVID-19 pandemic in 2020-2021 determine the use of advanced technologies and artificial intelligence, which will contribute to the development of high-tech sectors of Ukraine's economy as a whole. In such conditions, the functioning of financial and economic entities in terms of investment and financial activities using artificial intelligence, modern information technology, Internet trading, the development of which will contribute to a positive impact on achieving high socio-economic development of Ukraine. The use of modern digital technologies, computerization and the penetration of the Internet into all spheres of public life is a global trend. The International Economic Forum in Davos in 2016 marked the beginning of the

Fourth Industrial Revolution, the development of which was studied by the famous economist, founder and president of the World Economic Forum Klaus Schwab. He noted that “we are on the threshold of a technical revolution that will completely change our way of life, work and communication. The greatest transformation in the history of mankind awaits us - the greatest in scale and complexity. We do not yet know exactly how this coup will take place, but it is already clear: the answer to it must be appropriate to the scale of the revolution itself; all participants in global politics must change, all players, from the private to the public sector, both the academic world and society itself must change. [1].

Exploring the special features of the Fourth Technological Industrial Revolution (Industry 4.0), most scientists emphasize its connection with artificial intelligence, intelligent production, self-control, the Internet of Things, etc. [2, 3]. Industry 4.0 includes many technologies, the main purpose of which is to create a single space for data exchange and virtual visualization of processes and objects, as well as the creation of robotic systems in combination with Internet technologies in the format of "smart" enterprises. In particular, among the characteristic features of the Fourth Technological Revolution should be noted such as:

- increasing the share of high-tech products in GDP,
- changing the structure of the economy and the needs of society, focusing on meeting individual consumer demand;
- expanding the computing power of computer technology and strengthening the interaction between man, nature and technology ;
- Internet of Things: smart city, smart home, smart clothes;
- innovative renewal of transport infrastructure, which is manifested in the widespread use of electric vehicles, unmanned vehicles, etc .;
- use alternative sources of renewable energy and its wireless transmission;
- introduction of new technologies in the financial and credit system using Block chain technology, etc..

An important prerequisite for the development of the digital economy, the use of artificial intelligence in Ukraine approved a number of laws, including the Laws of Ukraine "On e-commerce", "On telecommunications", "On electronic digital signature", "On electronic documents and electronic document management", "On financial services and state regulation of financial services markets "approved" Strategy for the development of the information society in Ukraine "," Concept of digital economy and society of Ukraine for 2018-2020 ", which states the basic principles of digitalization, directions of digital development, defines an action plan for its implementation [4, 5, 6, 7].

The development of the digital economy, which is based on artificial intelligence, is manifested in "creating market incentives, motivation, demand and needs for the use of digital technologies, products and services among Ukrainian sectors of industry, life, business and society for their efficiency, competitiveness and national development , growth of high-tech production and welfare of the population" [7].

According to reality, in Ukraine the main areas of use of digital technologies are e-business, e-commerce, information technology, telecommunications services. The spread of the Internet has helped to intensify the sphere of non-cash circulation, modern financial instruments, new markets related to network systems and telecommunications. The progressive development of Internet trading, the introduction of e-commerce are some of the most significant changes in modern business. Given the rapid development of Internet technologies, e-commerce increases its volume, attracts new customers, improves the financial results of e-commerce market participants and has many other advantages (Fig. 31).

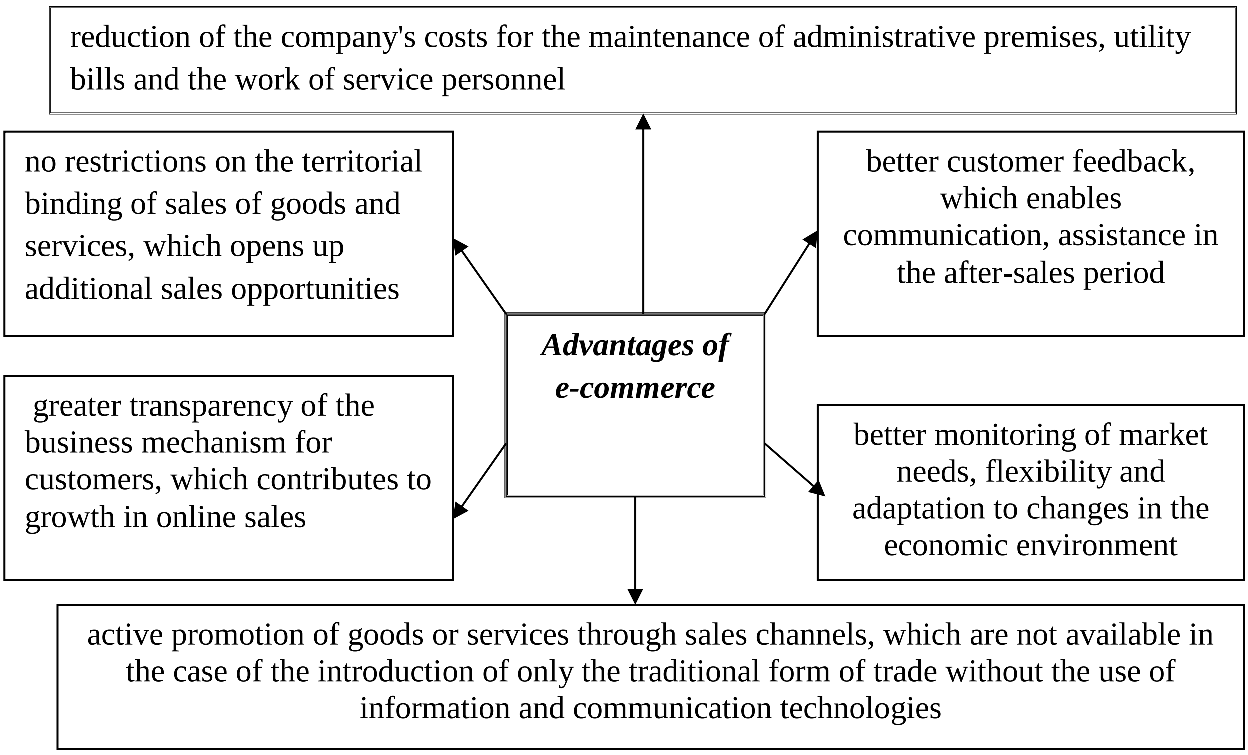


Figure 31. Characteristics of the advantages of Internet commerce

Source: Law of Ukraine "On e-commerce" (2015), Digital Agenda of Ukraine - 2020 (2016), The Concept of a "Digital Economy" (2015**)**

However, the functioning of enterprises in the field of e-commerce on the basis of e-commerce may have its drawbacks, including:

- consumer distrust of online shopping due to fraud and violation of deadlines, the quality of goods due to impossibility more detailed acquaintance with them before ordering;
- insufficiently formed culture of online purchases by customers, which requires the spread of advertising, modern forms of payment via the Internet, the introduction of bonus programs, etc .;
- additional costs for the consumer for the delivery of goods and its high cost;

- a high level of risk of loss of information, financial and economic security of business, etc.

According to statistics, in recent years there has been a general increase in e-commerce [8]. Thus, if in 2012 the penetration of e-commerce in the economy of Ukraine was 0.6%, then five years later this figure increased almost 6 times and reached in 2017 - 3.9%, in 2018 - 3.5% , In 2019 - 4.5%. The largest share of the volume of sold products (goods, services) received through e-commerce is observed in such activities as transport, warehousing, postal and courier activities; temporary accommodation and catering; wholesale and retail trade (Table 18).

Table 18

Sectoral features of the use of information and communication technologies at enterprises in Ukraine

Type of economic activity	Number of legal entities, units		Use of information and communication technologies at enterprises,%			
	2018	2019	had access to the Internet, %		bought cloud computing services, %	
			2018	2019	2018	2019
Processing industry	63309	67078	90,0	89,5	9,3	10,0
Agriculture, forestry and fisheries	65185	67906	86,3	84,4	8,6	8,9
Supply of electricity, gas, steam and conditioned air	4015	5318	93,2	92,3	9,7	11,6
Wholesale and retail trade; repair of vehicles, vehicles and motorcycles	210534	242334	88,1	86,1	11,3	11,5
Transportation, warehousing , postal and courier activities	26604	29099	87,8	87,9	7,5	8,1
Information and telecommunications	25468	28185	90,0	89,2	15,4	17,5
Professional, scientific and technical activities	57875	62833	88,4	87,2	13,1	13,6

Source: State Statistics Committee of Ukraine

Since Internet trading is directly connected to the Internet, the possibility of its development is directly proportional to its availability, accessibility, geographical features, etc. The ability to use Internet devices in online commerce is determined by the presence of Internet communication, which includes cable communication, mobile Internet, Internet via radio, satellite Internet [9]. During the period 2018-2020, Ukraine has significantly increased access to high-quality and high-speed Internet, including the introduction of mobile 4G Internet, and the number of mobile users far exceeds the total population, due to the presence of several mobile devices. [8].

The International Organization for Economic Cooperation and Development (OECD) identifies only three key components of the digital economy: infrastructure (hardware and software, telecommunications, networks, etc.); e-commerce (distribution of goods via the Internet); e-business (doing business and other business processes through computer networks) [10]. Considering e-commerce, it is worth emphasizing the growth of its pace in all countries. The number of e-commerce users increased to 2.8 billion in 2019. [11] If we compare e-commerce figures with GDP per capita, we should take the example of China, where consumers of goods and services spend about 7% of this figure on the Internet, which is almost twice the rate of the United States (3.3%).

The dynamic development of today continues to dictate more and more opportunities for intelligent technologies - Internet - trading as a way to invest and increase their capital, because at this stage of development of our country this service has become the best alternative to bank deposits, buying real estate to save and increase personal capital [1]. Internet trading (internet trading) is an opportunity to make transactions on all classes of assets and currencies via the Internet. Although in recent decades this method of trading has become very widespread, on the Ukrainian stock market this concept has been used recently and has become quite popular in the investment sphere. In Ukraine, the official launch date of Internet trading is March 26, 2009 and the decisive role belongs to JSC "Ukrainian Exchange", and the penetration of the Internet in almost all areas has led to the reality of access to trading on the exchange of anyone [12]. Among the most important arguments that emphasize the positive trends in the stock market, including Internet trading itself, is the adoption of the Law of Ukraine "On Joint Stock Companies", which provides a number of important changes: undocumented form of securities in Ukraine; closer work of all companies established in Ukraine with stock exchanges; division of all joint-stock companies into public and private, etc.

Online trading includes: trading in goods through auctions, trading in services, online trading in financial instruments such as currency or securities. Internet trading in the stock market provides direct access of the investor to trading in securities on the stock exchange (direct market access) via the Internet. Also, online trading is also called: online brokerage, online investing, online trading, trading in securities (stocks) via the Internet, online trading, etc.

In modern conditions, the stock exchange is a financial institution that creates special conditions for investment and is an indicator of the economic situation in the country. The largest trading platforms are located in New York, where the shares of the world's most famous corporations are quoted. Also in the top ten are organizations from China, Japan, India and the United Kingdom. Unfortunately, Ukraine is still far behind such giants and ranks only 59th in the world rankings. There are more than 10 stock exchanges in Ukraine, located in Kyiv, Dnipro and Mykolayiv. Among them, the leading positions as the largest bidders are held by PFTS, Prospect, and the Ukrainian Stock Exchange, which constantly compete for the title of the first in the country. Most investment operations are carried out on the PFTS platform, and the PFTS Index is considered an indicator of the financial situation of the state. The direct competitor of PFTS is the Ukrainian Exchange, which is actively developing online trading among domestic investors.

Thus, in Ukraine during 2019-2020 there was a very positive dynamics of the stock market, as evidenced by the volume of stock trading in securities (Table 2). Thus, according to the results of trading on the organized market, the volume of exchange contracts (agreements) with securities in 2019 amounted to UAH 304.97 billion, which is 17% more (or UAH 44.9 billion) than the volume of trades in 2018. year. In 2020, the positive trend of growth of exchange contracts to UAH 335.41 billion continued, which is 10% more (or UAH 30.44 billion) than the volume of trades in 2019. The largest volume of trades in financial instruments by trade organizers during this period was recorded with government bonds of Ukraine (in 2019 it amounted to UAH 295 billion (96.81% of the total volume of exchange contracts, in 2020 - respectively UAH 328.7 billion). (98%) [13] There was a consolidation of trading in securities on the two stock exchanges "Perspective" and "PFTS", which accounted for 98.7% of the value of exchange contracts in 2019, 99.28% in 2020. Such a moderate The increase in trading volumes on the stock market is explained by the increase in the amount of financial resources invested in securities, as well as the increase in the value of securities of issuers with whom agreements were concluded.

Table 19

Trading volume on the largest stock exchanges of Ukraine in 2018-2020, billion UAH.

№	Exchange	2018		2019		2020	
		Primary market	Secondary market	Primary market	Secondary market	Primary market	Secondary market
1	Prospect	2,90	124,42	0,008	186,35	0,0	201,46
2	PFTS	1,26	111,26	0,56	114,76	0,247	131,53
3	UMFB	0,035	0,0	0,0	0,004	0,0	0,007
4	Ukrainian stock exchange	1,74	19,25	2,61	0,0	0,0	2,41
5	Total	5,94	212,13	3,27	301,72	0,247	335,41

Source: National Securities and Stock Market Commission (2021)

Analyzing the data given in Table 19, it can be seen that in terms of trading volume, the stock exchange " Prospect " ranks first, increasing their volume by 8.11% to 201.46 billion UAH. in 2020 compared to 2019. The total increase in trading volumes in 2020 was 11.17% compared to 2019. In addition, a number of securities of foreign issuers are currently admitted to trading on the Prospect stock exchange: shares Facebook, Tesla, Netflix, Visa, Microsoft, AMD, APPLE, bonds US Department of the Treasury [14].

One of the important prerequisites for achieving positive trading results on the stock exchange " Prospect " is the use of Internet trading based on the electronic trading system of the Exchange (hereinafter - ETS Exchange), which is a set of organizational, technological and technical means used by the Exchange to ensure contracts with securities and other financial instruments. The exchange of information in the ETS Exchange is carried out by electronic document management, which is a set of processes for creating, processing, sending, transmitting, receiving, storing, using and destroying electronic documents, which are performed using integrity checks and, if necessary, confirming receipt of such documents.

The Exchange, with the participation of the duly registered Key Certification Authority, provides electronic document flow between Exchange Trading Participants, the Payment Organization, banks and depository institutions that are subjects of electronic document circulation. The Key Certification Authority is of great importance in the Exchange's activities in the stock market, as it discusses important information systems used by professional stock market participants - subjects of electronic document management, namely:

- electronic trading system of the Exchange used by Members Of the Exchange and Exchange Trading Participants,
- BIT eTrade Mail e-mail system,
- software products created to automate the activities of professional stock market participants,
- interbank non-governmental payment system "Settlement Stock" System".

To participate in the Exchange Trading or view the information on trading on the Exchange, it is necessary to access the electronic trading system of the Exchange in trading or review modes, respectively. With the help of the specified system and BIT eTrade Trading Terminal the Exchange Trading Participant gets authorized access to the Markets, which are a separate segment of the Exchange Trading and has features of circulation of securities and other financial instruments, conditions, procedure, terms of fulfillment of obligations under the Agreements. In addition, the Exchange uses several other types of trading terminals as components of Internet trading in order to perform its operational tasks (Table 20).

Table 20

Components of Internet trading of the stock exchange «Prospect»

№	*Type of trading terminal*	*The purpose of implementation*	*Performed functions*
1.	BIT eTrade IPO	Provision of a system of initial public offering of securities on the Exchange's trading platform.	Debugging the hardware and software part of access to the trading system as a module of the electronic system of the Exchange. Defining and implementing the Rules of the Exchange. agreements and sending orders for settlements when placing securities.
2.	BIT eTrade	Ensuring interaction between the Exchange Trading Participant and the Exchange regarding the submission of Applications, conclusion of	Registration of the Application for the Exchange in the form of Electronic documents. users, confidentiality of information exchange during the submission of Applications and conclusion of Agreements. Obtaining information on Exchange Trading,

		Agreements and receipt of information on the progress of Exchange Trading	maintaining a database on submitting Applications and concluding Agreements.
3	BIT eTrade Future	Ensuring interaction between the Exchange Trading Participant and the Exchange when concluding Term Contracts, concluding Agreements and obtaining information on the Exchange Trading Process	Submission of the Order on the Derivatives Market in the form of Electronic Documents. Ensuring authorized user access, confidentiality of information exchange during the submission of Applications and conclusion of Term Contracts.
4.	BIT eTrade Mail	Creation of organizational-legal and technological preconditions of Electronic document circulation between stock market participants and use of Electronic documents by Users due to performance of their guaranteed delivery, check of integrity and validity	Authorship verification: EDS verification allows the recipient to identify the author of the electronic document. Denial protection: the sender will not be able to deny the fact of sending the electronic document. Creation of archives and duplicates of electronic documents. Use of cryptographic protection of information that meets the standards of public key technology (Public Key Infrastructure), which implements encryption based on asymmetric algorithms and electronic digital signature, which provides the ability to decrypt an electronic document only to its recipient.

Source: Perspective Stock Exchange (2021)

Another example of the use of Internet trading in the securities market of the Ukrainian Stock Exchange is the activity of FREEDOM FINANCE UKRAINE, which is a division of the international group Freedom Holding Corp. The holding is registered in the United States and provides clients with access to global stock markets and provides comprehensive investment assistance, providing brokerage operations for large and small investors, expert assistance in investing, stock market research and analysis. In 2019, Freedom Holding Corporation entered the TOP-5 OTCQX Best 50 in terms of trading activity, overtaking well-known global brands. Among the characteristic features of the holding's activity are the ability to trade online, namely: clients use the online platform for trading Tradernet securities; the holding's clients can use multi-currency accounts and mobile banking [15].

Today, thanks to the full transition to electronic document management, to automate the implementation of operations in the stock market, Internet trading provides the most favorable conditions for private investors, which intensifies the investment market of Ukraine. The main criteria for the rapid development of all services related to online securities trading is the availability and efficiency of the relevant operations.

In the complex conditions of today's business environment, Internet trading attracts potential investors, primarily by the external simplicity of transactions and low tariffs for online brokers. In this case, as in reality, the investor can use a full-featured service, relying entirely on qualified advice from a broker, or discount service, when all responsibility for making a trading decision is transferred to the investor. The trader gets access to the exchange through a special trading program and can monitor the market situation in real time and make informed investment decisions. The trading program is provided to traders by an online broker who provides technical and analytical support to its clients. Therefore, we can conclude that Internet trading can be carried out as a way of investing, doing business or as an aid to the main activity (table 21).

Table 21

Type characteristics of Internet trading in the stock market

№	*Type of Internet trading*	*Species characteristics*
1.	Internet trading - as a business	A private trader constantly monitors the dynamics of the value of shares, analyzes the market and carries out relevant operations on it.
		The main income is the profit received from the purchase / sale of securities.
		The advantage of this type of activity is freedom of action and free schedule, as the trader independently makes investment decisions and, accordingly, is solely responsible for them..
2.	Internet trading - as a way to invest	Lack of time and desire to constantly monitor the market encourages the investor to understand the opportunities and benefits provided by the process of investing in stocks, with a predominantly annual period.
		Allows you to increase your capital through accumulative investment
3.	Internet trading - as an aid	Provides the opportunity to work at the main job and in parallel to monitor the stock market.
		Allows you to play on the stock exchange, earning extra income on the difference in stock prices.

Source: Law of Ukraine “On Electronic Commerce” (2015), Law of Ukraine “On Electronic Documents and Electronic Document Management” (2018), Order of the Cabinet of Ministers of Ukraine “On Approval of the Concept of Development of Digital Economy and Society of Ukraine for 2018-2020” regarding its implementation " (2018)

As can be seen from the table, there are many benefits of Internet trading for private investors, namely: simplifies and speeds up the process of concluding contracts; the number of transactions that an investor can perform per day increases; the ability to adjust the investment portfolio over time for the most attractive stocks; it is possible to trade on two stock exchanges at the same time and earn on the difference in securities prices, etc. This, in turn, will promote the development of the Ukrainian stock market on the basis of agreements with both residents and non-residents within the legislation of Ukraine.

It should be noted that Internet trading is carried out with the help of professional stock market participants, who, fulfilling the requests of investors, ensure the quality of services provided and additional services of brokers. Therefore, Internet trading operations in the stock market should be carried out in the main generalized stages, which will allow to work on establishing relations between clients and brokers in order to successfully complete the transaction of purchase and sale of securities (Fig. 32).

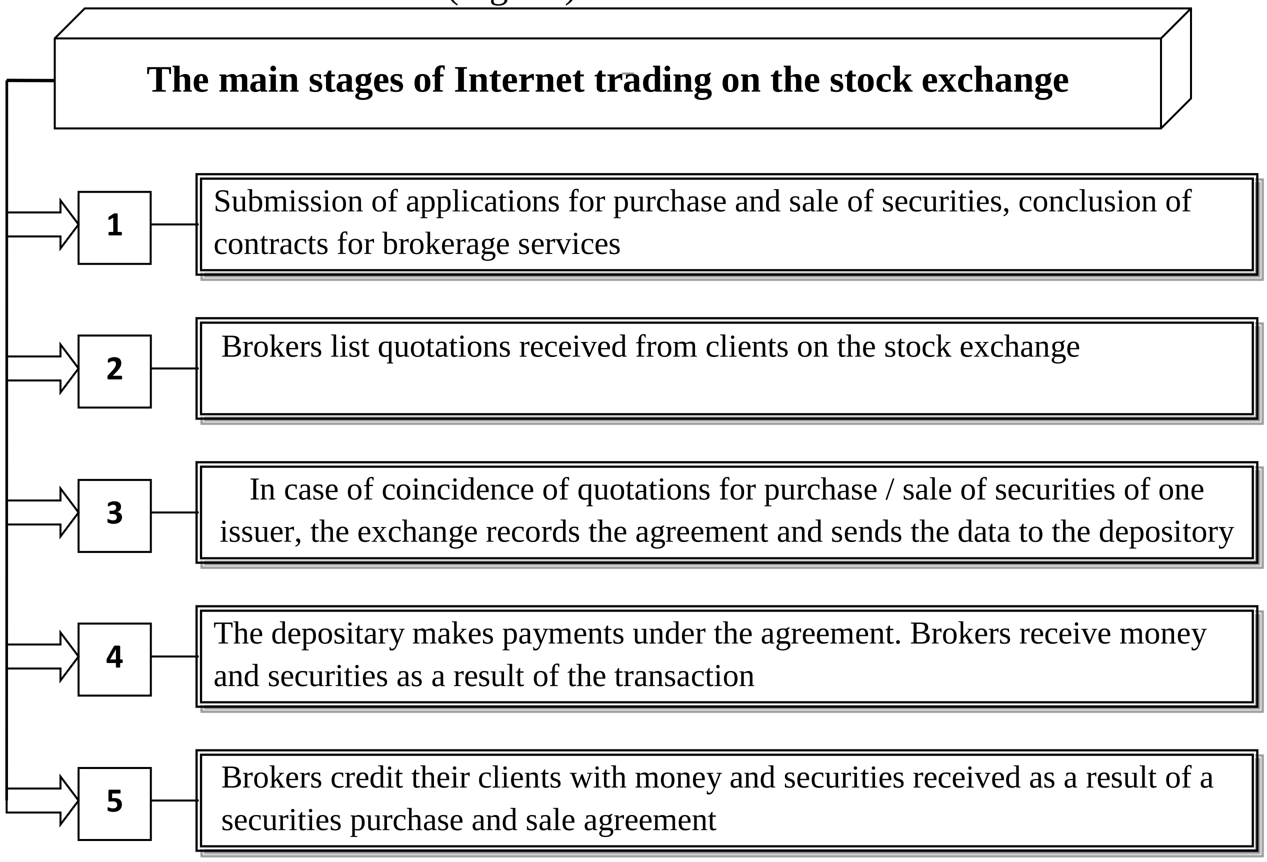


Figure 32. Algorithm for trading securities through the Internet trading system

Source: Ukrainian Stock Exchange (2021), Stock Exchange Perspective (2021), National Commission on Securities and Stock Market (2021)

Thus, Internet trading is a real way for private investors and traders to increase their capital in stock trading, along with professional participants in the securities market. Internet trading provides an opportunity to buy and sell shares of Ukrainian companies from anywhere in the world with a computer and the Internet, using direct access to the stock exchange. Internet trading will interest such a category of investors who care about financial stability and increase their capital; ready to constantly learn, use new tools in trading on the stock exchange; is financially literate, ambitious.

In today's reality, investing in the securities market has become much easier, more affordable and cheaper for Ukrainian investors. All the privileges that previously could only be enjoyed by professional participants or very large investors are now available to any investor who wishes to do so. Thus, Ukraine already uses several certified programs for access to stock exchanges, such as QUIK, WEB2L, SmartTrade. Over time, their number will only increase. In Ukraine today we can name such online brokers who have the opportunity to connect participants to Internet trading on stock exchanges: City Brock LLC, JV LLC Dragon Capital, FC OK-2 LLC, Ginsfort-Online LLC , JSC "IC Prospect Investments", LLC "FC Ukrnet", LLC "Securities Specialist", etc.. [9, 13].

One of the ways to improve the mechanisms of Internet trading should be noted the development of margin trading, which is a speculative trade using money and goods provided to the speculator on credit secured by a specified amount (margin). A simple margin loan differs in that the amount of money received (or the value of the goods received) is usually several times the amount of collateral (margin), in other words, the investor-trader is given a leverage. Increasing the popularity of marginal trading in financial markets will intensify the activities of Internet investors, which is a very important task today for the domestic economy.

In order to develop Internet trading in Ukraine, it is necessary to intensify work on strengthening the information and software of the stock market based on the experience of using innovative technologies of foreign companies. Improving the quality and availability of analytical information on the functioning of the stock market and its electronic trading systems will help attract novice traders, intensify investment activities in the financial sector of the Ukrainian economy. This, in turn, requires equal, complete, sufficient access to telecommunications and digital technologies. The use of a set of technologies of electronic payments and transactions, e-commerce and online interaction of business entities, financial digital infrastructures will contribute to qualitative changes in investment research and Internet trading with artificial intelligence, which will ensure Ukraine's success in digital development and increase competitiveness of Ukrainian business in the international arena.

REFERENCES

1. Schwab K. (2016) The Fourth Industrial Revolution: what it means, how to respond. Retrieved from: https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond/ (Last accessed: 12.03.2021)

2. Schlaepfer R.C., Koch M. and Merkofer P. (2014), Industry 4.0. Challenges and solutions for the digital transformation and use of exponential technologies. Retrieved from: https://www2.deloitte.com/content/dam/Deloitte/ch/ Documents/manufacturing/ch-en-manufacturing-industry-4-0-24102014.pdf (Last accessed: 12.03.2021).

3. Russmann M., Lorenz M., Gerbert P., Waldner M., Justus J., Engel P., Harnisch M. (2015), “Industry 4.0: The Future of Productivity and Growth in Manufacturing Industries”. Retrieved from: https://www.bcg.com/publications/2015/ engineered_products_project_business _industry_4_future_productivity_growth_manufacturing_industries (Last accessed: 15.03.2021).

4. Zakon Ukrainy Pro elektronnu komerciju vid 3 veresnja 2015 roku № 675-VIII [Law of Ukraine on e-commerce from september 3, 2015, № 675-

VIII]. Vidomosti Verkhovnoi Rady Ukrainy 2015, № 45, Art. 410. Retrieved from: https://zakon.rada.gov.ua/laws/show/675-19 (Last accessed: 22.03.2021).

5. Zakon Ukrainy Pro elektronni dokumenty ta elektronnyj dokumentoobigh vid 22 travnja 2003 roku № 851-IV [Law of Ukraine about electronic documents and electronic document flow from may 22, 2003, № 851-IV]. Vidomosti Verkhovnoi Rady Ukrainy 2003, № 36, Art. 275. Retrieved from: https://zakon.rada.gov.ua/laws/show/851-15 (Last accessed: 29.03.2021).

6. Rozporjadzhennja Kabinetu Ministriv Ukrajiny «Pro skhvalennja Strateghiji rozvytku informacijnogho suspiljstva v Ukrajini» vid 15 travnja 2013 r. № 386-p. [Order of the Cabinet of Ministers of Ukraine "On approval of the Strategy for the development of the information society in Ukraine"]. Retrieved from: https://www.kmu.gov.ua/npas/246420577 (Last accessed: 20.03.2021).

7. Rozporjadzhennja Kabinetu Ministriv Ukrajiny «Pro skhvalennja Koncepciji rozvytku cyfrovoji ekonomiky ta suspiljstva Ukrajiny na 2018-2020 roky ta zatverdzhennja planu zakhodiv shhodo jiji realizaciji» vid 17 sichnja 2018 r. № 67-r.]. [Order of the Cabinet of Ministers of Ukraine "On approval of the Concept of development of the digital economy and society of Ukraine. Retrieved from: https://zakon.rada.gov.ua/laws/show/67-2018-p/ed20180117#n23 (Last accessed: 20.03.2021).

8. Derzhavna sluzhba statystyky Ukrajiny [State Statistics Service of Ukraine]. Retrieved from: http://www.ukrstat.gov.ua/ (Last accessed: 23.03.2021).

9. Cyfrova adzhenda Ukrajiny – 2020. Konceptualjni zasady. Pershocherghovi sfery, iniciatyvy, proekty cyfrovizaciji Ukrajiny do 2020 roku [Digital Agenda of Ukraine - 2020. Conceptual principles. Priority areas, initiatives, projects of digitalization of Ukraine until 2020]. Retrieved from: https://ucci.org.ua/uploads/files/58e78ee3c3922.pdf (Last accessed: 23.03.2021).

10. The Concept of a “Digital Economy”. Retrieved from: https://www.alrc.gov.au/publication/copyright-and-the-digital-economy-dp-79/3-policy-context-of-the-inquiry/the-concept-of-the-digital-economy/. (Last accessed: 04.03.2021).

11. Hryshyna L., Mihai N., Pohorielova O., Hryshyna N., Khmarska I. Development of the digital economy as a determining factor for providing competitive advantages of Ukraine industries. [Social and economic aspects of internet services market development]: monograph. 2021, p. 188-202. OKTAN PRINT. DOI: https://doi.org/10.46489/saeaois-04

12. «Ukrajinsjka birzha» [Ukrainian stock exchange] Retrieved from: http://www.ux.ua/ru/members.aspx?online=1 (Last accessed: 05.03.2021).

13. Nacionaljna Komisija z Cinnykh Paperiv ta Fondovogho Rynku [National Securities and Stock Market Commission]. Retrieved from: http://www.nssmc.gov.ua/ 4 (Last accessed: 06.03.2021).

14. Fondova birzha «Perspektyva» [Perspective Stock Exchange] Retrieved from: http://fbp.com.ua/NewsEntry.aspx?id=6699 (Last accessed: 06.03.2021).

15. Freedom finance. Retrieved from: https://ffin.ua/ (Last accessed: 05.03.2021).

7.2. Methods of constructing the recruitment process based on artificial intelligence

Vovk Svetlana
doctor of Science in public administration, associate professor,
professor of the Department of higher education organization,
health and hygiene management
Donetsk National Medical University
E-mail: svitlana0632381668@gmail.com
ORCID ID 0000-0003-3883-1320

Vashcenko Valeriia
PhD in Economics,
Associate Professor of Non-Production Management,
Donetsk State University of Management
E-mail: valeriavasenko54@gmail.com
ORCID ID 0000-0003-4059-0722

Vovk Tatyana
senior lecturer,
departments of non-industrial management
Donetsk State University of management
E-mail: tanuvovk@ukr.net
ORCID ID 0000-0002-0946-8473

A study of recruitment issues in Ukraine during the crisis showed that it is during this period that human resources need to intensify their activities. This is due to the difficult operating conditions of enterprises. The task of management is to prevent a decline in profits and loss of weight among competitors. Most companies resort to the method of reducing costs, which is mainly the cause of mass layoffs. During this period, human resources face a number of difficult tasks: to prevent the leakage of better minds, get rid of ballast, reduce the cost of finding candidates and, at the same time, find qualified professionals of the highest level with a contract on favorable terms for the company. Monetary investment in a crisis in recruitment can be a stimulus for the company to rise rapidly. Subject to the successful construction of a recruitment system and the proper professionalism of internal recruiters, the company can close vacancies on its own, without seeking the help of specialized agencies. Exceptions are cases when the employer clearly knows which specialist he would like to "lure" with the help of headhunting, leaving the company's reputation unblemished.

Large companies seek to attract successful recruiters to the HR department. As this profession is relatively new, recruiters are mostly self-taught, and there are not many really talented professionals in the labor market. What is the system of recruitment at the enterprise, what processes should be mastered by novice recruiters, what rules to follow. A step-by-step scheme is proposed - a description of the entire process of personnel selection at the enterprise, including the stages of search, selection and hiring (figure 33). The essence of personnel selection at the enterprise consists of the following stages:

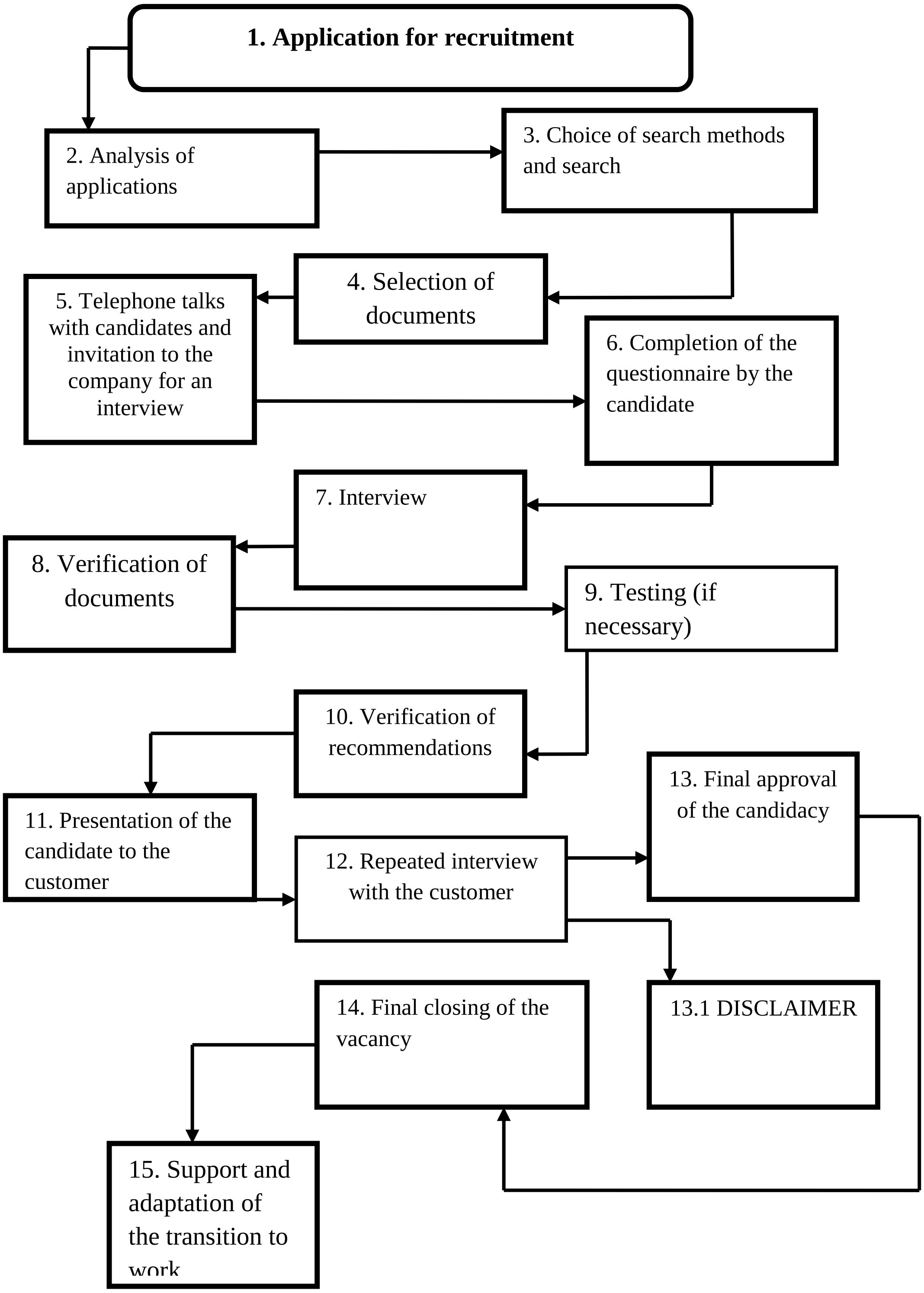


Figure 33. The process of recruiting staff in the enterprise on the basis of artificial intelligence

1. Acceptance of the application. It is advisable to sort and complete the completed questionnaires in the archives of the HR department, which will save time when working again with the same vacancies, or with similar vacancies for other departments.

2. Analysis of the application. The completed application form must be carefully studied. Additional questions may arise during the clarification of job responsibilities and working conditions. All incomplete answers should be clarified, all special, even unique, requirements to the applicant should be specified. For the recruiter, such a "meticulous" reading of the application will help to carefully prepare for the interview with the customer and the candidate, to avoid gross errors in the analysis of candidates' documents.

3. Choice of methods and search for candidates. Next you need to choose search methods and make an action plan. The correct definition of search directions and precisely composed text of the vacancy announcement will help to collect the base of resumes of candidates that best meet the requirements of the job. The more specific information the ad contains, the more likely it is that the right people will respond. Be sure to include in the ad text:

• exact job title;

• clear requirements for qualifications and work experience;

• a brief description of the functions performed in the specified position;

• description of personal qualities;

• form of employment (full-time or part-time);

• duration of the probationary period;

• the level of payment (or "fork" of payment with a mandatory explanation of what the amount depends on), including - elements of the compensation package;

• information about the company;

• contact details of the recruiter (name, e-mail address, rarely - phone number).

If the information about the remuneration is confidential, it should be noted: "payment by agreement". Asking candidates to indicate the desired salary will also help to select the required resumes without disclosing information about the level of remuneration. In addition, it is necessary to indicate that applicants send a resume with a note: what vacancy they are applying for. Recruiters use different methods of finding candidates, the choice depends on the specifics of the situation. You can divide all methods into two groups: ethical and unethical. Consider the ethical methods of finding professionals who are successfully used in the practice of domestic recruiters (Table 22).

Search for a candidate at the company (possibly with the announcement of a competition to fill a vacant position). Many euchars (recruitment manager) believe that the lack of a personnel reserve is the first sign of a company's weakness, because, in fact, it does not have a stock of human resources. However, nominating a candidate for a new position from among the existing employees is a very delicate matter. It is necessary to remember: personnel appointments (especially with increase) it is extremely difficult to "play back" painlessly. An employee who "did not pull" the leadership position, it is impossible to mechanically "return" to the former place of work, because it will be perceived by the person and the team as a career failure or even a professional failure.

Table 22

Methods of recruiters in the search for personnel

1	2
Ethical	Search for a candidate in the company itself (possibly with the announcement of a competition to fill a vacancy)
	Using a backup resume database
	Use of personal contacts
	Search for resumes on the Internet
	Placing ads on the Internet
	Placing vacancy announcements on the company's website
	Posting information about vacancies in the media
	Involvement of providers - recruitment agencies
	Search for candidates directly in educational institutions
Unethical	Notification of employment centers about open vacancies
	Dissemination of information about vacancies using printed materials (wall ads, postcards, etc.)
	Involvement of familiar external recruiters to fulfill one-time orders
	Personal agreement with an employee of a recruiting agency to fulfill an unofficial order of the company
	Obtaining an illegal database of personal data of enterprises and competitors
	Introduction of an agent into a competitor, through which there is a lure or access to the database

Unsuccessful increase leads to a sad result: the structural unit loses both the head and the specialist. Eichar faces the need to close not one, but two vacancies. Although in this case it is possible to keep a valuable employee in the company, offering him any position in a related department. In order not to provoke negative feelings in the team, when appointing a vacant employee who is already working, you should conduct several interviews with experts "from the outside". Use of personal contacts. Each recruiter later develops a wide range of contacts and acquaintances, including with colleagues from other companies, recruitment agencies. Search for resumes on the Internet. The required resumes can be collected in the shortest possible time on specialized sites. This method is especially convenient if the vacancy is urgent. Almost every specialized site has a convenient function "view resume", and some provide the ability to save the necessary information in a separate folder.

Resume search will be faster and more effective when using the following criteria for selection (filtering) of resume data: profession; city, region; salary expectations. If the age and sex of the candidate are important to the employer, these restrictions should also be entered in the relevant query line. When searching for keywords, it is necessary to define the position as precisely and concretely as possible, including the part of the keyword that can be used for search. For example, when searching for candidates for the position of "investment manager" should not use the word "manager", it is better to enter "investor" in the line "keyword".

Placing ads on the Internet. Vacancies can usually be advertised on sites where candidates' resumes are published (in the general section or in the section "vacancies of leading employers"). This service is both paid and free for the company. There are also sites that specialize in recruiting staff for banks, insurance, marketing, construction companies, etc. Some of them have a convenient service ("notebook"), when the vacancy application must be filled out only once; if you need to resubmit the ad, the application procedure is simplified. Some sites provide information about the number of views of individual ads, provide such a service as sending resumes on the specified parameters by e-mail - it's very convenient. We should not forget about professional forums, where you can meet valuable professionals (and attract them, interested in a position in the company).

The Internet has its drawbacks: on popular sites (especially free) the speed of updating information is very high, so the vacancy announcement quickly "goes" from the field of the most active viewing. In this case, you should duplicate information about vacancies every day (post again or update in the "notebook"). When publishing paid ads, there are many more opportunities to draw the attention of applicants for this vacancy: you can place them in the sections: "Leading employers", "VIP-vacancies", "Hot" vacancies, etc., install a colorful banner with the company logo, link to the ad etc.

The use of modern technologies in recruitment not only accelerates the process of search and selection, but also enhances the image of the company in the labor market. You should not include contact numbers in the ad posted on the Internet - chaotic calls will take too much time. It is much more efficient to specify an e-mail number and provide a link to the company's website (which has detailed information, including phone numbers).

Exceptions are cases when the recruiter selects technical staff - engineers, builders, etc. Low-income people do not always have access to modern means of communication. In such cases, phone numbers should be provided - they will reach the applicants through their acquaintances, relatives and friends who help in finding a job (including via the Internet).

Placing vacancy announcements on the company's website is one of the easiest ways to publish vacancy information.

Search for candidates directly in educational institutions. Universities and technical schools are a constant "source" of specialists. Increasingly, companies seek to establish partnerships with educational institutions to influence the training of the right staff: the level of wages in such organizations is often higher than the market average, and the young specialist "grown" in the company remains loyal to him for many years . And those companies in which the level of wages is low, hiring mostly students and young professionals, risk becoming a "forge of personnel" for competitors.

The notification of employment centers about open vacancies is rarely used today, although the effectiveness of this method will increase in the future, when employment centers will become key nodes in the civilized labor market. Now this path is effective mainly in cases where you need to find low-skilled staff.

Posting materials and distributing leaflets in crowded places are used when searching for unskilled low-paid workers.

Participation in job fairs is a very effective method for attracting young professionals (and sometimes experienced ones). This is an excellent PR-campaign on the labor market, participation in it will not only attract new employees, but also improve the image of the company as an employer. For it to succeed, you need to prepare promotional materials, business cards, calendars with the company logo, and so on.

When participating in the fair, you should make a short questionnaire (be sure to indicate the address to which the form should be sent or given in person) so that it can be quickly filled out on the spot. The potential candidate for the fair will not always find time to fill out the detailed questionnaire. After learning brief information about the candidate and being interested in him, the recruiter will be able to invite him for an interview later.

Notification of all employees of the enterprise about the available vacancy. When using this method, the result is rarely predictable. In most cases, it is not highly effective. However, employees can be notified that they will receive an additional reward for hiring the right specialist (if the candidate's professionalism meets the stated requirements). However, the recruiter must be prepared for the fact that the resumes of relatives, friends and acquaintances may be "pacifiers". In addition, there is a high probability of negative emotions if a relative is denied employment (or one candidate out of several is preferred).

To avoid such problems, it is necessary to inform colleagues in advance about the need for strict compliance of the candidate with the requirements of the vacant position. For example, you can place an application form on a bulletin board or on a corporate website. Try not to leak information about the level of remuneration for an open vacancy. Otherwise, employees who receive less for similar duties will begin to demand a salary increase.

Direct enticing of employees of a competing company is used to save time (alternative - training a specialist who already works in the company). An option is to apply to a recruitment agency with a request to select specific specialists. The internal recruiter usually risks using this method if he is personally acquainted with a potential "candidate for enticement" or has mutual friends with him. Otherwise, the company is in danger of leaking information, which, ultimately, harms its image, adds tension to the relationship of top managers with competitors.

Attracting employees of a competing company through people close to them. Sometimes a high-class specialist works not so much for a fee, but out of love for the cause and extraordinary dedication to the company. Management does not always adequately assess the enthusiasm of such employees. A recruiter who wants to lure this person often faces a strong reluctance to change jobs. Then an insidious attempt is made to achieve the desired through communication with family members of a valuable specialist (usually with his wife, mother or mother-in-law). Manipulating their desire to increase the welfare of the family (and get an adequate estimate of the labor costs of relatives), the recruiter ensures that the proposal to change jobs no longer comes from him, but from loved ones, often in the ultimate form. There are two scenarios:

- the specialist yields to the pressure of relatives and moves to a competitor;
- he reports about unethical procedures of enticement to the head, and that raises a salary to the worker who has shown such high loyalty.

Seduction with the help of private security services. It is used both as an independent method and as an auxiliary. The recruiter, with the help of a private detective, provides detailed information about the personal life of the specialist, as well as about his family members. Further communication using the information obtained in criminal law qualifies as blackmail. If a person changes his place of work under such pressure, his loyalty to the new employer and motivation will be extremely low, at the first opportunity he will most likely break off relations with the company, which uses such methods of "selection" of staff.

Personal agreement with an employee of a recruiting agency to fulfill an unofficial order of the company. In this case, the recruiter of the agency, with which the company has already cooperated, receives a "private order". The resulting reward is several times higher than his salary (but several times less than the amount that the company would have to pay the agency officially).

Beginner recruiters are of the opinion that conclusions are drawn about the candidate from his resume. However, the successful submission of information in the resume does not always correspond to the competence of the specialist. Of course, it is very gratifying when a well-written resume presents a resume and the achievements of the employee who is looking for a company. But an experienced recruiter will prefer to call the author, not even a very "correct" resume, so as not to miss a qualified professional.

4. Selection of documents. Resumes that accumulate for a particular vacancy, I advise you to sort as they come. If you receive this data electronically, it should not only be distributed by electronic folders, but also printed out for ease of use.

Resumes that are received, it is desirable to divide into five folders (you can use cardboard or plastic), gradually adding new data. The first folder contains information about the candidates to be contacted as soon as possible. In the second - resumes of applicants who are able to apply for a vacancy, but whose professional opportunities do not always coincide with the basic requirements of the position. The third is a resume of candidates who are not suitable for this vacancy, but, in the opinion of Eichar, can apply for others available in the company. Fourth - data that are not of interest now, but will be in demand in the event of a possible vacancy. Fifth - contains information about applicants, in no way of interest to the company. It is advisable to move to a separate folder from the already existing five resumes of "ideal" candidates who require too high a salary.

According to the "five folders" scheme, the candidates' resumes should be considered: when the first one is exhausted, go to the second one and further (without forgetting to replenish them regularly). If the submitted resume contains only brief information, it is necessary to contact the applicants and ask them to send detailed information. If the recruiter is very interested in the candidate (even on the basis of brief information) it is necessary to arrange a meeting with this person and ask him to bring a detailed resume (or, if possible, send such a resume by e-mail). Resumes and other data about candidates should not be destroyed immediately after the vacancy closes. First, it is not a fact that a novice will successfully pass the probationary period; secondly, a similar vacancy may open; thirdly, thanks to the accumulated resume, the recruiter will have a database that is convenient to work with.

5. Telephone conversations with candidates and invitations to the enterprise. Its main purpose is to find out the degree of interest of the applicant in this vacancy and provide him with brief information about the company, the requirements for the candidate. It is recommended to find out what level of remuneration a person expects (for the probationary period, minimum / maximum salary, bonuses). Telephone conversations should be organized so that the parties can decide to continue or terminate contact about the vacancy.

If, when inviting a person to work, you have not clarified his salary expectations, the interview will be just a waste of time for both the applicant and the recruiter. For significantly higher pay requirements than the company provides for this vacancy, you should thank the person for their interest and make it clear that his services may be needed by your company in the future.

If the candidate does not suit the employer for any other reason, you should notify him immediately or say that you need time to evaluate his candidacy in more detail. Also agree on a redial date.

In any case, the conversation should end with words of gratitude for the interest in the company and wishes of success in further job search. It is important not to offend a person when refusing - this is a positive contribution to maintaining the reputation of your company.

6. Completion of the questionnaire by the candidate.

7. Interview. A candidate who is interested in the company and has shown a reciprocal interest during a telephone interview receives an invitation to an initial interview with a recruiter. When making an appointment, do not forget:

• agree on the exact time of the visit, convenient for both parties (with a margin of half an hour), inform about the estimated time spent on the interview;

• describe in detail the location of the enterprise and office, tell about convenient transport routes;

• inform the name and position of the interviewer, his contact numbers;

• express gratitude for the interest shown in the enterprise.

It is better to avoid meetings of applicants for the same vacancy (unless, of course, it is a group interview as a selection method).

As a rule, the interview takes from 20 minutes to 1 hour (for applicants for the vacancy of a top manager - about 1.5-2 hours). We recommend starting the meeting by handing the candidate a small card with brief information about the company and contact numbers of the HR department.

Thanks to the questionnaire, the recruiter receives important information about the candidate. The method of filling it out (answering the oral questions of the interviewer who makes notes in the column "answer", or filling in the form by the candidate himself, followed by clarification of the details by the interviewer) is not significant. If the candidate fills in the questionnaire independently, the recruiter will be able to check the level of his literacy, see the individual characteristics of the person, make sure he wants to work in the company.

Then begin a detailed discussion of the requirements of the position and the professional capabilities of the candidate. Various methods of psychological testing can help in the selection of candidates for the vacant position of euchar. Diagnosis of a person's personality traits, determination of behavior and temperament style, level of anxiety, stress resistance, and motivation orientation make it possible to predict with high probability the "survival" of a new employee in a team, facilitate the development of an individual adaptation program, and so on.

8. Verification of documents. After the recruitment service has made a positive decision on the further recommendation of the candidate for a certain position, he is asked to fill in the traditional accounting sheet. Many managers are accustomed to receiving information about the applicant in this form. At our company, for the convenience of candidates, they are offered to fill out questionnaires in electronic form (then you do not have to do it again when making changes). It usually takes about half an hour to fill up; the document is certified by the personal signature of the HR director. It indicates which position the applicant is recommended for.

9. Testing. Various tests are often used to compile a comprehensive portrait of the individual, to assess the psychological and business competence of the candidate HR department (especially in large companies).

The use of tests should not be considered as a "technological" substitute for personnel manager (practical psychologist), it is just a tool in the hands of a qualified specialist who can select the right techniques, correctly interpret the information obtained, to conduct consultative and corrective measures. The results of psychological testing can be used to solve a variety of tasks related to personnel management, for example:

• harmonious selection of staff;

• selection of the most suitable candidate for the vacancy;

• selection of one of several candidates;

• assistance to managers in case of disagreements on the choice of a candidate;

• forecast of success of adaptation of the employee in the company, individualization of the plan of adaptation;

• selection of working groups (teams) to solve specific production tasks;

• building an effective system of motivation;

• advising managers on the personal characteristics of future employees, their strengths and "weaknesses";

• forecast the behavior of employees in difficult work situations, including stress;

• advising employees, helping them to correct behavior.

The results can be processed manually or with the help of special computer programs. The process of compiling data manually using complex tests is very time consuming, often two different professionals can get very different results. The probability of mechanical errors is also quite high, especially if the eucharist has to solve many other problems at the same time. The standardization of many "popular" test methods was conducted 20-30 years ago (if at all), so the test results today cannot be considered valid. Added to this is the problem of "tracing" modern Western test methods that are not adapted to the domestic socio-cultural environment and are not valid by the national sample.

In addition, the vast majority of such tests give the result in the form of a set of numbers or give a very primitive interpretation. All this allows the practical application of such "tools" is not only inefficient, time consuming, but also harmful! It is better to refuse testing than to use "pirated" copies. For more than four years, an integral part of the recruitment procedure is to determine the business and psychological qualities of applicants using a program developed by professional psychologists. The appendix contains a sample of a short report obtained as a result of the candidate passing three professional tests.

Since socio-psychological testing is designed for in-depth analysis of personal characteristics, it is necessary to remember the ethical and legal responsibility for the use of the results of this study. The next stage of the recruiter's activity is the recommendation of the selected candidate to the head. The scheme of representation of the candidate accepted at the enterprise corresponds to the standard of a full package of documents for its recommendation. At the enterprises the package for the recommendation consists of the following documents:

• resume;

• questionnaire;

• accounting sheet;

• psychological characteristics;

• Cover Letter.

If necessary, additional documents are provided.10. Verification of recommendations. As domestic practice shows, letters of recommendation from past jobs are not always a reliable source of information. Checking the security service of the enterprise (or news agency) is much more effective. The Security Council can provide information that the candidate "forgot" to display in the resume (information on criminal record, being under investigation, administrative offenses, alimony, etc.), as well as to obtain a description of the applicant at his place of residence, learn about "dark spots" in the biographies of his closest relatives, etc.

11. Presentation of the candidate to the customer. Different options of transfer of a package of documents to the customer are possible: at a personal meeting; delivery by courier; data transmission by e-mail or fax, etc.

Sometimes a package of documents is sent to the customer directly during the presentation of the candidate, but this is rather an exception to the rule. It is desirable to acquaint the head of the structural unit with the documents of the candidate for the position in advance. If, due to employment, the documents are provided on the day of the interview with the candidate, it is still better to submit them in 30-60 minutes. see you. The presence of a recruiter is mandatory during the interview.

12. Repeated interview. With the right selection process at the company, one or two re-interviews are usually enough. The meeting is held by the immediate supervisor of the future employee, and then by the top manager. The presence of a recruiter during the re-interview is also desirable. It helps everyone: the candidate feels more confident, the recruiter covers all the moments of the autobiography of the recommended person more fully, and the manager gets to know the future employee better. No less important is the fact that joint interviews help the recruiter and the manager to "work", and the recruiter begins to better represent all the requirements of this manager to employees.

13. Final approval of the candidacy. After the managers give positive conclusions, the final approval of the employee for the position takes place during a personal (brief) acquaintance with the head of the department. From this moment, the vacancy is considered pre-closed, and the search for candidates is stopped (including applications are removed on the Internet and on the company's website). If the block of vacancy announcements in the media has already been paid, you should ask the editors to replace the text of the announcement with other, more relevant information or to suspend the publication for a while (if possible, submit information later).

Refusal.

14. Final closing of the vacancy. When applying for a job, it is important to stipulate the powers of a new employee - the right to make decisions independently, sign documents, work directly with clients, reorganize the unit, expand staff, etc. In addition, it is necessary to determine the composition of the compensation package, as a rule, this is done after the successful completion of the probationary period (increasing the level of payment, providing various bonuses and benefits). It is very important to record the rights and responsibilities of the employee in writing.

15. Support and adaptation of the process of transition to the enterprise. We should not "forget" about the candidate after he was approved as the head of the company - the transition process also requires support. "Supervision" of the

candidate is simply necessary if it is a "goldfish". Already "almost your" employee who is fired from the previous job may be offered more attractive conditions (according to statistics, about 10% of employees remain in their former jobs with a salary increase).

From the moment of making a positive decision about the candidate, the vacancy is considered closed, the new employee is enrolled in the staff of the enterprise. For the HR department, this means that the recruitment phase is over. In order to streamline the search and recruitment activities, to be able to analyze and improve it, it is important to properly organize statistical data accounting. Internal recruiters should constantly prepare reports on their work for management. The content of reports and their frequency are determined by the recruitment department of each company.

In such a rank, it is possible to create visnova, the methodology is proponated to induce the process of recruiting personnel, the day of which is presented by a step-by-step diagram of the process of recruiting personnel at the enterprise. The scheme for the personnel selection process includes the following steps: application for personnel training, analysis of the application, vibrating methods for sending, viewing documents, telephone conversations with candidates, filling in the questionnaire by the candidate, feedback, re-revision of documents, re-revision of the candidate, testing hardened, suprovid and adaptation during the transition to a robot.

REFERENCES

1. Vashchenko VV (2017) Management of process of recruitment of the personnel of the industrial enterprises: dis. . Candidate of Economics Science: 08.00.04. Mariupol, 208 p.
2. Vashchenko VV (2016) The main problems in the process of recruiting staff at an industrial enterprise [State Higher Educational Institution "Pryazovskyi State Technical University"] "*Bulletin of Priazovsky Technical University"(32),* 308 - 311. DOI: 10.31498/2225-6725.32.2016.105603

7.3. Artificial intelligence in HR – processes

Svetlana Rudakova
PhD (Engineering),
Associate professor of department of socioeconomics
and personnel management
National Economic University named after Vadym Hetman
E-mail: svetlana.rudakova.home@gmail.com
ORCID ID 0000-0002-0623-6140

Nataliia Danylevych
PhD (Engineering),
Associate professor of department of socioeconomics
and personnel management
National Economic University named after Vadym Hetman
E-mail: danylevych.nataliia@kneu.edu.ua
ORCID ID 0000-0002-2321-0487

Liudmyla Shchetinina
PhD (Economics),
Associate professor of department of socioeconomics
and personnel management
National Economic University named after Vadym Hetman
E-mail: sludval@ukr.net
ORCID ID 0000-0003-1519-0647

Modern technologies do not stand still but are constantly evolving. Every company has to look for new approaches to solving both old and new problems. A popular area of business development currently is the use of artificial intelligence (AI). The advantages of AI for employers are the accuracy of work processes and its cost-effectiveness. Dartmouth College professor John McCarthy first introduced the term “artificial intelligence” in 1956. In his opinion, “artificial intelligence is a branch of computer linguistics and computer science that formalizes tasks that resemble human actions. In other words, the computer will do what we used to do” [1].

Artificial intelligence technologies can be extremely important instruments for changing the way we do business and for many other areas of human activity. They are designed to greatly facilitate the process of strategy development and decision-making and optimize management activities in general. Artificial Intelligence (AI) — This is the feature of either hardware or software systems to perform creative functions that are inherent in humans. One of the main tasks of AI is to understand human intelligence.

There are 3 types of artificial intelligence:

Narrow (Artificial Narrow Intelligence, ANI) — it is AI that is designed to solve specific problems. For example, recognize the image, play chess.

General (Artificial General Intelligence, AGI) — it is a universal artificial intelligence that is on par with humans and is capable of solving a wide variety of tasks.

Artificial Superintelligence (ASI) — it is AI that exceeds the level of the individual or humankind.

At present, all existing forms of artificial intelligence are narrow. That is, they can solve only specific, applied problems and cannot compete with the human mind in its universality.

In the theory of AI, there are defined directions of its development (Fig. 34):

- Machine Learning provides automated creation of analytical models, collects, analyzes, and uses statistical data;
- Neural Network establishes the links necessary to improve the implementation of the task, or to make the correct decisions in appropriate situations;
- Cognitive Computing is used for the processes simulation. Taking the human being who first interprets images and language as an example, it then can process language and perform certain actions independently;
- Computer Vision allows machines to independently process and analyze video or images and offer their solutions for processing and the usage of data;
- Images Recognition forms a list of features on which the quality of recognition depends;
- Machine Translation and Language Recognition create a language for the internal presentation of knowledge based on a semantic model of text representation, i.e. carry out the analysis of phrases and texts;
- Game Programs teach systems through the game. The levels of difficulty used to reflect the quality of the system's gameplay and identify clear criteria for assessing the intellectual growth of the system;
- Machine Creativity independently creates music, poems, stories, articles, etc. (for example, musical applications: sound processing systems, sound synthesis, interactive composition systems, and algorithmic composition programs);
- Expert Systems use algorithms in applied fields (for example, business, technology, production, etc.);
- Chabot simplifies human interaction with the computer using its ability to understand and respond to human language.

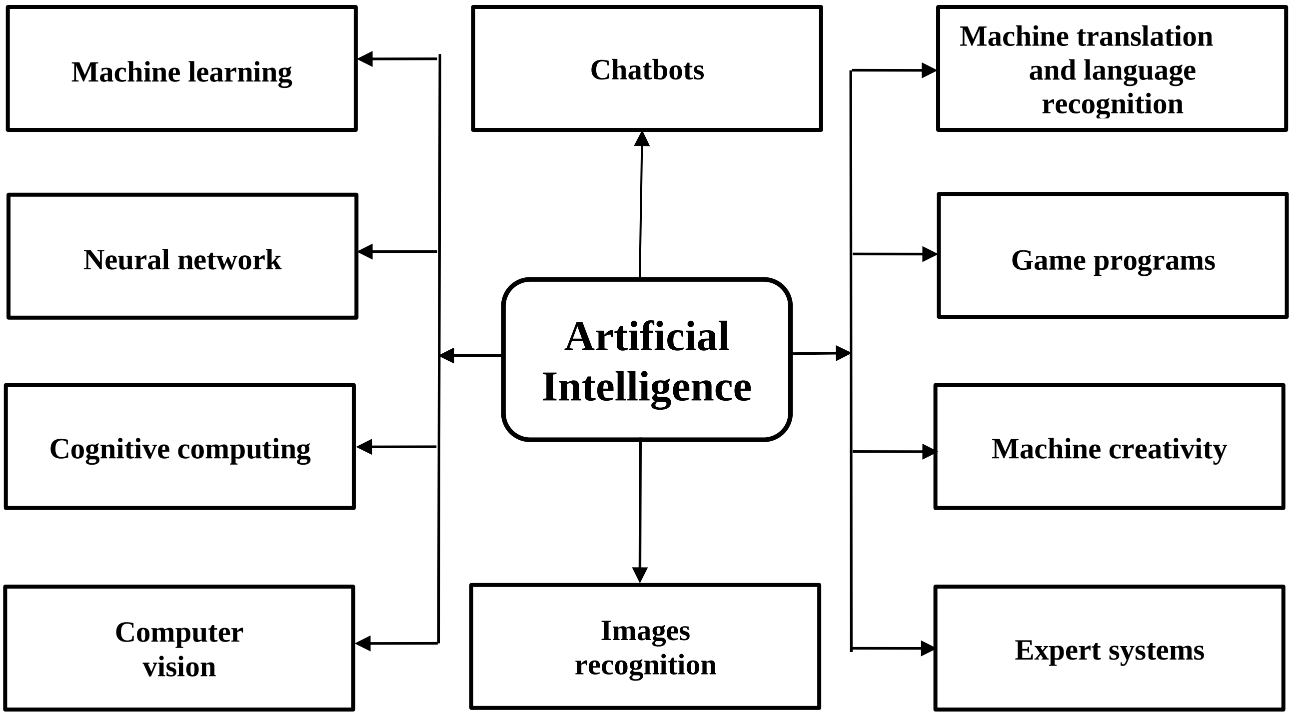


Figure 34. The main directions of AI development

AI has two basic properties; it is capable of self-management and can learn (external learning and self-learning). Therefore, AI is a self-managed cyber system that has a certain amount of knowledge and, on the basis of it, capable to perceive and analyze the current situation in order to plan actions aimed at achieving the goals, and learning [2].

The development level of artificial intelligence can be described such: at the moment it acts as a human assistant to perform complex operations, relieves people from routine tasks, and allows to optimize management decisions [3]. The accelerated introduction of artificial intelligence is noticeable in high-tech businesses, which use a lot of computer technology. But it should be noted that artificial intelligence is an ideal tool for use in HR. This is due to the presence of algorithms capable of collecting, analyzing, and organizing data in “smart” systems.

Ten years ago HR evolved into the so-called developed HR Management, where the first functional distribution of various HR processes took place. If earlier HR was considered as a complex of all processes, at this stage such processes as Talent Management, Recruiting, Efficiency management, Planning, etc. became separate. That is, the key processes of personnel management, the evolutionary changes in which are directed towards the optimization and transactions of the costs associated with the company's employees, receive dedicated attention. At this stage, basic HR tools that simplified some processes and made it possible to compare the effectiveness of their functions appeared (Fig. 35).

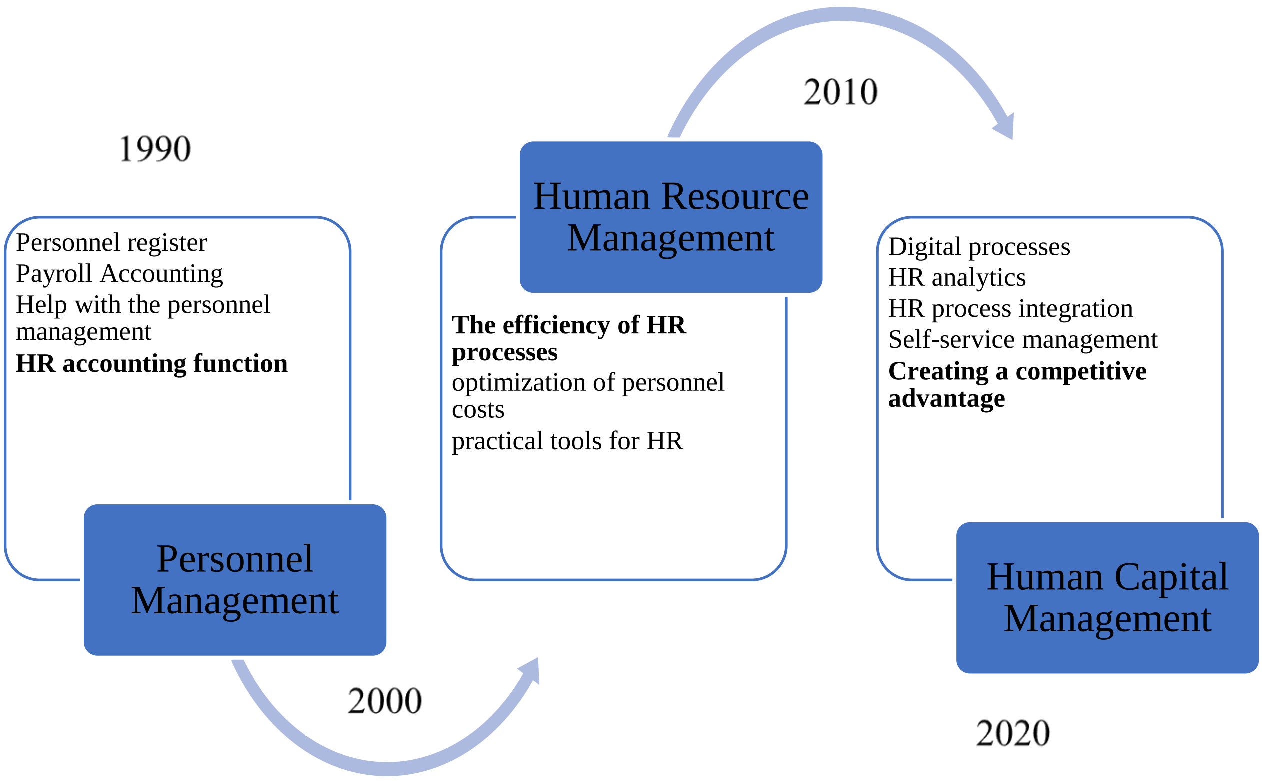


Figure 35. Transformation of HR functions

Today, most Ukrainian companies are at this stage, but there are certainly technologically advanced leaders on the market who have moved to the third stage – where HR serves as a tool to create competitive advantage and the task of the HR manager is to directly influence the top priorities of the business. Artificial intelligence is a tool for the transformation of HR departments from ineffective cost ballast to a major strategic asset. Employers here have the opportunity to form a holistic view of each employee and create individual recommendations and action plans in various areas of activity, such as career development, employee cooperation, and recruitment, to meet the needs of the XXI century workforce.

In the digital world, companies' demands for the quality of the personnel management functions are constantly growing, and the role of HR as a unit and professional team is changing: “people experts” are learning to work with data and rely on them in decision-making.

Digital HR integrates social networks, mobile applications, cloud technologies, augmented reality and becomes a new platform suitable for improving the work with both employees and candidates, processing and updating their experience. Digital solution developers provide the technical component of digital HR, while the company management and HR departments must build their own integrated digital personnel management strategies and programs. At the same time, the transition to the digital transformation should be based on an in-depth analysis of internal and external factors, the study of advantages and disadvantages as well as industry constraints and potential partners.

The importance of the implementation of digital HR is undeniable, it is especially essential for companies in growth and expansion, large and international companies, with a high weight of investment attractiveness and a significant number of vacancies, or those that pay special attention to quality selection and adaptation of employees [4]. In other cases, the various capabilities of digital HR can significantly improve the performance of any HR functions, increase the efficiency of human capital and develop the HR brand.

Automation of standard, typical, routine, and long processes is a priority for many companies that seek to improve the efficiency of personnel management - AI comes to help solve these problems.

AI in HR - processes reduces the financial and temporal costs for labor-intensive operations in recruiting, adaptation, management efficiency, corporate education. Among the main tasks of AI in HR - processes are the following:

- Analysis of personnel data (resume analysis, performance evaluation);
- Analysis of the need for employees;
- Conduct the routine tasks (for example, managing requests with bots);
- Selection of candidates for the vacancy;
- Send questions to candidates for interviews and conduct interviews;
- Conduct intelligent evaluations (without additional research AI is able to evaluate according to the given parameters the employee who can effectively become a manager and who is going to resign soon).

One of the main skills of AI is making an informed decision. Human is biased by subjective feelings, not always following the rules, while artificial intelligence cannot violate the established order of decision-making, and therefore is impartial and objective.

When selecting staff, HR professionals should focus on the skills of the applicants. Artificial intelligence will promote transparency in the recruitment process and career advancement. The so-called “skills base” will help. The employee indicates in his profile the skills, certificates, competencies that he has. He can then choose a position in the organization for which he is applying. The vacancy, in turn, is described by a standard set of skills. Artificial intelligence marks appropriate training and skills in order to have the skills and knowledge that will be required in order to take the given position. When this vacancy opens, the bot will offer the HR manager profiles of those employees who have marked this position in the priorities and have relevant training. If the first candidate has experience with artificial intelligence and services based on it, and the second does not, the first candidate is more likely to be selected for the vacancy. The HR bot with the help of clarifying questions will find out how competent the future employee is. In addition, modern AI systems use intelligent modeling technology. Thanks to artificial intelligence, the company can develop algorithms for the selection of candidates and the system itself will indicate which candidate is ideal for the vacancy. Functions like this have already begun to be used.

For example, in Ukraine, Deloitte created a recruitment bot D.TalCa (Deloitte Talent Candidate) in 2018. It selects and offers a vacancy that best suits the candidate. The Chabot is ready to conduct an initial interview even at night, recommends job seekers to Deloitte, and introduces the company, its history, and events. The uniqueness of bots is that with the accumulation of data they can learn and become “smarter”. Specialists of the company's HR department are confident that over time it will be able to completely replace the preparation of resumes with candidates and manual analysis of such resumes, which is carried out by the recruitment team [5]. The digitalization of the recruitment process facilitates the full maintenance of the candidate base and the progression of candidates through all stages of their employment. Leading programs can process resumes from almost any source (text files in docx, odt, rtf, csv, txt, etc. formats), which significantly saves the recruiter’s time.

Artificial intelligence compares job data with information in the applicant's resume and offers the most relevant positions. For registered users, the algorithms will show the most appropriate suggestions. The algorithm contains several hundred features that are selected based on user behavior. Specialists in big data and machine learning managed to teach the search engine to think like humans. According to companies that use this technology, more users respond to vacancies picked up by artificial intelligence compared to traditional full-text search. However, it should be understood that the opportunities for successful use of artificial intelligence in the recruitment process, among other things, depend on the type of vacancies to be filled. In other words, the more complex is the position, the more difficult it is to automate the process of filling the relevant vacancy.

A number of marketing tools with built-in artificial intelligence help the recruiter to find the target audience. HR marketing, along with Big Data, is already used in the largest banks all over the world. Moreover, it is currently the most popular area of development of artificial intelligence for personnel management.

Recruitment marketing allows the recruiter to choose the most optimal channel of interaction. So you can contact the candidate by mail, phone, messenger, etc. As the HR marketing goes, the communication with potential employees takes place exactly where they can show their skills and abilities to the maximum. The robot is able to place vacancies to where the most successful candidates come from.

Marketing tools allow you to create the full portrait of the candidate, as well as the model of a potential regular customer. Moreover, HR solutions allow you to create such a project literally on the fly. For example, one of the managers of the recruitment team might prepare it to advertise jobs on his or her tablet while waiting in the airport for the flight. In addition, during this time he or she can organize a kind of “promotional campaign” for this hot vacancy (configured all the parameters of the mail, posted the banners on Facebook, Twitter, and YouTube). Now, any simple content design can be done quickly in any visual editing program. In the near future, a smart system will be able to analyze the most successful HR campaign and determine whom to address it to in order to reach an ideal target audience.

A unified database of candidates will help to avoid such cases when several managers from different departments of one company compete for the same candidate. So the next step will be a single database of candidates in a particular field of work. Then an advanced algorithm will search for people not only by the specified parameters but also by defining the criteria independently, which will ensure the best search results for successful candidates for a given position. The work with new employees while helping them to adapt is adjacent to the tasks of selecting candidates. Chatbots in this area serve as a more "human-like" knowledge base. A new employee can ask the bot about the work schedule, company structure, benefits, and other questions that are important during the first months of work [6].

The field of HR analytics is in an active growth zone — it provides management and employees of the organization with information on their operations, which can help in the effective management of the company. Additionally, it creates models predicting the various ways in which an organization can obtain an optimal return on investment (ROI) in its human capital. Some tools that can be used to automatically process and download information required for HR analytics, for example, the use of IMB WebSphere, DataStage, and Cognos Data Manager or Microsoft SQL Server Integration Services are some of the most popular options. When implementing HR analytics, most organizations face problems such as the difficulty of data comparison from multiple systems, the high cost of reporting, the difficulty of finding the right information in large amounts of data, and the inability to analyze data in the proper sections. Artificial intelligence technologies in HR analytics processes are based on the accumulation and analysis of large data sets, which are used today by almost every successful company. The HR department can use AI technology to predict the intention of employees to leave the company. This helps to take timely dismissal measures and offer the employee a promotion or salary increase when required.

Gamification involves stimulating the desirable behavior of employees through the game. This process is implemented usually in young companies and startups using game techniques built into software products and web applications. There could be external and internal gamification. The first is aimed at attracting the right candidates for vacant positions, etc., while the other — at improving the efficiency of the company through motivation and increased loyalty of employees instead. HR can use gaming within the realm of all their functions.

Modern technologies make the process of learning, training, and retraining more dynamic and accessible by using AI. Meanwhile, modern solutions designed for education allow creating unique conditions for training and retraining of professionals in accordance with current requirements. This happens to be, thanks to the leading technologies with AI included, not only more efficient but also cheaper than traditional training schemes.

Production is becoming more and more computerized and the need for highly qualified personnel, operators, technologists, service technicians, and even warehouse workers, is growing. Staff training at all levels becomes a non-trivial task. On one hand, the training should be as close as possible to the real conditions, on the other — no one will allow practicing on the expensive equipment that is in use. Nevertheless, the costs of training stations can be on par with the cost of the equipment itself, so virtual simulators are becoming the most attractive alternative (although their creation will also have to cost time and money).

Thanks to the use of intelligent analytics, you can create individual learning paths for each employee. The required courses and tests (including those that use virtual reality) can and should be selected based on individual achievements and their direct responsibilities, taking into account the changes that occur at the enterprise. Thus, thanks to artificial intelligence, HR managers can automatically schedule a refresher course.

In virtual reality, you can simulate a variety of life-threatening and health-threatening situations. For example, a virtual model of a downloadable platform at one of the enterprises helps to avoid serious injuries and illnesses in real life by allowing a person to “test” his work in a virtual environment.

If an emergency might develop, virtual reality can predict such a course of events. Today, there are already working solutions for training the actions of the State Emergency Service personnel in case of fire, previously such training was purely theoretical. The fact is that no one will organize a fire specifically for training purposes, and immersion into virtual reality and conduct the training can be repeated as many times as required to get decent results of the teamwork.

Augmented reality is also developing rapidly. In augmented reality, a person will be able to track on the screen of his smartphone or tablet what is in front of him, but can also see additional computer graphics. Augmented reality systems do not immerse you into the virtual world but help you to understand the new procedures and learn how to work in new situations. Today already, augmented reality tools allow companies to save on retraining, showing tips to operators when they are working with new machinery and installations.

With the help of specially designed glasses, the system can recognize and recommend professionals to perform the necessary actions, merging the real and virtual worlds. The person can be instructed “which lever to lift and to which position” and perform necessary action immediately. Such assistance is invaluable in emergencies. Today, augmented reality is increasingly used for training at remote locations, where it isn’t possible to send an emergency team in case of an accident. With the augmented reality tools, the operator can perform any new actions, even if he has never done them before.

Thanks to the use of mobile devices and the development of positioning technologies, the concepts of “invisible learning” and “lifelong learning” are successfully used today. They are truly effective for young professionals from the so-called Generation Z.

Let us look at several examples of the usage of AI in HR processes in the work of local and international companies (Table 23).

Table 23

The use of AI in HR processes by local and international companies

The company name	The name of the technology	Characteristics of the result
Salateira	90 seconds long interview with Job Bot on Telegram, Viber, or Facebook.	The company takes care of job seekers' time and helps to overcome the fear of conducting the first interview with the HR manager. It also has benefits for the company itself: an increase in the wider personnel pool within 2.5 months by 2767 people and a 2-fold reduction in the cost of attracting one candidate.
SoftServe	The feedback survey. Each session goes as a separate round, after which the results are summed up and grades are given. The next round takes place in 4 months — a new survey session and a new assessment. In between the rounds, there is active communication regarding the status and plans for innovation.	Employees are always aware of what company's activities are ongoing and can ask their questions and leave comments. It allows increasing the number of employees who are loyal to the company (promoters) and reduce the number of those who are dissatisfied with certain aspects of work (detractors).
Datagroup	The integrated space for the exchange of ideas, interaction, and active self-realization of employees — DataLab, is a portal for distance learning. The purpose of DataLab is not to force learning, but to form a meaningful need for self-development in employees.	Employees of the company get the opportunity to influence the choice of the materials on which they study individually, to set topics for discussion, to form the community they need.
Privat Bank	An online platform for internships that provides high-quality training for interns and meets the needs of university students and the bank.	The training consists of 10 modules of theory and 5 practical tasks, upon successful completion of which trainees can obtain a personal certificate with the specialization name and scores. This online practice provides the company with a continuous flow of motivated candidates, which covers more than a third of external vacancies.
Deloitte	Chabot D.TalCa (Deloitte Talent Candidate), which picks up and offers jobs to the most suitable candidate. The use of online games to speed up innovation and development.	Conducts an initial interview even at night, recommends job seekers to Deloitte, introduces the company, its history, and events. The use of multiplayer online role-playing games in training has increased the involvement of staff in training programs. Intellectual game sharpens the attention of employees and allows them to discuss the details of the new ideas and explore new options and opportunities.
Lincoln	Virtual reality systems designed to train	It mimics real welding equipment,

Electric	welders. In addition to the VR helmet of the welder, it uses a welding machine, a stand for welding, a welding gun, and samples for welding.	that is why the actions of a trainee in virtual reality are very similar to real ones.
HP	HP Z VR — virtual reality backpack. It houses a high-performance computer running on two external, easily replaceable batteries. A person with such a backpack (weighing only 4.6 kg) behind his back and a VR helmet on his head can move relatively freely in the real world and, at the same time, in the virtual environment.	HP Z VR is an excellent system for training people, especially suitable for soldiers, doctors, industrial and maintenance workers, drivers, astronauts, and other professionals who can work with this backpack.
UPS	It uses virtual reality technology to train truck drivers. UPS has more than one hundred thousand vehicles.	The drivers can learn to respond to visual and audible signals that indicate potential danger.

As we can see, the opportunities, given by AI digital transformation of HR services are:

- The introduction of the integrated mobile applications;
- The introduction of VR technologies;
- The gamification of the training;
- The digital integration with cloud systems;
- HR analytics and Big Data.

It is impossible to determine all required various AI tools suitable for every organization. Each organization can use only those AI technologies that are beneficial for its development and existence. It is necessary to combine different approaches and methods; this will allow the organization to optimize HR processes of personnel selection, increase the efficiency and competitiveness of the company. Thanks to a common digital platform, employees can track and manage information in real-time. The same information is available to managers, who can always access it even with their smartphones. Workflow becomes more transparent and understandable. Employees can track their progress and plan their careers strategically. These opportunities are integral factors of a "smart" company.

Every HR department, today, must first define its role, which will help managers and employees to quickly transform and adapt to the digital way of thinking. The HR department creates a strategy and advises on how to use the benefits of AI implementation into the work of the organization properly. At the same time, the introduction of AI requires time and money. The most important thing is to decide to implement AI, the willingness to change routine processes, and take risks. In any case, AI is spreading into all areas of public life and it is impossible to ignore this process. The internal qualities of HR itself become very important. And now HR departments must determine their place and role in the process of AI implementation in the areas of HR responsibilities.

REFERENCES

1. Averkyna M., Sydorchuk L. (2019). Shtuctnyj intelekt u biznesi: perevahy ta pereshkody u vprovadzenni. [Artificial intelligence in business: advantages and obstacles in implementation]. *Market infrastructure*. 37. pp. 164-168. DOI: 10.32843/infrastruct37-23 (in Ukrainian).
2. Pchelianskyi D., Voinova S. (2019). Shtuchnyi intelekt: perspektyvy ta tendentsii rozvytku. [Artificial intelligence: prospects and development trends] *Automation of Technological and Business Processes*. 11(3). 59-64. DOI: 10.15673/atbp.v11i3.1500 (in Ukrainian).
3. Mashliy G., Mosiy O., Pelcher M. (2019). Information provided for labor relationship management as compositional social responsibility of enterprises. *Galician economic journal (Tern.*). Vol. 57 (2). pp. 80-89. DOI: 10.33108/galicianvisnyk_tntu2019.02.080 (in English).
4. Yak polehshyty zhyttia HR-am: tsyfrova transformatsiia poshuku personalu [How to make life easier for HR: the digital transformation of staff search]. URL: https://prohr.rabota.ua/yak-polegshiti-zhittya-hram-tsifrova-transformatsiya-poshuku-personalu/ (Last accessed: 20.06.2020).
5. Do «Deloit» v Ukraini pratsevlashtuvavsia bot-rekruter [A Bot Recruiter has been Employed in Deloitte in Ukraine]. URL: https://www2.deloitte.com/ua/uk/pages/ press-room/press-release/2018/ chatbot-dtalca-atdeloitte-ukraine.html. (Last accessed: 29.04.2021).
6. Kak iskusstvennyj intelekt menyaet hr [How artificial intelligence is changing HR]. URL: https://www.ecopsy.ru/insights/kak-iskusstvennyy-intellekt-menyaet-hr-/. (Last accessed: 29.04.2021).

7.4. Use of AI in accounting and auditing

Yuliya Manachynska
Associate Professor of Accounting and Taxation
Chernivtsi Institute of Trade and Economics, Kyiv National University of Trade and Economics

The impact of artificial intelligence on accounting and auditing

In a digital economy, artificial intelligence (AI) has a significant impact on auditing and accounting in companies. Moreover, AI is a strategic tool for building a new model of Ukraine's economy.

The digital transformation of the economy is a permanent process involving the development of various IT sectors in order to stimulate the creation of innovative technologies for cooperation and development at the international level. Joint participation in the digital processes of the public sector, the private sector and civil society is needed. The key advantage of the digital economy over the traditional one is the possibility of automatic control of the whole system (or individual components), as well as its virtually unlimited scaling without loss of efficiency, which significantly increases the efficiency of economic management (economic activity and resources in different industries). macro levels [1, c.36].

The advent of artificial intelligence has changed the usual activities of companies. In the field of HR AI has long gone beyond just personnel management. And the main task of HR-leaders is a competent combination of human and software resources. According to a survey of IBM, conducted among 6 thousand managers of large, medium and small enterprises, 66% of managers agree with the need to introduce intelligent technology in personnel management and other internal processes of the company [2]. That is why AI significantly affects the audit activity, which is based on the organizational and methodological support of the audit, the practical implementation of audits and the provision of other audit services in today's era. After all, the requirement of today is a comprehensive digitalization of business processes of companies.

Article 1 of the Law of Ukraine "On Auditing Financial Statements and Auditing Activities" № 2258-VIII of December 21, 2017 [3] treats auditing activities as independent professional activities of auditors and auditing entities registered in the Register of Auditors and Auditing Entities activities for the provision of audit services.

Artificial intelligence is a tool that is ideal for use in HR. This is due to the presence in "smart" systems of algorithms capable of collecting, analyzing, organizing data. According to IBM, in the coming years, 120 million employees in the world's most developed economies will need to retrain to use the potential of the artificial technology market [1]. AI is a branch of computational linguistics and computer science that takes care of the formalization of problems and tasks that are similar to human actions, ie the ability of an engineering system to acquire, process and apply knowledge and skills..

Shamil Musayev, partner, auditor of KRMG in Ukraine, emphasizes that artificial intelligence, blockchain, and the Internet of Things offer great opportunities to create a competitive advantage for business. However, by using them, companies take on a higher level of risk, so management must think about ways to minimize it. With the penetration of the Internet and smartphones in Ukraine, the amount of data received from customers is also growing. The need for quality solutions based on artificial intelligence and big data is increasing, and the range of applications for such solutions is rapidly expanding. Already today, businesses use artificial intelligence to communicate with customers 24/7, in online bidding, in the field of e-commerce, in banks, in the city government. In particular, it is planned to use artificial intelligence in Kyiv in such areas as city security, infrastructure, education, etc.. In the Netherlands, for example, artificial intelligence algorithms have been used to ensure equal school occupancy, while providing optimal conditions and opportunities for all children[4].

A blockchain is a distributed database that maintains an ordered chain of records (so-called blocks) that is constantly lengthening. Each block contains a timestamp, a hash of the previous block, and transaction data presented as a hash tree. Transaction information is usually provided in an open, unencrypted manner. Protection against forgery and distortion is the inclusion of the hash of the whole block in the next block. Therefore, making changes to one of the blocks requires appropriate changes in all blocks after it, which is usually either very difficult or very expensive. This distributed database is the basis of the cryptocurrency Bitcoin. In fact, this is a kind of record book of all transactions.

The use of analytics and technology, working with big data increase the efficiency of decision-making, provide an opportunity to create new business models and ecosystems, as well as improve the customer experience. At the same time, organizations of any type expect that their business decisions will be based on reliable data analysis. Accordingly, the issues of risk assessment of the use of technology and data are becoming increasingly important.

Today there is a rapid pace of reindustrialization of technologically developed countries on new grounds (additive technologies (3D printing), robotics, renewable energy, etc.). No less important are the socio-economic consequences of digitalization. The ousting of man from industry, agriculture and services cannot but have systemic consequences. Objective automation processes, even if restrained by governments and society, will accelerate and possibly reach the point where only a few million highly qualified professionals will be enough to support the entire global production and logistics system. In this sense, the reduction of available jobs in the world economy, the emergence of a whole class of "extra" people, total retraining of staff, the destruction of the usual mechanisms of "guarantees of the future" (decent pension, guaranteed social protection, etc.) - can be seen as a revolution [1, c.6].

Confirmation of confidence in the digital revolution is very important. Requires an assessment of the adequacy of data analysis processes. Human trust in AI and a number of machine algorithms are quite subjective.

Companies have started competing in digital racing. New technologies have not only competitive advantages, but also a higher level of risk. For example, management is asked to make important decisions based on the results of an algorithm that they have not created and do not fully understand. According to the latest KPMG Guardians of Trust report, a survey of 2,200 executives of international IT and business decision-making companies found that only 35% had a high level of confidence in their organization's analytics. Company executives are beginning to ask difficult questions about the reliability of data and analytics. Research points to a clear need for active analytics management to build trust [4].

According to a study by Deloitte, in 2019. the number of companies using intelligent automation has doubled. In most cases, companies redistribute their employees, giving them a more complex, and therefore more valuable work for the company. This increases their involvement in business value chains. Cloud technologies and cloud computing. According to forecasts, in five years about 80% of enterprises will switch to cloud technology - this provides great opportunities for remote work and attracting third-party contractors, connecting them to a single system with the ability to monitor and control all processes[1, c.39].

Another aspect of data reliability and related risks is determining who is responsible and to what extent if something goes wrong. No matter how much we blame our computers, they are just machines and therefore cannot be held responsible for the decisions or insights they generate. According to the above study, 62% of respondents believe that in the event of an accident without casualties caused by an autonomous vehicle, when they were not driven by a human driver, the responsibility should be borne by the software developer. However, the answer to the question "who should be responsible in situations with more significant consequences?", Previously voiced by such celebrities as Hawking and Musk, still remains open, although actively discussed in society [4].

Socio-economic phenomenon associated with the emergence of technological capabilities to analyze a huge variety of data sets. The Internet is becoming a "network of everything." Total industrial and domestic computerization has led to the emergence of big data, which opens up new opportunities for the development of artificial intelligence technologies, which provide the ability of computing devices to solve complex problems on their own. Due to the constant growth of computer productivity and the development of machine learning technologies, huge streams of digitized data have become a material for learning artificial neural networks. [1, c.40].

As the use of machine learning and AI grows, humanity may be quite surprised at how machines can fail:

– The problem of "superman" behavior is that sometimes it becomes "too perfect" and we find ourselves in a situation where it becomes impossible to predict its consequences. It recalls the uprising of machines from a famous fantasy film.

–The problem with the behavior of "sub-humans" - although the algorithms may seem incredibly reasonable, their use can result in a completely abnormal situation. For example, people may be "injured by GPS" by following outdated and incorrect instructions: there have been cases where people have entered Death Valley and disappeared due to a lack of correct GPS data.

– The problem with the behavior of a "bad person" - the algorithms used for machine learning can also get into bad habits. There have been cases where dishonest users have "taught" algorithms to distribute messages written in hate speech and with discriminatory statements. [4].

On the basis of European standards and normative documents in the field of robotics it is expedient: to determine the authorized state subject of law on which the right to regulate public relations in the field of robotics and artificial intelligence should be placed, by establishing legal norms, and to determine on the basis of these norms relations of participants of legal relations and establishment of responsibility for infringement; development of an open online platform for attracting developers of robotics and AI pre-state programs of digitalization of the country and providing them with state financial support and legal protection [5].

Independent audit of artificial intelligence: theoretical and methodological justification

AI can become transformative for a business only if there is complete trust in how it operates. That is why a comprehensive confidence model is so important. It should build trust by ensuring that algorithms are robust, that the system is secure in cybernetics, that IT processes and management tools are properly implemented, that adequate data management is in place, and that there is a governance structure that understands machine learning ethics. This understanding should subsequently be incorporated into the management of a wide range of organizational risks, such as the potential impact of the failure on financial performance or reputation. If we consider this model of assurance, conducting an "audit" of artificial intelligence is similar to the audit of financial statements and internal controls. The same principles and good practices apply, such as three lines of defense and the assessment of the significance of the impact of potential errors. As with financial reporting, the public interest should be a top priority for the "auditor", including an absolute willingness to be transparent and to work closely with national and international regulators. And in this case, the "auditor" is also accountable to the general public, as well as regulators and the corporate sector [4].

Clause 16, Article 1 of the Law of Ukraine "On Auditing Financial Statements and Auditing" № 2258-VIII of December 21, 2017 [3] interprets the mandatory audit of financial statements as an audit of financial statements (consolidated financial statements) of business entities , which in accordance with the law are required to disclose or provide financial statements (consolidated financial statements) to users of financial statements together with the audit report conducted by audit entities on the grounds and in the manner prescribed by this Law.

After all, machine control should not be significantly different from human control, and it should be integrated into the structure of the whole enterprise. Thus, those affected by artificial intelligence decisions will trust the system in the same way as Dutch parents, whose children will have a better chance of choosing a school using a machine algorithm that has passed an independent "audit". [4].

Therefore, we propose to amend the Law of Ukraine № 2258-VI [3] and to supplement Section 1 "General Provisions", Article 1 "Definition of Terms" with the following concept:

Independent audit of artificial intelligence is an audit of artificial intelligence (blockchain , the Internet of Things) of business entities, which in accordance with the law are obliged to provide users with a comprehensive model of ensuring the confidence of IT processes together with the audit report conducted by audit entities on the grounds and in the manner prescribed by this Law.

Amendments made by Law №466-IX to paragraph 46.2 of the TCU stipulate that income taxpayers who, in accordance with the Law of Ukraine “On Accounting and Financial Reporting in Ukraine” are required to publish annual financial statements and annual consolidated financial statements together with the audit report, submitted to the State Tax Service, by June 10 of the year following the reporting year, audited financial statements together with the audit report [6].

That is, income taxpayers who in accordance with the Law of Ukraine Accounting and Financial Reporting in Ukraine ”are obliged to publish annual financial statements, must submit to the supervisory authority:

–Tax return for the tax (reporting) period (2020) together with the statement of financial position (balance sheet) and profit and loss statement and other comprehensive income (statement of financial performance), prepared BEFORE the audit of the financial statements by the auditor;

– Annual financial statements for 2020 together with the auditor's report no later than June 10, 2021.

The above reports are submitted in electronic form in compliance with the laws of Ukraine "On electronic documents and electronic document management" and "On electronic trust services "to regulatory authorities. But a clear mechanism for filing by lawmakers has not yet been prescribed. Therefore, while there is time, each income taxpayer can get individual tax advice or can wait for changes in the procedure for submitting financial statements and recommendations of the State Tax Service. Mandatory audit of financial statements - the task of providing reasonable assurance that is accepted and performed by the audit entity in accordance with the requirements of this Law and international auditing standards by auditing financial statements or consolidated financial statements to express an independent opinion of the auditor on its compliance in all material respects and compliance with the requirements of international financial reporting standards or national provisions (standards) of accounting and laws of Ukraine [3].

At the meeting of the National Committee for Financial Services on February 25, 2020. the order of Natskomfinprslug №326 “On approval of Methodical recommendations on information related to the audit of financial statements for 2019 of business entities supervised by Natskomfinposlug” was approved.

The order was developed in accordance with paragraphs 8 and 18 of Part 1 of Article 28 of the Law of Ukraine "On Financial Services and State Regulation of Financial Services Markets", Article 14 of the Law of Ukraine "On Auditing Financial Statements and Auditing", paragraph 13 of the Regulation on the National Commission , which carries out state regulation in the field of financial services markets, approved by the Decree of the President of Ukraine dated 23.11.2011. № 1070 and in order to improve the information related to the audit of financial statements and must contain in the audit report prepared as a result of the statutory audit of financial statements, consolidated financial statements and other information on the financial and economic activities of entities that in accordance with the law are obliged to publish or provide financial statements (consolidated statements) to users of financial statements together with the audit report conducted by audit entities at enterprises and in the manner prescribed by law, in accordance with International Standards on Audit Quality Control, other assurance and related services and submit to Natskomfinposlug [9].

1. An artificial intelligence (AI) audit should include:

2. 1. Regulatory framework for AI audit (in particular, as noted above, there is a need to amend the Law of Ukraine "On Auditing Financial Statements and Auditing"); The main subject area of AI inspections;

3. Methods of inspections of cyber security, IT processes, controls and machine learning ethics.

Sources of AI audit:

1) Machine algorithms;

2) IT processes and management tools;

3) Organizational risks.

Main tasks of AI audit:

1) Assessment of the state of IT processes at the enterprise of the audit customer;

2) Study of the state of a wide range of organizational risks that potentially affect the reputation of the enterprise;

3) their operation;

4) Inspection of cyberspace of the enterprise and as a consequence of indicators of financial results of the enterprise;

5) Identification of probability of violation of machine algorithms and check of their adjustment.

Methods and techniques of AI audit:

1) Confirmation;

2) Observation;

3) Analytical procedures;

4) Generalization.

The greatest value of AI comes from its application in the processing of large arrays of information. Implementation of all transactions through analysis, which goes beyond the rules and statistical methods. There is no statistical sample of AI and it is not necessary. Moreover, costs are significantly reduced, and time for analytical procedures is reduced. New ways are emerging to reflect the completeness of information and the risk of significant discrepancies. All these facts reduce the risk of misrepresentation of the client's financial statements, and consequently the claims of regulatory authorities, if such a company soon goes bankrupt.

Artificial intelligence technologies - advantages and disadvantages for accounting and auditing

AI, robotization of work processes, cognitive calculations - all this is rapidly invading our lives. It is rumored that the fourth industrial revolution we are witnessing will radically change this world. So far, only the tip of the iceberg of future transformations has opened up for us. Soon everything will change radically [7]. Particular attention needs to be paid to assessing the level of impact of AI technologies on the future of accounting and auditing. After all, the complex digitalization of almost all socio-economic processes has one major drawback - job cuts. Today's companies increasingly need universal staff, ie employees who have professional competencies in a wide range of responsibilities. To some extent, both the profession of accountant and the auditor are at a crossroads between the advantages and disadvantages of the digitalization of national and international economies.

For the Institute of Accounting a clear manifestation of the technological revolution 4.0 is the use of digital, electronic or IT-oriented structured version of general purpose financial reporting, an improvement that promotes accounting and ensures its development in accordance with the latest technologies for transmitting and providing information on the one hand and growing volumes. the complexity and importance of financial information on the other. Digital financial reporting is financial reporting using a structured computer-based form as opposed to the traditional paper-based financial reporting format, electronic versions of paper reports such as HTML, PDF, or as a readable document in a text editor format. only man [10, C.87].

From 1 January 2020, the preparation and submission of financial statements for taxonomy in XBRL format becomes mandatory for all IFRS compliant. In the context of taxonomy of financial reporting in a single electronic format, artificial intelligence technology can only benefit accounting and auditing.

A taxonomy is an approved classification of possible lines in financial statements, which is then codified in XBRL format. You can get acquainted with the Ukrainian translation of the taxonomy of IFRS on the website of the Ministry of Finance of Ukraine (IFI Order of 25.10.2019 № 452). However, the IASB already has an illustrated taxonomy for 2020, albeit in English. IFRS reporting on taxonomy is submitted on the principle of a single window - simultaneously to all government agencies and in a single format. The necessary information for the preparation and submission of IFRS reporting in XBRL format can be found on the websites of the relevant national regulators: National Commission on Securities and Stock Market (NSSMC taxonomy); National Commission for Financial Services Markets.

The procedure of electronic submission of financial statements, in terms of taxonomy, is repetitive, so it is easily exposed to AI technology. In addition, reporting has a standard structure, which also contains a number of advantages for AI technologies. The algorithm of actions at electronic reporting is easily formalized by means of machine algorithms. Therefore, in the future the preparation and submission of financial, tax and statistical reports will be carried out fairly quickly only with the use of AI technologies. In the course of audits, AI is also used quite effectively to evaluate accounting information. AI allows modern software to perform algorithms that are characteristic of human intelligence. Artificial intelligence technologies are used quite effectively in auditing. After all, when using them, the probability of error is zero. Moreover, the time spent on the audit is significantly reduced**.**

In particular, CaseWare Audit provides a powerful AI tool for managing audit engagements, both for a small audit firm and for global audit leaders (Figure 36). In combination with working documents, CaseWare Audit creates an optimized, efficient and effective solution. For inspections, analysis and reporting. AI technology in the automation of audit processes will quickly accelerate all business processes of the company. CaseWare Audit provides considerable flexibility, you can use embedded content and templates. Also, add and create your own to meet proprietary standards. The OneForm document is a single area for documenting all areas of participation in the audit process. This in turn simplifies the audit process for even the most complex clients [11].

Moreover, modern artificial intelligence technologies make complex decisions, which in most cases are the best in each situation. Machine learning, the AI section, is currently in full swing to help computers develop a human-like thinking process. So, today machines are able to learn independently, accumulating the latest knowledge, the latest developments, the most advanced technologies. The machine can learn at lightning speed, many times ahead of people. The machine is not programmed to act according to a given algorithm, but learns to make decisions based on their previous actions and acquired information, ie experience [7].

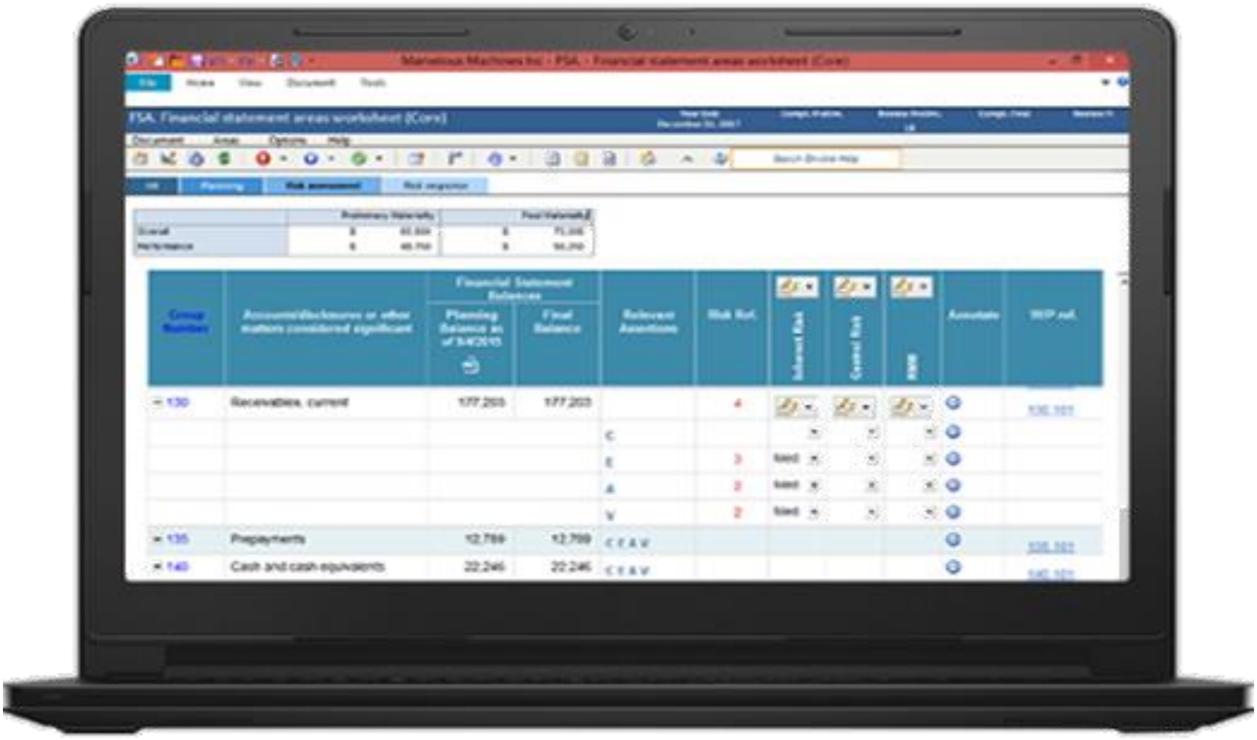


Fig. 36. User interface in the software environment CaseWare Audit

AI technology implemented in the software product CaseWare licenses certain content for Audit Ukraine under an agreement with certified professional accountants of Canada (CPA Canada). The table of contents contains unauthorized instructions for the application of International Standards on Auditing (ISAs) issued by the International Auditing and Assurance Standards Board (IAASB)

[11]. Characteristic features of AI technology in the CaseWare environment are clearly presented in Fig. 37.

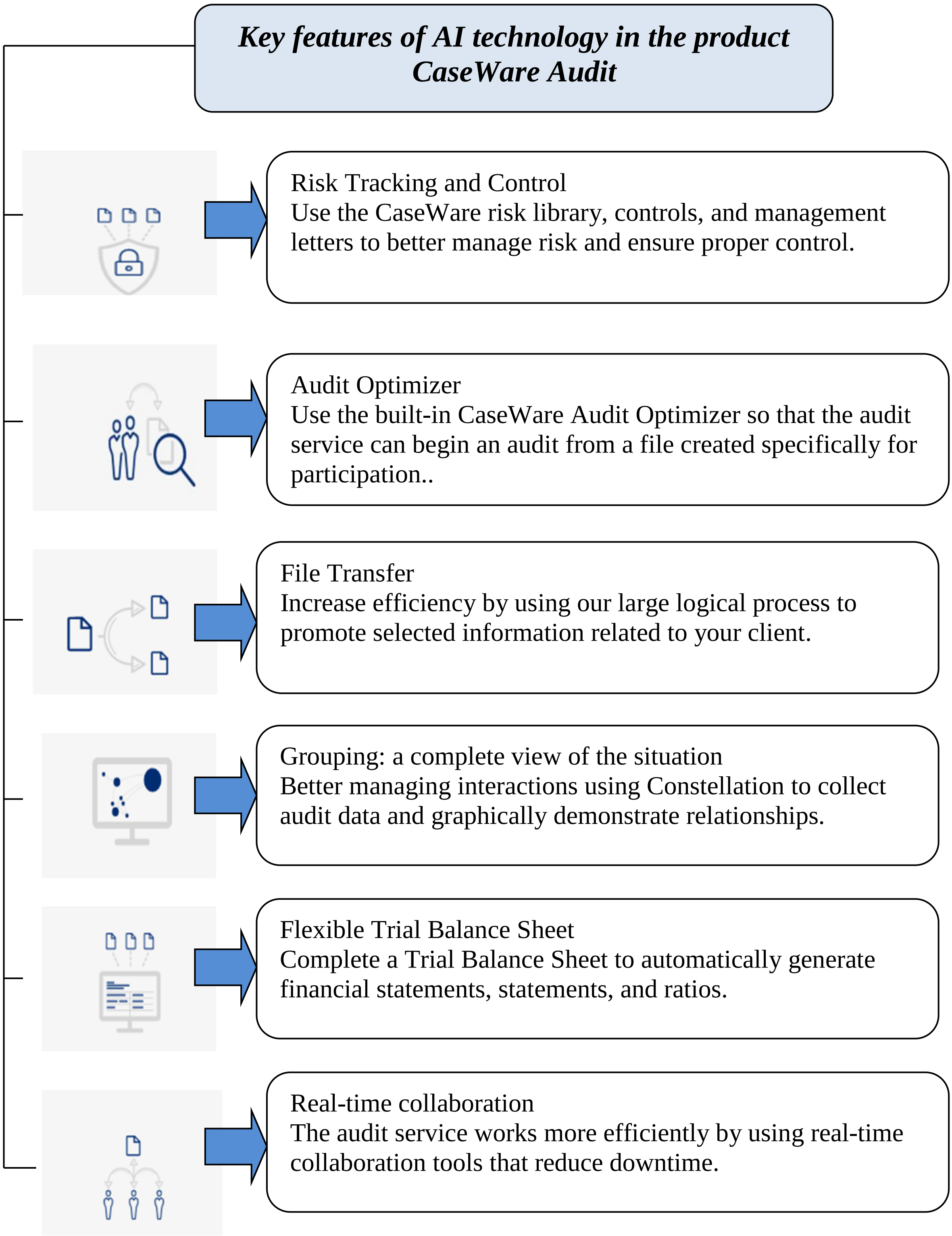


Fig. 37. Features of AI technology in the product CaseWare Audit

As we can see, the scope of AI technologies in auditing and accounting can be quite wide. Such technologies can act as a kind of digital workforce, ready to come to the rescue at any time and solve quite difficult tasks related to conducting audits.

The introduction of AI technologies that significantly change the rules of the game in business requires innovative approaches to studying the possibilities of effective management decision-making. Accordingly, AI-based management decisions have the potential to facilitate risk control at a hitherto unknown level. That is why it is quite important for the management of audit companies to choose a manufacturer that is able to provide them with the most competitive advantages.

The new digital accounting paradigm opens a number of horizons, features and prospects for the development of accounting. Topical issues of accounting in terms of AI are:

– application of contactless identification technology in accounting and asset management of the enterprise;

– use of electronic financial reporting format;

– blockchain as a promising accounting technology;

– cryptocurrencies in the accounting and financial reporting system[12].

One of the main goals of the Ministry of Digital Transformation of Ukraine [6] in building a digital state is to digitize 100% of public services. In particular, in 2020 the "Action" portal was launched, where more than 50 public services are available. About 573 thousand Ukrainians have already used them [13]. Even with the complex digitalization of business processes, the profession of accountant and auditor will not disappear. It is clear that there will be a transformation of professional competencies and adaptation to digital change.

Yes, auditors and accountants will have to develop the new skills needed to work more comfortably alongside artificial intelligence. And although technological progress will inevitably lead to a reduction in the number of jobs, at the same time it will create new professions, the function of which will be to ensure the transition to the use of technology in the workplace. To fit well into the era of artificial intelligence and digitalization, auditors and accountants will have to be technically literate, know the latest technologies, be able to apply them in their work and, most importantly, develop their potential[14].

Some internal audit services are determined for a high-tech future. They already provide advice on issues such as risks and control mechanisms for robotic process automation (RAP) technologies, the use of AI technologies in their organizations and the use of drones. They work closely with various stakeholders in the organization to maximize the effectiveness and compliance of their activities with corporate strategy and actively use data acquisition and processing tools and RAP to correctly determine the feasibility and scope of audit, as well as AI analytics and technology and machine learning to provide innovative recommendations to increase its shareholder value [9].

The only thing that is changing under the influence of AI technology is the traditional role of auditor and accountant. After a while, they will act as business advisors to their clients, providing them with something more than compiling and auditing financial statements or auditing certain areas of the company's operations. Customers will demand additional benefits. In particular, they will be expected to have a professional view of the information processed by the machine, assistance in making such important business decisions as, for example, a growth strategy or pricing mechanism, as well as recommendations on risk factors. The position of the profession should not be shaken by the development of new technologies. To do this, auditors and accountants desperately need to develop new qualities. In particular, they must learn to see the business as a whole, not limited to finance, accounting and taxes. [16].

Thus, significant technological and informational changes caused by the digitalization of the economy, as well as the growth of information potential of the economic space stimulate the modernization of accounting and auditing, contribute to the development of methodology and organization of the accounting process. In the conditions of development of information society and digital economy there are a number of preconditions for formation of a new paradigm of accounting[5]. However, such trends necessitate an independent audit of AI (blockchain, Internet of Things) of business entities according to the methodology we have proposed in this section, which needs to be substantiated at the legislative level. The latter involves the formation of a model for ensuring the confidence of IT processes, with the formation of a level of confidence in AI technology.

REFERENCES

1. Pyshchulina O. Digital economy: trends, risks and common determinants. Report. Kiev. 2020. Razumkov Center. Testament Publishing House. 274 p.. URL. https://razumkov.org.ua/uploads/article/2020_digitalization.pdf (Last accessed: 16.04.2021).
2. Artificial intelligence in HR: how technology helps companies manage personnel // EVEREST digital technology integrator. URL. https://www.everest.ua/pro-nas/#who-we-are Last accessed (: 05.05.2021).
3. On the audit of financial statements and auditing activities: Law of Ukraine of December 21, 2017, № 2258-VIII. URL. https://zakon.rada.gov.ua/laws/show/2258-19#Text (Last accessed: 03.05.2021).
4. Shamil M. How artificial intelligence affects audit. URL. https://home.kpmg/ua/uk/home/media/press-releases/2018/10/yak-shtucniy-intelekt-vplivae-na-audit.html (Last accessed: 03.05.2021).
5. Kostenko OV, Kostenko VV Legal responsibility and identification of subjects and objects with artificial intelligence (IOT) // Legal Scientific Electronic Journal. №1. 2020. P.158-162. URL. http://lsej.org.ua/1_2020/39.pdf (Last accessed: 26.04.2021).
DOI https://doi.org/10.32782/2524-0374/2020-1/37
6. Mandatory audit 2021. The audit report should be submitted to the tax office. Accounting. Auditing & Consulting. URL. https://www.account.ua/obovyazkoviy-audit-2021-auditorskiy-zvit-slid-podavati-v-podatkovu/ (Last accessed: 16.04.2021).
7. Boyko O. Technologies of artificial intelligence - new perspectives or threat to the profession of auditor. September 24. 2018. URL. https://www.pabu.com.ua/

ua/mediacentr-3/blog-prezydenta/21-bloh-prezydenta/879-tekhnolohii-shtuchnoho-intelektu-novi-perspektyvy-chy-zahroza-dlia-profesii-audytora (Last accessed: 17.04.2021).

8. Ministry and Committee for Digital Transformation of Ukraine. Official web-site URL. https://thedigital.gov.ua/ (Last accessed: 16.04.2021).

9. Audit of financial statements: Natskomfinposlug approved guidelines. URL. https://www.account.ua/obovyazkoviy-audit-2021-auditorskiy-zvit-slid-podavati-v-podatkovu/ (Last accessed: 19.04.2021).

10. Spilnyk I., Palyukh M. Accounting in the digital economy // International scientific journal. Issue 1-2. 2019. P.83 - 96. URL. http://ibo.wunu.edu.ua/index.php/ibo/article/view/405/404 (Last accessed: 21.04.2021). DOI: https://doi.org/10.35774/ibo2019.01.083

11. Artificial intelligence AnalyticsAI, brings results directly to projects. URL. https://caseware.com.ua/cloud-products/analyticsai (Last accessed: 21.04.2021).

12. Audit automation. URL. https://caseware.com.ua/desktop-products/caseware-audit 83/ (Last accessed: 25.04.2021).

13. The draft law on electronic provision of public services was registered in the Verkhovna Rada on May 17, 2021. URL. https://www.kadrovik01.com.ua/news/6004-u-vr-zarestruvali-zakonoproekt-pro-elektronne-nadannya-derjavnih-poslug (Last accessed: 20.04.2021).

14. Coolhart John (02/02/2019) Artificial Intelligence Audit (AI). URL. https://www.zakon.help/article/audit-iskusstvennogo-intellekta-ii?menu=227 (Last accessed: 22.04.2021).

15. Movement with innovative speed. High-tech internal audit service: a key tool and personnel strategy. Research of the current state of the auditing profession. URL. https://www.pwc.com/ua/uk/survey/2018/pwc-2018-state-of-the-internal-audit-ukr.pdf (Last accessed: 27.04.2021).

16. Kondratyuk OM, Rudenko OV, Chernobrovkina AE Possibilities and prospects for the use of artificial intelligence in auditing // Electronic scientific professional publication "Effective Economics". №1. 2021. URL. http://www.economy.nayka.com.ua/pdf/1_2021/91.pdf (Last accessed: 27.04.2021). DOI: https://doi.org/10.32702/2307-2105-2021.1.89.

VIII. ROADMAP FOR STRATEGIC CHANGES IN THE DIGITAL TRANSFORMATION OF NATIONAL ECONOMIC SYSTEMS

8.1. Approaches to the development and implementation of road maps DX

Oksana Kushnir
Candidate of Economics
Associate Professor of department of economics of enterprise
Kamianets-Podilskyi National Ivan Ohiienko University
E-mail: oksana.kushnir@kpnu.edu.ua
ORCID ID 0000-0003-2679-2782

The key to the development of the digital economy is a comprehensive digital transformation of the country. The country's digital transformation requires a coherent strategy aimed at creating opportunities for the full use of new digital technologies in the future. The digital transformation strategy requires a step-by-step approach with a clear roadmap that engages a variety of stakeholders, without internal or external constraints. At the same time, a necessary condition for the success of digital transformations is their implementation not as separate projects, but as a holistic strategy. Thus, the roadmap for digital transformation is a time-ordered set of projects for the implementation of technological and non-technological innovations that ensure the achievement of strategic goals based on the growth of its digital maturity.

The digital roadmap (DX) is a strategic medium-term development plan for digital transformation that details the priorities and timing of new technologies, products, processes, and organizational change. Roadmapping is a business tool of strategic planning, through which there is a direct transition from the idea of any management situation and possible ways to achieve its goal to concrete steps for its implementation [1, p. 12].

This tool is widely used in various fields of management. In the 1970s, roadmapping was first used by the large industrial technology corporations Motorola and Corning to plan certain areas for future development. Subsequently, it began to be used in various areas of public administration, which led to the improvement of road maps on an in-depth scientific basis. At present, road mapping is increasingly being developed as a tool for developing long-term strategies, which helps to visualize possible ways to achieve the goal, assess potential directions of development and identify the most optimal ones.

Roadmapping involves the construction of so-called «road maps» – routes for future development in key areas of activity, including such as: market, products, technology, competitors, raw materials and more. At the same time, its main dominant is the introduction of innovations and innovative technologies. Today in the literature you can find the concepts of «road map», «strategic map» and roadmapping (roadmapping), which are essentially synonymous. According to

R. Kaplan and D. Norton, a strategic map is an applied image of a strategy, which on a single sheet of paper tells how integrated and combined goals are transformed into a single strategy and contains indicators by which it can be implemented [2].

Roadmapping is widely used to great affect by companies and government agencies in the context of strategy, innovation and (policy) foresight, despite the method having a lack of theoretical underpinning. Technology roadmapping is recognized at the highest levels [3].

In contrast, academic research into roadmapping has lagged well behind industrial practice, with interest developing in the late 1990s in the United States, Europe and Japan, starting with research groups that had high levels of industrial engagement – typically within engineering departments. Publications on roadmapping have steadily grown since and with three principal outlets for disseminating research, namely Research-Technology Management (RTM), Technological Forecasting & Social Change (TFSC), and the Portland International Conference on Management of Engineering and Technology (PICMET). RTM were the first to publish a formal roadmapping paper that of Willyard and McClees (1987) on Motorola's approach [4]. Furthermore, the relevance and importance of technology roadmapping is evidenced by the inclusion of a roadmapping paper reprinted in the 50th anniversary edition of RTM, published by the U.S. Industrial Research Institute (IRI) – an account of the Philips approach to technology roadmapping [5, 6]. The first roadmapping paper to appear at PICMET was in 1991 and entitled «Strategic technology planning: Developing roadmaps for competitive advantage» [7]. In regards to TFSC, the first significant mention of roadmapping was by Joseph F. Coates in one of his «From My Perspective» columns, where he pointed out a key shift taking place in strategic planning, usually a solely internal organizational function, to mutual sector-level activities with the uptake and collective generation of industry roadmaps [8]. The first full papers to appear in TSFC were in the 2004 special issue on roadmapping (Volume 71, Issue 1-2); containing nine papers including a perspective from Bob Galvin, CEO of Motorola.

With this approach, the essence and content of the roadmap can be defined as a visualization of a strategy that reflects the relationship between strategic goals, tactical decisions and business functions through a common element of time [9, p. 89]. The roadmap describes the steps that need to be taken to achieve the stated results and goals. It clearly outlines the links between objectives and priorities for the short, medium and long term. An effective roadmap also includes indicators and milestones that allow regular monitoring of progress towards the roadmap's ultimate goals. There are many types of road maps (table 24).

If a roadmap has a graphical interpretation, rather than just a text format, its developers usually reflect the links between the goals and business functions that will help them achieve them. Such connections help managers to identify not only the factors that promote technological and innovative development, but also the «bottlenecks», the factors that hinder its development. The identification of such factors in the initial stages of strategy development will contribute to the formation of more scenarios for their disposal, which ultimately reduces the negative impact of such factors on innovation development.

Table 24

Classification of road maps

Sign	Types	Contents
The purpose of creation	Product planning	Product production technology roadmap.
	Service planning	Roadmap of service technology.
	Strategic planning	Roadmap for future activities in terms of markets, business, products, technologies, skills, culture and taking into account various opportunities or threats.
	Long-term planning	Roadmap for extended planning horizons (sectors, national).
	Intellectual asset (staff) planning	Intellectual asset management roadmap and align knowledge with business goals.
	Program planning	Roadmap for strategy implementation and project planning.
	Process planning	Roadmap for planning a specific component of the process.
	Integrated planning	Roadmap for the integration or evolution of production technology and service delivery.
Level of planning	Sectoral	Roadmap for the development of a particular industry, market, industry sector.
	Corporate	Roadmap for development at the macro level of management.
	Product	Roadmap of product development over time through market analysis, product evaluation and technology study.
	Technological	Roadmap for technology development, technology sector.
	Scientifical, research	Roadmap for the development of new technologies that are formed taking into account research.
	Programmatic	Roadmap for development at the micro, macro and meso levels to identify the impact of possible problems on the development of programs and strategies.
Development format	Multilevel	Roadmap of several levels (sublevels), such as technology, product and market.
	Columns	Road map in the form of a series of columns for each level or sublevel.
	Tabular	Road map in the form of tables.
	Graphically	Road map in the form of a graph.
	Illustrated	Road map in the form of a picture (tree).
	Schematic	A roadmap in the form of a flowchart linking the goal, actions and results.
	Monolevel	The road map focuses on a single level.
	Text	Road in the form of text.

Source: Developed by the author based on [2, 9]

When creating a roadmap for digital transformation, attention should be paid to such items as the specific business results of each step, scaling and integration of implemented solutions, the need to invest in changing work processes. At the same time, all initiatives go through several stages: research of the idea, the result of which is a project plan and a description of the desired result, including success criteria; development, the result of which is a detailed description of the implemented technology; implementation, which is directly the process of technology implementation and performance appraisal.

There are five steps to creating a road map [10]:

Step 1: Define the strategy

Strategy is the «why» of what you will build. Set the vision, goals, and initiatives for your product and how they will support overall business objectives. A strong product vision captures the crucial information the team must understand to develop and maintain a competitive advantage. This includes details of who your customers are, what they need, and how you will go to market with your offering.

Step 2: Review and manage ideas

The best way to consider customer requests is to rank each one. You can do this by scoring ideas comprised of metrics that reflect your strategy. Scoring takes subjectivity out of the idea evaluation and allows the ideas that have the most significant impact to rank higher in priority.

Step 3: Define features and requirements

If strategy is the «why» then features are the «what» – the «how» is for your development team to determine. Identify the specific features that best support your strategy. Build those out into user stories and detailed requirements that give engineering teams the context they need to implement the best solution.

Step 4: Organize into releases

Now you are ready to organize those features into themes. Agile teams may also use epics to organize major work efforts. Once you have everything sorted, you can set timing for releases. These can be grouped according to a specific launch or your development capacity.

Step 5: Choose a view

For each roadmap you create, customize the types of information and level of detail you want to include.

Roadmaps can be applied at various levels of granularity, focusing on from components of complex systems, to entire sectors or fields or science. The architecture of Roadmap is configured to suit the focus and scope of issues being addressed, to provide a framework to support the dialogue necessary to develop and implement the desired innovation, strategy or policy [11].

The structure of Roadmap is usually composed of three layers, technology, product, and market (typically the vertical axis) with time frame (typically the horizontal axis). According to firm's objective and vision, future needs are mapped and visualized on the Roadmap in the form of pathways by connecting each node (or box) based on causal relationships.

The structure of the road map contains the following two main elements [11]:

- Terms (usually a horizontal axis), which may include past (or present), short-term, medium-term and long-term perspectives, as well as aspirations / visions.

- Layers (usually a vertical axis) represent a system-based hierarchical taxonomy that allows the use of different levels of detail. The strategic objective provided by the roadmap can «zoom in» and focus on the issues and areas of the system that are most important.

Roadmaps are able to support the development and implementation of integrated strategic business, product and technology plans, providing companies with the information, process and tools to produce them.

Roadmap development has its own features, which include the implementation of the following principles:

1) temporal distribution: determining the period of time during which a particular process or phenomenon will become widespread;

2) coverage: a clear definition of the topic and boundaries of the area;

3) initiative and development: the formation of a circle of organizations involved in the development of the map;

4) use: identification of expected and actual users of forecast materials;

5) goal setting: formulation of the target landmark, the achievement of which is aimed at the development trajectories described in the map;

6) unique methodology: development of a detailed approach to the collection, synthesis and presentation of information;

7) progress into the future: a description of perceptions of the uncertainty of the future, including short-, medium- or long-term forecasts – usually in the form of several scenarios.

The roadmap provides advanced visualization tools that allow, on the one hand, effectively discussing ways of development at any level and presenting the results to decision makers, and on the other – to easily identify the relationships between the various elements of the strategy, checking them for completeness and consistency.

When constructing a road map, two research schemes are used – «from the future to the present» and «from the present to the future». The first of these schemes is considered the main. The prerequisite for the development of the map in this case is to determine the parameters of the desired future state of the field, which is expressed in the form of a system of goals and details of its tasks. Properly formulated «tree of goals» should provide an opportunity to assess the achievement of the planned benchmarks with the help of specific indicators – both quantitative and qualitative. The roadmap, built on the principle of «from future to present», should take into account that the ways to achieve the goals may be different, as well as the trajectory of development, so the scheme will allow comparisons on different criteria – cost, results, and time to achieve targets. The map, which based on the principle «from present to future», shows what measures are currently being implemented and what effects they may lead to in the future. The starting point for building such a map is not the «image of the future», as in the previous case, but the identification of existing initiatives and plans for their implementation.

Roadmaps can be a tool for policy and indicative development planning. In other words, such a document may reflect a binding action plan (directive method), and at the same time it may show indicative development options drawn up with the participation of different categories of experts and be the result of reconciling their perceptions of the future (indicative method). To ensure the relevance of road map information, the data is updated at regular intervals. This achieves the conformity of ideas about long-term prospects for development, taking into account new data on the current situation.

The scheme of construction of the road map is chosen taking into account what type of information will be needed by its specific consumers. Therefore, one of the key issues addressed in the development of such a document is to determine its consumers – the target audience. The widest possible range of stakeholders should be involved in the development of the roadmap and its further implementation, and the completeness of the coverage of the measures envisaged by it and the effectiveness of their implementation directly depend on this. It is expedient to make the materials of the map open, which will facilitate a wide public discussion of the obtained results, during which the final document is validated and finalized.

The roadmap as a document can be effectively used in the management decision-making process only when it is based on a list of specific measures and their performers, established appropriate indicators of efficiency and effectiveness. To do this, the following functions must be implemented:

- forecasting: the road map gives an idea of the target level of development to a certain point in time, as well as ways to achieve it;
- planning: the road map as a document allows you to make an informed choice of directions and priorities for future development among the possible alternatives, plan the stages of their implementation, identify and agree on the necessary measures;
- monitoring: the road map is a convenient tool for monitoring the implementation of measures, it allows you to identify emerging deviations, analyze their consequences, if necessary, determine the direction of adjustments;
- popularization: an element of the road map, as a rule, is its visual representation, which will provide an understanding of all elements of the strategy – not only a specialist in the subject area, but also any reader; this makes the map a convenient tool for discussing strategic developments, presenting them to the public and decision-makers.

A feature of the road map as a method of strategic planning is the presence of a developed visual scheme. The most common way to visualize a road map is to group its elements by layers. Under the layer in this case means a set of similar elements of the map – goals, objectives, activities. Road map layers are usually displayed in a single time coordinate system to match the periods of occurrence of the elements displayed on them. Sometimes a situation is allowed in which one or more layers are displayed outside the timeline – for example, the events included in it occur throughout the time horizon (ongoing activities) or they all relate to one point in time (targets at the end of the program). Depending on the goals and objectives of the study, different layers can be shown on the map.

When constructing a map, the principle of the hierarchy of its goals must be followed. At the first, upper level are the target installations of the highest order. They should not be many (about 3-5), they capture the most important aspects of system development. Usually such benchmarks are determined taking into account the general development goals of the country or region. At the next, lower level, the goals are detailed using a list of tasks. Experts should formulate tasks in such a way that they can be clearly correlated with measures and performance indicators.

The moderator's job is to check the map for correct links. Each element of the road map must contain a connection with certain elements in all layers: each measure must be related to the goal, task, and expected result. The presence of an element without links suggests that it is redundant – this situation becomes the subject of special discussion.

The object of verification during the discussion is the mutual correspondence of all layers of the map. Thus, the list of goals should be clearly correlated with the tasks; measures should contribute to the solution of a specific task and achieve the appropriate goal, and performance indicators – to reflect the success of specific measures and progress in solving more general tasks.

To assess the correctness of the construction of the map as a whole, you need to assess the composition of each of its layers for compliance with two criteria – necessity and sufficiency.

The criterion of necessity means that each measure must be necessary to solve the problem, to contribute to the achievement of any goal. In other words, the map should not contain «unnecessary» measures, goals, objectives, indicators.

The criterion of sufficiency presupposes the provision of the solution of the set task (achievement of the goal) by the planned set of measures – if not in full, then at least in a significant part. Therefore, the successful implementation of these measures should lead to the solution of all tasks.

These criteria apply to all layers of the map.

In the process of expert discussion, special attention is paid to the degree of detail of the selected elements, as a result of which the level of detail of information in each layer of the map is unified. At the same time, excessively private issues should be avoided. The selection of elements should be carried out at a level that is essential for making the necessary management decisions.

When constructing a roadmap, it is important to clearly link all activities to the timeline, and mark events within certain time limits, so that each action is subject to assessment of the degree of implementation (in the form of performance indicators) and resource conservation (in the form of efficiency indicators) [13].

To date, there is no generally accepted methodology and a single algorithm for developing «road maps». However, all roadmaps are based on general methodological approaches to their compilation, namely:

1) selection of the period of realization of the «road map» and drawing up of the temporary schedule of its realization;

2) clear formulation of expected results;

3) ensuring a logical connection between strategic goals, tactical tasks and expected results;

4) development of a system of benchmarks for monitoring the achievement of goals and objectives;

5) assessment of development for the future depending on available and available resources;

6) assessment of risks, problems and warnings that exist or may arise in the implementation of the «road map» for the formation of alternative ways of development;

7) determination of sets of justified measures in key areas (sections of the «road map»), painted for the main participants to consolidate personal responsibility.

Under such requirements, the road map is an important tool of strategic management. The main feature of «road maps», in contrast to traditional, familiar in form and content of planned activities, is that they should provide for variability of development paths depending on the nature of the risks that inevitably arise in the further development of mapping objects [14]. The availability of different types of road maps is determined by different planning objects. However, all roadmaps have basic characteristics: goal, development tasks, functions, construction format, planning horizon (table 25).

Table 25

Basic characteristics of road maps

Characteristic	Contents
Goal development	Visualization of the project management plan, program, project portfolio; visual presentation of the results of strategic prognostication, planning or forecasting.
Tasks	Integration of requirements for the development of the planning object; construction of trajectories of achievement of the set purposes.
Functions	Forecast – representation of the development of the planning object or its potential directions of development (scenarios). Planning – a graphical representation of the project management plan, program, project portfolio, scenarios for the development of the planning object. Management – managing the development of the situation depending on the goals. Information – information support of the decision-making process for the development of the planning object. Regulatory – a roadmap as a mandatory regulatory document. Marketing – promotion of the object of mapping to attract investors to the development of the object of planning. Communication – creation of common strategic guidelines for the subject of mapping, identification by different subjects of the vector of development of the planning object.
Construction format	Single-axis single-layer (X-axis – time; layer – one planning object). Two-axis single-layer (X-axis – time; Y-axis – development of the planning object; layer – one planning object). Biaxial multilayer (X-axis – time; Y-axis – development of several planning objects). Multi-axis multi-layer – the use of a multigraphic image of the development of planning objects. Polar or multicentric – the only center of the trajectories of several planning objects, a round image. Polycentric – the use of multiple centers and trajectories for one or more planning

	objects.
Planning horizon	Tactical – 2-3 years. Medium-term – 3-5 years. Strategic – 5-8-10 years.

Source: [15]

Roadmaps, depending on the maturity that characterizes its completeness and completeness, can be divided into different levels of operation.

Level 1. Network or calendar schedule.

A roadmap is a plan or set of activities that defines those responsible, deadlines, resources, and benchmarks. The road map is usually the main document, which is drawn up in text or tabular form. This level is inherent in the maps developed by the authorities and marked by detailed calculations of the strategic perspective, the lack of analysis of the impact of external and internal environment, the presence of subjective visions of developers. These maps are intended to declare the intention to develop a planning object and perform a regulatory function.

Level 2. Expert level.

The roadmap is developed as a forecast of changes in planning objects over time. It determines the nodal time points of planning objects and the relationships between them. The road map is the main document, is a diagram with several layers. This level is inherent in road maps, which determine the vector of development of the planning object, performs communication and information functions.

Level 3. Concept, strategy.

A roadmap is a concept, a strategy, a scenario of changes in planning objects over time. It identifies nodal time points and relationships between them. The roadmap with an explanatory note can be both the main document and included in the set of documents on the basis of which it is developed. It consists of a set of diagrams and layers, the level is characterized by the development of the main stages of achieving the goal, performs marketing, communication, information, forecasting, planning functions. It can be used as a foresight tool.

Level 4. Management plan.

The roadmap is based on a project management plan, program, and project portfolio. It serves to visualize intermediate results, connections of functional areas of projects. The road map is not an independent document and is part of the set of documents on the basis of which it is developed. It consists of a set of diagrams, layers, several road maps. It can consist of independent parts, which together form a holistic picture, determining the necessary course of action. The complexity of road map development is characterized by the scale of implementing projects or programs. The level performs a managerial function.

The method of constructing road maps depends on the required level of maturity. Thus, the road map of the first level will be a table that will contain the following main fields: activities, deadlines, performers, resources, benchmarks.

The methodology of construction of the road map of the first level corresponds to the development and approval of the strategic action plan agreed by the subject of mapping. In turn, the roadmap of the fourth level is based on the already developed project management plan, program, project portfolio, and the methodology will be to build on the roadmap template network schedule using layers that are functional areas of the project. The program and project portfolio roadmap will cover all projects included in it. The fourth level roadmap is used to visualize the project management plan; the level of decomposition will be determined by the subject of mapping. The method of constructing road maps of the second and third levels is similar to the development of a project management plan with some differences in the procedure of decomposition of the goal. The method is based on the «folding» of many elementary parameters into a small range of complex factors in the course of expert assessments. Maturity levels differ in the degree of miscalculation of the goal and the final presentation of the results. Table 26 presents the stages of the methodology for constructing road maps using expert assessments.

Table 26

Methodology of building a road map using expert assessments

Stage	Contents
1. Collection and analysis of expert information	Formation of a working group (subject of mapping, stakeholders, interested representatives of government, science, business), drawing up a schedule of work on the road map. Formulation of the goals of the road map, definition of the object of mapping, choice of the main characteristics, properties and layers (sections) of the road map. Determining the required level of road map calculations for different layers, its coverage and boundaries. Conducting marketing research, collecting information on the layers of the planning object. Carrying out a systematic analysis of the planning object, its internal and external environment, markets, competitiveness, development potential, identification of bottlenecks, risks, threats and opportunities for growth, resource needs. Identification of key characteristics that the planning object should have. Formulation of problems and directions of development of the planning object, determination of the necessary volumes of financing. Presentation of the final conclusion of stage 1.
2. Roadmap development	Option 1. Project approach Based on the goal of the road map, problems and directions of development of the planning object, presented in the conclusion of stage 1, the goal is decomposed and measures are developed to achieve it. Resources, deadlines, performers are determined for each event. The network schedule is built, the critical way is defined, the matrix of correspondence and the budget is made, risks and methods of their management are revealed. The road map of the fifth level is built on the basis of the developed plan of management of the object of planning. Option 2. Foresight approach The development of forecasts and scenarios for the development of the planning object on the basis of expert «vision of the future» is envisaged. The group of experts answers the key questions prepared by the working group, identifies opportunities, risks, and financial costs, and identifies trends and alternatives. The work of experts can be carried out both remotely and during personal meetings (foresight sessions). Based on expert opinions, the working group compiles forecasts and possible scenarios for the development of layers (sections) of the road map and the planning object.

	Option 3. Combined approach Represents various combinations of elements of design and foresight approaches.
3. Expert assessment and approval of the road map	Establishment of communication between the participants of the road map, final agreement with the executors of measures and deadlines. Depending on the type of map, the examination and adoption of the roadmap by experts, authorities, business and the public. Taking into account critical remarks, the road map is supplemented, verified and approved (accepted). A plan for the implementation and monitoring of the road map is being developed, and a set of supporting documents is being prepared.
4. Implementation and control of the road map	Stage of implementation of road map measures by executors. Necessary conditions for successful implementation are the organization of control over the implementation of road map measures and risk monitoring, assessment and updating of intermediate results and links between road map layers, revision and updating of the strategy to achieve the goal when changing internal and external conditions (change management), making necessary adjustments to the road map.

Source: [15]

The effectiveness of roadmap development is determined by a single vector of research and synergy of developer ideas. Given that the main advantage of road maps is their structure and clarity, so there is no strictly regulated template for their development and presentation. The most road maps template in the form of a netting or calendar graph which can have several layers with a horizontal location of the time axis. The number of graphic elements of the road map is determined by the developers and depends on the level of maturity, the purpose of the road map, the number of layers (sections), and the depth of decomposition. The main elements of the roadmap template are given in table 27.

Table 27

The main elements of the road map template

Element of template	Contents
Goal of the road map	Different wording of the purpose of the road map is possible: - development of the concept, strategy (strategic documents), scenario, plan, visualization of the project management plan, program, project portfolio; - targets, indicators and indicators, expected results (control indicators); - long-term goals of the planning object for each layer; - identification of critical factors (stages), identification of key points of effort, optimization of decisions; - creating a vision of the future, developing forecasts; - goal as the transition of the planning object from the initial state to the set. It is possible to represent the goal as a set of goals, a limited number of goals. Depending on the purpose the type of a road map, necessary layers, level of structural completeness, planning horizon and construction format is defined. The goal is depicted as a result or fixed on the edge of the road map.
Strategy (scenarios) to achieve the goal	Strategy (scenario) – a method of achieving the goal by determining the necessary intermediate results (layers, measures, works). It is represented by drawing graphic elements in the form of map nodes and connections between them. To achieve the result, the goal by the method of decomposition is divided to the required level on the tasks, sets of works, works that serve as nodes displayed on the road map. Each layer has its own decomposition, which can be carried out from the result to the current state (from right to left), from the current state and available resources to

	the goal (from left to right). If there are three or more strategies (scenarios), the decomposition results are displayed as a map system, representing each strategy (scenario) on a separate map or as several levels of the map, placed vertically using «windows of opportunity» to switch between strategies (scenarios).
Layers	Are sections of the road map, reflect the objects of planning. On the map can be placed horizontally, vertically, sequentially interconnected, parallel-interconnected, unrelated.
Nodes	The size, type and location of the node on the road map depend on the layer and deadline. The sequence of nodes is determined by the strategy and logic of the decomposition of the target. Types of road map nodes: - project, stage of development, task, work, event, checkpoint, event, object, changes in the environment or process; - intermediate result, document, expert assessment; - plan change points in case of risks or threats; - point of management decision; - scenario fork in the interaction of map layers; - window of opportunity ─ transition from one strategy (scenario) to another; - break point.
Connections	Nodes that characterize successive events or causal relationships are interconnected. Links can be indicated by arrows of different thickness, shape and colour. Connected nodes are a netting or calendar schedule.
Graphic representation	Depending on the layer, the graphic image of nodes and connections may differ in shape, size, colour, font, text or numerical designation.
Axis of time	The time axis is the same for the entire map or is used separately for each layer. Usually the X axis. This is implementation schedule and a tool for placing nodes on the road map.
Additional Information	At the discretion of the subject, the mapping is given on the road map or presented in an explanatory note.

Source: [15]

Depending on the type, the road map should contain certain layers (sections). These layers can be divided into three types:

1) layers that must be included in the full road map;

2) layers, the use of which is possible for this type of cards;

3) layers that are rarely used for this type of card.

The goal and strategy layers are included in the template and are present in all roadmaps. The choice of layers is determined by the subject of mapping depending on the required completeness of the road map.

The need to use road maps as a planning and forecasting tool is due to several reasons: road maps are a simple tool for visualizing developed strategies and plans to identify inconsistencies that may not be visible in text format; the method of road mapping allows to make the simplified network (calendar) schedule of achievement of the purpose by means of some layers (sections); roadmaps allow you to take into account risks, threats, availability of resources and other factors when choosing goals and making management decisions.

Road mapping has a number of advantages over other methods of strategic planning and forecasting:

1) has a high level of clarity of developed concepts, strategies, scenarios, which allows them to be better understood by all actors, provides an opportunity to make management decisions in a single vector of development;

2) provides scientific forecasting of changes and the internal environment of planning objects, considers their complex development;

3) means of communication between road map participants increases the level of trust on the part of investors.

Ensuring the benefits of this tool requires developers to the required level of knowledge and experience, and with high detail for visualization, monitoring – significant funds.

The use of road maps at the state level of government requires a clear methodological framework, which in Ukraine is still under development. There are no industry roadmaps DX in Ukraine. Enterprise-level roadmaps DX or related strategic development plans (usually IT strategies) exist only at the level of individual large enterprises. The consequence of this situation is that Ukrainian companies will always lose to Western competitors or global companies, for which the intensive introduction of 4.0 technologies has long been on the agenda. The roadmap DX at the enterprise level identifies the main changes over time by category – products, business processes, technologies, organizational changes, skills, and, if necessary, other elements of organizations that are relevant to the successful implementation of digitalization.

REFERENCES

1. Marie L. Garcia, Olin H. Bray (1997). Fundamentals of technology roadmapping. Albuquerque, NM: Sandia National Laboratories. 34 p.

2. Sokhatska O.M., Smereka S.V. (2020). Osoblyvosti formuvannia stratehichnykh kart pidpryiemstva [Features of formation of strategic maps of the enterprise]. *Efficient economy*, 4. Retrieved from: http://www.economy.nayka.com.ua/?op=1&z=7826. DOI: 10.32702/2307-2105-2020.4.21

(Last accessed: 20.04.2021)

3. Kerr C. & Phaal R. (2020). Technology roadmapping: Industrial roots, forgotten history and unknown origins. *Technological Forecasting and Social Change*, 155. Retrieved from: https://doi.org/10.1016/j.techfore.2020.119967.

(Last accessed: 22.04.2021)

4. Willyard C.H. & McClees C.W. (1987). Motorola's technology roadmap process. *Research Management*, 30 (5), 13-19. DOI: 10.1080/00345334.1987.11757057

5. Groenveld P. (1997). Roadmapping integrates business and technology. *Research-Technology Management,* 40 (5), 48-55. DOI: 10.1080/08956308.1997.11671157

6. Groenveld P. (2007). Roadmapping integrates business and technology. *Research-Technology Management*, 50 (6), 49-58. DOI: 10.1080/08956308.2007.11657472

7. Nauda A. & Hall D.L. (1991). Strategic technology planning-developing roadmaps for competitive advantage. *Technology Management: the New International Language*, 745-748. DOI: 10.1109/PICMET.1991.183788.

8. Coates J.F. (2000). Scenario planning. *Technological Forecasting and Social Change*, 65 (1), 115-123. DOI: 10.1016/S0040-1625(99)00084-0

9. Kopishynska K.O. (2014). Dorozhnia karta yak instrument vyznachennia stratehii innovatsiinoho rozvytku pidpryiemstv mashynobuduvannia [Road map as a tool for determining the strategy of innovative development of machine-building enterprises]. *Business Inform*, 11, 88-94.

10. Introduction to product roadmaps. Retrieved from: https://www.aha.io/roadmapping/guide/product-roadmap.

(Last accessed: 20.04.2021)

11. Phaal R., & Muller G. (2009). An architectural framework for roadmapping: Towards visual strategy. *Technological Forecasting and Social Change,* 76(1), 39-49. DOI: 10.1016/j.techfore.2008.03.018

12. Jeong Y., Jang H. & Yoon B. (2021). Developing a risk-adaptive technology roadmap using a Bayesian network and topic modeling under deep uncertainty. *Scientometrics,* 126, 3697-3722. DOI: 10.1007/s11192-021-03945-8

13. Velikanova N.P., Karasev O.I. (2014). Metod dorozhnikh kart v stratehichnomu planuvanni rozvytku osvity [Roadmapping as a method of strategic planning of education sector's development]. *University Management: Practice and Analysis*, (4-5), 95-105.

14. Syniahyn A.K. (2014). «Dorozhni karty» v derzhsektori: plan zakhodiv abo instrument stratehichnoho upravlinnia [Roadmaps in the public sector: an action plan or a strategic management tool]. *Budget*, 1. Retrieved from: http://bujet.ru/article/241951.php.

(Last accessed: 25.04.2021)

15. Lohynov M.P. (2017). Dorozhni karty: poniattia, sutnist, klasyfikatsiia. [Road maps: concept, essence, classification]. *Management problems*, 5, 1-17. Retrieved from: http://pu.mtas.ru/archive/Loginov_517.pdf. (Last accessed: 29.04.2021)

8.2 Organizational and methodological support of digital transformation of national economic systems

Tetiana Marusei
Ph.D. in Economics,
Associate Professor of the Department of tourism and hotel-restaurant business chair, Kamianets-Podilskyi Ivan Ohiienko National University
E-mail: nikmar76@gmail.com
ORCID ID 0000-0002-1018-702X

Results. The rapid development of the digital economy in the world provides an increase in the competitiveness of enterprises, industries and countries. The widespread level of digitalization entails significant changes in the organization of national economic systems. Today's trend is a digital transformation that affects all areas, focused on the global application of digital technologies in the activities of economic entities, the formation of the information society and the digital economy in general.

Among the various economic categories that characterize the neo-economy, the most acceptable and understandable is the determinant "digital economy". It has been used in research since 1995. The classical understanding of the economic category "digital economy" means an activity in which the main factors of production are digital electronic, virtual data, both numerical and textual. In the scientific literature and practice, the digital economy is called the new economy, the Internet or the web economy. It is based on the traditional economy and it is very difficult to distinguish between the conventional and digital economies. However, digitalization complements and improves the traditional economy by using electronic technologies of the Internet in the production, sale of products and acquisition of necessary resources.

However, today the term "digital economy" does not have a clear definition in the literature. One of the main reasons for this is the lack of a clear and universal idea of what factors should be taken into account when measuring the digital economy. Another reason that complicates the definition of the digital economy is the rapidly changing nature of technology. The technologies that businesses and consumers use to perform tasks or communicate are relevant today, but may be outdated tomorrow. Ideally, the definition of the digital economy over time may change the nature of what it covers. Thus, summarizing the interpretation of the category "digital economy" by domestic and foreign scientists, we formulate the definition of "digital economy" as a focus on computer technology, modern and informational systems which allow to increase productivity in enterprises and living standards. Although modern domestic and foreign scholars identify the digital economy with the traditional one, these are completely opposite concepts, between which there are almost no common features [1].

There are fundamental rules for building a digital enterprise, which are determined by the business model, promotion channels, operating environment, business structure and processes, as well as the applied digital technologies. According to preventive studies conducted in 1999–2000 by foreign scientists L. Margherio, R. Kling, R. Lamb, four main components of the digital economy in the enterprise have been identified (Figure 38).

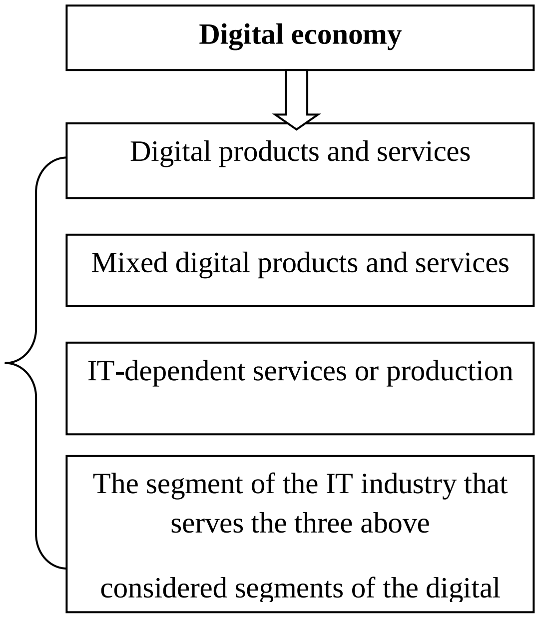


Figure 38. Components of the digital economy in the enterprise

Source:built by the authors according to sources [1]

For fig. 38, digital products and services include components that are delivered using digital technologies and come in digital form (online information services, software sales, e-learning, etc.). Mixed digital products and services include the retail sale of real goods, as well as related sales and marketing. For services or the production of IT-dependent goods, this component includes services that are critically dependent on information technology (eg accounting services or complex technical projects), the production of real goods, in which the use of information technology is crucial. (such categories of goods that require high-precision machining using numerical program control or computer-controlled chemical plants). The IT industry segment serves and includes IT sector products and services that are primarily designed to serve the three aforementioned components of the digital economy. This includes manufacturers of network equipment and personal computers, as well as IT consulting firms (some analysts apply broader concepts to the IT industry and include in this list communication equipment, including TV and radio broadcasting, as well as communication services).

However, in 2001, scientist Thomas Mesenburg identified three main components of the digital economy, such as supporting infrastructure (hardware and software, telecommunications, networks, etc.); e-business, or e-business (conducting business and any other business processes through computer networks); e-commerce, or e-commerce (distribution of goods via the Internet) [4]. Thus, the digital economy of the enterprise is a dynamic innovation economy, which is based on the active introduction of innovations and information and communication technologies in all economic activities and spheres of society, which increases the efficiency and competitiveness of individual enterprises, economy and living standards [1].

Today, digitalization is one of the main factors in the growth of the world economy, because it not only increases productivity (direct advantage), but also saves time, creates new demand for new goods and services, new quality and value (indirect advantage) and more. At the same time, the use of digital data as a resource for production determines the transition from a traditional market economy to a digital economy, which will permeate all sectors: public and private, real, non-productive and financial, mining, manufacturing and services.

The key goal of digitalization of Ukraine is to achieve digital transformation of existing and creation of new branches of economy, as well as transformation of spheres of life of Ukraine into new, more efficient and modern ones. Such growth is possible only when the ideas, actions, initiatives and programs related to digitalization are integrated into national, regional, sectoral, etc. development strategies and programs [1].

The main goals of digital development are:

- accelerating economic growth and attracting investment; transformation of economic sectors into competitive and efficient;

- technological and digital modernization of industry and creation of high-tech industries; accessibility to citizens of the benefits and opportunities of the digital world;

- realization of human capital, development of digital industries and digital entrepreneurship.

The introduction of the digital economy in Ukraine at the initial stage should take place simultaneously in the following three areas:

technological, where all solutions of technical and technological nature must be standardized, i.e. be safe and certified;

institutional and economic, which involves the organization of new management models and business models using smart things, industrial Internet of Things, blockchain technology, its institutional support, to comply with the regulatory framework of socio-economic relations of society;

production, which includes specific business applications that meet the requirements of management models of the second direction, which is based on the technical support and infrastructure of the first direction.

To achieve the set goals, Ukraine must achieve economic and technical goals, Figure 39.

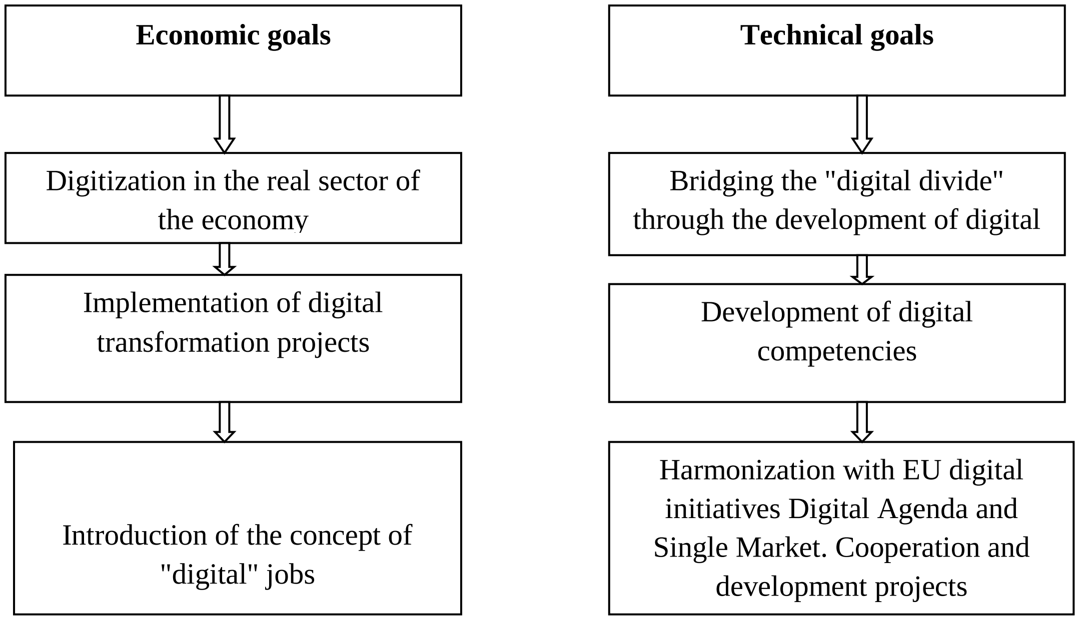


Figure 39. Basic economic and technical goals of the digital economy of Ukraine

Source: built by the authors according to sources [5]

Ukraine has all the conditions for a digital leap and technological transition to a higher level, and faster, better, large-scale renewal and development, namely:

– ability to produce and use information and communication and digital technologies, availability of professional staff, human capital, "school". This is evidenced by the statistics of real success of Ukrainian IT companies in international markets;

– access to appropriate equipment, technologies, growth of technology dissemination among citizens and businesses. This is evidenced by the gradual recovery of domestic demand for technology, market "success stories" in various spheres of life and economy, the presence of local offices of technology manufacturers, distribution of high-tech equipment;

– sufficient level of system integration of technological products and services, from design to complex implementation of various technologies, software and hardware;

– creative culture and ability to generate ideas, as evidenced by high performance in the Global Innovation Index.

An interesting phenomenon (in transition) is the digital transformation. Digital transformations are not automation in its modern sense. They also include automation (at a qualitatively new level) and provide for the creation of other forms of organization and models of operational processes based on digital technologies, which lead to the formation of new approaches in economic activity. A good example is joint consumption and digital production (industry platforms) with direct market entry. While digital transformations are mainly considered in relation to business (for reorganization, creation of new business models, optimization, performance management, product transformation and change of interaction with clients), however, as experience of developed and even many developing countries show, they can be applied in the study of the development of national and world economy.

Digital transformation involves profound and comprehensive changes in production and social processes associated with the total replacement of analog technical systems with digital and large-scale application of digital technologies. Along with this, not only the installation of modern equipment or software is required, but also fundamental changes in approaches to management, corporate culture, and external communications. As a result, the productivity of each employee and customer satisfaction increase, and companies gain a reputation as progressive and modern organizations, digitalization creates the potential for successful development, as digital technologies objectively and inevitably lead to a radical renewal based on digital transformation.

To minimize risks and increase the effects of the introduction of digital technologies, first, it is necessary to form a concept and develop a strategy for digital transformation, which should include:

1) the choice of focal processes and target areas of activity for transformation;

2) evaluation of the effectiveness of the proposed changes;

3) development of the concept of digital enterprise;

4) development of strategy and business model; formation of a portfolio and a roadmap of projects.

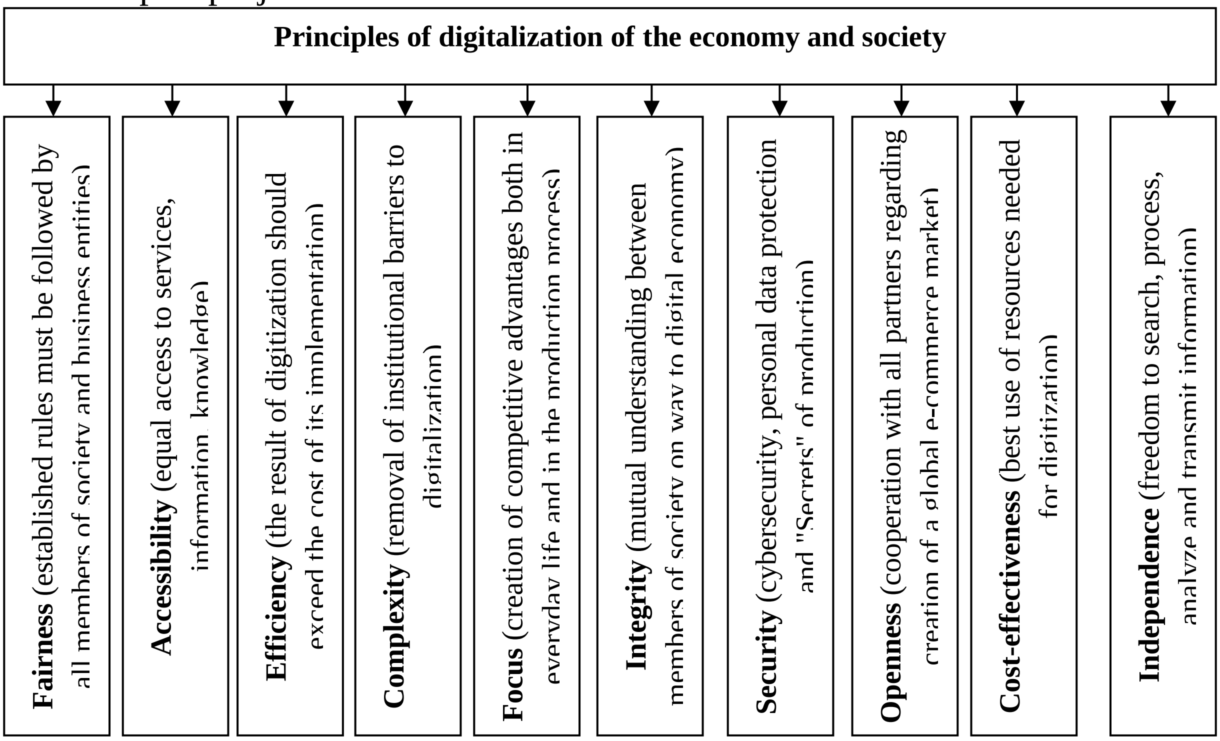


Figure 40. Principles of digitalization of the economy and society

Source:built by the authors according to sources [2, 8]

The process of digital transformation of national economic systems is based on the generalization of existing practical experience and formulated in the form of basic provisions, circumstances, requirements and practices that underlie it, i.e. a set of generally accepted rules that serve as a foundation (necessary condition) for implementing the above process objects of management. The basic principles of digitalization of the economy and society are presented in Figure 40.

The main prerequisites for organizing the transition to digitalization of the economy in Ukraine are as follows: development of physical infrastructure of Internet access; growth in the number of Internet users; e-commerce development; development of the country's IT industry; improving the national e-government system. The creation of the digital economy in Ukraine has acquired the status of a state task, and therefore in 2018 the Government approved the Concept of digital economy development. This Concept is designed to encourage the digitalization of all areas of economic activity, stimulate the use of digital technologies in enterprises and indicate the priority of the development of these technologies on the state level.

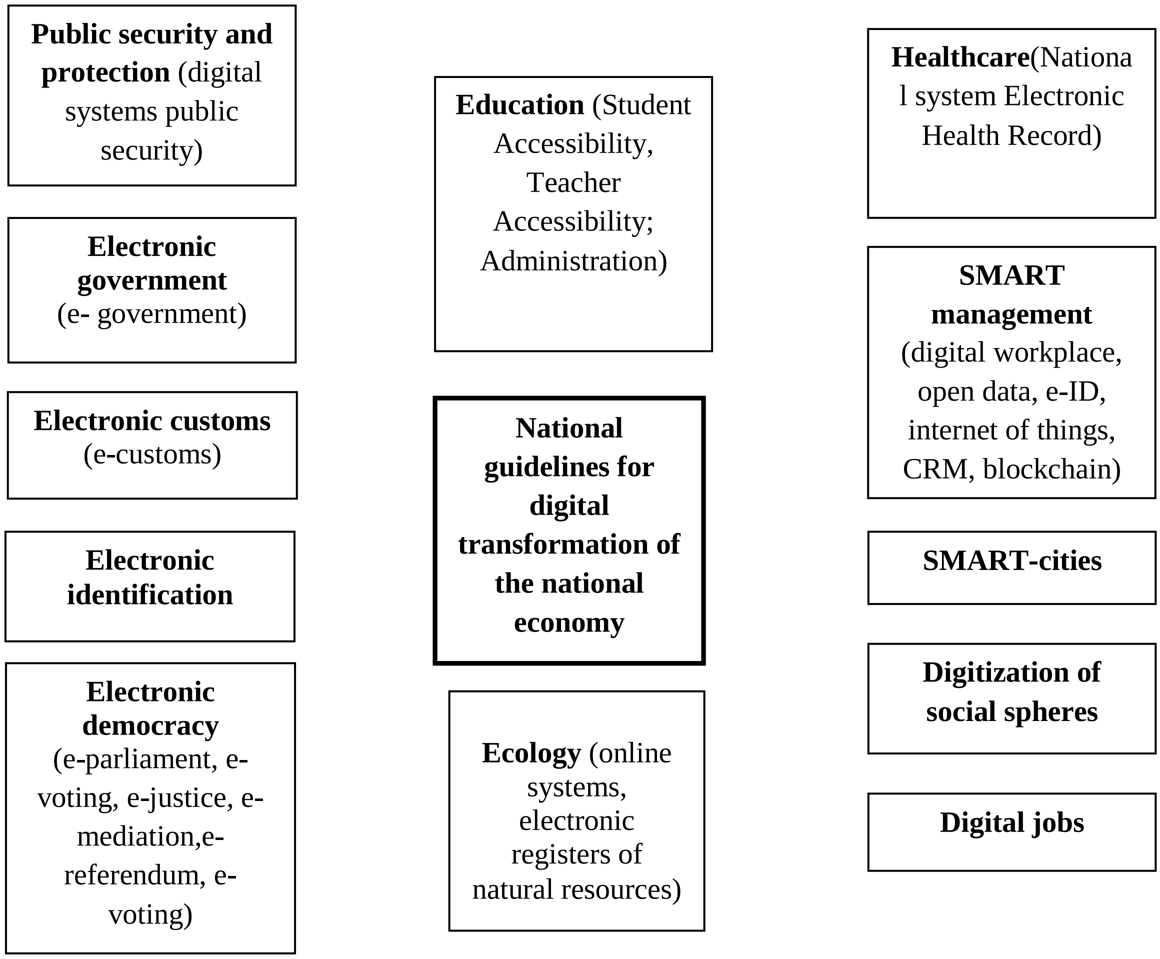


Figure 41. National guidelines for digital transformation of the national economy

Source: built by the authors according to sources [2, 7]

It is important to develop effective directions and priorities for the development of digitalization both in Ukraine in general and at the local level. Directions and priorities of digital economy development should cover all socially significant spheres of medicine, education, safety, ecology, economy (Figure 41).

It should be noted that today digitalization has already absorbed education, medicine, management, and economics. Thus, the recently adopted medical reform includes a call for the development of telemedicine in regions inaccessible for prompt access (mostly in rural areas). In a world where access to mobile communications is ahead of access to electricity and water, telemedicine is an initiative that can and should build a bridge between patient and doctor. Filling out declarations for maintenance and implementation of the helsi.me site has greatly simplified the lives of ordinary citizens. The most significant changes have taken place in education. The Prometheus project has become a clear example of how effective governance can build a strong education system in Ukraine. Digitization of the educational process is rapid. Today there are online courses, online conferences, online testing, and webinars. This format has long been an integral part of citizens.

The main advantages of science and digital economy for sustainable development and social welfare are:

- increasing competition and quality of products and services;
- reduction of production costs and product prices;
- expanding the range of goods and services;
- increasing the availability of goods and services for ordinary citizens through the use of the Internet;
- development of technologies in the medical field that will facilitate the treatment of fatal diseases;
- emergence of new professions;
- greater mobility and flexibility of the education system (higher and vocational);
- use of scientific developments to improve the environmental situation in the country;
- increase in life expectancy;
- improvement of life quality of the population.

However, a number of institutional, infrastructural, ecosystem and governmental problems can be identified that hinder the development of digital trends in Ukraine and the transformation of the Ukrainian economy into a digital one.

Institutional problems include [8]:

– low involvement of state institutions in the implementation of the Concept of digital economy and society (Digital Agenda of Ukraine);

– inconsistency of relevant legislation with global challenges and opportunities;

– inconsistency of national, regional, sectoral strategies and development programs with digital opportunities.

– Infrastructure problems are [8]:
– low level of coverage of the country's territory by digital infrastructures;
– Lack of separate digital infrastructures (for example, the infrastructure of the Internet of Things, electronic identification and trust, etc.);
– unequal access of citizens to digital technologies and new opportunities (digital gaps).

FACTORS THAT ARE AN OBSTACLE ON THE WAY TO DIGITAL TRANSFORMATION

External factors

- ✓ Lack of digital solutions that take into account the specifics of the company's business
- ✓ Underdeveloped information infrastructure
- ✓ Lack of standards for the use of digital technologies
- ✓ Underdeveloped digital trust infrastructure
- ✓ Problems of interdepartmental interaction
- ✓ Insufficient legal regulation of relations that are formed in the digital economy
- ✓ Identification of determining the legal status of stakeholders
- ✓ Lack of special measures of state support for use digital technology companies
- ✓ Data security and confidentiality, protection against cybercrime
- ✓ Availability of unstructured, contradictory data

Resource constraints

- ✓ Lack of own funds
- ✓ Lack of investment resources
- ✓ High cost of digital technology projects
- ✓ High operating costs of systems using digital technologies
- ✓ Low innovative potential of the organization
- ✓ Lack of opportunities for cooperation with others. enterprises and scientific organizations

The human factor

- ✓ Shortage of specialists who meet the requirements of the digital age
- ✓ Lack of qualifications in the staff that implements and maintains digital technologies
- ✓ Technological incompetence of users
- ✓ Different levels of digital knowledge between different generations
- ✓ Unwillingness of employees to change the usual forms of work
- ✓ Low digital culture

Figure 45. Factors that are an obstacle on the way to digital transformation
Source:built by the authors according to sources [2, 4]

Among the most influential ecosystem problems are [8]:
– weak state policy on incentives and incentives for the development of innovative economy;
– immature investment capital market;
– outdated education system, teaching methods, lack of focus on STEM-education, soft skills and entrepreneurial skills, imperfect models of technology transfer and consolidation of knowledge and skills;

– shortage of highly qualified personnel. The main problem in the field of e-government and governance is the low level of automation and digitalization of public services [6].

Regarding the introduction of digital technologies, not all domestic enterprises are transforming their activities in this direction. In Figure 45 identifies factors that are an obstacle to digital transformation. The processes of development and transformation of the economy into a digital one are influenced by many factors. Four main factors play an extremely important role in promoting the development of the digital economy:

a) social networks - interaction, is a source of innovative ideas and a basis for collecting and disseminating information, promotes the involvement of participants in political life and social change;

b) digital finance - the introduction of digital technologies in the financial and credit sector of the economy, online payments in e-commerce, electronic transfers, e-bidding, e-government procurement, e-state budget, state social benefits (pensions, mobile money, digital currency);

c) data revolution - the focus is on interconnected innovations - big data and data discovery. At the same time, the analysis of large data sets is used to improve traffic flows, assess generalized macroeconomic indicators, improve management processes. Regarding open data, governments are or may be an important source of open data;

d) digital identification - the use of a single electronic identity system for secure banking, voting, access to social services, payment of utility bills, etc.

The International Organization for Economic Cooperation and Development (OECD) identifies only three key components of the digital economy:

1) infrastructure (hardware and software, telecommunications, networks, etc.);

2) e-commerce (distribution of goods via the Internet).

3) e-business (doing business and any other business processes through computer networks).

The transition to the next stage of civilizational development - digitalization led to a fundamental change in the structure of the world economy, its global virtualization due to the emergence of new forms of cross-border movement of electronic goods, capital and labor. Therefore, measuring the level of digital transformation of a country's economy is becoming one of the most important tasks. The development of a system of indicators for monitoring the digital transformation of the economy at the international level is carried out by many international organizations and reputable analytical agencies, whose efforts have developed more than 20 different composite indices of digital transformation of the economy and society.

The most well-known ratings of digitalization of the economy are based on such indices as:

– ICT Development Index (IDI);
– Digital Economy and Society Index (DESI);

- Digital Evolution Index (DEI);
- IMD World Digital Competitiveness Index (WDCI);
- Networked Readiness Index (NRI);
- BCG economy digitization index (e-Intensity).
- Digital Adoption Index (DAI);
- Global Innovation Index (GII);
- Networked Readiness Index (NRI);
- economic digitization index (Boston Consulting Group - e-Intensity).

To the above indices, some scholars add the Global Competitiveness Index, but this index can only be tentatively considered an indicator of the digital economy, as the Global Competitiveness Index measures a set of institutions, policies and factors that determine sustainable current and medium-term levels of economic prosperity associated with the development of digitalization [3, 6].

For further in-depth analysis of the above indices of digital economy development, we will use the following methodological approach - we will analyze the indices according to the following three main criteria:

1) determine the popularity (significance) of the index (i.e. the frequency with which an index occurs (mentioned) when making relevant queries on Google search sites), in order to increase the objectivity of the study will use the English version of index names;

2) identify the representation of our state in each index (presence or absence), which are selected for in-depth study in order to determine the place of Ukraine in comparison with the nearest geographical neighbors;

3) outline the time frame (period) of the representation of our state in the above indices in order to identify the dynamics of changes occurring in our country under the influence of factors of general digitalization of world economies, which will allow further research to describe current trends in the economy individual digitization indices and outline possible promising areas for digitization of the domestic economy with minimal investment burden.

The results of the analysis of the main rating indices of digitalization and the description of the representation of our state in them will be reflected in Table 1, on the basis of which we will select for further study those indices in which our state is represented [6]. Analyzing the data in Table 28, we can state that the most popular and recognizable in the modern world is the Global Innovation Index (GII), as the number of mentions when making queries on Google search sites on the Internet is 457 million units. The second most popular is the Digital Adoption Index (DAI) - 191 million mentions. In the following indexes - the Digital Evolution Index (DEI) and the Digital Economy and Society Index (DESI) our country is not represented, so we omit them according to the methodology described above. Also, based on the data in Table 1, we consider it appropriate to analyze in detail the third most popular Index of Information and Communication Technology Development (ICT Development Index - IDI), which is quite popular on the Internet (70.7 million mentions) and in which our country presented since 2002.

Table 28

Analysis of rating indices of digitalization and representation of Ukraine in them (as of December 2020)

Index name	The popularity of the index (number of mentions when exercising queries on sites search engine Google Online Internet), thousand units	Representation Of Ukraine (+ ;-)	Period representative office in our states (from what year)
1. Index of digital economy and society (Digital Economy and Society Index - DESI)	107 000	-	-
2. Index of digital evolution (Digital Evolution Index - DEI)	173 000	-	-
3. Index of digitalization acceptance (Digital Adoption Index - DAI)	191 000	+	since 2014
4. Index of development of information and communication technologies (ICT Development Index - IDI)	70 700	+	since 2002
5. Global Innovation Index (Global Innovation Index - GII)	457 000	+	since 2007
6. Network readiness index (Networked Readiness Index - NRI	897	+	since 2002
7. Index of digitalization of the economy (Boston Consulting Group - e Intensity)	7 990	+	since 2011
8. World Digital Index competitiveness (IMD World Digital Competiveness Index - WDCI)	16 600	+	since 2014

Source:built by the authors according to sources [6]

The Global Innovation Index (GII) is a global study of the INSEAD International Business School, Cornell University (USA) and the World Intellectual Property Organization. The study analyzes the level of innovation in institutions, education, infrastructure and business (has 82 different variables) on the basis of which the corresponding rating is formed. In 2020, 131 countries at different levels of innovation development were included in this ranking. Given the high dynamism of the innovation process, the list of basic indicators is periodically updated and supplemented. GII indicators cover the components of the innovation sphere and are combined into two sub-indices: 1st - 55 indicators characterize the innovation potential of the country - Innovation Sub-index (Innovation Input Sub-index), 2nd - 27 indicators characterize the scientific and creative results of innovation and form Innovation Output Sub-index.

The Global Connectivity Index (GCI), developed by Huawei, was created to analyze a wide range of indicators for ICT infrastructure and digital transformation. The GCI assesses the development of the digital economy in 79 countries, using 40 indicators that track the impact of ICT on the country's economy, digital competitiveness and future growth. The GCI index contains four sub-indices: supply, demand, experience and potential; and five technological factors: broadband, the cloud, the data center, big data, and the Internet of Things (IoT). According to this methodological approach, countries belong to one of the clusters: Starters (GCI Score 20-34), Adopters (35-55) and Frontrunners (56-85). Together, these countries account for 95% of world GDP. In 2018, Ukraine took 50th place in the GCI ranking.

The Digital Transformation Index, developed by the independent British firm Vanson Bourne, is calculated as follows: the firm surveys business leaders - executives who have the right to make strategically important decisions for the business organization. In 2019, 4,600 business leaders from 42 countries took part in the survey. Ukraine was not among them, but the results of the survey can be interesting and useful for domestic business to understand global trends.

According to the McKinsey Global Institute's industry digitization index, Europe currently operates at 12% of its digital potential, Germany at 10% of its digital potential, the United Kingdom at 17% and the United States at 18%. That is, even developed countries do not fully use their digitization potential.

The Digitization index (IDI), developed by Ukrainian scientists allows us to assess the real level of implementation of digital technologies and competencies in enterprises. The index makes it possible to assess the changes taking place and see in which direction digitalization is moving. Analysis of best practices and identification of digitalization leaders will allow market participants to analyze their experience in digital innovations, assess the level of development of digital technologies and competencies in the enterprise, compare their practices with other market participants, and identify general trends in digitalization.

The Enterprise Digitization Index (IDI) is proposed to be calculated as the weighted average of three sub-indices:

1) subindex "Infrastructure Development" (IID - Infrastructure development) - reflects the degree of infrastructure development (degree of infrastructure development), the availability of Internet access (Availability of Internet access) and the quality of Internet access (Internet access quality);

2) sub-index "Online costs" (IOE - Online expenses) - includes the cost of online retail (Online trading) and online advertising (Online advertising);

3) sub-index "User activity" (IUA - User activity) - is calculated as the weighted average of sub-indices of lower levels: activity of firms (activity of enterprises), activity of consumers (activity of consumers) and activity of state institutions (activity of state institutions). All sub-indices are formed from the weighted average values of several parameters that underlie them[6].

Thus, the trend of digitalization of various social spheres on a global scale is obvious. This process is the basis for a new stage of "technological" race, which should result in geopolitical and geoeconomic leadership. At the same time, it is a chance for both developed and developing countries to improve their domestic socio-economic situation. Today, the main agenda for most countries in the world is digital transformation and the creation of a hypercompetitive digital economy. Thus, the digital transformation is an exceptional phenomenon in its speed and scale, which calls into question the traditional thinking about the most effective way of organizing economic and social activities.

REFERENCES

1. Hrabchuk I., Reminska O., KurinnaYu. (2020). Innovatsiini perevahy rozvytku tsyfrovoi ekonomiky na pidpryiemstvakh [Innovative advantages of digital economy development at enterprises]. Black sea economic studies, 59-1, 114-119. DOI:doi.org/10.32843/bses.59-19
2. Cabinet of Ministers of Ukraine (2018). Resolution "About the conceptualization of the development of the digital economy for Ukraine and Ukraine for 2018-2020 and the hardening of the plan forentryinto the project". Retrievedfrom:https://zakon.rada.gov.ua/laws/show/67-2018-%D1%80 (Lastaccessed: 15.05.2021)
3. Pizhuk O. (2020).Tsyfrova transformatsiia ekonomiky Ukrainy: obmezhennia ta mozhlyvosti[Digital transformation of Ukraine's economy: limitations and opportunities]*: monograph.*University of the State Fiscal Service of Ukraine, 504 p.
4. *Pyshchulina O. (2020).* Digital economy: trends, risks and social determinants. Razumkov Center.Retrieved from: https://razumkov.org.ua/uploads/article/2020_digitalization.pdf (Last accessed: 15.05.2021)
5. Pletnov M., Adamenko T. Formation of digital economy of Ukraine: technical and economic aspect. Retrieved from: https://ndipzir.org.ua/wp-content/uploads/2019/Ryha_09.10.19/Ryha_09.10.19_26.pdf(Last accessed: 15.05.2021)
6. Rudenko M. (2021). AnalizpozytsiiUkrainy v hlobalnykhindeksakhtsyfrovoiekonomiky [Analysis of Ukraine's position in the global indices of the digital economy]. Economy and state, 2, 11-18. DOI: 10.32702/2306-6806.2021.2.11
7. Ukraine 2030E is a country with a developed digital economy. Retrieved from: https://strategy.uifuture.org/kraina-z-rozvinutoyu-cifrovoyu-ekonomikoyu.html (Last accessed: 15.05.2021)
8. Shevchuk I., Deputat B., Tarasenko O. (2019). Tsyfrovizatsiia ta yiivplyvnaekonomikuUkrainy: perevahy, vyklyky, zahrozy y ryzyky [Digitalization and its impact on the economy of Ukraine: advantages, challenges, threats and risks]. Black sea economic studies, 47-2, 173-177. DOI: https://doi.org/10.32843/bses.47-66

8.3. Comparative analysis of state programs for the development of artificial intelligence

Nataliia Mazur
Doctor of Sciences (Economics), professor
Head of Department of Enterprise Economics,
Kamianets-Podilskyi National Ivan Ohiienko University
e-mail: mazur@kpnu.edu.ua
ORCID ID 0000-0002-4670-6805

Dariusz Nowak
Doctor of Sciences (Economics), PUEB Professor,
Head of Department of Corporate Resources Management,
Poznań University of Economics and Business
e-mail: dariusz.nowak@ue.poznan.pl
ORCID ID 0000-0001-7448-6101

With the change of government in 2019, digitalization became a priority of state policy, and the goal was to create a «state in a smartphone». Naturally, the newly created Ministry of Digital Transformation has become one of the locomotives in this area in Ukraine. Among its tasks was a fairly new issue for Ukraine, but not for the world - to ensure the development of artificial intelligence.

The Order of the Cabinet of Ministers of Ukraine of December 2, 2020 approved the Concept of the development of artificial intelligence in Ukraine. This strategic document defines the purpose, principles and objectives of the development of artificial intelligence technologies in Ukraine as one of the priority areas in the field of scientific and technological research. The concept is developed in accordance with the Government's priority action plan for 2020, approved by the Cabinet of Ministers of Ukraine dated September 9, 2020. The concept seeks to build on and reflect the basic principles of the Organization for Economic Co-operation and Development (OECD) Guidelines on Artificial Intelligence.

Among the basic principles of development and use of artificial intelligence technologies are the following – Figure 46. The introduction of information technology, part of which is the technology of artificial intelligence, is an integral part of the development of socio-economic, scientific and technical, defense, legal and other activities in areas of national importance – Figure 47.

artificial intelligence should benefit people and the planet by promoting inclusive growth, sustainable development and prosperity;

artificial intelligence systems are developed and used only subject to the rule of law, and their use must be ensured by appropriate guarantees, in particular, the possibility of unimpeded human intervention in the functioning of the system;

ensuring transparency and responsible disclosure of information about artificial intelligence systems;

Organizations and individuals who develop, implement or use artificial intelligence systems are responsible for their proper functioning in accordance with the above principles.

Figure 46. Basic principles of development and use of artificial intelligence technologies

Source: Developed by the authors based on How the Ministry of Digitalization sees AI in Ukraine: analysis of the concept of artificial intelligence development (2020)

The lack of conceptual foundations of state policy in the field of artificial intelligence does not allow to create and develop a competitive environment in these areas. The purpose of the Concept is to determine the priority areas and main tasks of the development of artificial intelligence technologies to meet the rights and legitimate interests of individuals and legal entities, build a competitive national economy, improve the system of public administration. Ukraine, which is a member of the Special Committee on Artificial Intelligence at the Council of Europe, in October 2019 joined the Recommendations of the Organization for Economic Cooperation and Development on Artificial Intelligence (Organization for Economic Co-operation and Development, Recommendation of the Council on Artificial Intelligence, OECD/LEGAL/0449).

The principles of development and use of artificial intelligence technologies, compliance with which fully complies with the principles of the Organization for Economic Cooperation and Development on artificial intelligence, are:

1) promoting inclusive growth, sustainable development and prosperity;

2) development and use of artificial intelligence systems only under the condition of observance of the rule of law, fundamental human and civil rights and freedoms, democratic values, as well as provision of appropriate guarantees during the use of such technologies;

- low level of digital literacy, public awareness of general aspects, opportunities, risks and safety of artificial intelligence;
- lack or imperfection of legal regulation of artificial intelligence (including in the fields of education, economics, public administration, cybersecurity, defense), as well as imperfection of legislation on personal data protection;
- low level of investment in the development of artificial intelligence technologies;
- low level of implementation and implementation of innovative projects by economic entities using artificial intelligence technologies compared to the world's leading countries, which leads to lower productivity and the emergence of a large percentage of jobs that need to be automated;
- low level of mathematical competence of graduates of general secondary education, necessary for the development and research in the field of artificial intelligence;
- insufficient level of quality of higher education and educational programs aimed at training specialists in the field of artificial intelligence in higher education institutions;
- lack of modern in-service training programs for teachers of higher education institutions in the field of artificial intelligence;
- low level of investment in artificial intelligence research in higher education institutions;
- lack of grant funding for research in the field of artificial intelligence;
- a small number of publications in the publications of leading industry conferences (CVPR /ICCV/ECCV - for computer vision, NeurIPS, ICML, ICLR - for machine learning, etc.) and leading peer-reviewed publications;
- insufficient level of information security and data protection in information and telecommunication systems of state bodies due to the obsolescence of automatic systems for detection and assessment of information threats, failure to use the potential for forecasting and forecasting threats in order to timely prepare the system for a possible attack;
- increase in the number of attempts of unauthorized interference in the work of automated systems, computer networks;
- the risk of rising unemployment due to the use of artificial intelligence technologies;
- imperfection of management decisions in the public sphere, bureaucratization of the system of administrative services, limited access to information and its low quality, insufficient level of implementation of electronic document management between government agencies, as well as the low degree of digitization of data owned by government agencies.

Figure 47. Problems to be solved by a single coordinated state policy

3) compliance of the activity and algorithm of solutions of artificial intelligence systems with the requirements of the legislation on personal data protection, as well as observance of the constitutional right of everyone to not interfere in personal and family life in connection with the processing of personal data;

4) ensuring transparency and responsible disclosure of information about artificial intelligence systems;

5) reliable and safe operation of artificial intelligence systems throughout their life cycle and implementation on an ongoing basis of their assessment and management of potential risks;

6) placing on organizations and individuals who develop, implement or use artificial intelligence systems, responsibility for their proper functioning in accordance with these principles.

The priority areas for the implementation of the Concept are:

- ✓ occupation of a significant segment of the world market of artificial intelligence technologies and leading positions in international rankings (AI Readiness Index by Oxford Insights, AI Index by Stanford University, etc.);
- ✓ creating conditions for participation in the activities of international organizations and the implementation of initiatives for the formation of strategies for the development, regulation and standardization of artificial intelligence;
- ✓ introduction of artificial intelligence technologies in the field of education, economy, public administration, cybersecurity, defense and other areas to ensure long-term competitiveness of Ukraine in the international market;
- ✓ providing access to information (databases, electronic registers, etc.), its use in the development of artificial intelligence technologies for the production of goods and services;
- ✓ promoting the dissemination of research results in the field of artificial intelligence and improving their quality;
- ✓ raising the level of professional training of specialists to provide the field of artificial intelligence technologies with qualified personnel;
- ✓ protection of information space from unauthorized interference, ensuring safe operation of information and telecommunication systems;
- ✓ increasing the level of public safety through the use of artificial intelligence technologies in the development of measures for the re-socialization of convicts and the risk of re-offending;
- ✓ bringing legislation in the field of artificial intelligence technologies in line with international regulations.

Implementation of the Concept is planned for the period up to 2030.

The concept identifies eight key areas of a single coordinated public policy in the field of artificial intelligence – figure 48:

1) education and vocational training;

2) science and innovation;

3) economy and business;

4) cybersecurity;

5) defense;

6) public administration;

7) legal regulation and ethics;

8) justice.

Figure 48. Key areas of a unified coordinated state policy in the field of artificial intelligence

Source: Developed by the authors based on The concept of development of artificial intelligence in Ukraine (2020)

Let's analyze these key areas in more detail.

1. **Education and vocational training**

The main task of education in the development of artificial intelligence is to provide the relevant field with qualified personnel. Demand in the labor market suggests that the modern education system must be much better able to train competitive professionals in the field of artificial intelligence. To achieve the goal of the Concept in the field of education, the following tasks should be ensured:

a) in the field of general secondary education:

improvement of educational and methodical base;

organization of courses for teachers on working with data and the basics of artificial intelligence;

dissemination of digital literacy among schoolchildren (use of digital tools for solving applied problems, searching for information on the Internet, protection of personal data, media literacy, digital hygiene, etc.);

b) in the field of higher education:

creation of specialized educational programs of artificial intelligence within the field of "Information Technology", inclusion of artificial intelligence in other educational programs in various specialties, creation of interdisciplinary, including joint, master's and doctoral programs;

involvement of specialists in the IT industry and other industries in the formation of qualification requirements for specialists in artificial intelligence, development and implementation of educational programs, certification of applicants for higher education;

integration of leading online courses on artificial intelligence into educational programs;

organization and provision of internships for teachers of IT areas in IT companies, IT departments of enterprises and institutions, as well as public organizations that develop and apply artificial intelligence technologies;

establishing international cooperation and programs of double and joint diplomas in the field of artificial intelligence, including with foreign partners;

c) in the field of advanced training and professional retraining:

development of specialized educational programs for professional development and adult education in the field of artificial intelligence, as well as the provision of scholarships to persons studying in such programs, including specialized for certain groups, including people with special needs, internally displaced persons;

providing social protection for specialists receiving additional education in the field of artificial intelligence;

development and implementation of a nationwide information campaign on general aspects, risks and threats of use and further dissemination of artificial intelligence technologies in Ukraine.

2. **Science**

To achieve the goal of the Concept in the field of science, the following tasks should be ensured:

promoting the attraction of grant funding for research in the field of artificial intelligence in order to stimulate the transition of Ukrainian scientists to effective models, standards and formats of cooperation, in particular through the National Research Fund;

stimulating research in the field of artificial intelligence by partially reimbursing the costs of researchers to participate in international conferences from the list of Core A/A conferences*;

support/stimulation of scientific cooperation with international research centers and organization of events for exchange of professional experience;

promoting the application of artificial intelligence technologies in the fields of science, as well as interdisciplinary research at the intersection of artificial intelligence and other branches of science.

3. **Economics**

To achieve the goal of the Concept in the field of economics, the following tasks should be ensured:

- stimulating the development of entrepreneurship in the field of artificial intelligence by ensuring access of innovative enterprises to investment, partnership with venture funds, organization of business events with Ukrainian IT entrepreneurs abroad, improving the business climate, ensuring predictable tax policy, creating closed information environments for isolated testing artificial intelligence technologies, development of computer infrastructure for the development of artificial intelligence technologies within the priority areas, etc.;
- motivating business entities to introduce artificial intelligence technologies to increase their own efficiency by ensuring their access to educational programs / information portals on artificial intelligence technologies;
- development of a Roadmap for the retraining of people whose work can be automated in the next five to ten years;
- introduction of a state order for artificial intelligence systems, IT specialists and data researchers;
- stimulating the partnership between the state and business in the field of innovative projects, as well as improving the legislation in the relevant field.

4. **Cybersecurity**

The main task in the field of cybersecurity in the implementation of state policy for the development of artificial intelligence is the protection of communication, information and technological systems, information technology, especially those used by operators (providers) of key services (including critical infrastructure) and are important for continuity functioning of the state, society and security of citizens. A comprehensive solution to cybersecurity requires the following tasks:

improving legislation and creating a modern regulatory framework for the implementation of the world's best practices of artificial intelligence in the field of cybersecurity and cybersecurity;

development of innovative cybersecurity systems that widely use artificial intelligence technologies for automatic analysis and classification of threats and automatic selection of strategies for their containment and prevention;

studying the issue of licensing foreign developments in artificial intelligence in the field of cybersecurity, especially in the public sector;

creation of national information systems, platforms and products in order to reduce the share of foreign software in the field of cybersecurity used by public administration bodies;

updating state standards on information security, including state information resources, and developing new national standards in the field of cybersecurity and cyber security, including organizational and technical requirements for the security of applications, mobile devices, workstations, servers and networks, cloud computing models.

Standards should be updated and new ones developed taking into account European and international standards, in particular ISO 27001, ISO / IEC 27032. Informational security. The use of artificial intelligence technologies in ensuring information security is one of the factors that will contribute to the national interests. In particular, the monitoring of social networks and Internet resources of electronic media with the use of artificial intelligence technologies makes it possible to identify systemic trends and issues, to act ahead, to analyze the target audience. To achieve the goal of the Concept in this area should ensure the implementation of the following tasks:

formation and use of information resources, ensuring high rates of its filling and set quality criteria (availability, reliability, timeliness, completeness);

creation of a protected national information space with the help of artificial intelligence technologies;

detection, prevention and neutralization of real and potential threats to the spread by the media of the cult of violence, cruelty, pornography, attempts to manipulate the public consciousness, in particular, by disseminating inaccurate, incomplete or biased information.

5. Defense

To achieve the goal of the Concept in the field of defense, it is necessary to ensure the use of artificial intelligence technologies in systems:

- ✓ command and control;
- ✓ armaments and military equipment;
- ✓ collection and analysis of information during hostilities;

✓ analysis / reconnaissance, support of reconnaissance activities, processing of cartographic information;

✓ countering cyber threats in the field of defense based on the use of artificial intelligence technologies, including those that allow you to quickly detect cyberattacks, pre-scan and subsequent avoidance of malicious code or scanning suspicious patterns of behavior, rather than specific code;

✓ simulation and cognitive modeling of the combat situation;

✓ cognitive analysis of the capabilities of military units.

Priority areas and main tasks for the development of artificial intelligence technologies in the field of defense are defined in the relevant defense planning documents.

6. Public administration

To achieve the goal of the Concept in the field of public administration, the following tasks should be ensured:

formation of the list of administrative services, decisions on which are made automatically, with the minimum participation of civil servants and / or employees of state and / or communal enterprises, institutions, organizations;

research and application of artificial intelligence technologies in the field of health care, in particular to combat epidemics and pandemics, as well as to predict and prevent potential epidemic outbreaks in the future;

introduction of a dialog interface for electronic administrative services with the use of artificial intelligence technologies;

development of artificial intelligence technologies for digital identification and verification of persons, including for the provision of public services;

application of artificial intelligence technologies for analysis, forecasting and modeling of development of indicators of efficiency of public administration system, separate branches of economy during planning, technical regulation and standardization;

optimization of the processes of analysis and evaluation of international information, political, economic and defense trends for the use of such results in management decisions in foreign and domestic policy of Ukraine;

application of artificial intelligence technologies in order to identify cases of illegal interference in the activities of the electronic system of public procurement and other public electronic systems;

application of artificial intelligence technologies to detect unfair practices in the activities of officials and civil servants in various areas by analyzing the texts of management decisions and other data generated in computerized systems/registers during such activities

In addition, to solve problems related to the functioning of state registers, cadastres, databases, archives owned by the state, it is necessary: determination of directions of data conversion into electronic form, creation (in case of absence) or updating and cleaning of available state electronic information resources; ensuring, in the framework of open data development, the priority of publishing dynamic data; publishing such data in real time through the application programming interface (API); determination of the list of thematic categories of data sets of high public value, which are managed by public authorities; development of mechanisms for anonymization of personal and other data during processing in artificial intelligence systems, which will make it impossible to identify individuals.

7. Legal regulation and ethics

The main task of state policy in the field of legal regulation of artificial intelligence is to protect the rights and freedoms of participants in the field of artificial intelligence, development and use of artificial intelligence technologies in compliance with ethical standards. To achieve the goal of the Concept in this area should ensure the implementation of the following tasks:

implementation of the norms enshrined in the “Recommendations on Artificial Intelligence” adopted in June 2019 by the Organization for Economic Cooperation and Development (OECD / LEGAL / 0449), subject to the ethical standards set out in Recommendations CM / Rec (2020) 1, approved April 8, 2020 by the Committee of Ministers of the Council of Europe for member states on the impact of algorithmic systems on human rights in the legislation of Ukraine;

elaboration of the issue of compliance of the legislation of Ukraine with the guiding principles established by the Council of Europe on the development and use of artificial intelligence technologies and its harmonization with the European one;

assessment of the possibility and determination of the limits (ethical, legal) application of artificial intelligence systems for the purposes of providing professional legal assistance;

ensuring the functioning and operation of technical committees of standardization in accordance with the requirements of 7.1.5 DSTU 1.14: 2015 "National standardization. Procedures for the establishment, operation and termination of technical committees of standardization "in the field of artificial intelligence;

ensuring cooperation between the relevant Technical Committees of Ukraine and international subcommittees of standardization ISO / IEC JTC 1 / SC 42 Artificial Intelligence on the joint development of standards in the field of artificial intelligence;

support for initiatives to create organizational forms of cooperation between interested legal entities and individuals in the field of artificial intelligence;

development of a Code of Ethics for artificial intelligence with the participation of a wide range of stakeholders.

8. Justice

To achieve the goal of the Concept in this area should ensure the implementation of the following tasks:

further development of existing technologies in the field of justice (Unified Judicial Information and Telecommunication System, Electronic Court, Unified Register of Pre-trial Investigations, etc.);

introduction of advisory programs based on artificial intelligence, which will open access to legal advice to the general population;

prevention of socially dangerous phenomena by analyzing the available data with the help of artificial intelligence;

determining the necessary measures for the re-socialization of convicts by analyzing the available data using artificial intelligence technologies;

making court decisions in cases of insignificant complexity (by mutual agreement of the parties) on the basis of the results of the analysis carried out using artificial intelligence technologies, the state of compliance with legislation and case law..

The development and introduction of artificial intelligence technologies in the judicial systems of the world's leading countries have contributed to the need to develop common principles and rules for their use. In December 2018, the European Commission for the Efficiency of Justice adopted the Charter of Ethics on the Use of Artificial Intelligence in Judicial Systems and Their Environment, which was the European Commission's first step towards the efficiency of justice in promoting the responsible use of artificial intelligence in the European judicial system.

In 2021, revenues from the global artificial intelligence market were expected to reach 327.5 billion U.S. dollars. The global AI market is forecast to see rapid growth in the coming years, reaching more than half a trillion U.S. dollars by 2024.

Simply put, artificial intelligence (AI) is the ability of a computer or machine to mimic the competencies of the human mind, which often learns from previous experiences to understand and respond to language, decisions, and problems. In the case of AI, a great amount of data is often used to train AI into developing algorithms that enable these abilities. Different AI capabilities such as computer vision and conversational interfaces are embedded in many standard business processes in industries such as retail, finance, healthcare, and high tech.

The AI market can be broken down into three segments:

1) software,
2) hardware, and
3) services.

The AI software segment is the largest of the three segments, bringing in the most revenue recently. The segment is comprised of AI applications, AI software platforms, and AI system infrastructure software sub-segments. Popular AI software vendors include companies such as IBM, Microsoft, SAS, and Google to name a few.

The AI hardware market and the AI services market are smaller in size but have significant potential for growth in the coming years.

In January 2019, the AI4EU consortium was established to build the first European Artificial Intelligence On-Demand Platform and Ecosystem with the support of the European Commission under the H2020 programme. The activities of the AI4EU project include:

✓ The creation and support of a large European ecosystem spanning the 28 countries to facilitate collaboration between all Europeans actors in AI (scientists, entrepreneurs, SMEs, Industries, funding organizations, citizens…);

✓ The design of a European AI on-Demand Platform to support this ecosystem and share AI resources produced in European projects, including high-level services, expertise in AI research and innovation, AI components and datasets, high-powered computing resources and access to seed funding for innovative projects using the platform;

✓ The implementation of industry-led pilots through the AI4EU platform, which demonstrates the capabilities of the platform to enable real applications and foster innovation;

✓ Research activities in five key interconnected AI scientific areas (Explainable AI, Physical AI ,Verifiable AI, Collaborative AI, Integrative AI), which arise from the application of AI in real-world scenarios;

✓ The funding of SMEs and start-ups benefitting from AI resources available on the platform (cascade funding plan of €3m) to solve AI challenges and promote new solutions with AI;

✓ The creation of a European Ethical Observatory to ensure that European AI projects adhere to high ethical, legal, and socio-economical standards;

✓ The production of a comprehensive Strategic Research Innovation Agenda for Europe;

✓ The establishment of an AI4EU Foundation that will ensure a handover of the platform in a sustainable structure that supports the European AI community in the long run.

To become a global leader in human-centred AI, Europe requires to build upon its strengths and to tackle its gaps related to AI. While Europe has a robust and reliable public education system, high excellence in fundamental and applied research and deep domain expertise in industrial processes and public services, it has a fragmented research landscape, difficulties in transforming research results to actual products and growth, in scaling start-ups and requires to spend more efforts in ensuring seamless access to data and domain knowledge models as well as needs to increase industrial investments and ensure more stability in funding. To boost the vision of becoming a global leader in AI, several areas for actions are critical for Europe to be addressed. In this context, the AI4EU on-demand platform can support in implementing this European vision by building a platform which brings together the AI community, allows it to work more collectively, to publish and exchange AI assets and skills. By connecting multiple organizations with developers, researchers with industry, and by linking existing European initiatives, the AI4EU ondemand platform will serve as a channel that gives access to AI resources to all related communities. To support the implementation of the European vision, the AI4EU on-demand platform has identified strategic actions in the area of community building, funding, start-ups, European values, technology and its uptake, as well as talents and skills, have been prioritised.

The AI4EU Platform will bring the AI stakeholders and AI resources together in one dedicated place, overcoming fragmentation, so that AI-based innovations (research, products, solutions) will be accelerated. The AI4EU Platform will act as the one-stop-shop for anyone looking for AI knowledge, technology, services, software, and experts. AI4EU will function as European AI market driver, offering a critical mass of resources, community networking effects, and rapid development and growth.

To fulfil the user needs and strategic objectives, the following design principles were considered:

- ✓ Service-oriented and Web platform: The AI4EU Platform is designed to accessible only by using a web browser, without requiring any client software installation. All AI resources are accessible through a comprehensive service layer facilitating the Platform use and uptake by users.
- ✓ Multi-disciplinary and cross-sector: AI4EU hosts workflows and algorithms for a wide range of AI symbolic and machine learning problems. This increases the achievable innovation potential by providing immediate access to AI technologies in multiple fields of expertise as opposed to existing systems that isolate the various research communities.
- ✓ Scalable and interoperable: The AI4EU Platform is fully scalable and interoperable in terms of data sources, programming languages, IT infrastructures, and third-party platforms. It will efficiently construct toolchains utilising state-of-the-art technology components and large data resources applied across multiple sectors.
- ✓ Curated Data access: AI4EU data build upon previous EU projects, existing Big Data communities, and data exchange activities that will further be enriched by additional curated data coming from the AI4EU consortium, affiliated partners, as well as from all parties involved in AI experimentation projects.
- ✓ Collaborative, Social and Confidential: The AI4EU Platform allows users to form virtual and interdisciplinary teams sharing activities (workflows, algorithms, data, and data experiment reports) towards common goals.

In summary, the European AI on-Demand Platform aims to fulfil the needs of the European AI community at large.

Europe has an excellent tradition in AI research, and many of today's most successful AI methods originate in European universities and research institutes. Current AI tools, however, often lack features that are crucial to the need of having AI systems that are truly human-centred. Such systems would need to be:

✓ *Explainable*, i.e., they allow humans to understand the reasons behind their recommendations or decisions;

✓ *Verifiable*, i.e., they guarantee fundamental properties like safety, privacy and security;

✓ *Physical*, i.e., they can interact with the physical world of humans;

✓ *Collaborative*, i.e., they can share knowledge with humans and take decisions jointly with them;

✓ *Integrative*, i.e., they can combine different requirements and methods into one AI system – figure 49.

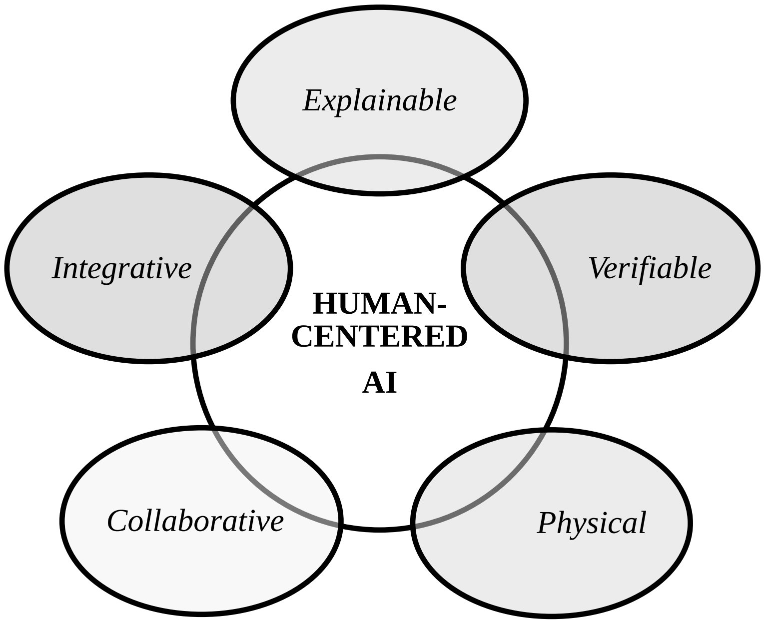


Figure 49. AI systems human-centred

Source: Developed by the authors based on AI4EU project (2020)

Ensuring that future AI-based systems have these five properties is paramount to our ability to use AI to produce benefits for the European society, industry and economy, while being compliant to the ethical values that are at the centre of European culture. The scientific vision of AI4EU is to facilitate European AI research in these five priority areas, and make research results available to all through the AI on-demand platform.

The use of artificial intelligence (AI) is already a reality in many industries, but the technology also has significantly more potential, as an analysis from Accenture and Frontier Economics shows. The report predicts that labor productivity in developed countries can increase by up to 40 percent until 2035 due to the influence of artificial intelligence. A high increase in productivity is projected in Sweden at around 37 percent. The U.S. (35 percent) and Japan (34 percent) are also expected to benefit greatly from the effects of AI. In Germany and Austria, AI can potentially maximize labor productivity by around 30 percent within the next 15 years. Nonetheless, as automation advances, fewer unskilled workers will be required by industries, raising questions of what will become of these workers. According to McKinsey, 15 percent of companies in the global automotive industry recorded an AI-related decline in their workforces of 3 to 10 percent in 2019. Approximately 10 percent of companies even exceeded that number.

Around half of respondents from the consumer goods and retail industry state that deployment of artificial intelligence can help improve customer care. This means that an AI solution can take over augmented conversations to answer customer questions and lead the customer on to the right agent in situations it cannot assist, for example. Additionally, 47 percent of respondents say that AI can greatly enhance inventory management by helping to effectively manage costs and buyers' needs. That is, AI technology tracks quantities of supply and demand at both ecommerce sites and physical locations, ensuring they are in sync.

The Ministry of Digital Transformation, together with representatives of other agencies and the crypto business, outlined the target model of the virtual assets ecosystem in Ukraine, its development scenarios and the roadmap for joint work in the coming years. On May 13, the final session of the foresight study of the virtual assets industry in Ukraine took place, during which the participants of the event formed a vision and a roadmap for the development of new industry in Ukraine. During the last session of the foresight, key scenarios for the development of the virtual asset industry were identified based on rethought trends that affect the future of the new industry.

Foresight «Virtual Assets 2030» is a study of the virtual assets industry in Ukraine, its prospects in the Ukrainian economy and the world market. Foresight purpose:

- ✓ to form a common vision of the development of virtual asset ecosystems in Ukraine, taking into account the interests of different stakeholders;
- ✓ develop a roadmap and joint action strategy to optimize the development trajectory of this industry;
- ✓ to create a community as a subject of implementation of this strategy on the basis of a common vision of the development of new industry in Ukraine.

REFERENCES

1. How the Ministry of Digitalization sees AI in Ukraine: analysis of the concept of artificial intelligence development (Ukraine). Retrieved from: https://dslua.org/publications/yak-mintsyfry-bachyt-ai-v-ukraini-analiz-kontseptsii-rozvytku-shtuchnoho-intelektu/ (Last accessed: 10.05.2021).
2. The concept of development of artificial intelligence in Ukraine (2020). Approved by the order of the Cabinet of Ministers of Ukraine from December 2, № 1556-r. Retrieved from:https://thedigital.gov.ua (Last accessed: 01.05.2021).

3. AI4EU project (2020). Retrieved from: https://www.ai4eu.eu/about-project (Last accessed: 25.04.2021).

4. Artificial Intelligence (AI) worldwide - Statistics & Facts (2021). Retrieved from: https://www.statista.com/topics/3104/artificial-intelligence-ai-worldwide/#dossierSummary (Last accessed: 29.04.2021).

5. A roadmap for the development of virtual assets in Ukraine has been formed (2021). Retrieved from: https://thedigital.gov.ua/news/sformovano-dorozhnyu-kartu-rozvitku-sferi-virtualnikh-aktiviv-v-ukraini (Last accessed: 14.05.2021).

8.4. Machine learning in engineering thermodynamics

Sergey Artemenko
Doctor of Sciences,
Head of Department of Computer Engineering
Odessa National Academy of Food Technologies,
1/3 Dvoryanskaya Str., Odesa, 65082 Ukraine
E-mail: sergey.artemenko@gmail.com
https://orcid.org/0000-0002-1398

Victor Mazur
Doctor of Sciences,
Professor of Department of Thermodynamic and Renewable Energy
Odessa National Academy of Food Technologies,
1/3 Dvoryanskaya Str., Odesa, 65082 Ukraine
E-mail: victor.mazur@gmail.com
https://orcid.org/0000-0003-3049-9570

«Everything leads us to believe that there is a certain state of mind from which life and death, the real and the imaginary, past and future, the communicable and the incommunicable, height and depth are no longer perceived as contradictory»

André Breton, *Second Manifesto of Surrealism* (1929)

1 Introduction

The innovative nature of the modern economy produces a breakthrough in the field of thermodynamics. The interdisciplinary nature of new objectives aimed at designing the working matters for environmentally friendly technologies requires a more dynamic use of information technology (IT) to ensure proper trade-off decisions under a competitive environment. In this case, the competence and experience of the experts are replaced by the “wisdom of many”. There is a shift in motivation for research: from traditional "just in case" to research "just in time."

The generic term that describes a new research strategy aimed at solving new scientific and technical problems by applying the recent development of the information systems that support collection, storage, intelligent processing, and management of data, as well as other computing and information capabilities, is called cyberinfrastructure. The establishment of cyberinfrastructure for solving problems in engineering thermodynamics does not replace the existing traditional approaches but combines and expands on a more general IT basis the theoretical concepts and practical technologies in specialised scientific areas. Development of the cyberinfrastructure requires at least management and modelling of the data and knowledge.

Machine learning (ML) is the part of artificial intelligence (AI) methodologies that uses algorithms that are not a direct solution to a problem but learning through solutions to innumerable similar problems. The first definition of "machine learning" can be attributed to Salvador Dali, who was a Spanish surrealist artist renowned for his technical skill, precise draftsmanship images in his work. Surrealism is a movement in literature and art whose life is generally assigned the years 1924-1945 by historians. In 1924, André Breton's first *Manifesto of Surrealism* appeared, defining the movement in philosophical and psychological terms. Salvador Dali, who coined the term "machine learning" in 1929 in the Journal D'un Genie. Surrealism intended to undermine the stability of the picture of the world, using the latest achievements of thought, science, technology, philosophy and appealing to art, thoughts, literature of the past, in which one can assume irrational meanings.

The use of machine learning for the determination of fluid property correlations recently was applied in the study [1], equation of state for fluid properties was generated by the machine learning approach in [2]. The presented examples of machine learning applications in soft matter, including design of self-assembling materials, nonlinear learning of protein folding landscapes, high throughput antimicrobial peptide design, and data-driven materials design engines, are given in [3]. Prediction of activity coefficients with ML was performed in [4], a general-purpose machine learning framework for predicting properties of inorganic materials was presented in [5], computer-aided synthesis planning is discussed in [6]. The neural network is one example of machine learning algorithms applying to quantum physics [7], physical chemistry [8] and [9]. Recent trends of machine learning in the heat transfer sector are reflected in applying renewable energy [10].

In this study, we present applications of machine learning in engineering thermodynamics as an illustrative example of integration of data science paradigms and thermodynamic approach to predict azeotropic behaviour of binary refrigerants and determine the coefficient of performance (COP) for Organic Rankine Cycle (ORC) working media. The conventional artificial neural networks approach was applied to evaluate the data, capable of recognising complex input-output relationships.

2 Background

Data science is the modern direction in poorly structured large data sets, in which hidden patterns between variables are revealed. Data science algorithms combine a wide range of scientific disciplines: machine learning, statistics, artificial intelligence, databases and others. The main methods and algorithms of Data science include the following: artificial neural networks, decision trees, symbolic rules, nearest neighbour methods, and k-nearest neighbour, support vector machine, Bayesian networks, including the Apriori algorithm; evolutionary programming and genetic algorithms, various methods of data visualisation and many other methods.

Recently, estimates based on the theory of fuzzy sets have become widespread. SVM (Support vector machines) algorithm provides users with the most robust and accurate method to solve machine-learning problems. Linear or nonlinear regressions are often used in modelling and predicting thermodynamic properties. However, real-world problems do not fit well-developed statistical methods for this case. The main algorithms and solution methods are reduced to the following: Statistical methods – Neural network algorithms – Genetic algorithms – Evolutionary algorithms – Decision trees – Bounded search algorithms – Fuzzy logic algorithms – Systems for visualisation of multidimensional data along with classical schemes of correlation, regression, and factor analysis. Artificial neural networks (ANNs) allow the learning process to establish relationships between input data and output characteristics of any degree of complexity. These models consist of interconnected groups of artificial neurons, which are, in fact, process and transform input data according to the neuronal architecture.

In most cases, ANNs are adaptive systems that change their structure under the influence of information flows entering the network during the learning process. The goal of training is to find the coefficients of connections between neurons, which determine the ability of a neural network to identify hidden relationships between input and output values. After training, the network can predict new data based on a limited sample of known relationships between input and output values.

3 Azeotrope prediction by artificial neural networks

The rate of global warming has set the task of accelerating the phase-out of ozone-depleting substances in all areas of activity. The demands of the world community have posed a serious scientific and technical challenge for refrigerant manufacturers.

Attempts to find new working fluids that would combine the best energy and environmental performance led to the fact that binary mixtures became the most promising substances. Among this class of substances, azeotropic mixtures show significant advantages over zeotropic mixtures since the difference in the composition of the vapour and liquid phases leads to a negative impact on the efficiency of the cycles.

The article discusses a general approach to predicting the appearance of azeotropy in binary mixtures, which does not require cumbersome calculations of vapour-liquid equilibrium and provides valuable information on azeotropic liquids. An azeotrope is a mixture of two or more pure compounds (chemicals) in such a ratio that its composition cannot be changed by simple distillation. When an azeotrope is boiled, the resulting vapour has the same ratio of constituents as the original mixture of liquids. The word azeotrope comes from the Greek words "α ζειν τρόπος", meaning "no change on boiling".

The desire of refrigerant manufacturers to create an "ideal" fluid, which would simultaneously combine conflicting indicators, such as

- environmental (natural origin, low global warming potential (GWP), zero ozone depletion potential (ODP), non-flammable and non-toxic as well as non-corrosive);
- economic (low price);
- energy efficiency (high critical temperature, good solubility with refrigerant oil, low triple point, acceptable thermophysical properties, etc.).

3.1. Global phase behaviour of binary refrigerants

A theoretical analysis of the topology of phase diagrams is a handy tool for understanding the phenomena of phase equilibrium observed in multicomponent refrigerant blends. The pioneering work of van Konynenburg and Scott [11] demonstrated that the van der Waals one fluid model has vast possibilities of qualitative reproducing the main types of phase diagrams of binary fluids. The proposed classification was successful and is now used to describe the different types of phase behaviour in binary mixtures. Conventional phase diagrams visualise the state of a substance as a function of temperature *T*, pressure *p*, and component concentration *x*. Therefore, they are used as a tool for visual analysis of the physical picture of the solubility phenomena. These variables are inherently different. Pressure and temperature are the “field” variables that are the same for all phases coexisting in equilibrium. The molar fraction is the “density” that is in principle different for different phases. Global phase diagrams of binary mixtures represent boundaries between different types of phase behaviour in a dimensionless space of equation of state parameters. For the first time, the idea of mapping the surface of phase equilibria onto the space of field variables, i.e., parameters of an equation of state, was proposed by van der Waals. The boundaries of the global phase diagrams (tricritical points (TCPs), double critical endpoints (DCEPs), azeotropic line, etc.) divide the space of model parameters into the regions that correspond to the different types of phase behaviour. The mapping of the global surface of a thermodynamic equilibrium onto the space of parameters of an equation of state is the most extensive and sequential system of criteria for predicting the phase behaviour of a binary mixture. The types of phase behaviour within the Van Konynenburg and Scott classification scheme of interest are characterised (Fig. 50). Contrary to apparent ideas, it turns out that the lines connecting the critical points of pure components are not continuous, and the picture of the phase behaviour of solutions is not limited to the relatively simple diagrams shown in Fig. 50. It was found that there are 6 main types of the phase behaviour of binary solutions, which have been experimentally confirmed.

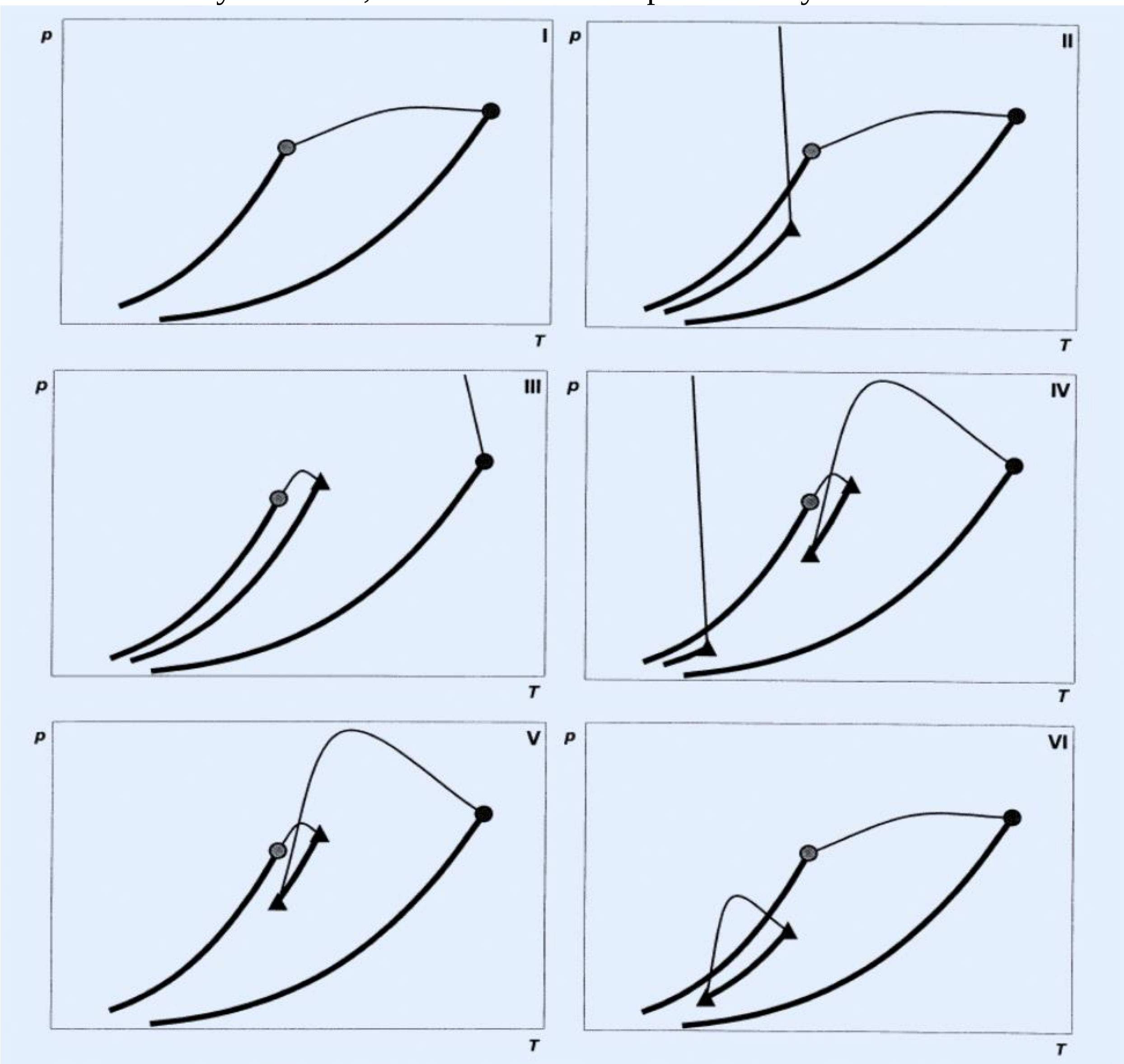


Figure 50. The main types of the phase behaviour of binary mixtures in the coordinates pressure - temperature

Type I: a single permanent critical line between **C_1** and **C_2**;

- Type II: one critical line connecting **C_1** and **C_2**, another line going from **C_m** to a critical endpoint;
- Type III: one critical line going from **C_1** to an upper critical endpoint, another line going from **C_2** to **C_m**;
  Type III-H: a subclass of III having hetero-azeotropic three-phase curve.
  Type III-A: a subclass of III with a genuine positive azeotropic line.
- Type IV: one critical line going from **C_1** to an upper critical endpoint, a second critical line is going from **C_2** to a lower critical endpoint, a third line is going from **C_m** to an upper critical endpoint.

- Type V: similar to IV, but without the low-temperature critical curve going to **C_m**.
- Type V-A: a subclass of V with a simple negative azeotropic line.
- Type VI: involving closed-loop liquid-liquid immiscibility at low temperatures and practically impossible for supercritical conditions.

Here **C_1** and **C_2** are critical points of refrigerant liquid; **Cm** is a hypothetic critical point beyond the solidification line.

At present, the topological analysis of equilibrium surfaces of binary fluid systems contains 26 singularities and 56 scenarios of evolution of the *p–T* diagrams [12].

3.2. Azeotrope classifiers

To describe the thermodynamic and phase behaviour of the binary fluids in this study, we use the one fluid model of the Redlich and Kwong (RK) equation of state [13]

$$p = \frac{RT}{v-b} - \frac{a(T)}{v(v+b)}\ , \tag{1}$$

where R is the universal gas constant and v is the molar volume; the model parameters a and b depend on the molar composition of x_i and x_j for the components i and j. The respective model parameters a and b are determined by quadratic dependences on composition and classical combining rules for the different pairs of interacting molecules a_{ij} and b_{ij}:

$$a = \sum_{i=1}^{N}\sum_{j=1}^{N} x_i x_j \sqrt{a_{ii}a_{jj}}(1-k_{ij}), \tag{2}$$

$$b = \sum_{i=1}^{N}\sum_{j=1}^{N} x_i x_j \frac{(b_{ii}+b_{jj})}{2}(1-l_{ij}), \tag{3}$$

$$a_{ii} = 0.4274\,\frac{R^2 Tc^2{}_{ii}}{P_{c,ii}}\ ,\ b_{ii} = 0.866\,\frac{RT_{c,ii}}{P_{c,ii}} \tag{4}$$

Global phase diagrams of binary fluids represent the boundaries between different types of phase behaviour in dimensionless parameter space. The dimensionless coordinates depend on the model of the equation of state; however, usually, they are represented by analogy with the coordinates introduced by van Konynenburg and Scott [11]:

$$\begin{aligned}
Z_1 &= (a_{22}-a_{11})/(a_{22}+a_{11}),\\
Z_2 &= (a_{22}-2a_{12}+a_{11})/(a_{22}+a_{11}),\\
Z_3 &= (b_{22}-b_{11})/(b_{22}+b_{11}),\\
Z_4 &= (b_{22}-2b_{12}+b_{11})/(b_{22}+b_{11}).
\end{aligned} \tag{5}$$

Global phase diagrams for all realistic models have a very similar structure, particularly for molecules of the same size.

One may obtain the relationships for azeotropy boundaries from the global phase diagram [shaded ***A*** (Azeotropy) and ***H*** (Hetero-azeotropy)] regions in Fig. 2 . The above azeotropic boundaries are straight lines in the **(**Z_1, Z_2**)**-plane that crosses at a single point in the vicinity of the centre for equal-sized molecules. It opens the opportunity for obtaining the series of inequalities to separate azeotropic and zeotropic regions of the global phase diagram. The selection criterion for azeotrope for the RK one fluid equation of state for binary mixture in global phase diagram variables [14]

$$Z_2 = \mp Z_1 - 0.67(1 \pm Z_1)\left(\frac{1-Z_4}{1 \pm Z_3} - 1\right), \tag{6}$$

where the upper signs «+» or «-» correspond to the value of the composition of the critical azeotropic point at $x_c = 0$, the lower at $x_c = 1$. According to equation (6), in the Z_1 - Z_2 plane, at fixed values Z_3 and Z_4, the boundary that separates the zeotropic and azeotropic states is a straight line). If a characteristic point is located in the northern or southern quadrants (Fig. 2), azeotropy phenomena should appear in the binary mixture.

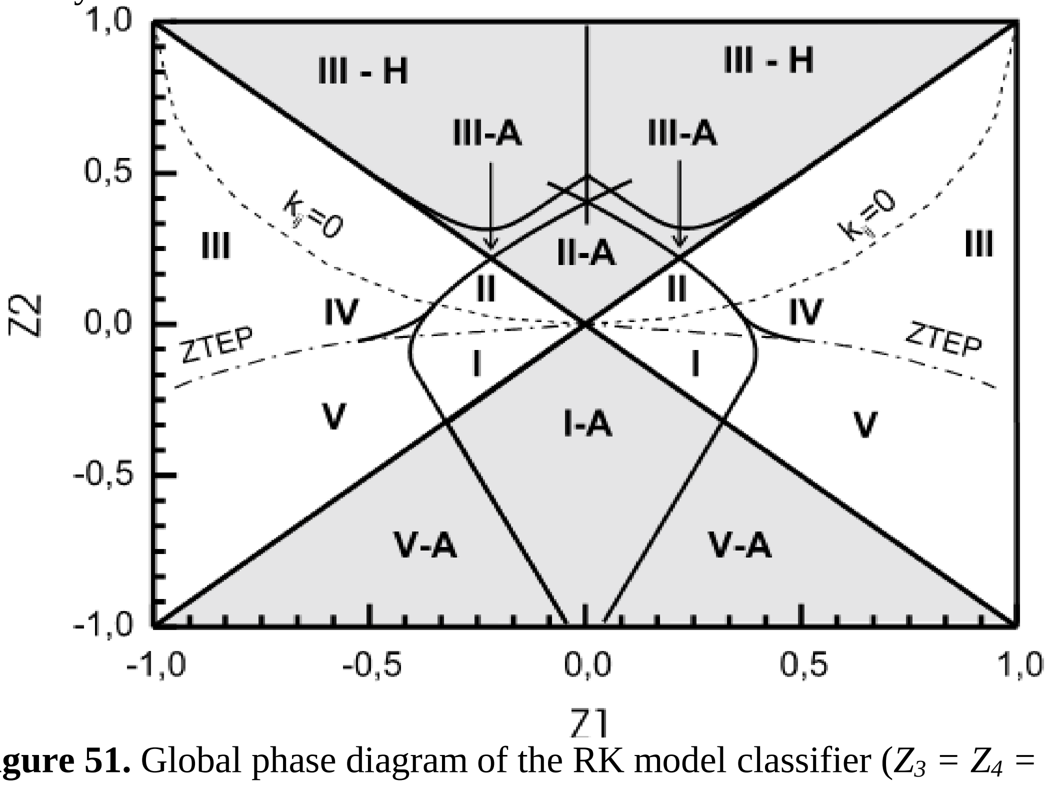


Figure 51. Global phase diagram of the RK model classifier ($Z_3 = Z_4 = 0$)

For example, in the simplest case, for the van der Waals equation of state, the critical constants are related to the geometric (free volume - *b*) and energy parameters (*a)* well-known relations, which are found from the critical conditions.

The boundaries separating the azeotropic and zeotropic states are determined by a system of thermodynamic equations [15], [16]. This relationship includes all the variety of azeotropic phenomena in binary mixtures, including azeotropic endpoint, critical azeotropic point, double azeotropic endpoint, azeotropic states in the so-called shield region and some others. A detailed list of the features of azeotropic states arising in two-component systems is given in [17]. In order to isolate the azeotropic regions, it is necessary to know the equation of state *p (T, V, x)* of the mixture and to map the above derivatives to a set of critical parameters of the components.

Here we consider the cubic equations of state for a mixture in the one-fluid approximation where *R* is the universal gas constant. Parameters *a* and *b* of the mixture, depending on the molar compositions x_i and x_j of components *i* and *j* include parameters and, as well as adjustable coefficients k_{ij} and l_{ij}, which characterise the imperfection of the solution as a result of intermolecular interactions between components *i* and *j*. Dimensionless variables, on which the thermodynamic surface of the mixture is mapped, is written either as a combination of parameters of the equation of state of pure components: or through the corresponding critical constants (T_{c1}, T_{c2}, P_{c1}, P_{c2}), as well as energy (k_{12}) and geometric (l_{12}) parameters of the interaction between the two components.

To construct artificial neural networks, models of linear networks and networks with backpropagation of an error were applied. The values of the critical temperature, critical pressure, and the acentricity factor (or normal boiling point) (*Tci, Pci, Ωi*) for each of the components were used as the input vector (Fig. 3). The training was carried out using the standard algorithms of the Neural Network Toolbox package of the MATLAB program.

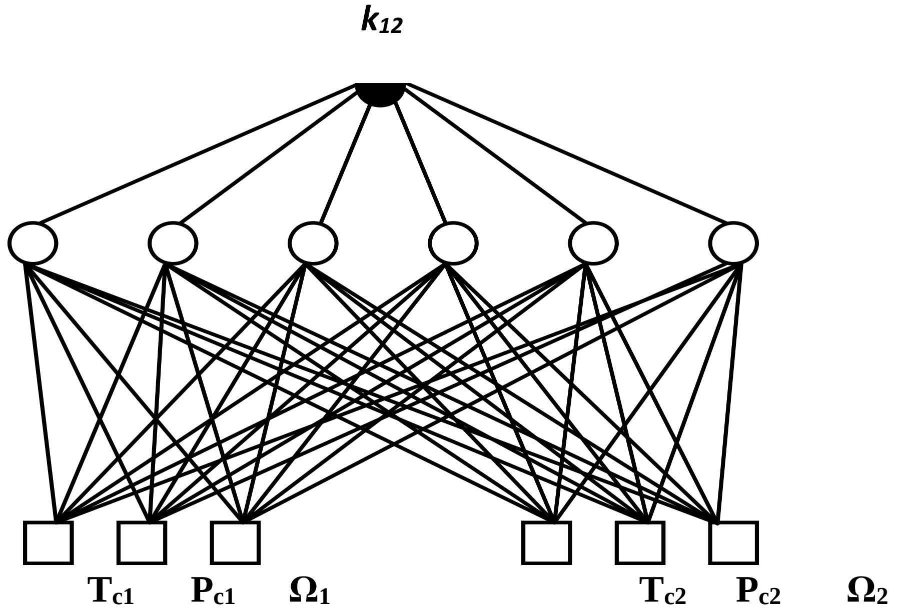


Figure 52. The inputs of simulated neural network

Reliability of the predictions of azeotropic behaviour in the binary mixtures of the refrigerants using neural networks relies on the choice of output value, which classifies mixtures as the azeotropic. We assume implicitly that the model contains submodels, including equation of state, mixing rules, thermodynamic relationships, neural networks models, phase equilibrium data, etc. Prediction of azeotrope can be obtained from the critical parameters and acentric factors of mixture's components. The algorithm is as follows: critical parameters and acentric factors for pure components are provided, and binary interaction parameter k_{12} (output value) is determined by neural network model and criterion of the azeotrope is calculated to classify an azeotrope membership [14]. The data on binary azeotropes were grouped into four subsets to obtain interaction coefficients using the available literature and experimental sources (binary synthetic refrigerants, hydrocarbon-synthetic refrigerants, and R744, hydrocarbons, R717, hydrocarbons). The correlation for k_{12} does not depend on the chemical structure of components. The subsets were selected to avoid the membership for allocated classes of substances to select training and validation sets. To demonstrate the universal approach, we included the systems formed with clearly different chemical nature of the components. Critical parameters and acentric factors applying to mixture components, as well as corresponding values k_{12} were included in the training set, which contained the data set for such systems as: R32, R143a, R32, R116, R32, R125, R32, R290, R23, R116, R744, and R125, R717 [18]. In addition, experimental data on phase equilibria for the temperature range 220 - 300K at different feeds were obtained to find interaction parameters of the RK equation of state for mixtures of natural and alternative refrigerants (CFCs, HCFCs, HCCs, HFCs, HFOs, hydrocarbons, ethers, and other). All potential cases of azeotropy appearance/absence are described for 1540 samples of natural and synthetic refrigerants.

4 ANN approach for determination of the Organic Rankine Cycle COP

The sustainable development principle considers an integrated and balanced solution of the ecological, economic, social, and cultural challenges arising from the design processes. Power generation utilising the low-temperature heat sources (320 – 570 K) as biomass, thermal solar, or waste heat has been becoming more and more significant during the last few decades. ORC uses organic working fluids, obtaining higher thermal efficiency than with water used in traditional Rankine Cycles, because of the thermodynamic properties of these fluids. The problem of selecting the working media is intricately linked with advanced technologies that incorporate sustainable development concepts. The Challenge of the working fluid selection has been treated using recent achievements of molecular theory and experimental studies.

The selection of the working fluids with pre-defined set of properties as inter alia greenhouse effect, flammability, toxicity, thermodynamic properties, performance specifications is one of the most important stages in simulation and the process design. Strategy for working fluid selection is an inverse problem of incorporating the technological performance parameters directly into the design of the ORC plants. However, algorithms for searching optimal working media that possess optimal combination of the properties can be formalised mathematically based on the multicriteria decision-making theory. The generalised efficiency criterion can be represented for the whole system by the vector ***K*,** including the local criteria ***Ki*** as the components for mapping the multiple requirements imposed on the ORC system. A final decision is defined as the intersection of all fuzzy criteria. The fuzzy criteria are represented by its membership function ***μ(X)***.

The membership function can be selected of a linear or nonlinear type upon the nature of the problem. One of the possible fuzzy convolution schemes is presented below. Maximum (minimum) values for each criterion K_i are established via scalar maximisation (minimisation). Results are denoted as “perfect” X^0 points.

The matrix *[T]*, where the diagonal elements are “perfect” points, is defined as follows:

$$[T]=\begin{bmatrix} K_1(X_1^0) & K_2(X_1^0)\ldots & K_n(X_1^0) \\ K_1(X_2^0) & K_2(X_2^0)\ldots & K_n(X_2^0) \\ : & : & : \\ K_1(X_m^0) & K_2(X_m^0)\ldots & K_n(X_m^0) \end{bmatrix} \qquad (7)$$

.

Minimum and maximum for criteria are defined:

$$\begin{aligned} K_i^{\min} &= \min_j K_j(X_j^0) = K_i(X_i^0),\ i=1\ldots n; \\ K_i^{\max} &= \max_j K_j(X_j^0),\ \ i=1\ldots n. \end{aligned} \qquad (8)$$

.

The membership functions are assumed for all fuzzy goals as follows

$$\mu_{Ki}(X)=\begin{cases} 0, & if\ \ K_i(X)>K_i^{max} \\ \dfrac{K_i^{max}-K_i}{K_i^{max}-K_i^{min}} & if\ \ K_i^{min}<K_i\ \le K_i^{max}, \\ 1, & if\ \ K_i(X)\le K_i^{min} \end{cases} \qquad (9)$$

.

A decision is determined as the intersection of all fuzzy criteria under constraints represented by its membership functions. The solution of the multicriteria problem discloses the meaning of the optimality operator and depends on the decision-maker experience and problem understanding. The criterion is written in the C-metrics form

$$K_C=\sum_{i=1}^{N}|\mu_i| \qquad (10)$$

The level of energy efficiency (Fig. 4) using the HFE – $C_5H_2F_6$(more attractive among HFEs: (CF_3OCF_2H - HFE-125), (CHF_2OCHF_2 - HFE-134), (CF_3OCH_3 - HFE-143a), ($CF_3OCFHCF_3$ - HFE-227me), ($CF_3CHFCF_2OCH_3$ - HFE-245mf), (n- $C_3F_7OCH_3$ - HFE-700-347mcc), ($C_4F_9OCH_3$ - HFE-7100 (HFE-449mccc)), and ($C_4F_9OC_2H_5$ - HFE-7200).

Working fluid selection problem has been tackled using achievements of molecular theory, engineering experience and experimental studies. The *COP* comparison among the ORC with HFE working fluids (Fig. 4) shows the maximum value 4.1% for $C_5H_2F_6O_2$ and minimum *COP* – 3.6% for C_2HF_5O.

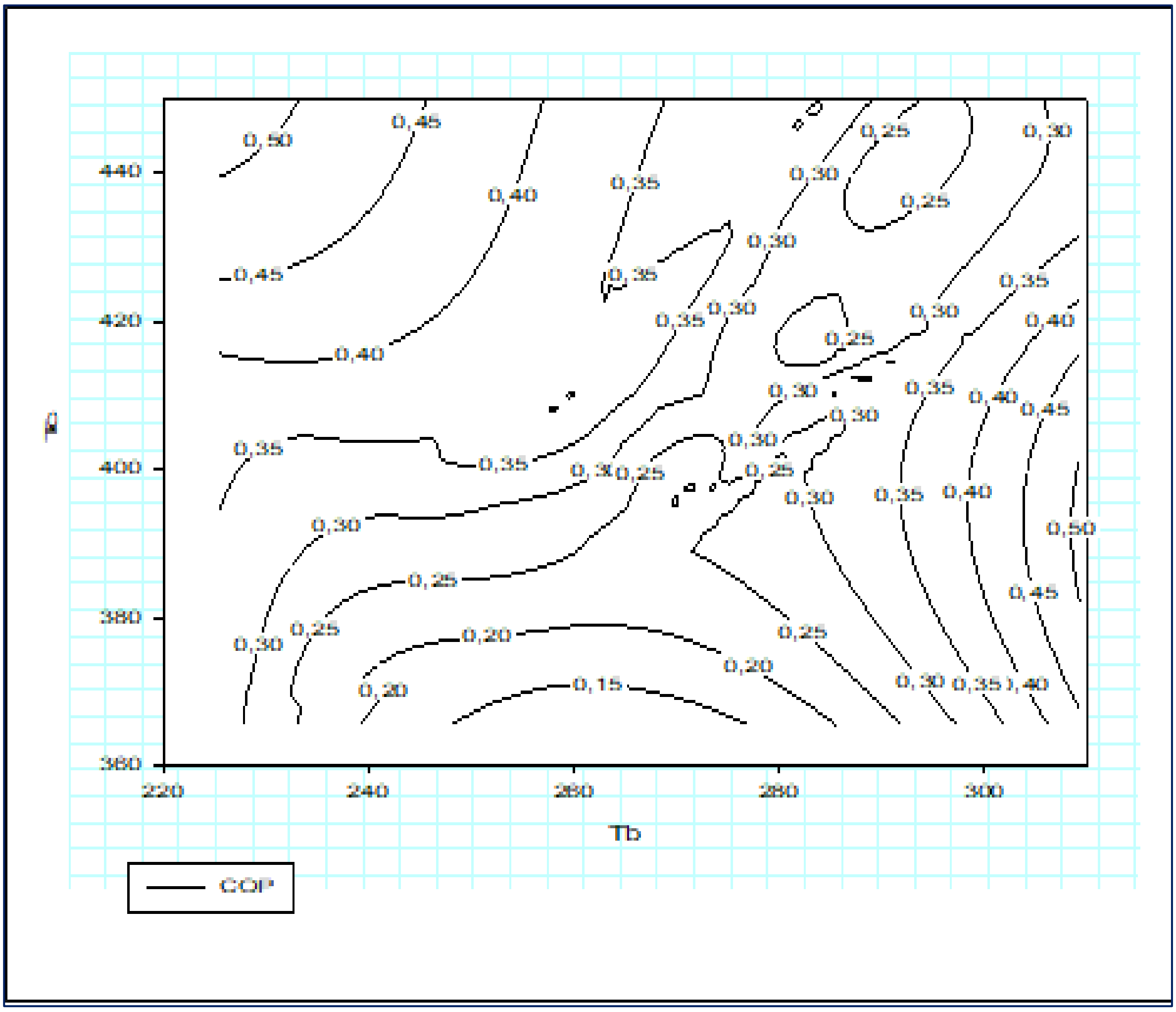


Figure 53. COP of the organic Rankine cycle with ANN as a function of the boiling point (*Tb*) and critical point (*Tc*)

5 Conclusion

A new approach to predicting the formation of the azeotropic state in a mixture is developed and presented. This approach employs synergy of neural networks and global phase diagram methodologies to correlate azeotropic data for binary mixtures based only on critical properties and acentric factor of the individual components in refrigerant mixtures and does not require intensive calculations.

The most reliable and straightforward way to transform heat into mechanical work is to apply the Rankine cycle. The typical working fluid for such high-temperature cycles is water vapour. Low-temperature heat sources (industrial heat discharges, geothermal sources, solar ponds, etc.) can also be converted into work if organic substances with a normal boiling point are lower than the boiling point for water vapour, are used as working fluids.

This study is one of the first attempts to apply the methodology of tailored, smart substances to select optimal working fluid for the ORC. Construction of ANN correlations between information attributes of the working fluids and efficiency criteria of the Rankine cycle narrows the area of compromise in the space of competitive economic, environmental, and technological criteria.

REFERENCES

1. Joss, L., Müller, E. (2019). Machine Learning for Fluid Property Correlations: Classroom Examples with MATLAB. *Journal of Chemical Education, 96(*4), 697. https://doi.org/10.1021/acs.jchemed.8b00692
2. Zhu, K., and Müller, E., A. **(**2020). Generating a Machine-Learned Equation of State for Fluid Properties. *Journal Physical Chemistry B*, *124(*39), 8628–8639. https://doi.org/10.1021/acs.jpcb.0c05806
3. Ferguson, A. (2018). Machine learning and data science in soft materials engineering. *Journal of Physics: Condensed Matter, 30*(4), 043002. https://doi.org/10.1088/1361-648X/aa98bd
4. Alves, F., Vandermeulen, J., Bamler, R., Bort, M., Mandt, S., Kloft, M., and Hasse, H. (2020). Machine Learning in Thermodynamics: Prediction of Activity Coefficients by Matrix Completion. *Journal Physical Chemistry Letter*, *11*(3), 981–985. https://doi.org/10.1021/acs.jpclett.9b03657
5. Ward, L., Agrawa, A., Choudhary, A., and Wolverton, K. (2016) A general-purpose machine learning framework for predicting properties of inorganic materials. *Computational Materials, 2*, 16028. https://doi.org/10.1038/npjcompumats.2016.28
6. Coley, C., Green, W., and Klavs F. Jensen, K. (2018). Machine Learning in Computer-Aided Synthesis Planning. *Accounts of Chemical Research*, *51*(5), 1281–1289. https://doi.org/10.1021/acs.accounts.8b00087
7. Sarma, S., Deng, D.L., and Duan, L.M. (2019). Machine learning meets quantum physics. *Physics Today*, *72*(3), 48. https://doi.org/10.1063/PT.3.4164
8. Ferguson, A., Hachmann, J., Miller, T., and Pfaendtne, J. (2020). The Journal of Physical Chemistry A/B/C Virtual Special Issue on Machine Learning in Physical Chemistry. *Journal Physical Chemistry, A*, *124*, 44, 9113–9118. https://doi.org/10.1021/acs.jpca.0c09205
9. Middleton, C. (2019). Machine learning improves image restoration. *Physics Today, 72*(2), 17. https://doi.org/10.1063/PT.3.4128
10. Ma, T., Guo, Z., Lin, M., Wang, Q. (2021). Recent trends on nanofluid heat transfer machine learning research applied to renewable energy. *Renewable and Sustainable Energy Reviews*, *138*, 110494. https://doi.org/10.1016/j.rser.2020.110494
11. Van Konynenburg P, Scott R. (1980) Critical lines and phase equilibria in binary van der Waals mixtures. *Philosophical Transactions of the Royal Society of London, Series A: Mathematical, Physical and Engineering Sciences*, *298*, 495 540. https://doi.org/10.1098/rsta.1980.0266
12. Aicardi F, Valentin P, Ferrand E. (2002) On the classification of generic phenomena in one-parameter families of thermodynamic binary mixtures. *Physical Chemistry Chemical Physics, 4*, 884-895. https://doi.org/ 10.1039/b109105k

13.Redlich O, Kwong JNS. (1949) On the Thermodynamics of Solutions. *Chemical Reviews*, *44*, 233-244. https://doi.org/10.1021/cr60137a013 76

14.Artemenko, S., Mazur, V. (2007) Azeotropy in the natural and synthetic refrigerant mixtures. *International Journal of Refrigeration, 30,* 831- 839. https://doi.org/10.1016/j.ijrefrig.2006.11.010

15.Deiters UK, Kraska T. (2018) High-Pressure Fluid Phase Equilibria: Phenomenology and Computation. Elsevier; p. 370. ISBN: 9780444563545

16.Kolafa J. (1999) Azeotropic phenomena in the global phase diagram of the Redlich- Kwong equation of state. *Physical Chemistry Chemical Physics*, *1*, 5665 - 5670. https://doi.org/10.1039/A906114B

17.Patel K, Sunol A. (2009) Automatic generation of global phase equilibrium diagrams for binary systems from equations of state. *Computers and Chemical Engineering, 3*,1793. https://doi.org/10.1016/j.compchemeng. 2009.03.004

18.McLinden, M., Huber, M. (2020). R) Evolution of Refrigerants. *Journal of Chemical & Engineering Data, 65(9)*, 4176-4193. https://doi.org/10.1021/acs.jced.0c00338

IX. AI ON ENVIRONMENTAL PROTECTION

9.1. Reasonable international technologies for environmental protection

Vira Tupychak
Deputy Director for Educational Work, Biology Teacher
of the Popelivka Educational Complex «General Secondary Education Institution of I-III Grades - Preschool Education Institution» of Boryslav City Council of Drohobych District, Lviv Region
E-mail: vira180480@gmail.com

Marian Uniatytskyi
teacher of computer science
Popelivsky educational complex «Institution of general secondary education of I-III degrees - institution of preschool education» of Boryslav city council of Drohobych district of Lviv region
E-mail: unyatytskyy@gmail.com

Reckless human activity, which destroys natural resources and pollutes nature, has led to the fact that the planet is in a critical state. With the development of civilization and scientific and technological progress, the great growth of the population on Earth, through production and its waste, the problem of ecology is becoming more acute. This was caused by famine, polluted rivers and seas, polluted air in large cities, many extinct species of animals and plants. Today, environmental protection is a key issue in the political and legal space and an important issue that exists at the national, regional, European and international levels. The critical situation in the field of environment is well known. The globalization of environmental problems requires comprehensive operational measures to protect the local, regional and universal environment. The environmental problem is one that states cannot solve on their own, relying solely on their own strength. This state of affairs necessitates measures to protect the environment at the international and supranational levels.

The most intensive national and international legal regulation of environmental protection is carried out on the European continent. The solution to the environmental problem has been particularly successful in the context of European integration, which has ensured stability, peace and economic prosperity over the past sixty years. It has helped raise living standards, create an internal market, introduce the euro and strengthen the role of the European Union (EU) in the world. The European Union is paying close attention to this issue, as further economic growth and political integration of the Member States are impossible without taking into account the environmental factor. Environmental issues are of concern to various institutions and bodies of the European Union. At the international level, the European Union takes an active law-making position in the field of environmental protection, participates in various intergovernmental conferences and international organizations on this issue, promotes UN measures for the transition to sustainable development..

Note also that the prospects for research are seen in the deepening of the participation of scientists in solving the most pressing socially and economically significant problems, the solution of which is directly related to environmental protection and the establishment of measures for production, sale, use or waste. Just as technological progress has negatively affected the environment, it is possible to protect the environment through this progress. Many organizations are working on this issue: Global Nest, World Wide Fund for Nature, Greenpeace, European Environment Agency and others.

International environmental cooperation

In recent decades, the process of forming a new system of values of social, economic and ethical nature, including the environmental imperative, has begun at the international level. The end of the twentieth century was marked by an awareness of the mutual responsibility of states for the state of the environment. International communication, cooperation in solving environmental problems, mutual consultations and exchange of information have become the norm. The main goal is to develop a system of global environmental security.

After all, the growing impact of human activities on the environment causes undesirable changes in the natural environment: pollution of the air basin, oceans, depletion of natural resources worldwide. And the violation of ecological balance causes great damage to the gene pool of all living things, including humans. Therefore, the problem of harmonization of relations between society and nature, environmental protection has become global. There is a need to develop effective international mechanisms that would ensure the rational use of the planet's resources, their protection, would contribute to the preservation of ecological balance.

The need for international legal regulation of environmental protection is due to the fact that nature does not recognize state borders. Pollution of air and water resources, in particular the world's oceans, is transboundary. The problems of climate change, ozone depletion, and desertification are global. Some of the unique natural complexes, areas and sites that are specially protected are located in several states, which requires coordination of their efforts. The nature of environmental problems is global. They cannot be solved separately in one or another state.

Environmental protection involves addressing this issue at the regional and international levels. The solution of all these problems is possible only on the basis of international cooperation carried out on a bilateral and multilateral basis. Forms of such cooperation are the organization of scientific and practical meetings; creation of international organizations that coordinate joint efforts for nature protection; conclusion of official treaties and agreements, as well as the activities of international public organizations. A series of specific programs for the study and protection of certain areas, the creation of reserves and national parks. An important task is the promotion of environmental knowledge, training of specialists in nature protection, the formation of environmental knowledge and the creation of new institutional structures.

Important documents in international environmental relations are the World Charter for Nature Conservation, which proclaimed and protected the right of all life to survive; Convention on the Prohibition of the Use of the Force and of Hostile Means of Influence on the Environment, which is a set of basic principles of international cooperation; Climate Change Convention; Convention on Biological Diversity, Convention to Combat Destruction. Of particular importance is the main document adopted by UNCEP, Agenda 21 - A Global Plan of Action for Sustainable Development, which should be understood as a model for the socio-economic progress of society where the vital needs of people are met by the rights of future generations. living in a healthy and inexhaustible natural environment. In addition, achieving sustainable development is impossible without a fairer use of nature's resources, the fight against poverty, on the one hand, and unacceptable luxuries, on the other.

There are two levels in the structure of international environmental policy:

1. International global environmental policy is the development and implementation of international legal, political and foreign economic actions, taking into account environmental constraints in socio-economic development, the world's natural resources and their distribution between regions and countries. The purpose of such a policy is to preserve the global integrated resource of the planet. Therefore, in the course of its implementation, zones, quotas and limits on the use of certain minerals are set, pollution charges are agreed, and emissions of certain substances are banned. International global environmental policy is still under development, although it is the main focus of all international environmental forums. Sometimes it can become quite aggressive, beyond international agreements and norms. An element of global environmental policy is a certain transnational level, common to several states linked into a single ecological system, the state of which affects these countries in the first place.

2. International regional environmental policy covers the interests of countries on one continent, which are united by natural and geographical environment, sometimes by one sea or river. The countries with common borders have the closest contacts. They also determine the nature of transboundary transport of air, water, set quotas for the extraction of natural resources, etc. It should be noted that the regional environmental policy, unfortunately, has not yet gone beyond general declarations of emerging threats. Countries operate mainly in isolation at their state level. As a rule, there is no clear coordination between the nearest neighbors.

UN experts believe that the main international efforts in resolving the global environmental crisis should now focus on:

- researching the root causes of the crisis, assessing global risk and combating its consequences;
- involving the general public and providing legal remedies,
- investing in our future through smart international technology.

Thus, environmental issues are increasingly becoming a priority in international relations. The European Union has become a basic platform for solving global problems facing humanity, including the establishment of the legal framework for a single environmental strategy and the development of European principles and national systems of environmental legislation, as well as the establishment and implementation of environmental standards. A powerful force in the development of modern society is the intensive global spread of information and communication technologies that help collect, store, analyze and disseminate information.

It should be noted that the greatest development of information technology has reached in the United States. Computers created by computers and posted on the website of the Silicon Valley Toxicants Coalition, which contain data on pollution, are just one example of how information technology helps people monitor the environment. There are many other examples. Satellite sensors give us clearer pictures of changes in the environment than ever before. Many of these images include the spread of fires in the rainforests of southeastern Africa, the loss of ozone over Antarctica, and the shrinking and shallowing of the Aral Sea. Today, more and more satellites are capturing such pictures of human activity on Earth. The European Space Agency (ESA) is also quite active in this direction. An example of this is the Global Monitoring for Environment and Security project. The growing flow of satellite data provides invaluable information, in particular for the management of nature, the assessment of the consequences of natural and man-made disasters and the distribution of humanitarian aid. Mention should also be made of a joint UNESCO-ESA project to save World Heritage sites, which provides continuous monitoring of various architectural and natural monuments, as well as national parks and habitats of rare and endangered species of animals and plants.

One of the most important issues is the solution of demoregulation and the introduction of effective biotechnology and smart international technologies to protect the environment. Computers and GIS software (geographic information system) allow you to store, analyze and skillfully use images obtained by satellites. This information, along with ground-based observations and other data, can help researchers study pollution and other environmental hazards, locate resource-rich regions, and model changes in the environment. It can also help those who plan and make decisions to better build our relationships with the environment. In addition, researchers are using computers to study a variety of environmental scenarios, from alternative vehicles for urban transportation to burning fossil fuels around the world.

What is Geographic Information Systems (GIS)? This is a modern computer technology for mapping objects of the natural environment, as well as real events occurring in it. GIS stores many layers (slices) of information tied to the area. Data layers can contain satellite images, topography, state borders, rivers, highways, power lines, pollution sources, wildlife habitats.

Maps stored in GIS allow you to take advantage of computers that can store large amounts of data and perform complex multiple calculations. Thus, by entering into the GIS a variety of data tied to the terrain, you can use a computer to determine changes over time, study the interaction between different slices of data, change parameters to ask the question "what if?", And also the study of various alternatives for choosing the option of further action.

Geographic information system provides the possibility of long-term storage, periodic replenishment and updating of information. With unique capabilities for full analysis and operation of geographic information, GIS is a real tool that can provide an information basis for making optimal management decisions. The ability to process spatial information presented on maps is fundamentally different from GIS from other information systems.

Thus, GIS technology provides a new, more modern, more efficient, convenient and fast means of analyzing and solving problems.

Computer programs are also helping Europe's efforts to stop transboundary air pollution, which has killed fish in small Scandinavian rivers and trees in Germany's Black Forest caused by sulfur dioxide emissions from the burning of fossil fuels. The model, developed by scientists from a non-governmental research institute in Austria, made it possible to analyze the environmental impact of different sulfur emission scenarios. In preparing the decision, the computer indicated how reductions could be made to protect ecosystems from exceeding the «critical level» of acid rain, beyond which long-term disturbances are likely.

In addition, GIS helps environmental activists identify local sources of pollution; enables developing country energy agencies to identify the best locations for renewable energy facilities, such as wind turbines, and helps environmental groups develop effective natural resource management and biodiversity strategies. The New York Public Interest Group, through its community mapping project, demonstrated the power of maps to local activists. Using a fairly simple GIS, activists from local communities in contaminated areas and its suburbs were able to create maps that linked the location of businesses such as garbage stations, refineries and wastewater treatment plants, and places where high levels were recorded. incidence of cancer and asthma.

Several large environmental organizations have also used GIS. The Washington-based Conservation International was one of the first to bring the technology to developing countries. The group has developed relatively inexpensive GIS in various languages and has invested heavily in training local professionals to create databases and maps to better manage national parks and other natural resources. Today, these computer programs are used by more than 200 organizations in at least 30 countries.

Another environmental group, the Wildlife Fund (WWF), uses GIS to conserve the environment in a wide range of projects - from local. By regionally and globally combining satellite imagery with many other types of data, such as the road network and national parks and other areas, the team can help local and state authorities identify priority areas for biodiversity conservation. In the field of environmental management today there are several areas of specialization of GIS, which have practical application:

- GIS for site management (national, regional, local and object levels);
- GIS for inventory. natural resources,
- monitoring GIS of dangerous objects;
- GIS for geospatial data banks;
- GIS for thematic and specialized data banks;
- GIS for corporate systems

Thus, GIS is a modern computer technology that allows you to combine a model image of the territory (electronic display of maps, diagrams of space and aerial images of the earth's surface) with tabular information (various statistics, lists, economic indicators, etc.).

Technologies for environmental protection

An important point for environmental protection is its monitoring. Sometimes it is difficult to monitor due to the complexity or high cost of the equipment. But now, with the introduction of STEM lessons in schools, a lot of equipment has appeared to create interesting devices. The ideas and devices that students create are very interesting and need more consideration.

A good example of this is the Ukrainian student Valentyn Frechka, who is an honorary member of the Small Academy of Sciences of Ukraine and has been engaged in research for many years. He participated in various competitions in Tunisia, won gold at the Ecology Olympiad in Kenya, presented his invention at the Genius Olympiad 2018 in the United States. At first it was an experiment, but now the project has been transferred to paper production.

Simple and inexpensive tools for monitoring the environment are platforms on Arduino microcontrollers, Rasbery Pi single-board computers, NodeMCU platform with built-in Wi-Fi and others. Based on these tools, you can create many interesting devices for monitoring the status ecology and to create tools and robots for cleaning nature and beyond. Based on them, you can create servers to which various sensors are connected and receive data in real time via the Internet. Depending on the readings of the sensors, prohibit traffic on streets with excessive readings.

A similar idea was used by Google in 2017. University of Texas at Austin employees installed sensors and equipment for air monitoring on the Google Street View car. Google Maps displays places with different air pollution. Google also cooperates with the State Coinspection of Ukraine. With Ecoinspector 2 and Google Maps, you can report environmental issues to an environmental inspectorate at a location determined by your geolocation. Another interesting service from Google is Your Plan, Your Planet. He gives advice on how to properly cook, take a shower and more, to reduce the harmful effects on the environment.

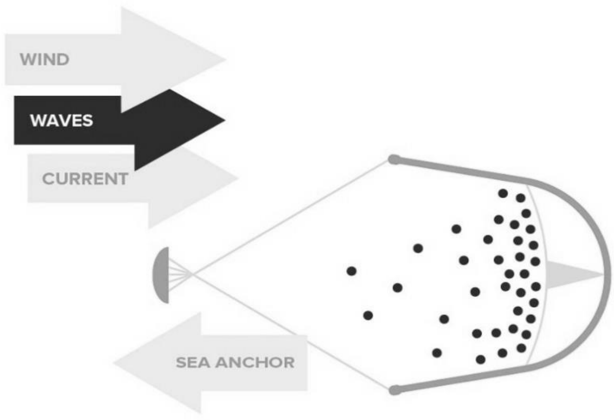


Figure 54. NodeMCU platform
Source: (https://seaclear-project.eu)

Many other useful applications for environmental protection are being developed by IT companies in Ukraine. So GlobalLogic has created the EcoHike application, which allows you to mark places on the map with garbage. With this application, it is easier for volunteers to organize their work on already knowing in advance the places with garbage to clean them. After cleaning, people mark the cleaned places in the application. Microsoft is also actively working to improve the world's environment. It is launching the Planetary Computer project, which will allow it to track changes in the environment. Microsoft also announced that it plans to become more environmentally friendly by 2030.
By 2025, it plans to convert its employees to electric vehicles and servers and offices to environmentally friendly energy.

Speaking of electric cars, they are increasingly found in cities around the world. According to J. P. Morgan, by 2030 only 41% of cars in the world will have internal combustion engines. More and more countries are abandoning the sale of cars with internal combustion engines, preferring electric cars and hybrids. Some of Europe's largest cities, such as Barcelona and Madrid, have only allowed cars to travel around the city without emissions. In the future, more and more cities are joining this initiative. This frees cities from harmful emissions and increases clean air. The Ocean Cleanup system works to clean the oceans from debris. This is a 600 meter long installation that collects garbage. The authors of the system say that the use of their installation will help reduce the garbage spot in the Pacific Ocean in two years. This system collects debris from the ocean's surface.

Deep-sea debris will be removed by autonomous underwater SeaClear projects. These works will collect garbage independently. With the help of artificial intelligence, they can distinguish debris from fish and other inhabitants of the oceans. The system consists of a main ship, a drone and underwater robots. The drone and one of the robots will look for rubbish, after which the other robot will dive in and remove the underwater rubbish. The robots will be controlled and powered from the ship.

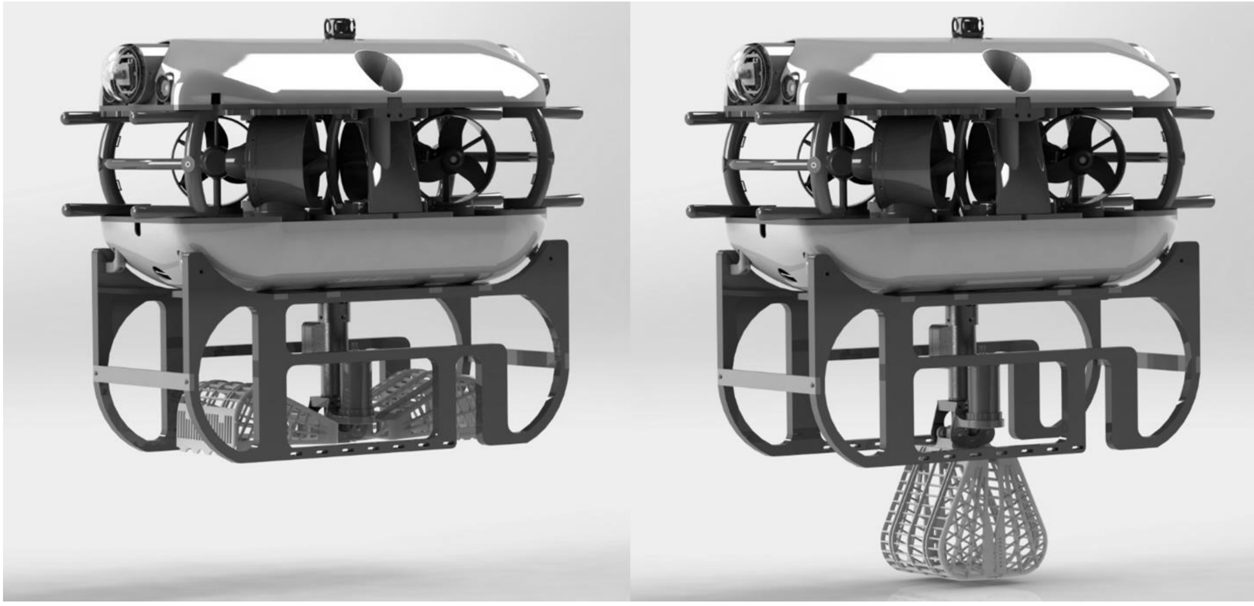


Figure 55. Underwater robot for garbage collection SeaClear
Source: (https://seaclear-project.eu)

To clean rivers of debris in the United States was created by Mr. Trash Wheel. It is a ship that catches debris with the help of a water wheel and solar panels. Then it places the waste in a container, from where it is delivered for recycling.

Figure 56. The mechanism for cleaning rivers from debris Mr. Trash Wheel
Source: (https://www.mrtrashwheel.com

To save forests from deforestation in Peru, Rainforest Connection has developed devices called "Guardians". They consist of smartphones connected to solar panels. They respond with machine learning algorithms to the sounds of chainsaws and send data on where the felling is taking place.

Figure 574. "Forest guard"
Source: (https://www.nbcnews.com)

Environmental pollution also occurs from space. Spent spacecraft, which are essentially space debris, entering the Earth's atmosphere burn up and turn into debris on the surface of our planet. That's why Japanese scientists have joined forces and plan to create the world's first wooden satellites by 2023. Burning in the Earth's atmosphere, these satellites will not make harmful emissions into the atmosphere.

Conclusions

A variety of technologies not only make our lives easier and better, but also help us preserve the environment in different parts of our planet and even in space. But communication systems such as the Internet and cell phones speed up the exchange of all kinds of information, including environmental data. By connecting long-distance people, the network helps researchers and activists work together to solve environmental problems. An increasingly extensive communication network also transmits information to remote areas where it can be used to support human development - to help teachers expand their curricula, doctors to provide people with information and ambulances, farmers and rural entrepreneurs to access urban areas. markets for their products.

And another use of information technology works in favor of the environment - for example, the replacement of computer data of the actual use of materials and energy or the replacement of communications (telecommunications) transportation needs. But the ultimate impact of information technology on the environment is far from clear. The downside is that computers consume electricity and use paper, and radio and television and the Internet transmit advertisements and programs that can encourage people to buy resource-intensive goods.

Computers, satellites, televisions and other telecommunications equipment during their lifetime significantly burden the Earth's resources. The production of computers requires energy and water, and also creates waste, many of which are hazardous. Toxic solutions, acids and heavy metals are used in the production of semiconductors, printed circuit boards and cathode ray tubes for computer monitors and television screens. For example, the production of a 25 kg computer generates 63 kg of waste, 22 kg of which is toxic.

Computers and mobile phones are a huge problem for their disposal, partly because they age quite quickly. Based on this, repairs are quite expensive compared to the cost of a new product. When computers are thrown away as rubbish, lead in monitors, mercury and chromium in the main processor unit, arsenic and halogen organic matter inside the devices - all pose a health risk. Recycling computers and phones complicated by the fact that the design of most of them does not provide for such a possibility, so the recycling of computers is economically unprofitable. It is especially difficult to recycle small electronic devices such as mobile phones.

Although remote sensing, GIS, and other technologies can contribute to our understanding of how we change the planet, they are not able to replace direct knowledge of the environment. Even when information technology helps to build environmental databases and connect people, they can also separate people from the world around them. The time spent at the computer in collaboration with distant colleagues via e-mail or in cell phone conversations is the time that was not spent in face-to-face communication or in interaction with nature. A recent study found a link between excessive Internet use and depression, confirming that e-communication will not be able to replace the time spent on personal relationships.

Information technology not only shapes our worldview, but also enhances our ability to change the world. We are responsible for using these tools to build a healthier and fairer future.

REFERENCES

1. Retrieved from: https://blogs.microsoft.com
2. Retrieved from: https://deisumy.gov.ua
3. Retrieved from: https://www.globallogic.com
4. Retrieved from: https://greencubator.info
5. Retrieved from: https://hmarochos.kiev.ua
6. Retrieved from: http: //www. oecd. org /
7. Retrieved from: https://seaclear-project.eu
8. Retrieved from: https://www.mrtrashwheel.com
9. Retrieved from: https://nachasi.com
10. Retrieved from: https://www.nbcnews.com
11. Retrieved from: http: //www. unece. org /press /execsec /current_ exec. html
12. Retrieved from: http: //www. unep. org /
13. Retrieved from: https://yourplanyourplanet.sustainability.google
14.Agreement of 5 march 1973 amending the agreement of the representatives of the governments of the member states meeting in council of 28 may 1969 concerning standstill and information for the commission // OJ C 009, 15 /03 /1973, P. 3.

15.Commission Decision of 26 November 1995 approving the programme for the eradication of rabies for 1997 presented by France and fixing the level of the Community's financial contribution (Only the French text is authentic) // OJ 023, 24 /01 /1997, P. 10.

16.Council Directive 75 /440 /EEC of 16 June 1975 concerning the quality required of surface water intended for the abstraction of drinking water in the Member States // OJ L 194, 25 /07 /1975, P. 26-31.

17.Council Directive 75 /442 /EEC of 15 July 1975 on waste // OJ L 194, 25 /07 /1975, P. 39-41.

18.Council Directive 92 /43 /EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora // OJ L 59, 08 /03 /1996, P. 63.

19. Antonyuk N.V. European Union: politics, economics, law: textbook / N.V. Antonyuk, M.M. Mikievich. Lviv, 2005. 532 pp.

20. Vyshnyakov OK Pravo of the European Union: textbook / OK Vyshnyakov. - O .: Phoenix, 2013. 883 pp.

21.Dubovik O.L. Ecological law of the EU: formation, development, achievements and current tasks / O.L. Dubovik // Law and Politics. 2004. № 12. P. 58-67.

22. Kashkin S. New program of actions of the European community in the field of environment / S. Kashkin, P. Kalinichenko // Russian justice. 2003. № 8. P. 19-20.

23.Kashkin S. Yu. Pravo Evropeyskogo Soyuz: uchebnik dlya vuzov / S. Yu. Kashkin. 3rd ed., Reworked. and ext. M .: Higher education, 2010. 1119 pp.

24. Kremer L. Ecological law of the European Union / L. Kremer, G. Winter; resp. ed. O.L. Dubovik. M .: 2007. 144 p.

25. Lozo V.I .Legal bases of ecological strategy of the European Union (concept, software, systematization and commentary of the current legislation of the EU): monograph / V.I . Lozo. X .:2008. 368 p.

26. Lozo V.I . The beginning of software for the legal basis of the environmental strategy of the European Union / V.I. Lozo // Theory and practice of jurisprudence: Electronic scientific professional publication of the National University "Yaroslav the Wise Law Academy of Ukraine". 2012. Vip. 1 (2). Retrieved from: http: // nauka. jur-academy. kharkov. ua / index. php? option = com_co ntent & view = article & id = 373 & Itemid = 229 & lang = uk

27. Mazur I.I. Globalism.Encyclopedia / I.I. Mazur, A.N. Chumakov. M .: Raduga, 2003. 1328 pp.

28.Mikievich MM European environmental law: a textbook / M.M. Mikievich, N.I. Andrusevich, T.O. Budyakova. L .: Lviv National University. I. Franka, 2004. 256 pp.

29. Popovych Yu. Experience of realization of ecological policy of EU by the countries of Central and Eastern Europe: lessons for Ukraine / Yu. Popovych // Virtual bibliographic reference. United Reference Service of Libraries of Ukraine, 2012. Retrieved from: http: //www. nbuv. gov. ua /portal / soc_gum /Dums /2012_2 /12pydeuu. pdf

30.Declaration of the Council of the European Communities and of the representatives of the Governments of the Member States meeting in the Council of 22 November 1973 on the programme of action of the European Communities on the environment // Official Journal C 112, 20 /12 /1973 P. 1-2.

9.2. Methodology of application of artificial intelligence in cognition and management of economy ecologization

Viacheslav Stepanov
Doctor of Sciences (Economics), Professor,
Institute of Market Problems and Economic and Ecological Research,
National Academy of Sciences of Ukraine
E-mail: stepanov.ipr@gmail.com
ORCID ID 0000-0001-5432-1115

1. Statement of the problem. In recent decades artificial intelligence has been actively used for solving problems of harmonization of economy, technosphere and natural environment. Artificial intelligence is used in the digital economy, knowledge economy, information economy and also to solve environmental problems. In this regard, we consider it is necessary to stress the following. Firstly, the triad of the development of society is economy, sociology and ecology. They are considered to be the pillars of civilization. Secondly, within the framework of artificial intelligence, both the digital economy and digital sociology and digital ecology are actively developing.

Taking into account the interconnection of economy, sociology and ecology in the modern world, we will clarify their “digital” content and expand the intellectual comprehension of the ecological component. In this regard, we proceed from the following conditions:

- increasing challenges and threats to the national security of Ukraine in the environmental sphere [1];
- increasing of attention to artificial intelligence in the Ukraine, which is expressed in the adoption in 2021 of the "Concept of Development of Artificial Intelligence in Ukraine" [2];
- complexity and nonlinearity of social, economic and environmental processes, the problems of which cannot be solved by traditional linear methods.

Based on the above conditions and prerequisites, this section aims to discuss methodological approaches of artificial intelligence in managing of economy ecologization considered in the context of Ukraine's interests. Within the framework of formulated goal, this paper sets the following tasks:

- a qualitative assessment of the potential for the development of artificial intelligence in Ukraine and the possibilities of its implementation in the system of greening of socio-economic development;

- concretization of the problems of economy greening as an object of artificial intelligence application;
- development of the model of implementation of artificial intelligence implementation for economy greening.

In this paper, the approaches to the analysis of the discussed problems are considered in the context of methodology of post-nonclassical science [3].

2. The potential of artificial intelligence development and application in Ukraine. In recent years, artificial intelligence has been actively developing in Ukraine. In order to insure this process the Ministry of Digital Transformation (MDT) of Ukraine was created. In 2020, the Cabinet of Ministers of Ukraine approved the "Concept of Development of Artificial Intelligence in Ukraine until 2030". This Concept aims to increase the competitiveness of Ukraine through application of artificial intelligence in science, socio-economic development, environmental protection and cultural spheres.

Ukraine has sufficient potential for successful implementation of this Concept. By the beginning of 2020 in Ukraine were created about 150 companies that develop artificial intelligence products. This is the largest number of companies in Eastern Europe. The Concept of Development of Artificial Intelligence in Ukraine, developed by the Ministry of Digital Transformation of Ukraine, is focusing on 8 directions:

1) education and human capital;
2) cybersecurity;
3) science and innovations;
4) economics and business;
5) defence and security;
6) public administration;
7) legal regulation and ethics;
8) justice.

In our opinion, at the subsequent stages of development and implementation of this Concept, it is necessary to develop also the section "economy greening" in order to address the strategic problems of Ukraine. In the context of the indicated prospects for global and regional ecologization, in this paper we will discuss some theoretical and methodological aspects of the development and implementation of artificial intelligence tools in the economy greening. In this regard, the following tasks are set:

- artificial intelligence communities development;
- legal framework development aimed at protecting the interests of the industry;
- integration of stakeholders around the idea of artificial intelligence promotion in Ukraine and other countries;
- implementation of social projects aimed at drawing attention to the problems solved with the help of artificial intelligence.

For example, the Ministry of Justice of Ukraine with the help of the Ministry of Digital Transformation has launched Kassandra program, which allows to prevent repeated crimes.

It should be also added that in Ukraine was created Association for the Development of Artificial Intelligence (ADAI) in 2020. This organization aims to integrate national potential of artificial intelligence in Ukraine.

According to Deep Knowledge Analytics, it includes 57 companies. 28 companies and 2,000 developers specialize directly in artificial intelligence and cover about 12% of the world market. Today Ukraine has the second place on the market of artificial intelligence products in Eastern Europe.

3. Problems of economy greening as an object of artificial intelligence application. The need to use artificial intelligence tools in the field of economy greening is conditioned by to the need of a transition to the VI and VII technological order. This, in turn, predetermines the need to search for new paradigms of greening, oriented towards the future [4-6].

In our opinion, artificial intelligence focused on solving the problems of ecologization should be defined as a subjective function of anthropogenic nature for decision making.

One of the objects of artificial intelligence application is self-organization of environmental and economic processes. It is important to emphasize that self-organization of ecological and economic processes requires complicated decision making, since a self-organizing structure is a dissipative structure in which energy (material, financial, etc.) is constantly dissipating.

Artificial intelligence application for economy greening should take into consideration relationship between society and natural environment. The lack of communication between ecology, economy and society can cause disbalance and additional stress on environment.

A lack of understanding of these problems has actually led to failure to achieve sustainability of the world community. In this regard, the famous Polish scientist Ryszard Domanski emphasized: “The intellect of society, managing values, among which one of the most important is protection of natural environment, makes it possible to establish such relationships and their sequence that no one member of the system is a subject of destruction to the extent leading to irreversible disorganization” [7, p. 344].

Thus, the intelligence of society, implemented in particular in artificial intelligence goes beyond the region or a single state. As an example of the threat of irreversible disorganization can be acid rains in the Ukrainian Carpathian region, the sources of which are located outside of Ukraine.

4. System model of artificial intelligence directions (context of ecologization). This section aims to discuss some system representation of artificial intelligence in the following aspects:

a) presentation of artificial intelligence system in the context of economy greening;

b) focus on concepts and experience of using artificial intelligence in the world and in Ukraine;

c) possibility of artificial intelligence application in relation to the tasks of greening the socio-economic development.

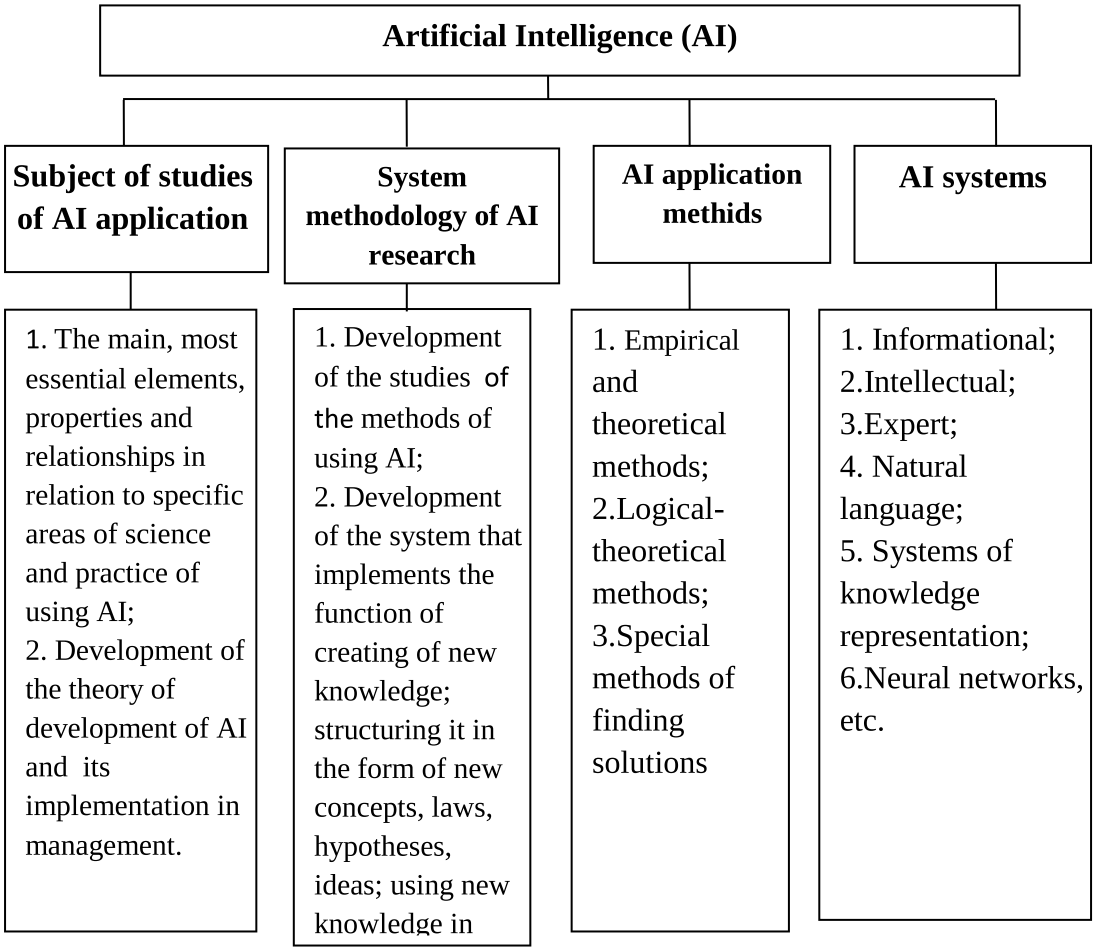


Fig. 58. Subject and objects of research and application of artificial intelligence

In relation to economy greening let us concretize such issues as:

1) conditions and prerequisites of artificial intelligence development in Ukraine;

2) artificial intelligence as an area of complex scientific research and possibility of practical use of artificial intelligence;

3) directions of artificial intelligence research in the context of the transition from technocratic to intellectual and innovative methods of management.

The results of the analysis of these issues can be summarized as follows. In a broad sense, artificial intelligence is considered as:

- the field of complex scientific and technical research of automation of intellectual activity in order to expand its capabilities on the basis of computer support;

- one of the directions of computer science, associated with the development of machines with learning and logical thinking capabilities similar to computing;

- capabilities of intelligent systems to perform creative functions that are considered to be the prerogative of a human.

Artificial intelligence is also considered as integration of disciplines in the fields of software, logic and philosophy, the goal of which is to create computers capable of performing functions previously unique to human [8, p. 245-247]. In fig. 58 is presented subject and object of research in the field of artificial intelligence for the purpose of its practical use in economics, sociology, ecology.

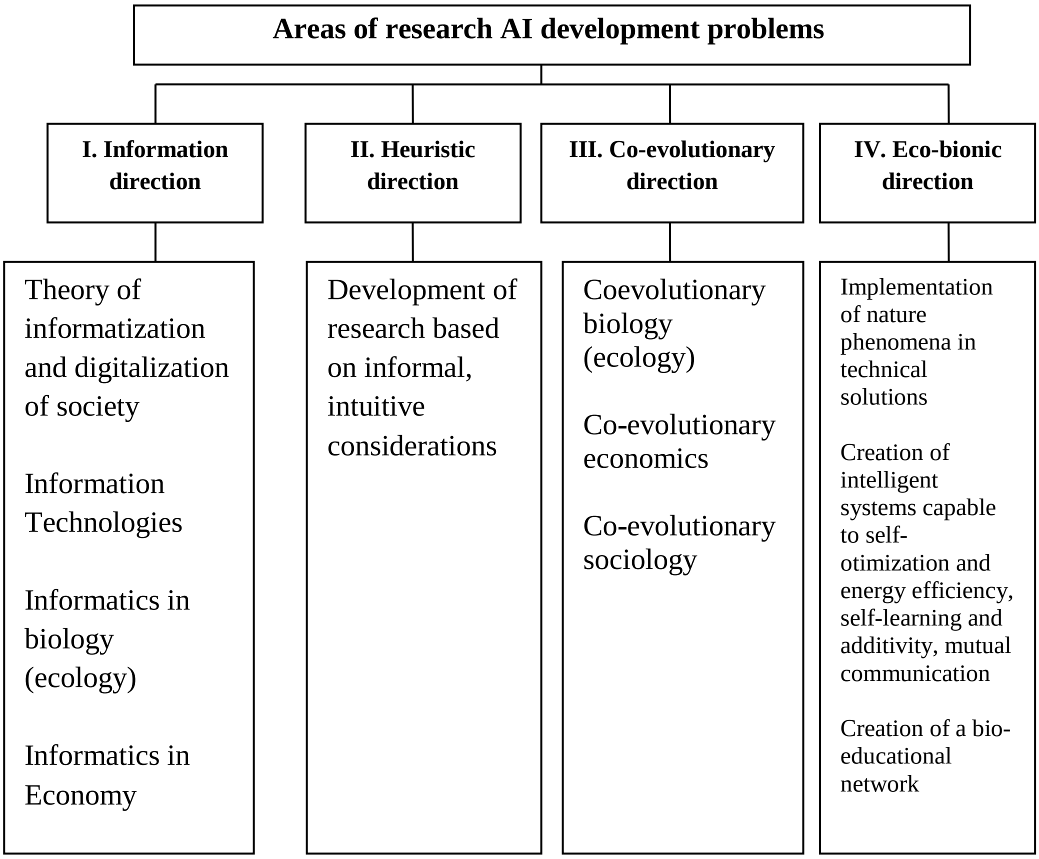


Fig. 59. System model of research directions of artificial intelligence

In this regard, ecology in conjunction with the development of artificial intelligence can give rise to a new direction - intellectual ecology. In the context of subject-object analysis, the artificial intelligence system can be represented in the following structural and functional form, reflecting the directions of research of artificial intelligence in relation to ecologization of social development:

1) Information direction - analysis of environmental data and information, development of environmental information systems;

2) Heuristic direction - into account informal, intuitive considerations in the complex phenomena studies;

3) Co-evolutionary direction - the study of the interdependent existence and development of society and nature;

4) Bio (economic) direction – implementation of the principles of bioorganisms and ecosystems in technical devices and economic systems.

System model of areas of research of artificial intelligence, built on the principles of the deductive-hypothetical approach, is shown in Fig. 59.

The quintessence of these directions can be presented as following:

1. *Information direction*. Modern informatization of socio-economic development greening is conditioned by the following points:

- informatization and digitalization as one of the most important productive forces of socio-economic development and the driving force of ecologization;
- globalization, increasing role of communication means (in particular Internet).

Globalization leads to the new post-industrial formation – informational formation, the main features of which are:

- development of a new type of civilization, where information plays a role of a leading resource and factor in the social organization of society;
- development of a new science direction that studies information receiving and application;
- development of new areas of informatics - economic, biological (environmental), social, etc.

2. *Heuristic direction* that studies complex nonlinear phenomena and processes based on intuitive considerations, taking into account not only experience, but also intuition. Studies of heuristic problems is closely related to the development of artificial intelligence and creation of thinking computer systems.

The heuristic method makes it possible give up part of unnecessary calculations and solve some problems with lower costs. Experience shows that combination of exact algorithmic methods with heuristic ones leads to effective results for finding solutions under conditions of uncertainty and instability.

3. *The co-evolutionary direction* of artificial intelligence development is determined by modern trends of sciences integration. In a broad sense, co-evolution is:

1) joint evolution of biological species interacting in an ecosystem;

2) principle of harmonious development of nature and society;

3) phenomenon of development of interacting systems.

In recent decades such scientific directions as evolutionary economics, evolutionary sociology and evolutionary politics have appeared.

Moreover, development of co-evolutionary ideas predetermined development of such scientific directions as ecological economics (econology), social economics, social ecology, etc. And also predetermined understanding of our time as a stage of co-evolution.

The co-evolutionary direction involves use of patterns and similarities of biological and ecological systems, as well as socio-economic systems. These patterns include, for example:

principle of stable imbalance in biosystem of Erwin Bauer (1935), which states that all living systems are never in equilibrium and perform, at the expense of their free energy, constant work against the equilibrium required by the laws of physics and chemistry under appropriate external conditions. The principle of stable disequilibrium is bioorganically aimed at satisfying the natural needs of the dynamic balancing of biosystems;

the law of systemic separatism of N. F. Reimers (1994) states that in biosystem and ecosystem different-quality components are always structurally independent, but functionally interconnected. But this does not deprive the system parts their structural independence with a common goal - sustainable dynamic development of the system.

4. Ecobionic direction. In recent decades, one of trends of nature and society studies is biospherology and its directions: bionics, bioengineering, biotechnology, etc., based in one way or another on the principles of artificial intelligence [9].

Modern bioengineering and biotechnology currently make it possible to solve important problems of greening of social and economic life, primarily in terms of solving such global problems as:

a) food, energy supply, improvement of health care (production of biologically active substances), etc.;

b) waste processing, biogas and biomass production from animal waste (currently there are tens of millions of biogas plants in the world);

c) maintaining a sufficient level of natural biodiversity as a necessary condition for normal functioning of ecosystems and biosphere as a whole to provide sustainable development.

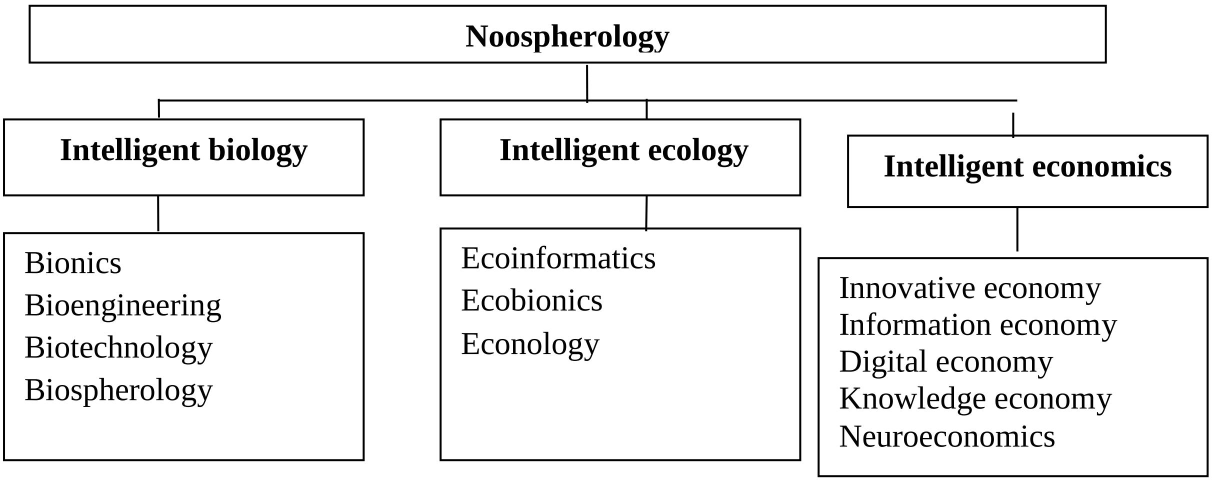


Fig. 60. System-parametric model of "intellectualization" of social and economic development greening

Abovementioned directions of using artificial intelligence in economy greeing make it possible to express the statement that this problem can be discussed in the context of modern ideas of noospherization, the postulates of which were formulated by V. I. Vernadsky. The concept of noosphere (from the

Greek. Noos - mind + sphere) includes ideas of future where mind and intellect will take a priority place. The doctrine of noosphere was developed as noospherology [10]. In this connection we can talk about intellectual sciences - intellectual biology, intellectual ecology, intellectual economy, etc. In this regard, system-parametric model of “intellectualization” of social and economic development greening can be represented in Fig. 60.

Thus, artificial intelligence regarding social and economic development greening can be considered in the following senses:

as a scientific area dealing with hardware or software for solving specific environmental problems;

direction in computer science and information technology, the task of which is recreation of the human mind with the help of computing systems and other artificial devices, analytical assessments of environmental situations and decision making;

the property of intelligent systems to perform creative functions, which are traditionally considered the prerogative of a human;

system capable to interpret complex nonlinear processes, economic and environmental data and adapt the obtained data for socio-economic development management.

Conclusion

Artificial intelligence application gives possibility to solve global and regional economic and environmental problems, and will also contribute to effective decision-making. Perspectives of civilization development depend on implementation of the law of noosphere of V. I. Vernadsky that proofs inevitable transformation of biosphere into the noosphere, where human mind dominates.

In this system, management will be based on following principes: co-evolution of the development of nature and society, "easy management" based on rejection of violence and voluntarism and orientation for human being. “Noospherization” of the system human-society-nature gives possibility to prevent the pessimistic forecast of the great physicist Stephen Hawking that ‘... the human race has no future if it does not go out into space’.

REFERENCES

1. Decision of the Council of National Security and Defence of Ukraine. About the challenges and threats to national security of Ukraine in the ecological sphere and the first steps in the process of their neutralization No. 111/2021 (2021, March 23) Retrieved from https://zakon.rada.gov.ua/laws/show/n0018525-21#Text [in Ukrainian].
2. Order of Cabinet of Ministers of Ukraine. About approval of the Concept of development of artificial intelligence in Ukraine No. 1556-р (2020, December 2) Retrieved from https://zakon.rada.gov.ua/laws/show/1556-2020-%D1%80#Text [in Ukrainian].

3. Stepanov V. (2015). Methodological principles of post-nonclassical science in the study of socio-ecological-economic processes. Odessa: IMPEER, 124 p.
4. Gurieva M. (2015). Global ecological problems of our time: trends. Theory and practice of social development, 1, P. 20-35.
5. Perelet P. (2018). Environmental aspects of the digital economy. World of a new economy, 4, 39-45. DOI: 10.26794/2220-6469-2018-12-4-39-45.
6. Stepanov V., Stepanova K. (2020). Searching Paradigms of Ecologization of Social Development (Methodological Aspect of the Problem). Economic Innovations, 48, P. 35.
7. Domansky R. (2010). Economic geography: dynamic aspect. New Chronograph, 74 p.
8. Mikhalevich V. (1989). Dictionary of Cybernetics, Kyiv, USE, 751 p.
9. Lipov A. (2010). At the origins of modern bionics, bio-morphological morphogenesis in artificial environment. Polygnosis. No. 1-2. Part 1-2. P. 126-136.
10. Vernadsky V. (1991). Scientific thought as a planetary phenomenon. M. Science. 271 p.

X. THE USE OF ARTIFICIAL INTELLIGENCE IN RETAIL AND E-COMMERCE

10.1 Transformation of the customer relationship management system in the digital economy

Aleksy Kwilinski
Ph.D., DrHab (Economics), Professor of the London Academy of Science and Business (London, United Kingdom)

Mariia Hryhorak
Doctor of Economics, Associate Professor National Aviation University (Kyiv)

Nataliia Trushkina
PhD (in Economics)
Institute of Industrial Economics of the NAS of Ukraine (Kyiv)

The key vector of digital transformation should be aimed at increasing the requirements for the level of logistics services, the emergence of new criteria for service quality, in other words, the formation of a customer-oriented approach to customer relationship management. This is confirmed by the various international analytical centres researches. According to a survey of 13 thousands customers, conducted by Accenture Digital [1], 2 out of 3 consumers change service providers due to low quality of service. According to Gartner [2], 9 out of 10 companies today compete primarily in terms of "quality of customer service".

According to the IDG Communications Inc. company's report, prepared on the basis of the more than 700 top managers opinions, was found that the digital transformation is a means of improving customer service (46% of respondents). A survey of 528 managers and specialists on strategic management of digital transformations, conducted by the consulting company Altimeter-Prophet, showed that the main efforts are aimed at improving the system of contacts with consumers (54% of experts).

According to a survey conducted by the e-consulting agency Econsultancy, among the most important characteristics for success in the digital economy is customer orientation (58% of respondents). That is, more than half of respondents believe that customer focus is an effective tool for doing business using digital technologies. At the same time, when forming a customer-oriented approach to customer service, companies face a number of problems, including: barrier to functional disconnection of data exchange (52% of respondents); non-compliance of corporate culture with customer requirements (39%); lack of technological platforms to manage data (35%); inability of IT departments to maintain communication with customers (28%); insufficient competence in data analysis (28%); focusing organizations on sales, not on the consumer (28%), etc. [3].

Thus, the problems of transformation of the customer relationship management system based on the formation of a customer-oriented approach in the context of digitalization remain relevant and require further research. The generalization of the scientific literature indicates the relevance of various aspects of the logistics customer service problem in the context of digitalization of enterprises' business processes. At the same time, the versatility, multifacetedness and debatability of certain issues on the selected topic necessitate further research. And especially the solution of this problem is actualized in modern conditions of digital economy rapid development.

International experience shows that the priority tasks of the digital strategy of enterprises include customer experience and improving its quality. According to Simpler Media, it has been found that of the 325 audience managers, 79% identify DCX (Digital Customer Experience) as an extremely important tool for their organizations. PwC, together with experts from the British economic research institute Oxford Economics, proved that investing in digital transformation primarily improves the quality of customer service (40% of respondents). For many global companies, digitalization of business, according to an IDC study, primarily means meeting consumer expectations (52% of respondents).

As a result of a survey of 1,155 managers of manufacturing companies in 26 countries around the world, conducted by PwC Strategy & [4], found that "Digital Champions" are continuously strengthening and improving their digital product offerings and access to customers. They have succeeded in building an understanding of customer needs and strive to take customer requirements into account when creating attractive and personalized solutions, improving traditional products through services, software, data analysis and the added value of engaging broad partner networks. More than 50% of Digital Champions' revenue comes from digitally advanced products and services. It is projected that investment in new technologies and digital ecosystems could contribute to a 15% increase in revenue over the next 5 years. The study found that 68% of Digital Champions respondents have mastered customer service programs that offer personalized products and services, while 63% take advantage of more complex value chains.

The main goals of the digital transformation, according to 100 IT managers of large companies in the financial, telecommunications, oil and gas and other sectors of the economy, are to increase customer satisfaction (58% of respondents); cost reduction (54%); entering new markets, expanding the range of products and services (33%).

An expert survey of 700 representatives of more than 300 Russian companies from 15 industries, conducted in 2018 by “Komanda-A Management” company [5], revealed that the most important area of digital transformation is digital customer service (65.6% of respondents). Channels and tools of client communications include: e-mail (86% of respondents); websites (78%); social networks, messengers (60%); mobile applications (38.5%); SMS (38.5%); chatbots

(25%). Only 6.2% of experts called omnichannel fully implemented tools in their company. The majority (75%) to some extent doubt the completion of this process, and 18.8% admit the lack of omnichannel. At the same time, 17.2% note that the digital channel is a fundamentally important factor for customers. 59.4% answered that for them the digital channel is important along with other factors, and for 23.4% of respondents the digital channel is unimportant.

Currently, many methods have been developed to assess the digital maturity of enterprises, one of the components of which is a customer relationship management system [6, p. 43; 7, p. 48]. A study by PwC Strategy & [4] shows that in order to implement the business model, Digital Champions has focused on the formation and development of the following platforms:

- omnichannel trading platform – multi-channel trading and marketing platform for products and services (42% of respondents);
- product platform as a service – the product is sold through the platform in a model with a pay per use system (23%);
- customer service quality platform – offers highly individualized products or services (33%);
- comprehensive solutions for customers – includes products from many partners (24%);
- open platform – others person have the opportunity to build their own digital business models (10%).

Based on statistical analysis, it has been established that in the last decade the problems of using information and communication technologies in the management of relations with consumers have also become relevant at Ukrainian enterprises. Thus, according to the State Statistics Service of Ukraine, the number of enterprises in which the website provided personalized content for regular customers increased by 99.4% in 2011-2019, and the implementation of proposals for the possibility of production in accordance with customer requirements decreased by 1.9% (*Table 29*).

Table 29

Website features when using the Internet

Years	Number of businesses that had a website	*Of these,* the companies in which the website provided:	
		proposals for the ability to manufacture products in accordance with customer requirements	personalized information content within the website for regular / repeat customers
2011	15962	4581	2330
2013	16916	4742	2648
2014	13485	3849	1903
2015	18323	4639	2635
2016	15608	4603	4118
2017	16240	4567	4018
2018	17522	4531	4565
2019	17856	4496	4647

Source: Compiled on the basis of information materials of the State Statistics Service of Ukraine.

The number of enterprises in which the website provided customer service opportunities increased in 2019 compared to 2016 by 17.8% or from 7188 to 8471. The number of enterprises that purchased programs for customer relationship management increased by 50.3% or from 967 to 1453. During 2011-2019, there was a tendency to increase the number of enterprises that used automated data exchange for: sending or receiving transport documentation (consignment notes) in 5.4 times; receiving orders from the customer – 3.4 times; sending or receiving information about products – 2.9 times (*Table 30*).

Table 30

Objectives of automated data exchange

Years	Businesses that have used automated data exchange for the following purposes:		
	receiving orders from the customer	sending or receiving product information	sending or receiving transport documentation
2011	13005	15038	6398
2013	14669	16031	8683
2014	19703	21139	12337
2015	22161	23702	14057
2016	26290	27551	17594
2017	31187	32026	22021
2018	36998	37226	27561
2019	43891	43271	34495

Source: Compiled on the basis of information materials of the State Statistics Service of Ukraine.

During the study period, the number of enterprises engaged in regular electronic exchange of information increased for: delivery of final products to customers in 2.2 times; formation of production plans or forecasting of consumer demand – 2.1 times (*Table 31*).

Table 31

Directions of electronic data exchange

Years	Enterprises that carried out regular electronic exchange of information in the following areas:	
	formation of production plans or forecasting consumer demand	delivery of final products to customers
2011	3840	4331
2013	4020	4894
2014	3874	4525
2015	5206	6088
2016	5803	6830
2017	6469	7663
2018	7211	8597
2019	8038	9645

Source: Compiled on the basis of information materials of the State Statistics Service of Ukraine.

The number of enterprises that used social media to receive customer feedback or provide answers to their questions increased by 119.2% in 2014-2019, and to attract customers to innovative product development – by 108.2% (*Table 32*).

Table 32

The purpose of using social media in enterprises

Years	Businesses that have used social media to:	
	receiving customer feedback or answering their questions	involvement of clients in development or innovation of products and services
2014	4002	2647
2015	5497	3703
2016	6089	3963
2017	6871	4388
2018	8260	5221
2019	8772	5511

Source: Compiled on the basis of information materials of the State Statistics Service of Ukraine.

Number of enterprises that made purchases through computer networks of goods or services, increased in 2016-2019 by 42.3%. The number of enterprises that received orders through computer networks for the sale of goods or services decreased – by 2.5% (*Table 33*). The volume of sold products (goods, services) received from trade through websites or applications (applications) in 2018 was 228035.6 million UAH or 3.5% of the total sales of enterprises; in 2019 – 292731.9 million UAH or 4.5% of the total sales of enterprises.

Table 33

E-commerce through computer networks

Years	Number of enterprises that	
	received orders through computer networks for the sale of goods or services	made purchases through computer networks of goods or services
2016	2503	7147
2017	2596	8168
2018	2476	9583
2019	2440	10169

Source: Compiled on the basis of information materials of the State Statistics Service of Ukraine.

However, despite the positive trends of increasing the number of domestic enterprises that implement information technology in the organization of logistics processes, as a result of own research [8-26] it was proved that the effective digital transformation of logistics customer service is hindered by many barriers that can be systematically systematized in 6 groups:

trading: constant fluctuations in market conditions; instability of consumer demand for finished products;

transport: untimely delivery of goods due to breakdown or unforeseen downtime of vehicles; unpreparedness of cargo in needed time; loss of cargo due to unfavourable transportation conditions;

marketing: insufficient consideration of the peculiarities of service to different categories of consumers depending on the specifics of enterprises; imperfection of contract activities of enterprises; inefficient use of marketing communication tools; lack of the generally accepted concept of "customer orientation"; insufficient application of a customer-oriented approach to customer logistics;

information: lack of a unified approach to the definition of the categorical-conceptual apparatus (for example, "digital economy", "digital transformation", "logistics service", etc.); lack of knowledge and skills in the digital economy; insufficient use of digital technologies and electronic platforms to manage customer relationships;

organizational: lack of a clearly defined strategy for digital transformation, vision of the digital future of the company and shortcomings of management; inability to manage organizational change; lack of a digital strategy for customer relationship management; low level of employee involvement; lack of qualified and competent personnel that would meet modern requirements of digitalization of the economy;

financial and economic: late payment for shipped products; insufficient amount of investment and financial resources.

Table 34

Characteristics of the main CRM-systems

Name	Description
AmoCRM	Its functionality allows you to build interaction with the customer at all stages of sales. The program generates orders, systematizes and organizes all orders from customers, creates a calendar plan for the sales department. The system has the following capabilities: agreements and contacts for sales management; sales funnel for reports; tasks and reminders; sales analysis. The interface is adapted for a smartphone.
Bitrix24	Optimization of work within the company's staff. Employees respond more quickly to various tasks and customer questions.
Salesforce	Accounting for industry specifics of the client. A convenient set of analytical tools allows you to track the traffic of potential customers and analyse the effectiveness of sales. The system is able to evaluate the marketing strategy of the business and provide suggestions for its improvement. This is a universal CRM, which is suitable for enterprises of different types of economic activity.
Zoho	Focused more on the business owner. The program is able to process information about interaction with the customer, and on this basis generates statistical reports on sales. Takes into account the activity of buyers and tracks the sources of traffic on the site.
Fresh Office	This is a platform that facilitates access to various information in a "single window". The system automatically keeps records, records all transactions and monitors the status of accounts. Possibility of warehouse accounting of business. The software automates the movement of goods in the warehouse / between warehouses. All document flow is integrated into a single system.

Source: compiled by the authors.

To eliminate the above barriers, it is advisable to implement effective customer relationship management tools. Among them is the CRM-system

(Customer Relationship Management), which implements a customer-oriented approach to logistics service and customer service. The essence of this system is the rational management of relationships with customers, i.e. attracting new customers, transforming neutral customers into loyal customers, the formation of business partners from regular customers (*Table 6*). McKinsey & Company research shows that the share of companies in the EU that use CRM systems is 33%. Based on the analysis and generalization of special literature [27-31] it is established that scientists and specialists understand CRM-system as:

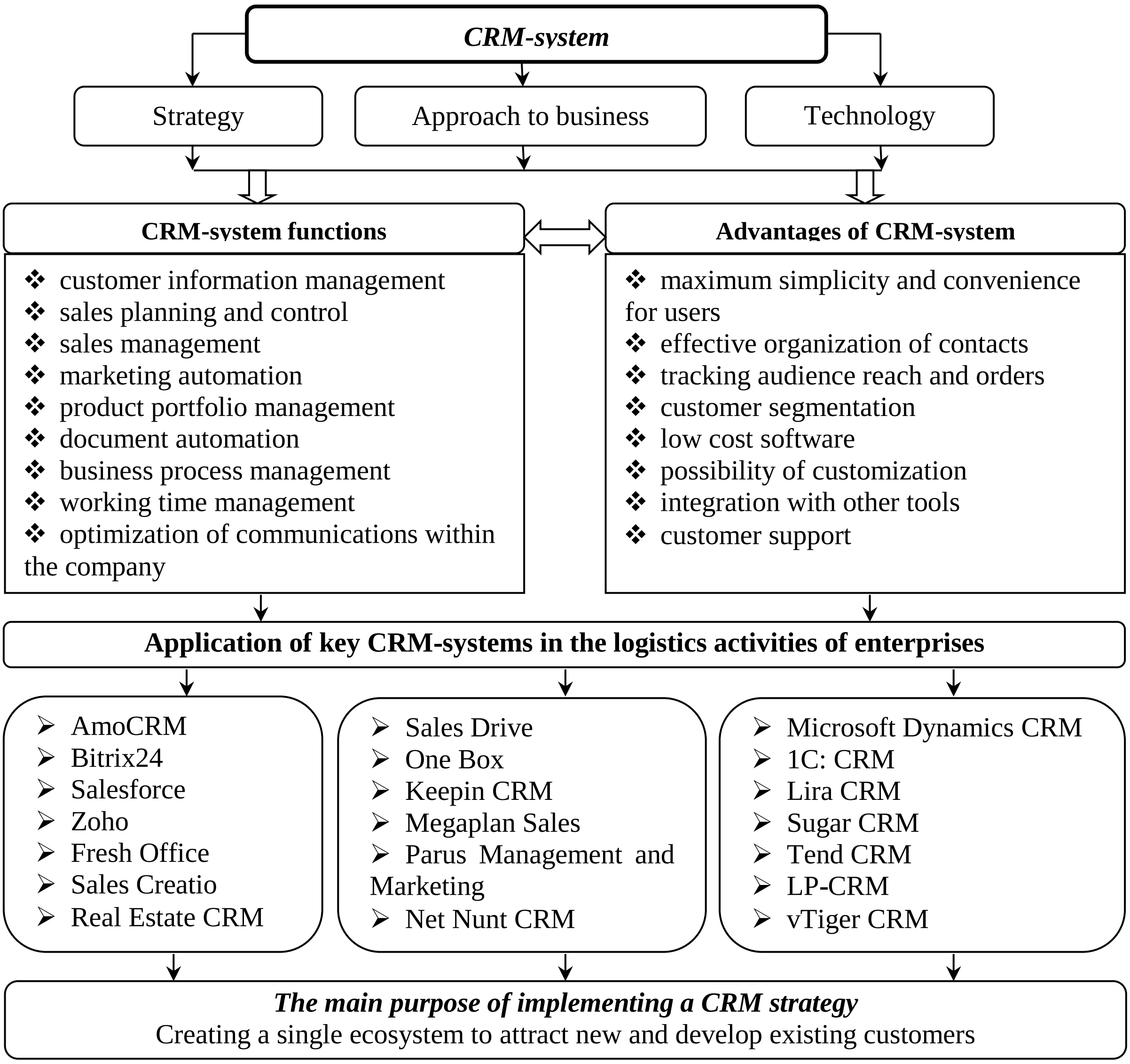


Figure 61. Features of CRM-system implementation as a tool of customer relationship management

Source: proposed by authors.

information technology, which provides functionality to automate the full cycle of relationships with customers and provides the necessary tools to manage the areas of marketing, sales, service;

strategy, which provides for the creation in the company of such mechanisms of interaction with customers, in which their needs are the highest priority for the company; the key goal of implementing a CRM strategy is to create a single ecosystem for attracting new and developing existing customers;

technology – specialized software that automates business processes, procedures and operations that implement the company's CRM strategy (*Fig. 61*.

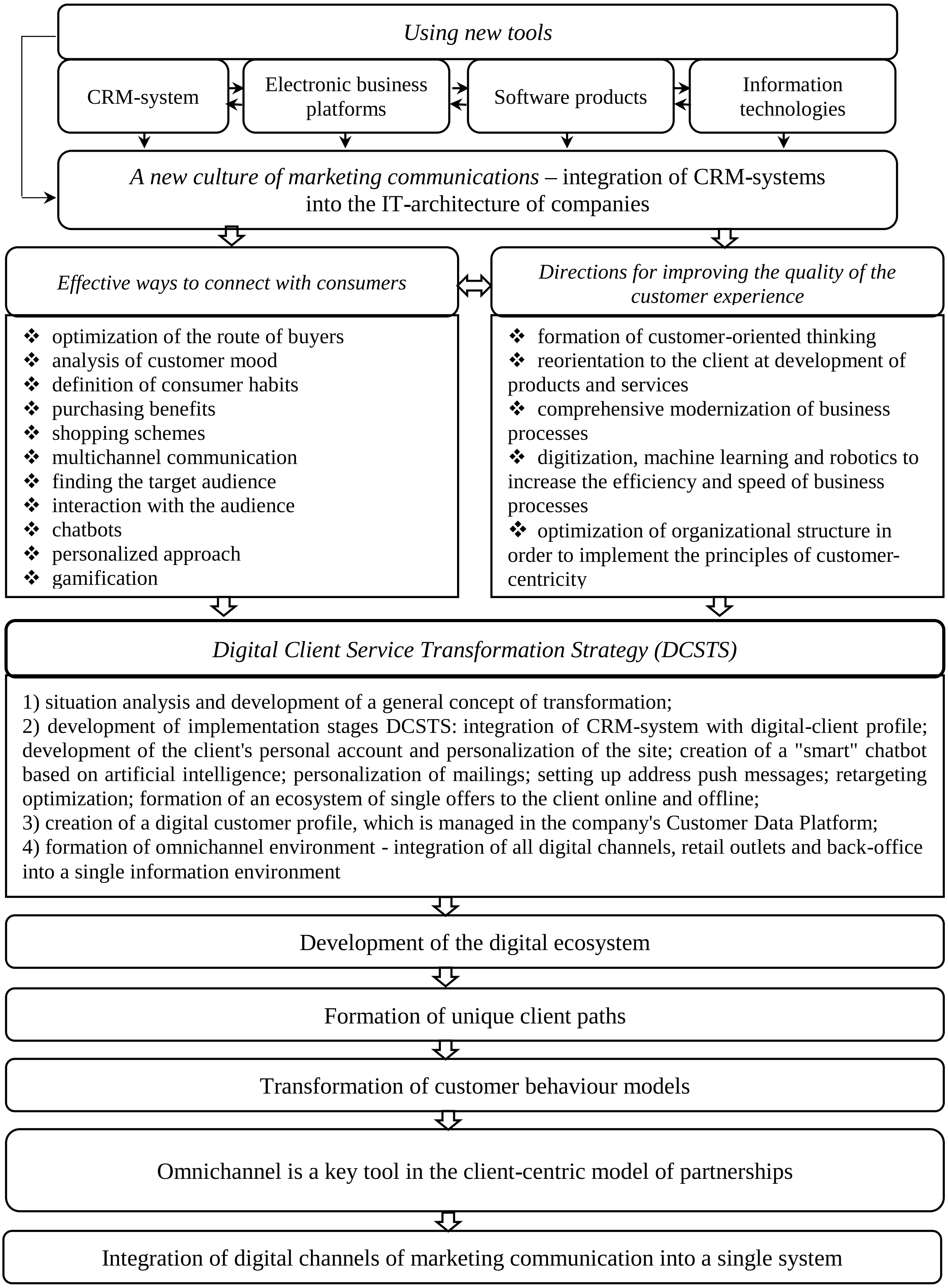


Figure 62. An integrated approach to the transformation of customer relationship management in the digital economy

Source: proposed by authors.

For digital transformation of consumers logistic service in the conditions of economy digitalization it is expedient to introduce the complex approach (*Fig. 62*).

According to PwC Strategy & [4], the integrated Customer Solutions ecosystem has a number of advantages, including: higher revenue from initiatives to increase customer satisfaction across all channels by offering individualized solutions; obtaining greater marginal profit as a result of optimal use of internal capabilities and an expanded partner network; great manoeuvrability by managing a flexible affiliate network; continuous connectivity of operational activity for increase of efficiency and reduction of expenses.

According to the Technical Assistance Research Program, the average return on investment in quality service for industrial enterprises is 100%, banking institutions – up to 170%, retail enterprises – up to 200% [32, p. 16]. The results of research by foreign scholars [33] show that a 5% increase in the number of loyal consumer companies is accompanied by an increase in profits from 25 to 85% depending on the type of economic activity. According to the calculations of J. Coleman [34], the implementation of strategies, methods and systems to increase customer loyalty helps to increase the company's profitability by 25-100%. At the same time, with the correct implementation of loyalty programs, sales volumes increase by 15%, the marketing effect by 20%, and the level of brand loyalty by 23%. [35, p. 12].

American researchers [36] found that a 1% increase in the customer satisfaction index leads to a 3% increase in company capitalization. The average cumulative effect of the increase in profitability (by 11.5% over five years) is from 1% of the annual increase in the consumer satisfaction index. According to expert estimates [37], the cost of acquiring a new consumer is 5-10 times higher, and the return of a lost consumer is 50-100 times higher than the cost of maintaining a satisfied consumer. It is proved that according to the Pareto principle, 80% of the company's profit comes from 20% of regular customers, and the cost of attracting a new customer is 5 times higher than the nominal cost of maintaining the existing one. An increase in turnover from existing customers by 10% leads to an increase in the company's shareholder value by 15.5% [38].

According to the consulting agency "PRCA" [39], in 2018 the average percentage of the marketing budget of companies to promote products and related services online is about 16% and will increase annually by 10%. PwC's Global Digital IQ Survey found that: 54% of transport and logistics executives believe that investing in digital technology can increase revenue; 16% - profit; 11% - to improve the quality of customer service. 64% of respondents say that over the next 5 years, changes in customer behaviour will lead to breakthrough transformations in their business [38].

According to the forecasts of the international analytical agency Gartner, by 2020 the customer service may outperform such indicators as price and product quality. Personalization, according to analysts at the international consulting firm McKinsey, already allows global players to increase revenue by 5-15%. According to Gartner, in 2019, companies in many countries have increased their investment in personalized marketing by 50%. According to Gartner Research, by 2025, companies that use more than 4 digital channels to interact with customers will be 300% more efficient than single- and dual-channel competitors. And the number of multi-channel consumers will double in 2025. At the same time, the cost of maintenance can be significantly reduced by redistributing requests to digital channels. Digital transformation of logistics service in the system of logistics management of enterprises will help to obtain a synergistic effect:

economic: increase in average profitability from the organization of logistics activities by 15-20%; increase in consumer retention by 5%; reduction of time for execution of current operations by 25-30%; increase the accuracy of forecasting shipments to 99%; reduction of costs for sales, marketing and customer support by 10-15%;

social: optimization of work of employees of the enterprise; increasing the speed of processing consumer orders and the level of information security; reduction of time spent on the organization of information exchange between the enterprise and economic contractors;

ecological – reduction of negative impact on the environment as a result of: improving the conditions of transportation and storage of products; application of the concept of industrial waste management in the context of the circular economy; implementation of "green" technologies in industrial production.

The transformation of the logistics activities of the enterprise is closely interrelated with the development of the digital economy. Full customer orientation is achieved through the organization of accumulation, structuring and exchange of information, and a high level of competitiveness in the digital economy is impossible without a customer-oriented approach to logistics service. Customer relationship management is becoming a priority in the context of business digitalization. In today's digital environment, the role and importance of improving the quality of logistics services using a customer approach is growing. This approach means building all business processes around customer needs and is seen as a tool for creating value for consumers and using digital technologies to enhance the customer experience.

The key trends in the digital transformation of customer service logistics on the basis of customer-centricity include: personalization of products, experience and communication using digital technologies; transition to flexible management methods; formation of a qualitatively new marketing structure of enterprises (the emergence of specialists in consumer preferences and data processing); ensuring multichannel in marketing communications; introduction of chatbots as one of the most effective ways to provide instant customer support; application of a comprehensive approach to the organization of logistics services, the essence of which is to modernize the corporate culture of communication in the company, maintaining a friendly atmosphere of communication and digital interaction with consumers through online channels; implementation of CRM-system. This will increase the level of customer satisfaction with service and quality of logistics services by about 3%; support regular and attract new customers through the implementation of loyalty programs; improve the level of organizational culture as a result of using the client's approach to personnel management; optimize costs for the organization of logistics activities; increase sales and profitability of sales.

10.2 Digital marketing as an effective tool for improving the quality of customer service

Kwilinski Aleksy
PhD., DrHab (Economics), Professor of the London Academy of Science and Business (London, United Kingdom)

Zaloznova Yuliya
Corresponding Member of the NAS of Ukraine, DrHab (Economics), Professor
Institute of Industrial Economics of the NAS of Ukraine (Kyiv)

Trushkina Nataliia
PhD (Economics)
Institute of Industrial Economics of the NAS of Ukraine (Kyiv)

Marketing is one of the areas whose development is significantly influenced by digital transformation. Marketing services have mastered new practices in the context of business digitalization. In this regard, the development of digital marketing is being actualized based on the formation of digital channels for product promotion and the emergence of new requirements for the organization of marketing activities [40-43]. This is confirmed by the results of the survey: 70% of customers want to use digital marketing tools, but they completely do not understand what it is.

Based on the generalization of the specialized literature on marketing [44-47], it has been established that there are many definitions of digital marketing. However, a number of scientific schools identify this concept with Internet marketing. However, as a result of the analysis of scientific literature [48-52] and our own research, it was revealed that digital marketing includes Internet marketing (SEO-website promotion, context, webinars, that is, all channels available to the user only on the Internet), as well as advertising and promotion on any digital media outside the network. That is, digital marketing differs from Internet marketing in such characteristics as the target audience, the sphere of influence on the target audience, distribution channels, and methods of communication with the audience (*Table 35*).

Digital (interactive, digital) marketing is considered as a type of marketing activity that involves the use of various forms of digital channels to interact with consumers and other counterparties in the market. The main advantages of digital marketing are interactivity, the absence of territorial restrictions, easy access to resources, and attraction of the target audience. Digital marketing in terms of marketing communications involves the use of all possible forms of digital channels to promote a brand. Digital marketing is one of the important areas of the modern information society, as well as a general term for the marketing of goods and services, which uses digital channels to attract and retain customers.

Digital marketing is a type of marketing activity that through digital channels, using digital methods, makes it possible to interact with target market segments in a virtual and real environment. This is the whole range of marketing actions, that is, modern marketing, which is inherent in duality due to its hybrid nature: some of the functions are implemented online, and some in the offline environment.

Table 35

Differences between Internet Marketing and Digital Marketing

Feature	Internet marketing	Digital marketing
The target audience	Internet users	Internet users and offline audience in the online market
Scope of influence on the target audience	Online scope	Online and offline sphere
Distribution channels	Internet channels	All kinds of digital channels
Ways to communicate with the audience	E-mail mailings, landing pages, sites, advertising (search, banner, targeted, contextual)	E-mail mailings, landing pages, websites, digital TV, advertising (search, banner, targeted, contextual, in online games, mobile applications), instant messengers, POS terminals, local networks

Source: compiled on the basis [48-52].

An analysis of the scientific literature shows that, scientists understand digital marketing as:

a communication tool;

type of marketing activity, which is carried out using digital product promotion channels;

digital communication that occurs both online and offline;

complex promotion, which includes many channels;

using all possible forms of digital channels for brand promotion;

a way to promote a business using digital technologies;

an integrated approach to promoting products in a digital environment;

brand promotion and customer acquisition using all possible digital channels (social networks, the Internet, e-mail newsletter, contextual advertising, content marketing);

integrated promotion of a product or service using different types of marketing;

integration of a large number of different technologies (social, mobile, web, CRM systems) with sales and customer service;

a set of different marketing tools to attract customers from both online and offline environments;

multichannel business promotion in the information space;

marketing, which provides interaction with customers and business partners using digital information and communication technologies and electronic devices;

implementation of marketing activities using digital information and communication technologies.

Summarizing the existing scientific approaches to the definition of “digital marketing”, they are conditionally systematized into the following groups:

type of marketing activity;

communication tool;

digital communication;

way to advance with digital technology;

multichannel promotion in digital space;

possible forms of digital channels;

a set of various marketing tools.

Thus, modern business conditions require the use of digital marketing tools as an innovative paradigm of enterprise development in the context of digital transformation. Under this term, it is proposed to consider an effective type of marketing activity, which consists in the promotion and sale of products using a set of digital channels.

Distinctive features of digital marketing are: interactivity; targeting; the ability to conduct web analytics. The main goal of digital marketing is to attract and retain customers, increase business profitability. The goal is achieved exclusively by attracting visitors to the Internet resource and transforming them into potential and then loyal customers. The tasks of digital marketing include collecting contact information of interested users; increasing reach and brand awareness; formation of a positive image; increasing consumer loyalty; collection of data for marketing research; informing the target audience; formation of a base of regular customers. It performs a full range of marketing tasks, but uses the Internet as its primary channel of interaction with the audience.

Digital marketing channels are: content marketing (SEO, SERM, SMM, content PR, E-mail marketing, ORM); digital advertising (contextual, targeted, display advertising); multichannel promotion; web analytics (*Table 36*).

Digital marketing does not include product promotion using traditional channels such as newspaper ads, TV ads, billboards (except for those with a QR code that can be used to go to the site). The modern reality is the transformation of media, distribution processes, consumers with new expectations and requirements. That is, digital channels require the development of a fundamentally new communication strategy with consumers.

The benefits of digital marketing include measurability, speed, versatility, and large reach. The main advantage of all digital promotion channels is that their effectiveness is easy to track. Banner clicks, link clicks, viewing time and depth, number of views and many other information about the performance of various tools is collected automatically and provided in a form that is convenient for evaluation and analysis. Thanks to the capabilities of digital tools, there is the ability to instantly reach thousands of users around the world with one ad impression, collect and analyze huge amounts of data on their reactions, and make adjustments to the campaign. This takes digital marketing to a new level of development. Customization flexibility, for example, advertising targeting, allows you to set up a campaign to work only with a target group of Internet users, excluding irrelevant impressions, which helps to reduce costs.

Table 36

Features of digital product promotion channels

Channels	Characteristic
SEO	due to complex optimization, an increase in the site's position in the search results is achieved
SERM (Search Engine Reputation Management)	managing customer brand reputation in search results
SMM	brand promotion on social networks, regular content updates on Social media. Interaction with users
PR content	creation and placement of native advertising, press releases, image articles about the company on the most visited sites, in online media and social media
E-mail-marketing	formation of a mailing base for the target audience, selection of specialized content development specialists for regular mailing
ORM (Online Reputation Management)	brand reputation management on the Internet, promotion of non-brand reputation queries to form a separate channel for new sales
Contextual advertising	it is one of the most effective tools for attracting interested visitors to the site. Advertisements are shown only to those users who are currently searching for a product on the Internet or have recently searched
Targeted advertising	this type of advertising is most popular on social networks, where it is possible to identify a suitable target audience for the sale of products or services
Display advertising	a set of text, graphic and sound information on the Internet and offline space, motivating potential buyers to pay attention to advertising materials about products / services
Multichannel promotion	this product integrates all digital promotion channels. Based on the results of the test period, the cost of one call / application is determined and all subsequent applications are paid at a fixed cost upon their receipt
Web analytics	analysis of quantitative data and qualitative indicators of the resource and sites of competitors, development of strategies to increase the behavioural indicators of users and improve the conversion of the site for potential customers

Source: compiled on the basis [53].

The digital marketing industry is dynamic and constantly changing [54; 55]. In this regard, it is necessary to constantly monitor analytical materials and track development trends. Among them:

93% of all online interactions start with a search engine. This shows how important it is to invest in SEO techniques. Increasing the ranking of a company or business website in search engines may be the best form of advertising a product or service;

72% of internet marketers consider creating high quality content as the most effective SEO tactic;

53% of marketers see blogging as their top priority in content marketing

70% of marketers don't have a consistent or integrated content strategy

the most successful marketers spend 40% of their total marketing budget on content marketing; the average indicator for all respondents is 26%;

89% of marketers prioritize improving their ability to measure and analyse marketing impact

content marketing revenue in 2020 is approximately $ 300 billion;

70% of Internet users want to learn about products through content rather than traditional advertising;

about 58% of marketers say they often manage to achieve their marketing goals;

five main B2B content marketing tactics: social media content 92%; e-newsletters 83%; articles on the site 81%; blogs 80%; personal meetings 77%;

57% of content downloads attract leads with the highest conversion rates;

nearly 90% of marketers say their social marketing efforts have increased the visibility of their business, and 75% say they've increased traffic;

video accounts for 80% of consumer online traffic;

by 2022, the number of emails may increase to 347 billion. This proves that email is still one of the best ways to reach your target audience;

98% of sales reps reach their quotas through social media. Sales methods must evolve to match the ever-changing consumer behavior. For example, sales agents can use social media to connect and interact with potential customers;

according to a HubSpot study, at least 71% of customers who have a good brand experience through social media are likely to recommend it;

more than 74% of 400 UK and US companies surveyed already have a website personalization program;

in 2020, retention (58%) overtook conversion (55%) and acquisition (45%) as a key goal of website personalization;

only 54% use AI prediction segments; barriers to scaling personalization strategies include: lack of experience (37%), limited functionality (36%), and lack of time (35%);

over 40% of online transactions were completed on mobile devices within 4 months;

51% of consumers use mobile devices to identify new brands and products on the market;

88% of consumers don't return to a site due to bad experiences.

According to Statista, global digital ad spending is on the rise every year. So, in 2021, their volume will increase by 58.3% compared to 2017, and by 83.1% in 2024 (*Table 37*).

Table 37

Dynamics of global spending on digital advertising

Years	Global digital ad spend, *USD billion*	Rate of change, *%*
2017	251.6	100.0
2018	293.2	116.7
2019	335.5	133.3
2020	355.8	141.4
2021	398.3	158.3
2022	428.2	170.2
2023	447.8	178.0
2024	460.6	183.1

Source: compiled according to data [56].

As analysts at Gartner note [57], marketing is transformed under the influence of such main factors: changes in consumer behavior; stricter data use legislation; organizational changes (more and more data scientists are involved in marketing); automation, which is becoming one of the key elements of marketing technology. Driven by these factors, by 2022, the main strategic goal of marketing activities will be profitability instead of improving customer experience (CX).

There are 3 phases of digital marketing development:

working with data, training employees and expertise – first, you need information about the behavior of buyers, their actions about purchases and basic indicators of online marketing (clicks on the site and steps to conversion);

building connections – the company must integrate analytics across all channels and create cross-functional teams, where related departments are collected. It is also important to combine internal and external sources of online audience data. It helps to better understand users, automate marketing messages and develop, test and customize ads faster;

from integration to multi-factor marketing – at this stage, technologies are integrated into the entire structure of the company. The organization monitors the performance of each channel, analyzes every purchase step, increases sales through personalized marketing, and reduces costs through automation.

The key trends in the development of digital marketing in the global information space are:

the emergence in companies of positions such as director of customer service, director of experience, director of digital technology and director of marketing data, who will establish and manage human and machine or system connections in the company. This role will create processes, policies and procedures to ensure that data is collected and integrated into the customer data platform. 61% of CEOs surveyed by MemSQL indicated that machine learning and artificial intelligence will be the most significant company initiatives in 2019;

enhancing the role of the digital brand manager, who promotes the products produced by the company, by transforming traditional methods of brand management, marketing and information into digital interaction with consumers;

the emergence of a tech-savvy martechnologist – marketer 4.0;

Artificial intelligence and machine learning are making hyperpersonalization a reality – 94% of companies agree that personalization is critical to their success. The main barriers to personalization include IT obstacles (47% of respondents) and outdated technology (46%);

transformation of digital marketing agencies into consulting agencies – with a combined revenue of $ 13.2 billion, the marketing divisions of Accenture, PwC, IBM, Deloitte are below WPP, Omnicom, Publicis Group, Interpublic, Dentsu. Consulting and services provided are often combined with a deep focus on technology services;

The GDPR (General Data Protection Regulation) helps marketers improve data hygiene, resulting in better targeting and better experiences. An IBM study found that nearly 60% of organizations surveyed see GDPR as an opportunity to improve privacy, security, data governance and as a catalyst for new business models;

Agile Marketing Implementation – A report from AgileSherpas noted that about 36.7% of marketing teams practice agile marketing to quickly set marketing priorities, get better work done, and increase productivity.

merger of MarTech and ReklamoTech – corporate brands use on average more than 90 marketing tools. The ability to connect to data and use it in artificial intelligence to understand customers in real time and optimize advertising costs is helping to create a flexible MarTech + Advertising ecosystem. This will allow markets to continually examine the impact of their spending on media and the profit margins achieved. By 2020, advertisers in the US will spend about 69 billion dollars USA on digital advertising, representing 86% of total digital advertising.

customer focus will drive continuous transformation – IDC FutureScape research predicts that by 2022, 35% of customer experience organizations will be adopting commercial business models everywhere and generating 50% of revenue from contextual discovery.

The priority directions for the development of digital marketing in the context of globalization include: personalization; influencer marketing; user-generated content; chat bots; augmented reality; content as the basis of marketing; video creation; posts with the option to purchase; data visualization; multichannel marketing; search by images; communication through instant messengers.

Thus, digital marketing is an effective type of product promotion activity using a set of digital channels. To develop digital marketing, it is necessary to introduce such modern tools as short videos; chat bots; voice search; video marketing; content; bidding in real time, providing for the purchase and sale of advertising displays at auctions; Artificial Intelligence; native advertising; audio content for more coverage; internet television; prompt response to mentions; microinfluencers; strategic planning and omnichannel; end-to-end analytics as the most effective way to optimize advertising budgets and make management decisions.

10.3. E-commerce trends in the digital economy

Olesia Bezpartochna
Postgraduate VUZF University of Finance, Business and Entrepreneurship, Sofia, Bulgaria

Valentina Misyuckevich
Ph.D. in Economics, Associate Professor,
Poltava University of Economics and Trade, Poltava, Ukraine

Nataliia Trushkina
PhD (in Economics),
Institute of Industrial Economics of NAS of Ukraine, Kyiv, Ukraine

Currently, e-commerce is becoming a modern challenge to accelerate the development of the global economy. This requires the introduction of qualitatively new approaches to the strategic management of marketing activities using information technology. This is especially true in the context of the digitalization of business processes in the context of the concept of Industry 4.0. According to expert estimates, the share of retail sales in the e-commerce market in 2021 will reach 17.5% or 4878 billion dollars USA. According to a report by The Fashion and Apparel Industry, global revenue from e-commerce will grow in 2018-2022 by 48.2%, or from 481.2 to 712.9 billion dollars USA. The total global revenue from e-commerce in 2022 will be 6.5 trillion dollars USA.

Thus, the problems of transformation of logistics activities with the use of digital technologies in the context of intensifying the development of the information environment remain relevant and require further research. And first of all, it concerns clarification of the conceptual apparatus on problems of development of e-commerce. Analysis and generalization of scientific literature show that scientists pay considerable attention to:

definition from different scientific points of view of the essence and content of the concepts "electronic business" (D. Chaffey); "e-commerce" (V. Zwass; A. Summer, Gr. Dunkan; D. Kozie); "Internet trade"; "Internet commerce"; "E-retail" (M. Hargrave);

improving the customer relationship management system using information technology (G. Balabanis, K. Keller, P. Kotler, A. Payne, V. Souitaris);

practical aspects of application of digital technologies in logistics activity of enterprises and substantiation of scientific and methodical approaches to the estimation of effect from their introduction (A. Amaral, L. Barreto, H. Dzwigol, A. Kwilinski, T. Pereira).

At the same time, the versatility, multifacetedness, and debatability of certain issues on the selected topic necessitate further research. And especially the solution of this problem is actualized in modern conditions of digital transformation of business processes of the enterprises and intensive development of e-commerce owing to COVID-19. Analysis of the specialized literature shows that there is no single scientific approach to the term "e-commerce". It is established that foreign and domestic researchers identify e-commerce with different terms: e-business, IT-commerce, e-payment service, online commerce, virtual commerce, e-trading, e-marketing, digital marketing, e-transaction, e-commerce retail trade, distance trade.

The categories "e-business" and "e-commerce" emerged in the United States in the 1980s as a result of the development of the ideas of the global information economy. As a rule, scientists and practitioners considered e-business and e-commerce to be synonymous. However, over time, researchers have begun to separate e-commerce from e-business.

According to D. Kozie [58], "… e-commerce began with the sale and transfer of funds through computer networks. But then this concept expanded significantly and included trade in fundamentally new types of goods, such as information in electronic form. To benefit from the possibilities of e-commerce, it is necessary to understand that the view of it exclusively as business transactions through computer networks is irrevocably obsolete ... E-commerce is based on the structure of traditional commerce, and the use of e-networks gives it flexibility ...". As a result of the conducted theoretical analysis and own previous researches on the chosen problems [59-62] various scientific approaches to the definition of essence and maintenance of concept "electronic commerce" are generalized (*Table 38*).

Scientists and experts under this definition, as a rule, understand:

economic activity, for the implementation of which information and communication technologies and networks are used, which allow enterprises to receive income;

economic activity, as a result of which ICT and networks play an important role in the implementation of key processes (consumption, exchange, distribution, production);

activities that create added value through ICT;

the interaction of a set of economic entities in the sales process using network technologies;

electronic interaction between business entities using Internet technologies;

purchase and sale of goods and services via the Internet for direct profit;

a set of operations between the company and contractors, which are carried out using information technology to optimize costs and increase the efficiency of business processes;

commercial interaction of business entities on the purchase and sale of goods and services using information networks;

sale or purchase of goods/services through electronic transactions made via the Internet or other computer networks;

activities that are focused on making a profit as a result of transactions and transactions on the Internet;

one of the modern forms of organization and implementation of economic activity, the distinctive feature of which is the use of public information systems and computer networks integrated into the Internet;

type of economic activity, where the object of the action is trade, purchase, and sale of goods, customer service via the Internet;

a set of rules governing the implementation of electronic relations in the execution of contracts of sale of goods;

commercial activities related to the Internet;

a process that is mediated through a network of interconnected computers;

a transaction using electronic media or computer networks;

a set of interactive methods of conducting activities to provide consumers with goods and services;

activities covering all types of electronic transactions between enterprises and stakeholders.

Table 38

Systematization of scientific approaches to formulation the term "e-commerce"

Group	Components
Element of e-business	• type of entrepreneurship; • a form of business process; • a component of e-business; • business activity
Type of activity	• commercial activity; • type of electronic commercial activity; • type of economic activity; • economic activity; • modern form of organization and implementation of economic activity
Type of trade	• a specific type of trade; • a form of trade through ICT; • a form of supply of products through computer networks
Form of electronic relations	• electronic interaction of economic entities; • a set of rules for electronic relations in the sale of goods; • the technology of commercial transactions; • type of public relations for the sale of goods; • commercial interaction of business entities in the process of buying and selling; • the relationship between economic entities

Agreement	• purchase and sale of goods via the Internet; • electronic commercial agreement; • a form of business transactions by electronic means
Type of electronic transaction	• electronic transaction in the process of selling or buying goods; • a system of non-cash payments
Strategy	• marketing strategy

Source: suggested by the authors.

On the basis of methods of groupings and classifications, the theoretical approaches to the interpretation of e-commerce which are offered by various scientific schools are conditionally systematized. As a result of generalization of existing scientific developments in the conceptual apparatus and analysis of its compliance with modern conditions of enterprises, the author's approach to the definition of the term "e-commerce" is given, which is considered as:

component of e-business, the essence of which is to achieve partnerships in the process of buying and selling products using digital technologies and information systems;

an effective form of organization of logistics activities of enterprises with the use of information and communication technologies and systems;

a tool for promoting products on the market using digital technologies.

The lockdown due to the COVID 2020 pandemic led to a boom in e-commerce, which was already growing steadily. In some areas, switching to online trading is the only way to keep a business. In others, it is an opportunity to reach an additional target audience. In 2022, online trading revenue is expected to be 6.54 trillion dollars USA (up from 3.53 trillion dollars in 2019). The mobile e-commerce sales niche is projected to reach 73% by the end of 2021. Of these, 30% of customers are likely to abandon checkout if they find that the site is not optimized for mobile use.

GroupM predicts more modest results and notes that the growth rate of e-commerce. However, the report says that the share of e-commerce in the retail turnover of the entire planet will reach 25% by 2024, and by 2027 the e-commerce industry will sell goods and services worth 10 trillion dollars USA. China has already become the main beneficiary in the segment, and in 2021 the share of e-commerce in the country will reach 27.3%.

Marketplaces will continue to gain popularity. They are easy to reach for businesses not yet familiar with digital aspects, and buyers prefer to find everything they need in one place. But not only giants will attract business – there are many undervalued sites that will receive their development in 2021. Personalization will evolve in the battle for the buyer. This approach is pushing nearly half of customers (48%) to spend more. And in the digital world, it cannot exist without data collection. Direct sales to consumers, gamification, discounts in exchange for filling out a questionnaire are all ways to get exactly the information you need for a personalized experience.

Social commerce will become a serious sales channel. And this is not about the fact that the user is redirected from the social network to the shopping site, but about the fact that he makes a deal directly on the pages of Facebook, Instagram, or Pinterest. But this does not mean that you do not need to attract customers to your selling site through social networks, it should be remembered that consumers want maximum simplicity when making a transaction.

Voice commerce will allow you to get closer to the buyer. Smart gadgets are gradually entering the lives of consumers, simplifying the buying process. Businesses have to optimize such contacts. Earlier, Gartner predicted that in 2020 50% of companies will use chatbots for voice communication with customers. In 2021, there will be even more such enterprises.

Shopify is adding a few more trends to this. Order fulfillment will become an important competitive factor. The consumer expects fast, high-quality, and inexpensive delivery. And for this, you need to optimize fulfillment as much as possible: place warehouses as close to customers as possible, offer flexible delivery and return options. FinancesOnline notes in its forecast that additional shipping costs are the most common reason for abandoning a purchase.

Refunds are becoming an e-commerce scourge. In 2020, they cost entrepreneurs 205 billion dollars USA. It is assumed that by 2023 the amount of annual damage will reach 348 billion dollars USA. Customer retention is becoming a priority against the background of the cost of attracting them. Loyalty programs, subscription sales models, and audience segmentation are the tricks that businesses will increasingly use to keep customers from leaving their competitors.

According to FinancesOnline, the growth rate of sales through mobile devices will decrease. The main reason here is saturation. Already, most online orders are made from smartphones.

Thus, the key trends in the development of e-commerce are:

online trading will continue to grow steadily;

mobile shopping will continue to gradually replace desktops;

social networks – the new elevator for trading;

voice commerce or “Ok Google, I want to buy ...”;

instant delivery is not just a nice bonus, but a competitive advantage;

multichannel sales to increase audience reach and increase conversions;

visual Commerce – The New Minimum Plan for Online Platforms;

AR is becoming the new e-commerce reality;

new payment options for greater security and convenience;

ecology and “green” consumption shape consumer preferences.

REFERENCES

1. Digital Transformation: Re-imagine From the Outside in. Accenture Digital. 2014. Retrieved from: https://www.accenture.com/us-en/insight-digital-marketing-transformation-reimagine-outside-aspx (Last accessed: 10.05.2021).
2. Gartner Survey Finds Importance of Customer Experience on the Rise – Marketing is on the Hook. Gartner. 2014. Retrieved from: https://www.gartner.com/doc/2857722/gartner-survey-finds-importance-customer (Last accessed: 11.05.2021).

3. Building a Digital Culture. Best practice guide, 2017. Retrieved from: https://www.econsultancy.com/reports/building-a-digital-culture/ (Last accessed: 11.05.2021).
4. *Globalnoye issledovaniye tsifrovykh operatsiy v 2018 g. [Global Digital Operations Survey 2018]*. Tsifrovyye chempiony. Kak lidery sozdayut integrirovannyye operatsionnyye ekosistemy dlya razrabotki kompleksnykh resheniy dlya potrebiteley. Moscow: PwC Strategy&.
5. Ryzhkov V. et al. (2018). *Tsifrovaya transformatsiya v Rossii: analiticheskiy otchet [Digital Transformation in Russia: Analytical Report]*. Moscow: Komanda-A Menedzhment.
6. Gileva T.A. (2019). Tsifrovaya zrelost' predpriyatiya: metody otsenki i upravleniya [Digital maturity of the enterprise: methods of assessment and management]. *USPTU Bulletin. Science, education, economics. Ser.: Economics*, 1(27), 38-52.
7. Savich Yu.A. (2018). Tsifrovaya transformatsiya i yeye vliyaniye na konkurentosposobnost' promyshlennykh predpriyatiy [Digital transformation and its impact on the competitiveness of industrial enterprises]. *EconomINFO*, 15(4), 44-48.
8. Hryhorak M.Yu., Karpunʹ O.V. (2010). Lohistychne obsluhovuvannya [Logistics service]. Kyiv: NAU.
9. Hryhorak M.Yu. (2017). *Intelektualizatsiya rynku lohistychnykh posluh: kontseptsiyi, metodolohiya, kompetentnist' [Intellectualization of the logistics services market: concepts, methodology, competence]*. Kyiv: Sik Group Ukraine.
10. Tryfonova O., Trushkina N. (2019). Application of information technologies in logistic activities of enterprises. *Conceptual aspects management of competitiveness the economic entities*: collective monograph / Edited by M. Bezpartochnyi, I. Britchenko. In 2 Vol.; Higher School of Social and Economic. Przeworsk: WSSG, vol. 1, pp. 161-172.
11. Trushkina N.V., Rynkevych N.S. Kliyentooriyentirovannost: osnovnyye podkhody k opredeleniyu [Client-Centricity: the Basic Approaches to Definition]. *Business Inform, 8*, 244-252 https://doi.org/10.32983/2222-4459-2019-8-244-252.
12. Trushkina N. (2019). Transformation of customer relationship management in the digital economy. *Digital economy and digital society*: monograph / Edited by T. Nestorenko, M. Wierzbik-Stronska; Katowice School of Technology. Katowice: Wydawnictwo Wyzszej Szkoly Technicznej w Katowicach, pp. 311-316.
13. Kashchena N., Solokha D., Trushkina N., Potemkin L., Mirkurbanova R. (2019). Use of multi-agent simulation modeling for predicting the sales of wholesale trade companies. *Journal of Management Information and Decision Sciences*, 22(4), 483-488.

14. Koev S.R., Tryfonova O., Inzhyievska L., Trushkina N., Radieva M. (2019). Management of Domestic Marketing of Service Enterprises. *IBIMA Business Review*, 2019, Article 681709. https://doi.org/10.5171/2019.681709.
15. Kwilinski A. (2019). Implementation of Blockchain Technology in Accounting Sphere. *Academy of Accounting and Financial Studies Journal*, 23(SI2), 1-6.
16. Trushkina N. (2019). Organizational-economic mechanism of management logistic activity of enterprise: essence and structure. *Strategies for sustainable socio-economic development and mechanisms their implementation in the global dimension*: collective monograph / VUZF University of Finance, Business and Entrepreneurship. Sofia: VUZF Publishing House «St. Grigorii Bogoslov», vol. 3, pp. 117-125
17. Trushkina N. (2019). Development of the information economy under the conditions of global economic transformations: features, factors and prospects. *Virtual Economics*, 2(4), 7-25. https://doi.org/10.34021/ ve.2019.02.04(1).
18. Trushkina N. (2020). Kliyentooriyentovanyy pidkhid do lohistychnoho servisu v umovakh informatsiynoyi ekonomiky [The Client-Oriented Approach to Logistics Service in the Information Economy]. *Business Inform*, *6*, 196-204. https://doi.org/10.32983/ 2222-4459-2020-6-196-204.
19. Zaloznova Yu.S., Trushkina N.V. (2020). *Udoskonalennya orhanizatsiyi zbutovoyi diyal'nosti vuhledobuvnykh pidpryyemstv Ukrayiny v umovakh nestabil'nosti popytu: teoriya i praktyka [Improving the organization of sales activities of coal mining enterprises of Ukraine in conditions of demand instability: theory and practice]*. Kyiv: IIE of NAS of Ukraine.
20. Grygorak M., Trushkina N. (2020). Introduction of purchase management information systems and partnership relations with suppliers. *Contemporary Issues of Digital Economy and Society*: monograph / Edited by T. Nestorenko, P. Mikos. Katowice: Publishing House of Katowice School of Technology, pp. 206-213.
21. Hryhorak M., Trushkina N., Popkowski T., Molchanova K. (2020). Digital transformations of logistics customer service business models. *Intellectualization of Logistics and Supply Chain Management*, *1*, 57-75. https://doi.org/10.46783/smart-scm/2020-1-6.
22. Kwilinski A., Zaloznova Yu., Trushkina N., Rynkevych N. (2020). Organizational and methodological support for Ukrainian coal enterprises marketing activity improvement. *E3S Web of Conferences*, *168*, Article 00031. https://doi.org/10/1051/e3sconf/202016800031
23. Dzwigol H. (2019). Research Methods and Techniques in New Management Trends: Research Results. *Virtual Economics*, 2(1), 31-48. https://doi.org/10.34021/ve.2019.02.01(2)
24. Dzwigol H. (2020). Methodological and Empirical Platform of Triangulation in Strategic Management. *Academy of Strategic Management Journal*, 19(4), 1-8.

25. Dzwigol, H., Dźwigoł–Barosz, M., & Kwilinski, A. (2020). Formation of Global Competitive Enterprise Environment Based on Industry 4.0 Concept. *International Journal of Entrepreneurship*, 24(1), 1-5.
26. Dzwigol H., Dzwigol-Barosz M., Miskiewicz R., & Kwilinski A. (2020). Manager Competency Assessment Model in the Conditions of Industry 4.0. *Entrepreneurship and Sustainability Issues*, 7(4), 2630-2644. https://doi.org/10.9770/jesi.2020.7.4(5)
27. Payne A. (2005). Handbook of CRM. Achieving Excellence in Customer Management. Oxford: Butterworth-Heinemann is an imprint of Elsevier Linacre House.
28. Souitaris V., Balabanis G. (2007). Tailoring online retail strategies to increase customer satisfaction and loyalty. *Long Range Planning*, 40(2), 244-261.
29. Krykavskyy Ye.V., Pokhylchenko O.A., Chornopyska N.V. et al. (2014). *Ekonomika lohistyky [Economics of logistics]*. Lviv: Lviv Polytechnic University.
30. Kotler P., Keller K.L. (2014). *Marketing Management*. 14th ed. Upper Saddle River, New Jersey: Prentice Hall.
31. Krykavskyy Ye., Lyulchak Z., Tsyran Ya., Petetskyy I. (2015). Partners′ki vidnosyny na rynku V2V ta V2S [Partnerships in the B2B and B2C market]. Lviv: Lviv Polytechnic University.
32. Shoul Dzh. (2013). *Pervoklassnyy servis kak konkurentnoye preimushchestvo [First-class Service as a Competitive Advantage]*. Moscow: Alpina Pablisher.
33. Raykheld F., Til T. (2005). *Effekt loyalnosti. Dvizhushchiye sily ekonomicheskogo rosta, pribyli i neprekhodyashchey tsennosti [Loyalty Effect. Drivers of Economic Growth, Profits and Enduring Value]*. Moscow: Vilyams.
34. Koulman Dzh. (2018). *Nikogda ne teryayte kliyenta. Prevratite lyubogo pokupatelya v pozhiznennogo kliyenta za 100 dney [Never Lose a Customer. Turn Any Customer Into a Lifetime Customer in 100 Days]*. Moscow: Biblos.
35. Zhiltsova O.N. (2015). Kliyentooriyentirovannost biznesa [Customer-oriented Business]. *Vedomosti*, *48*, 12-13.
36. Abdrakhmanova G.I. et al. (2019). *Chto takoye tsifrovaya ekonomika? Trendy, kompetentsii, izmereniya [What Is the Digital Economy? Trends, Competencies, Measurements]*. In Doklad k XX Aprelskoy Mezhdunarodnoy nauchnoy konferentsii po problemam razvitiya ekonomiki i obshchestva. Moscow: ID VShE.
37. Fomell C., Rust R., Dekimpe M. (2010). The Effect of Customer Satisfaction on Consumer Spending Growth. *Journal of Marketing Research*, 47(1), 28-35.
38. Schulze C., Skiera B., Wiesel T. (2012). Linking Customer and Financial Metrics to Shareholder Value: The Leverage Effect in Customer-Based Valuation. *Journal of Marketing*, 76(2), 17-32.

39. Kuzin D.V. (2019). Problemy tsifrovoy zrelosti v sovremennom biznese [Problems of Digital Maturity in Modern Business]. *Mir novoy ekonomiki*, 13(3), 89-99. https://doi.org/10.26794/2220-6469-2019-13-3-89-99.
40. Kwilinski A., Trushkina N. (2019). Development of digital marketing in conditions of transformational change. *Research and Innovations*: collection of scientific articles. New York: Yonona Publishing, pp. 170-173.
41. Trushkina N. V. (2019). Modern trends in the development of digital marketing in the context of globalization. *International Scientific-Practical Conference Global Marketing: analysis and challenges of our time*: Conference Proceedings, May 16-17th, 2019, Batumi Shota Rustaveli State University, National Institute of Economic Research. Batumi, Georgia, pp. 118-121.
42. Kwilinski A., Trushkina N. (2019). Features of digital marketing in the context of informational economy. *Modern innovative and information technologies in the development of society*: monograph / Edited by M. Ekkert, O. Nestorenko, M. Szynk; Katowice School of Technology. Katowice: Wydawnictwo Wyzszej Szkoly Technicznej w Katowicach, pp. 158-165.
43. Trushkina N., Bezpartochna O., Shkrygun Yu. (2020). Priority directions for development of digital marketing in the conditions of globalization. *Pandemic Economic Crisis: Changes and New Challenges to Society*: scientific monograph / Edited by M. Bezpartochnyi; VUZF University of Finance, Business and Entrepreneurship. Sofia: VUZF Publishing House “St. Grigorii Bogoslov”, pp. 227-238.
44. Vertime K., Fenwick J. (2010). *Digital marketing. How to increase sales through social networks, blogs, wikis, mobile phones and other modern technologies*. Moscow: Alpina Publisher.
45. Akulich M. (2017). *Digital Marketing*. Moscow: Publishing Solutions.
46. Jeffrey M. (2018). *Data Driven Marketing. 15 Key Metrics Everyone Should Know*. Moscow: Mann, Ivanov, Ferber.
47. Kotler P. (2018). *Marketing 4.0. From Traditional to Digital*. Kyiv: Dreamland Publishing House.
48. Yurasov A. V., Ivanov A. V. (2012). *Internet Marketing*. Moscow: Hot Line-Telecom.
49. Kapustina L. M., Mosunov I. D. (2015). *Internet Marketing. Theory and practice of brand promotion on the Web*. Yekaterinburg: USUE Publishing House.
50. Kozhushko O., Churkin I., Ageev A. et al. (2015). *Internet marketing and digital strategies. Principles of effective use*. Novosibirsk: RITs NSU.
51. Akulich M. V. (2017). *Internet Marketing Tools. Influencer marketing and newsjacking*. Moscow: Publishing Solutions.
52. Voronyuk A., Polishchuk A. (2018). *Actual Internet marketing*. Moscow: IPIO.
53. Digital marketing in business: 13 promotion channels and an overview of their benefits. Retrieved from: https://kirulanov.com/13-kanalov-prodvijeniy (Last accessed: 14.05.2021).

54. Laurinavicius T. (2020). Powerful Digital Marketing Statistics and Facts for 2020. August 26. Retrieved from: https://lauro.media/blog/digital-marketing-statistics (Last accessed: 14.05.2021)..
55. Cameron M. (2020). Top Digital Marketing Statistics 2020. September 14. Retrieved from: https://www.responsify.com/digital-marketing-statistics/ (Last accessed: 14.05.2021).
56. Statista (2020). Advertising & Marketing. Advertising. Digital advertising spending worldwide from 2017 to 2024, by format (in million U.S. dollars). Retrieved from: Rethttps://www.statista.com/statistics/456679/digital-advertising-revenue-format-digital-market-outlook-worldwide/ (Last accessed: 14.05.2021).
57. Gartner (2019). Innovative technologies and changes in consumer behaviour are forcing changes in marketing strategies. Digital Transformation Bulletin. January. Retrieved from: https://www.cio.ru (Last accessed: 14.05.2021).
58. Kozie D. (1999). Elektronnaya kommertsiya [E-commerce]. Moscow: Russkaya redaktsiya.
59. Tryfonova O.V., Trushkina N.V. (2019). E-commerce in the system of logistics management of the enterprise. *Innovation and Entrepreneurship*: collection of scientific articles Montreal: Ajax Publishing, pp. 101-104.
60. Tryfonova O., Trushkina N. (2019). E-commerce as an effective form of organization of logistics activities of enterprises. *Modern Technologies in Economy and Management*: collective scientific monograph / Edited by O. Nestorenko, T. Pokusa; The Academy of Management and Administration in Opole. Opole: Publishing House WSZiA w Opole, pp. 397-406.
61. Trushkina N., Bezpartochnyi M., Shkrygun Yu. (2020). E-commerce in the conditions of digitalization of business processes. *Strategies, models and technologies of economic systems management in the context of international economic integration*: scientific monograph / Edited by M. Bezpartochnyi, V. Riashchenko, N. Linde. 2nd ed. Riga: Institute of Economics of the Latvian Academy of Sciences, pp. 245-256.
62. Trushkina N.V., Serhieieva O.R., Shkrygun Y.O. (2020). Conceptual Approaches to Defining "E-commerce". *The Problems of Economy*, *4*, 231-240. https://doi.org/ 10.32983/2222-0712-2020-4-231-240.