Regarding the Draft Strategy Development of Artificial Intelligence in Ukraine (2022 – 2030).

Article *in* Artificial Intelligence · August 2022

DOI: 10.15407/jai2022.01.01

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UDC: 004.93 DOI: https://doi.org/10.15407/jai2022.01.008

REGARDING THE DRAFT STRATEGY DEVELOPMENT OF ARTIFICIAL INTELLIGENCE IN UKRAINE (2022 – 2030)

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The Head of the project is Anatoliy Shevchenko, a Correspondent member of the National Academy of Sciences of Ukraine expresses special thanks to the authors, members of the working group, as well as participants of 10 of the monthly conferences, your active participation in the creation of the project "Strategy of development of artificial intelligence in Ukraine for 2022-2030" and invites participate in the preparation of the final version of this an important document for Ukraine.

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Abstract. In the article, the project of the Strategy for the Development of Artificial Intelligence in Ukraine for the 2022-2030 years, which was created by the Institute of Artificial Intelligence Problems of the Ministry of Education and Science of Ukraine and the National Academy of Sciences of Ukraine, this proposed for discussion and suggestions**.** The project takes into account the strategies for the development of artificial intelligence of various countries of the world, in particular the Strategy for NATO on Artificial Intelligence (2021), the Concept of the Development of Artificial Intelligence in Ukraine (approved by the Decree of the Cabinet of Ministers of Ukraine of December 2, 2020 No. 1556-r), as well as the long-term development of domestic scientific structures. The elements of the texts of the participants in the discussion of the Strategy project are provided separately in order to detail its individual provisions.

Keywords: Artificial Intelligence; emerging disruptive technologies; a computing machine with artificial intelligence.

The development of artificial intelligence technologies is an important modern trend. Leading global companies and states pay great attention to this issue. More than 50 countries of the world have already created and adopted strategies for the development of artificial intelligence, in which they outlined the general directions of development in this area. Despite the systematic underfunding of scientific research, Ukraine cannot remain aloof from these processes. Therefore, in this article, we present the current project of the Strategy for the Development of Artificial Intelligence in Ukraine for discussion and suggestions.

A professional discussion of the current state of artificial intelligence issues took place during the annual International Scientific and Practical Conferences "Artificial Intelligence and Information Systems", in particular, the 20th conference (November 27, 2020), in which the vast majority of Ukrainian computer scientists participated (95 scientists), including 52 doctors of science who are specialists in artificial intelligence. It should be noted that representatives of

business structures are always invited and present at the conference in order to commercialize the results of scientific research. It was decided to use human intelligence as a prototype of artificial intelligence [1]. With the support of the National Security and Defense Council of Ukraine (letter dated 29.01.2021 No. 271/16 07/2-21), the Institute of Artificial Intelligence Problems of the Ministry of Education and the National Academy of Sciences of Ukraine sent letters of inquiry to more than 300 different organizations, in particular to most ministries of Ukraine, scientific institutions, public and private institutions of higher education, commercial organizations in order to determine the need to implement and use artificial intelligence technologies in their activities.

In the period from 2021 to July 2022, 10 specialized conferences, a number of scientific seminars and working group meetings were held on the topic "Creating a strategy for the development of artificial intelligence in Ukraine." The results of these scientific discussions found their application in the Strategy adapted specifically for Ukraine, in particular taking into account the presence of scientific structures in the field of artificial intelligence, the high general educational level of citizens. Separately, after the text of the draft Strategy, extended additional materials of the authors are provided, which detail the consideration of certain issues and are summarized in the Strategy.

During the preparation of the Strategy for the Development of Artificial Intelligence in Ukraine, similar documents of other states were carefully studied, as well as the NATO Strategy for the Implementation of Artificial Intelligence [2]. All this experience was adapted to the conditions of Ukraine and used in the text of the Strategy for the Development of Artificial Intelligence in Ukraine.

The analysis of available scientific research conducted in Ukraine in the field of informatics and artificial intelligence led to the conclusion that additional funding is not required to fulfill the tasks of the Strategy. **Instead, the available funding allocated to the field of informatics and artificial intelligence should be directed to the creation of specific systems with artificial intelligence**. Directed activity will help to clearly define and substantiate the object of research in this area (for example, it can be a computing machine with artificial intelligence), which provides the opportunity to conduct fundamental and applied research to create breakthrough technologies.

The Strategy for the Development of Artificial Intelligence in Ukraine was created on the basis of the Concept for the Development of Artificial Intelligence in Ukraine, approved by the Decree of the Cabinet of Ministers of Ukraine dated December 2, 2020 No. 1556. [3]. It is worth noting that concepts express only an understanding of a certain problem and are not a guide to action, while strategies involve a deeper understanding of the object of development than concepts and are always aimed at achieving a specific goal. Compared to concepts, strategies are the next step in the implementation of plans for the implementation of existing developments to identify breakthrough technologies, scientific potential and sources of funding. The strategy for the development of artificial intelligence in Ukraine envisages joining efforts of scientists dealing with these issues to fulfill the task of creating a new generation machine, which was not and could not be foreseen in the Concept. In order to illustrate the applied use of research results in the areas defined in the Strategy, at the end, samples of the created developments and technologies of the Institute of Artificial Intelligence Problems of the Ministry of Education and Science of Ukraine and the National Academy of Sciences of Ukraine are presented.

The directions for the development of artificial intelligence in Ukraine, stated in the Strategy, are correlated with the world's modern directions for the development of science and technology. It has been proven that breakthrough technologies in Ukraine can be created only on one's own achievements in fundamental science.

UKRAINIAN STRATEGY OF ARTIFICIAL INTELLIGENCE DEVELOPMENT 2022 – 2030 (working option)

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INTRODUCTION

The Ukrainian Strategy of Artificial Intelligence Development is a state-level document of national importance, which identifies research priority areas (basic research, applied research, and experimental study), sets tasks and methods for the adoption of national and global AI-based technologies for the benefit of the national security and defense, as well as socio-economic development of Ukraine.

Artificial intelligence is one of the most important technologies in this day and age. More than fifty developed countries as well as the North Atlantic Treaty Organization (NATO) have already created and adopted national strategies for the development of artificial intelligence in order to set tasks and priorities in the area, to accelerate socio-economic development, and to speed up scientific and technological progress.

With the adequate scientific potential of Ukraine, it is necessary to define the range of tasks for the decades-long artificial intelligence development, and to introduce laws and regulations concerning the utilization of artificial intelligence for technological needs of society. Despite the spread of information about AI and the partial application of its elements in some areas, AI as a knowledge-producing and decision-making system is not completely developed. The study of common AI challenges is done mainly in applied and commercial spheres, without the evaluation of risks associated with AI, and with no future forecast. The applied science is limited to building a high-tech, but still imperfect society – the so-called Internet of Things (IoT), the Internet of Everything.

The Ukrainian Strategy of Artificial Intelligence Development has been created on the basis of existing scientific structures, exceptional scientific accomplishments, and a high educational attainment. The information obtained from a great deal of agencies and institutions involved with defense and security, science, education, marketing, and logistics demonstrates that further development of enumerated sectors will not be effective without the introduction of artificial intelligence systems. **As evidenced by the contemporary research results analysis, there are realistic opportunities to create AI-based breakthrough technologies.**

For the reason that the utilization of AI-based technologies in the midst of stiff competition for intelligent solutions can be compared to the space exploration or the discovery of nuclear fission, the development and further adoption of the Ukrainian Strategy of Artificial Intelligence Development project is of considerable importance for the state.

Section 1. PARADIGM

The Ukrainian Strategy of Artificial Intelligence Development is designed with the aim of achieving sustainable development and adopting artificial intelligence. It will effectively improve competitiveness, ensure a high rank of Ukraine in global civilizational processes, and raise living standards. As long as the scientific potential of the country is effectively made use of, the aim will be achieved. Adoption of the Ukrainian Strategy of Artificial Intelligence Development will be a civilizational task solution, the essence of which is occupying a leading position in AI sphere and AI ecosystem creation process. It is crucial to give a comprehensive response to challenges and risks associated with technology gap between Ukraine and technologically advanced countries.

The world is in the middle of technological revolution, which pervades economic and social spheres by integrating abovementioned technologies. A new type of society is in the process of its establishment (Society 5.0). Its chains of production, logistics, and social infrastructure will be based on the artificial intelligence. Intelligent technology availability as well as the intensity and effectiveness of its adoption will be a criterion for evaluating the level of national economy development. Therefore, the attractiveness of countries and regions, concentration of skilled

workforce, high-tech enterprises, material and financial resources, educational institutions, infrastructure and cultural heritage will depend on the level of AI adoption.

Many countries aim to develop and adopt artificial intelligence. The plans, concepts, and strategies often highlight healthcare, technology, agriculture, and manufacturing as high-potential sectors for transformation by means of artificial intelligence. Governments comprehend the significant potential of this technology for retaining their positions and for possible building of competitive advantage in main manufacturing industries.

Risk assessment concepts are being introduced. Particular attention is paid to the development of the legal framework for AI systems (for instance, if it ceases to function), the study of algorithms impacting social inequality, and the necessity to increase transparency associated with AI systems.

Previously mentioned strategies share a common characteristic, which is the compliance with data confidentiality regulations, regarding AI system design, its launch and further application. Governments are aware of their crucial role in building tools for data exchange between the government and stakeholders for the acceleration of AI innovation.

Although objectives, principles and methods of the strategies are fairly similar, it is essential to adapt every strategic plan to the unique country set-up, which calls for taking different paths to reach the same goal. That judgment should be a principal standard pervading the Ukrainian Strategy of Artificial Intelligence Development execution process. For now, Ukraine does not occupy a leading position in the scientific and industrial sectors. It has gone adrift, which negatively affects its competitiveness and national security. Negative tendencies have to be destroyed. For that reason, **the Ukrainian Strategy of Artificial Intelligence Development not only defines the ways to bring AI-related technological dependence to an end. It is also designed to be a considerable basis for economic, technological and political development of Ukraine.**

Section 2. BASIC AI CONCEPTS. AI RESEARCH DIRECTIONS

2.1. Basic Concepts and Definitions

Definitions used in the project accord with ideas of the Concept for the Development of AI, introduced by the Ministry of Digital Transformation and approved by the Cabinet of Ministers of Ukraine at 02.12.2020 № 1556-p:

Artificial intelligence refers to a number of organized information technologies, capable of identifying strategies to achieve goals, performing complex tasks by means of scientific research methods system and information processing algorithms, as well as creating and utilizing knowledge bases, decision-making models, and data processing algorithms.

Scientists of the Ukrainian scientific school of artificial intelligence have suggested **another, parallel AI research direction,** which **implies the development of disruptive AI technologies** based on principles and neural mechanisms of human brain activity, including consciousness.

Human consciousness is a fundamental socio-cognitive system, a product of brain activity that consists of the abilities to perceive and recognize information, construct and systematize knowledge, learn, make independent motivated decisions determined by tasks and conditions, taking laws and rules of the society into consideration.

Qualitative assessment of conscious human actions correlates with the **intelligence quotient**, which is a quantitative measure of intelligence. **Therefore, creation of an intelligent system that forms artificial consciousness as a model of the functional apparatus of human consciousness is deemed a primary task of the artificial intelligence building process.**

On the basis of acquired results, the Ukrainian Strategy of Artificial Intelligence Development provides definition of the term “human intelligence” and the derived term “artificial intelligence”. **Similarly to human consciousness**, an artificial consciousness of the machine is proposed to be **a research subject**. National definitions formulated in the course of research:

- **human intelligence is a set of algorithms and programs generating new knowledge and searching for solutions to creative problems formed and controlled by the human consciousness;**
- **artificial intelligence is a set of algorithms and programs generating new knowledge and searching for solutions to creative problems formed and controlled by the artificial consciousness.**

Artificial consciousness function manifests itself as a global self-organized information product, which evaluates and **controls** core processes of the computer system**, transfers** data between components inside a system in order to coordinate its parts**,** and provides for **social**, personal perception of the reality**.**

As regards the technology development, **the artificial consciousness** is an emergent algorithm for the information processes **control** and computer system components **integration** with **prohibition on putting certain system's decisions into action**. It is a self-aware algorithm, which possesses knowledge of the environment, can train itself and make independent knowledge-based decisions conforming to the legislation and society rules. It conditions **internal integration and external separation** of the system. That interpretation of the **artificial consciousness correlates with NATO's Principles of Responsible Use for AI laid out in the Artificial Intelligence Strategy, in particular the ability to deactivate systems, when such systems demonstrate unintended behaviour.**

2.2. Main Research Directions

Conclusions based on the AI research analysis.

Fundamental research. Available scientific studies and papers **outline the most promising area of fundamental research, particularly in AI sphere.** The most promising area for fundamental research results introduction into applied science, experimental method, and manufacturing. The aim is to build an AI innovative product, which will substitute current computer systems. It corresponds to the insight into Ai offered in NATO's Artificial Intelligence Strategy**, which describes AI as a basic tool offering unique opportunity to attain technological supremacy.**

The research direction concerning the second AI definition entails strategical task of **disruptive technology** creation, a competitive computer of next generation in particular. The basic model of the machine (computer, artificial personality) must contain an essential component – **the artificial consciousness** – and be distinct in advanced **AI,** which provide for its versatile application.

That research direction implies science and business integration, as well as intellectual capital utilization.

The Ukrainian Strategy of Artificial Intelligence Development puts forward the global project for the next-generation computer introduction – **AI-enabled computer based on traditional technologies and quantum computing.** In order to adopt the project, it is suggested to merge scientific schools of the related fields of science for the purpose of producing new knowledge and utilizing available knowledge obtained in the process of natural intelligence examination. The information on functional, psychological, neurobiological, and chemical aspects of the human brain should be used as a basis for quantum computing and universal computer algorithm as a knowledge-producing tool. It is possible to use available human brain activity functional block diagram as well as a human intelligence formation diagram.

The Appendix contains a functional diagram of a next-generation machine created by Ukrainian scientists named **Functional Model of the AI-Enabled Computer,** which can serve as a basis for further research. The principles of functional block diagram of human consciousness activity with a decision-making control system construction were utilized in the process of its creation. The study defines primary and backup systems involved in information reception, its

preliminary processing and the formation of images, systems of short-term, long-term and genetic memory, and well as systems that control the observation of social laws and rules (conscience).

The key factor in functioning of the machine is a necessity to follow the laws of nature, spirituality, morality, national and international law. This approach ensures optimal decision-making beneficial for individual and humanity in general.

The Ukrainian Strategy of Artificial Intelligence Development suggests utilizing the "continuous chain" for research performance and commercialization. The scheme: **performing marketing research on innovations and high-tech research of the country, determining potential market for the final high-tech AI product ↔ determining and analyzing the workforce potential and the provision of funds ↔ identifying a subject of the fundamental research ↔ performing fundamental research ↔ performing applied research ↔ conducting experimental research ↔ introducing new technologies to various industries ↔ resuming manufacturing ↔ creating finished products ↔ market.**

The Ukrainian Strategy of Artificial Intelligence Development involves diverse models and approaches that contribute to the creation of disruptive technologies in the field of AI, quantum and neuro-inspired computers, machine learning system in particular.

Applied and experimental research. The establishments of the Ukrainian manufacturing sector require significant restoration and modernization. The technological level of domestic computer equipment and its elements production remains far behind the developed countries, while the abilities of scientists and their promising achievements are not properly involved. A number of scientists participating in international projects is constantly growing, **which demonstrates that developed countries benefit from Ukrainian scientific potential.** International projects arise chaotically in Ukraine, regardless of their relevance and with no central coordination. **Participation in projects of that kind, mostly small ones, dissipates efforts of Ukrainian scientists and distracts them from setting and solving crucial state-level tasks.**

Analysis of contemporary foreign innovations and products in the field of AI demonstrates the involvement of scientists and business, utilization of scheme for the rapid introduction of scientific results into manufacturing with access to the international market.

Therefore, the Ukrainian Strategy of Artificial Intelligence Development implies introduction of national applied and experimental developments for breakthrough technologies creation and advances various sectors of the country including national security, governmental powers, space sector, science, education, healthcare, manufacturing, telecom industry, agriculture, etc.) with latest technologies and AI-enabled systems. Adoption of the Concept for the Development of Artificial Intelligence approved by the Cabinet of Ministers of Ukraine at 02.12.2020 p. за № 1556p is an important step forward.

Section 3. AIMS AND OBJECTIVES OF THE STRATEGY

The aim of the Ukrainian Strategy of Artificial Intelligence Development is to create foundations for the new technological age that will ensure sustainable economic development of the state and increase welfare and living standards. Ukraine will occupy a leading position in the field of computer and information technology due to effective utilization of advantages and opportunities for the widespread introduction of AI in all social spheres.

Tasks to be completed:

- to provide funds for scientific research in the field of AI;
- to ensure the development of AI-based software;
- to increase the availability and quality of data necessary for the development of AI technologies in accordance with data protection regulations;
- to create a reliable communication infrastructure utilizing the available computing capacity;
- to increase the number of qualified workers at the national AI market;
- to raise awareness of possible sectors for AI application;

- to increase a demand for AI products and services;
- to create a comprehensive system for regulation of social relationships arising from development and application of AI technologies.

Steps to prepare for the implementation of tasks:

- To create a legal framework for protecting intellectual property, storing and transferring AI data.
- To underline the main stages of AI adoption at the state level.
- To establish organizations and institutions with scientific and technical potential corresponding to the tasks.
- To provide workforce training and to determine the required number of workers.
- To outline the stages and technological basis of AI technologies adoption process.
- To calculate financing needed for the AI implementation process, including possible investments to the industry.
- To launch a state program for the implementation of AI technologies in Ukraine.
- To attract investment for AI technologies development.
- To launch interdisciplinary AI research projects in various sectors of the economy.
- To perform and regularly update licensed research.
- To develop research infrastructure and provide access to computing resources, databases and datasets; to create national databases to store text and audio files in Ukrainian language.
- To stimulate international cooperation and the exchange of professionals, to induce participation of Ukrainian specialists in international AI programs and conferences.

Section 4. CURRENT STATE OF ARTIFICIAL INTELLIGENCE IN UKRAINE

Assessment of the current AI state in Ukraine in essential for raising awareness and understanding AI development prospects.

Nowadays, the use of artificial intelligence in Ukraine is limited mainly to the private sector, based on foreign developments. These developments are commonly created in Ukraine, however intellectual property rights belong to foreign companies. The artificial intelligence software market is growing rapidly, and increasing number of suppliers offers various AI solutions for businesses. According to *LinkedIn* research, there are currently more than 2,000 institutions and software development companies specializing in AI in Ukraine. Widely recognized companies *Grammarly, Reface, Ring Ukraine (SQUAD)* are on the list.

Scientific teams which conduct research in the field of AI and have already received a number of significant fundamental and applied scientific results have been created in scientific and higher education institutions of Ukraine, namely the V. M. Glushkov Institute of Cybernetics of the National Academy of Sciences of Ukraine, the Institute of Problems of Artificial Intelligence of the Ministry of Education and Science of Ukraine and the National Academy of Sciences of Ukraine, the Institute for Information Recording of the National Academy of Sciences of Ukraine, the International Research and Training Center for Information Technologies and Systems of the Ministry of Education and Science of Ukraine and the National Academy of Sciences of Ukraine, the Institute of Mathematical Machines and Systems Problems of the National Academy of Sciences of Ukraine, the Taras Shevchenko National University of Kyïv, the National Technical University of Ukraine “Igor Sikorsky Kyïv Polytechnic Institute”, the Institute of Applied Systems Analysis of the National Academy of Sciences of Ukraine and the Ministry of Education and Science of Ukraine, the Shupyk National Healthcare University of Ukraine, the Lviv Polytechnic National University, the Kharkiv National University of Radioelectronics, the Zaporizhzhia Polytechnic National University, the Odessa Polytechnic State University, the Petro Mohyla Black Sea National University, the Chernihiv Polytechnic National University, the Kyïv National Economic University, and in other institutions of Ukraine. Ukrainian AI community is growing

annually. The community frequently holds copious AI and machine learning conferences (*AI&Big Data Day, AI Ukraine*, International Conference "Artificial Intelligence and Intelligent Systems", etc.).

A number of AI developments for national security and defence are to be implemented – multifunctional products, primarily for explosives detection, effective unmanned aerial vehicle (UAV) control technologies, underwater work, namely:

- anti-drone technology, recognition and identification systems, as well as the creation of autonomous onboard navigation system with artificial intelligence under diverse obstacles;
- intelligent video surveillance system;
- long-term intelligent armored fire system with automatic target recognition and destruction technology;
- intelligent integrated human monitoring system on physiological parameters under combat conditions;
- theoretical and methodological foundations for AI-powered forecasting and biotechnical systems management under different conditions on the basis of figurative and sensory information.

Among a small number of areas in which national science is able to demonstrate world-class results, developments in the field of artificial intelligence are distinguished by significant achievements of a fundamental and applied nature. Nowadays, only fragmentary AI developments have been created and applied worldwide, and global science is moving toward creating a fully-developed AI. Ukraine remains far behind the leading countries in terms of pace and number of introduced AI developments, however it possesses promising fundamental knowledge for the development of completely new technologies in the field of AI.

Although, a shortage of funds and no AI sector development concept result in the dissipation of resources, loss of human capital leading to the flight of professionals and promising scientists who emigrate to countries with more favorable conditions for scientific research.

Section 5. GLOBAL AI STANDARDS

Nowadays, no state can operate in isolation from other countries as to the creation and implementation of AI: only international cooperation of scientists will foster the promotion of high-tech AI technologies. Ukraine being a part of the European community and a member of the Committee on Artificial Intelligence of the Council of Europe should focus primarily on the standards of NATO, the EU, the Council of Europe and other European AI institutions.

NATO's Artificial Intelligence Strategy, adopted in October 2021 to accelerate the implementation of AI, since it offers an opportunity strengthen technological edge and poses a broad set of challenges. The strategy aims to:

- to provide a foundation for NATO and Allies to lead by example and encourage the development and use of AI in a responsible manner for Allied defense and security purposes;
- to accelerate and mainstream AI adoption;
- to protect and monitor AI technologies and ability to innovate, addressing security policy considerations such as the operationalization of our Principles of Responsible Use;
- to identify and safeguard against the threats from malicious use of AI.

In the future, the NATO Alliance aims to integrate AI to support its core tasks.

Allied governments have committed to **Principles of Responsible Use** as a key component of NATO's AI Strategy.

1. ***Lawfulness***: AI applications will be developed and used in accordance with national and international law, including international humanitarian law and human rights law, as applicable.

2. ***Responsibility and Accountability***: AI applications will be developed and used with appropriate levels of judgment and care.
3. ***Explainability and Traceability***: AI applications will be appropriately understandable and transparent, including through the use of review methodologies, sources, and procedures.
4. ***Reliability***: AI applications will have explicit, well-defined use cases. The safety, security, and robustness of such capabilities will be subject to testing and assurance.
5. ***Governability***: AI applications will be developed and used according to their intended functions and will allow for: appropriate human-machine interaction; the ability to detect and avoid unintended consequences; and the ability to take steps, such as disengagement or deactivation of systems, when such systems demonstrate unintended behaviour.
6. ***Bias Mitigation***: Proactive steps will be taken to minimize any unintended bias in the development and use of AI applications and in data sets.

The OECD AI Principles adopted in May 2019:

- ***Inclusive growth, sustainable development and well-being***. AI actors should reduce economic, social, gender and other inequalities, and protect natural environments, thus invigorating inclusive growth, sustainable development and well-being.
- ***Human-centred values and fairness***. AI actors should respect the rule of law, human rights and democratic values, including freedom, dignity and autonomy, privacy and data protection, non-discrimination and equality, diversity, fairness, social justice, and internationally recognized labour rights.
- ***Transparency and explainability***. AI actors should commit to transparency and responsible disclosure regarding AI systems.
- ***Robustness, security and safety.*** AI systems should be robust, secure and safe throughout their entire lifecycle. AI actors should ensure traceability, including in relation to datasets, processes and decisions made during the AI system lifecycle, to enable analysis of the AI system's outcomes and responses to inquiry, appropriate to the context and consistent with the state of art. AI systems should not pose safety risks. AI actors can employ a risk management approach to identify and protect against foreseeable misuse, as well as against risks associated with use of AI systems.
- ***Accountability***. AI actors should be accountable for the proper functioning of AI systems and for the respect of the above principles, based on their roles, the context, and consistent with the state of art.
- ***Innovation cycle integration***. AI actors should integrate AI research and development into the sector of economy.
- ***Technological independence*****. Government should foster AI independence of the country, in particular through the predominant use of AI-based national technologies and solutions.**

At the UNESCO General Conference on November 21, 2021, 193 countries, including Ukraine, adopted global ethical standards for artificial intelligence, which highlight four main areas of regulation of AI behavior:

- data protection;
- social assessment and mass surveillance;
- control;
- environmental protection.

UNESCO expects these standards to facilitate the effective use of the benefits of machine algorithms while reducing transparency and privacy risks.

Global AL standards are carefully considered and incorporated in the Ukrainian Strategy of Artificial Intelligence Development.

Section 6. REGULATORY FRAMEWORK FOR ARTIFICIAL INTELLIGENCE

Successful adoption of the Ukrainian Strategy of Artificial Intelligence Development calls for the proper management of scientific and technical processes related to the AI research and implementation. It is essential to create a regulatory framework for the development and adoption of artificial intelligence that meets international standards, as well as NATO's standards, and coordinates with laws of the countries driving the development and use of AI. The government should adopt a law on artificial intelligence, as well as approve resolutions, by-laws and instructions. Ukraine should commit to international treaties and conventions; initiate the convening of international conferences to solve issues associated with AI codification.

The Ukrainian executive body for the AI management and regulation based on ethical norms and principles should ensure the effective control and sustainable development of AI technologies:

- Prioritization of well-being (the objective of well-being enhancement should prevail over other goals of the development and application of AI systems);
- Mitigation of adverse AI system behaviour (the development and use of AI systems capable of causing deliberate harm to human should be limited);
- Human-controlled systems (to the extent possible with regards to the required autonomy of AI systems);
- Compliance with law (the use of AI systems should not violate laws);
- Data security (personal and public data safety should be ensured).

In order to adopt the Ukrainian Strategy of Artificial Intelligence Development, it is necessary to introduce mechanisms to support fundamental research and applied developments as well as the introduction of AI in the production of goods and services, in particular, to establish **the Committee on the Development and Implementation of Artificial Intelligence.**

The Cabinet of Ministers of Ukraine should supervise the Ukrainian Strategy of Artificial Intelligence Development implementation process. The Committee on the Development and Implementation of Artificial Intelligence should coordinate the process.

The Scientific Center for Artificial Intelligence, Institute of Artificial Intelligence Problems, should provide scientific support. A flexible AI regulatory framework should be launched by 2030. It will guarantee the safety and will be aimed at the AI technologies and systems development stimulation.

Section 7. ARTIFICIAL INTELLIGENCE APPLICATION IN PRIORITY AREAS

7.1. Artificial Intelligence and National Security

The core task of the Ukrainian Strategy of Artificial Intelligence Development is the introduction of advanced AI technologies in the defense sector with regards to the NATO's Artificial Intelligence Strategy, the Military Security Strategy of Ukraine and the The Strategy for the Development of the Military Industrial Complex of Ukraine, in particular in the troop management system and logistics during peacetime and conflicts. It provides opportunity to solve the complex security and defense tasks.

The approval of the Ukrainian Strategy of Artificial Intelligence Development will prompt AI technologies adoption in defense sector and will be a catalyst of the effective development of the military industrial complex.

AI technologies will be used to support decision-making in the process of preparing strategic operations and tactical combat operations. These technologies will be used in control systems for space weapons; air, aquatic, and ground vehicles; reconnaissance systems. AI technologies will be

used for the satellite images analysis and cyber defense; for automation of labor-intensive operations in the construction of military engineering structures.

As for the information space and cyberspace, AI is significantly expanding the capabilities of data accumulation and processing, as well as the creation of aggregate data. It will have a synergistic effect in reconnaissance operations.

Challenges and threats posed by the destructive capabilities of AI should be carefully considered. The development of AI-based systems to counter highly intelligent enemy weapons and the research on AI security will be necessary precautions.

To this end, it is essential to found research establishments. It is also necessary to develop and implement regulatory documents governing the utilization of dual-use AI.

It is necessary to introduce AI methods and technologies in the field of cybersecurity in order to ensure prevention and effective RESTRAINT of challenges and threats arising in cyberspace, to ensure an effective COMBAT against cybercrime and cyberterrorism, to ensure the intelligence and counterintelligence of the relevant agencies.

The use of intelligent mobile systems in order to overload its resources is an essential step to AI implementation. The creation of intelligent mobile systems corresponds to global trends such as "mosaic wars" and "multi-domain operations. Considering the space weapons proliferation and advancement, it is urgent to introduce AI methods and technologies in the national space industry. **The establishment of space forces and the deployment of laser weapons in space inevitably call for the counteraction and AI-based instant decision-making.**

Scientists have to form conceptual approaches and effective solutions for the use of AI in order to monitor and process astronomical data, create intelligent navigation systems and uncrewed spacecraft defense systems, autonomous space probes, intelligent automatic missile control systems, smart interfaces of manned spacecraft. It will maintain and strengthen Ukraine’s status as a space nation.

The introduction of artificial intelligence in mobile systems, namely unmanned aerial vehicles, ground and underwater robots to combat hostile aircrafts, submarines and boats is a topical issue. Machine learning, computer vision and pattern recognition, big data analytics, speech recognition, sustainable communication systems, multi-agent autonomous robot swarms control technology, including UAVs are the principal technologies for AI application.

7.2. Artificial Intelligence in Science and Education

The Ukrainian Strategy of Artificial Intelligence Development implies the development of AI technologies as separate scientific areas: fuzzy sets and fuzzy logic, artificial neural network, hybrid neuro-fizzy and fuzzy neural networks, bioinspired metaevristic optimization algorithms (evolutionary and multiagent algorithms, algorithms that mimic physical and other processes), computer vision, natural language processing (machine translation, recognition and speech synthesis, identification of speech, summation, named entity recognition, emotional connotations analysis, etc.), bioinformatics, machine learning, etc. It provides for the introduction of AI methods and technologies in other areas of science and education, as well as the development of interdisciplinary research at the intersection of artificial intelligence and other branches of science.

It is planned to introduce AI study programs at different stages of education, namely: secondary school, vocational schools, higher education institutions.

The network of training centers aimed at training highly qualified professionals for Ukraine in the field of artificial intelligence will be expanded, unified and systematized.

7.3. Artificial Intelligence in Medicine

As for the healthcare, the Ukrainian Strategy of Artificial Intelligence Development provides for the measures aimed at improving standards of living and increasing life expectancy, namely:

- development of AI-powered national medical consultation system based on the AI analysis of health record, genetic and behavioral data;
- formation of AI-powered national electronic healthcare platform, which ensures the storage, targeted use and protection of health data at the local, regional and national levels;
- development of advanced 24/7 medical diagnosis systems (virtual consultants, cyber experts, etc.);
- establishment of situational national center for epidemiologic research; utilization of neural network and neuro-fizzy technologies for epidemic monitoring, modeling and forecasting;
- ensuring cognitive harmonization in family medicine (doctor - patient system); Diversification of medicine into an AI-controlled broader social sphere that uses all forms of health data, including genomics, metadata, electronic health records and biometrics;
- implementation of AI-based patient interaction tools (chatbots, mobile devices, etc.);
- educating patients on decision-making, self-monitoring and disease prevention through use of intelligent tools;
- prioritization of patient groups by risk and proactive intervention through use of AI;
- research on social determinants of healthcare and management of public health through use of AI technologies.

7.4. Artificial Intelligence in Manufacturing Industry. Artificial Intelligence in Power Sector

As for the manufacturing industry and power sector the Strategy suggests:

- introduction of advanced AI technologies to create fully automated industrial establishments;
- application of AI in fuzzy expert systems and decision support systems to manage manufacturing establishments at the strategic and tactical levels;
- utilization of AI in neuro-inspired and neuro-fizzy devices and subsystems for managing the units of manufacturing establishments;
- application of AI technologies to solve the problems of information analysis, planning, forecasting for the creation of the energy security strategy;
- forecasting, diagnosis of critical malfunctions, defect recognition, failure by diagnostics during operation, maintenance and repair of equipment and forecasting of its resource;
- optimization of operating modes of equipment and technological processes;
- flexible energy management to improve energy efficiency;
- forecasting equipment failures, optimizing supply planning, production processes and financial decision-making;
- identification of technological priorities of research considering limited resources – in particular those that do not require significant investments, while having significant competitive advantage due to the mass consumption of AI and machine learning algorithms.

AI-based production line robots can operate 24/7. Enterprises can expand their production capabilities through the increased intensity of production.

AI application to manufacturing will result in fewer workers needed to perform hazardous, harmful and stressful work, which will lead to a decrease in the number of accidents and a negative impact on health. Moreover, AI brings about opportunities for mineral exploration, as businesses and companies will no longer have to risk human lives.

7.5. Artificial Intelligence in Telecom Industry

As for the telecom industry, the Strategy suggests:

- development of mobile communication infrastructure (5G, IoT, 6G, edge computing), since infrastructure solutions give opportunities for the emergence and development of

innovations (for instance, the development of neural networks, pattern recognition and computer vision technologies);
- application of AI to enhance telecom operators' services (subscribers loss prevention, formation of flexible mobile phone tariffs, detection of fraudulent actions, etc.);
- creation and introduction of AI systems for geotargeting, scouting out locations for services delivery, analysis and identification of patterns in a certain target segment, development of relevant offers to new customers, etc.).

Anonymized location data of users uploaded to the public domain can form a fundamentally new market for small and midsize businesses in Ukraine to create and provide various services based of the data analysis.

7.6. Artificial Intelligence in Transportation and Infrastructure

As for the transportation and infrastructure, the Strategy suggests:
- introduction of advanced AI technologies for the creation of autonomous vehicles, as well as fully automated infrastructure;
- development of autonomous vehicle;
- intelligent traffic management;
- creation of an early warning system;
- routes forecasting and optimization of routes.

The autonomous public transport system is a promising area of municipal transportation advancement, since AI-powered vehicles are less harmful to the environment. Optimizing routes and driving intervals can reduce fuel consumption and significantly reduce greenhouse gas emissions.

7.7. Artificial Intelligence in Agriculture

The Strategy implies the startup support, introduction of advanced AI technologies in the process of creation of decision support system and control systems for agricultural facilities. It is planned to use agricultural drones, analyze crop market data based on artificial neural networks, introduce AI in horticulture to manage plant diseases and pests, etc. Unmanned aerial vehicles provide the exact position of the crop in the field and land use inventory, detect plant diseases, analyze crop yield, monitor and control land amelioration systems.

Section 8. NATIONAL AI ECOSYSTEM

The Strategy requires a systematic approach, which includes proper scientific support, funding, and a qualified workforce. It calls for state support, as well as the attraction of private sector funds and venture capital.

The basic points of AI and artificial neural networks theory should be introduced as a study program in schools and higher education institutions in Ukraine. Particular attention should be paid to the introduction of interactive software tools for deep learning and neural network building, natural speech processing, and computer vision technologies.

By 2030, top-tier study programs will be introduced in Ukraine to train highly qualified professionals and managers in the field of artificial intelligence. Ukrainian educational organizations should occupy leading positions, in particular, in AI areas. The research will be funded from the state budget and venture capital. Basic research will be financed from the budget funds already provided for research, which the state annually allocates to the Ministry of Education and Science of Ukraine and the National Academy of Sciences of Ukraine for the implementation of projects that have passed competitive selection. These projects should be actively attended by scientists who have taken responsibility for creating the foundations of the theory of artificial

intelligence for their further concrete implementation in applied development. Ukrainian scientists will be encouraged to participate in these competitions. In addition, there will be an opportunity to participate in competitions for applied projects, which provide mixed funding: 51–60% of funds will be obtained through the participation of higher education institutions and research organizations in competitions for research projects in order to preserve the state's intellectual property, and 40–49% of funds will come from private sector contributions.

Section 9. EVALUATING EFFECTIVENESS OF THE STRATEGY

According to the analysis of the labor market, artificial intelligence is not a cause of unemployment. AI advancements did not lead to the dismissal of millions of workers. On the contrary, the spread of AI has contributed to the creation of new jobs and specialties. Information technology labour market is characterized by that phenomenon.

The development of AI in Ukraine will significantly affect the labor market in the future. The percentage of jobs will be changed under the influence of digital transformations (from 10% to 40% according to the forecast of a number of EU countries) and a certain number of current professions will undergo serious changes. In addition to that, the development and widespread adoption of AI technologies will lead to the emergence of new jobs, some employees will have to change jobs, as well as change official relationships with employers and acquire new skills. Basic digital skills include the following:

- data analysis by means of software and further decision-making;
- IT skills and programming skills;
- development, design and maintenance of technology;
- modeling and interacting with robots; building trust (human-machine cooperation);
- basic data entry skills;
- processing and interpretation of complex data;
- problem-solving skills (intercultural or remote cooperation).

Therefore, the advanced training and retraining both in the workplace and through training programs will become increasingly important.

It order to assess effectiveness of the Strategy, it is necessary to introduce indicators that will determine the progress in priority areas and the improvement of well-being and quality of life.

Section 10. OUTLINE OF THE STRATEGY

The Ukrainian Strategy of Artificial Intelligence Development is designed for the period of 2022-2030, and its adoption process consists of two stages:

- I stage – 2022-2025;
- II stage – 2026-2030.

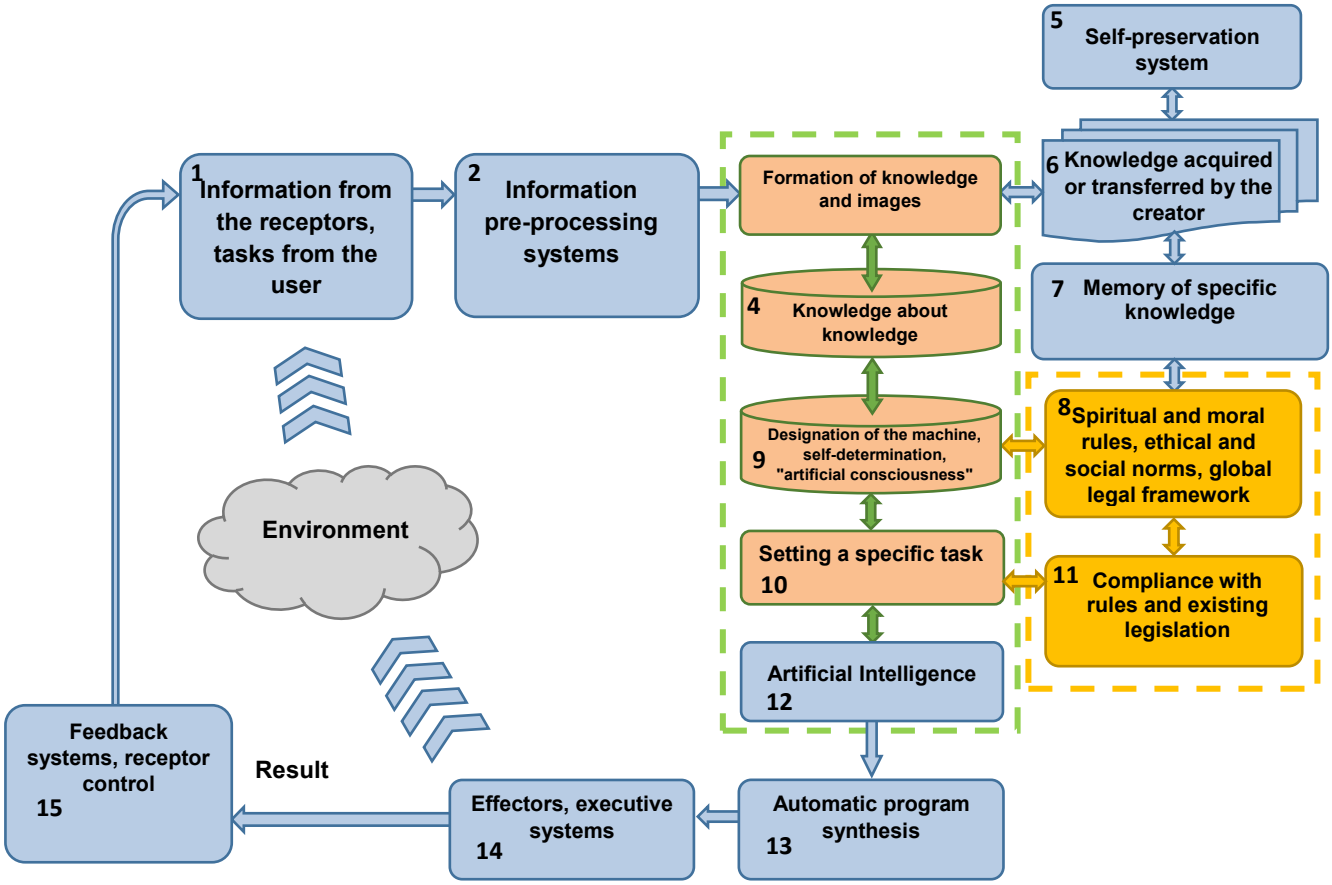
The main mechanism for the Ukrainian Strategy of Artificial Intelligence Development implementation is the annual action plans developed by the **Committee on the Development and Implementation of Artificial Intelligence and approved by the Cabinet of Ministers of Ukraine.**

The Ukrainian Strategy of Artificial Intelligence Development is based on the Constitution of Ukraine, as well as on the Laws of Ukraine “On National Security of Ukraine”, “On Scientific and Technical Activities”, “On Higher Education”, “On Copyright and Related Rights”, “On Protection of Rights to Industrial Designs”, “On Protection of Rights to Inventions and Utility Models”, and the Decree of the President of Ukraine of September 14, 2020 № 392 “On the Decision of the National Security and Defence Council of Ukraine”.

The Ukrainian Strategy of Artificial Intelligence Development serves as the basis for state programs and regulations concerning the development of artificial intelligence in Ukraine.

Appendix

Functional Model of the AI-Enabled Computer



Supplemental materials to the Ukrainian Strategy of Artificial Intelligence Development (2022-2030)

O. V. Bilokobyljsjkyj

To Introduction

The tasks of the Ukrainian Strategy of Artificial Intelligence Development are as follows:

- to ensure the functioning of IoT-based (Internet of Things) smart systems; to guarantee the development of a distributed databases and processing of data obtained through the use of AI technologies;
- to develop national electronic networks, databases, cloud storages, and cloud computing, which ensure the safe transmission of data;
- to provide national computing capabilities;
- to train and hire the required number of qualified professionals;
- to foster the introduction of AI technology in biotechnology, genomics, and the national healthcare system;
- to develop technologies that augment human labor, namely, robotics and autonomous systems, to avoid workplace hazards;
- to adopt AI technologies in national security, cybersecurity, and data protection;
- to intensify national AI research;
- to considerably enhance the fundamental research and technology through the use of AI, specifically, in quantum computing, nanotechnology, development of new products, aviation, and space industry, microelectronics;
- to cultivate digital literacy in Ukraine;
- to ensure the effective management and funding for the adoption of the Ukrainian Strategy of Artificial Intelligence Development.

To Section 6. Regulatory Framework for Artificial Intelligence

Particular attention should be paid to the formation of a central executive body with the power to enforce the law – the National Council on AI Safety. It will unify all entities, namely, the government, scientific community, civil society, and business. The executive body will be subject to the Prime Minister of Ukraine. The core task of the authority is to monitor the development of AI-based technologies, whether it corresponds to the main points outlined in the Ukrainian Strategy of Artificial Intelligence Development. It should also conform to the national law and legal documents, with priority given to safety and ethical principles. Duties of the National Council on AI Safety:

- to coordinate the activities of Ukrainian and international actors working in Ukraine on AI technologies; to create and develop a platform for joining forces and achieving synergy;
- to assess high-risk AI systems; to evaluate the steady adherence of society to the principles and ethical standards outlined in the Ukrainian Strategy of Artificial Intelligence Development;
- to license high-risk AI technologies related to strategically important sectors of the national economy;
- to periodically monitor adopted high-risk AI systems throughout the lifecycle to determine their impact on society and to modify them if needed;
- to verify compliance of Ukrainian AI technologies with European standards for security and data protection, privacy, transparency, etc.; to cooperate with European and international AI regulatory agencies;
- to initiate changes in the regulatory framework; to foster the adoption of new AI regulations, considering the incessant advancement of AI systems;

- to monitor the executive authorities responsible for the implementation of the Ukrainian Strategy of Artificial Intelligence Development; to improve the implementation process;
- to provide refresher training for officials engaged in the adoption of AI systems; to coordinate the introduction process of AI study programs in Ukraine;
- to raise awareness about the recent AI developments; to build trust through the introduction of transparent safety standards.

To Subsection 7.3. Artificial Intelligence in Medicine

Regarding the place of AI in **healthcare,** it is necessary to focus on several tasks.

To build a national digital healthcare platform

The task is to build a national healthcare platform that is being created to store anonymized biometric data, anonymized copies of medical records, images, medical test results, etc. The platform will allow experts to analyze data for population health assessment. Moreover, it will contribute to scientific research, in particular to the development of new pharmaceutical products and technologies. Access to the database of anonymized data will be open for research and statistical analysis.

To ensure data exchange and its utilization by local, regional, and national authorities

Considering the development of smart city information systems and the Internet of Things (IoT) technology, which, according to experts, will have up to 1 trillion web-enabled sensors by 2025: it can be deduced that personalized medical services, data exchange between different institutions and patients (via telemetry), processing of large amounts of data and AI tools analysis, etc. will shape the future of Ukrainian healthcare system. Alternations are not possible without a reliable and high-speed electronic communication network. The government strives to launch broadband technology and 5G networks.

To introduce deep learning and research in the healthcare sector

Deep learning is considered the basis of contemporary medical technologies concerning medical image processing and other diagnostics and autonomous robots for detecting anomalies data. Therefore, the government fosters deep learning R&D activities. In supplement to that, the government provides financial support for other medical products development, in particular through the public procurement mechanism for scientific and technical (experimental) developments and products.

To protect health-related personal data and data on received medical care

The development of AI technologies in the healthcare sector requires various categories of personal data, which are analyzed and utilized for research purposes. The government will contribute to further protection of personal health information and the regulation of access to the data at all levels of storage and utilization, in particular by initiating the adoption of a new regulatory framework and harmonizing Ukrainian and international standards.

To develop and improve the regulatory framework and ethical framework for health-related AI applications

The progression of AI technologies in the healthcare sector requires the development of a regulatory framework, in particular, for creating algorithms used in medical equipment software, such as robotic surgery systems or medical imaging software. The norms, criteria, and standards for ethical control over the use of AI in healthcare have to be regulated by the government.

To stimulate the development of telecommunication technologies, robotics, and autonomous medical technologies

In the future, the majority of tasks performed by healthcare professionals will be performed by autonomous systems with artificial intelligence. Including automated recording of medical

details of patients, patient logistics, providing patients with medicines and medical services, examining patients, and prioritizing medical care (triage), especially when hospitals are overwhelmed, etc. It is necessary to improve telehealth, in particular with remote delivery of medical care, for example, to attract professionals from regional centers or from abroad.

To develop AI skills of students and healthcare employees

Raising healthcare workers' awareness of AI, which involves obtaining knowledge of ethics, bioethics, data protection, and working with autonomous systems and software, is crucial for the development of the AI medical ecosphere. These competencies should become an essential component of medical education and be reflected in the curricula of Ukrainian educational institutions.

Digitalization of healthcare involves the creation of electronic databases, logistics algorithms, and a telemedicine system. A separate area of competence is the establishment of interaction between healthcare professionals and AI systems, the consolidation of specific opportunities for the most effective treatment of patients. In particular, it is necessary to determine the criteria for decision-making in case of discrepancy between the doctor and the AI system.

To foster the creation and introduction of a government program for the quality of life and life expectancy improvement, which relies on the spread of electronic applications produced in Ukraine that manage main health-related indicators. Such applications and control devices are widely spread among citizens, and further actions of the government will depend on research results concerning the utilization of these technologies.

M. O. Vakulenko

To Subsection 2.2. Main Directions of AI Research

Synergetic Modeling of Artificial Consciousness

Artificial consciousness models should be based on the results derived from studies of human consciousness considering biological, medical, and psychological factors. In particular, the study of human consciousness manifestations [Seth, Baars, and Edelman 2005], its senses [Dehaene, Lau, and Kouider 2017], and the attention schema theory [Graziano 2017; Graziano and Webb 2017] indicate that consciousness arises from two interrelated processes, which are the mechanism of attention that determines the consciousness of computation and report, and the mechanism of coherence that determines the consciousness of subjective perception and self-monitoring.

Therefore, modeling the artificial consciousness should include two approaches:

- modeling the **attention schema** as a mechanism to select and disseminate information (C1 by the classification of Dehaene, Lau, and Kouider [2017]);
- modeling the **coherence** mechanism, which provides the subjective perception of reality and management (C2 by [Dehaene, Lau, and Kouider 2017]).

The first approach indicates inner aspects of consciousness, and the second one is external. The attention schema that generates C1 is a comparative mechanism of the **global neural network**, which assesses the importance of processes in the system accordingly. The scoring system is based on the built-in values of AI activity, in particular on the moral and ethical principles laid down in the unit of artificial conscience. For a more important process, the system allocates more resources, including providing supplemental blocks and rebuilding the architecture to successfully solve the most necessary or immediate task. Prerequisites for the occurrence of C2: a nonlinear system with the feedback and external excitation. Therefore, consciousness can be modeled within the frame of synergetics. The fact that the **exploding gradient** in the recurrent networks is similar to the soliton indicates the feasibility of the approach. The features of this model:

- Consciousness is **a decaying strange attractor** with a frequency of 50-100 Hz, which exists for 3-4 periods.
- Consciousness extends to physical media that support a strange attractor.
- **Personality** is represented by the phase portrait of a system.

A possible mechanism for consciousness modeling is a system of neural networks in which there is a nonlinear coupling between neurons that are involved in different processes – that is, between parts of different networks. This can be done this way. We write equations that describe the propagation of a signal in two or more neural networks and then impose nonlinear links on the input neurons (for example, consider them as points of a plane wave). The resulting equations, which contain the necessary nonlinear relationships, can be used to construct phase portraits.

Since the natural neural network transfers electrical potential from neuron to neuron, an electrical analogy should be used. In this analogy, the process of brain activity or neural network calculations can be represented by a block diagram of the propagation of a set of electrical signals in a system of series-connected multipoles, including start relays, which are activated if the output exceeds a threshold.

Consciousness distinguishes and disseminates knowledge and processes that corresponds to the strategic task (morality) – for instance, the **survival** of mankind. It is possible to pick such knowledge out by determining the cosine similarity.

To Section 3. Aims and Objectives of the Ukrainian Strategy of Artificial Intelligence Development

Effective use of information banks and databases. Artificial intelligence technologies involve their language competence and the use of multilingual and multilingual information banks and databases. For effective processing of textual information written in the Ukrainian language, in particular, for its Latinization, it is necessary to use the national transliteration standard DSTU 9112: 2021 “Cyrillic-Latin transliteration and Latin-Cyrillic retransliteration of Ukrainian texts. Writing rules”, which provides isomorphic transliteration transformation of ancient, old and modern Ukrainian texts.

Security. AI security is an extremely important issue because those who have access to AI systems benefit from that technology. Therefore, it is valid and reasonable to control AI by military authorities that can ensure AI security. However, it is not enough.

To achieve the mandatory and sufficient level of security, it is necessary to create an international ethics committee that would constantly monitor the legality of the AI utilization, assessing moral and ethical aspects associated with AI. These aspects should cover legal norms and widely recognized moral and ethical guidelines. Recommendations of the committee should be compulsory for all AI applications. Technically, these recommendations should be input into the block of artificial conscience depicted on a diagram in the Appendix.

Particular attention should be paid to protection from malicious actions of terrorists and religious fanatics. It should provide for the possibility of automatic shutdown of the artificial personality in case of interferences in the block of conscience beyond the recommendations of the ethics committee.

Not only obvious attempts to make the behavior of an artificial person destructive and aggressive, but also intentions that are allegedly aimed at introducing certain religious values taught in the Bible, the Quran, the Torah, or some other sacred books.

The Ukrainian society is positively disposed towards religious literature, especially the Bible. It seems a great idea to base AI morality on religious texts, isn’t it? The commandments described in the nineteenth chapter of the Gospel of Matthew constitute the core of the moral values of the whole of mankind.

It is important to understand that these books contain diverse recommendations, and the perception of these recommendations largely depends on the beliefs of the person who perceives these recommendations, as well as on the person who interprets these recommendations and in which way one does it. Everybody interprets sacred texts differently. As a result, a large number of religious movements have emerged. Not all of them are peaceful.

For instance, Islamic suicide bombers are convinced that their death, as well as the death of many others, is justified by the sacred purpose. Someone instilled this purpose in them by the advisedly delusional interpretation of the Quran. It is easy to provide grounds for it. “I will cast

terror into the hearts of those who disbelieve. Therefore, strike off their heads and strike off every fingertip of them." (Surah Al-Anfal Verse 12 [8:12]).

Moreover, many texts of the Bible can be easily interpreted as a guide to terror and the extermination of people.

For instance, "the Lord struck down all the firstborn in the land of Egypt" (Exodus 12:29). Moses commanded three thousand people to kill each other just because "they made themselves an idol cast in the shape of a calf" (Exodus 32:27-28). Moses commanded the Righteous Phineas, grandson of the High Priest Aaron, to slay his tribesmen just because they were engaged in sexual intercourse with the Moabites (Numbers 25:5-9). Moses commanded to kill "every male among the little ones and kill every woman who has known a man intimately" (Numbers 31:17-18). The story of Achan and his children brutally murdered by the Israelites for Achan's sin, so that the Lord turned from his fierce anger serves as a good example (Joshua 7:24-26). Let alone the instructions to Saul to "attack the Amalekites and totally destroy all that belongs to them. Do not spare them; put to death men and women, children and infants, cattle and sheep, camels and donkeys." (1 Samuel 15:3). "Happy is the one who seizes your infants and dashes them against the rocks." (Psalm 136:8). There are many more examples.

Russia's military aggression against Ukraine, which is approved by the Russian Orthodox Church, serves as an example of such a delusional interpretation.

Previously mentioned examples demonstrate that AI morality should not be limited to quotations from religious texts, however, it should be based on generally accepted moral values of the cultural heritage. The only robust protection against religious fanaticism is the complete exclusion of religious values embedded in artificial personality because the road to hell is paved with good intentions. To do that, it is necessary to input the Bible, the Quran, the Torah, and other religious texts into the machine, and provide for automatic disconnection if any of these texts are being input into the block of conscience.

To Subsection 7.1. Artificial Intelligence and National Security

The cybersecurity issue is related to information hygiene.

Unfortunately, Ukrainian language learning websites, which are simply a translation of Russian texts concerning Russian language learning tips, have become a common occurrence.

For example, the website "How to memorize cases of the Ukrainian language easily for children. How to learn better and faster" (https://jak.koshachek.com/articles/jak-zapam-jatati-vidminki-ukrainskoi-movi-legko.html). From this website, one can learn that there are not seven, but six cases in the Ukrainian language (similar to the Russian language), and instead of the locative case there is the prepositional case. The website even suggests acrostics to memorize cases better. Naturally, it is a bad Russian to Ukrainian translation. The website "What is repetition? Examples in the Ukrainian language and literature" (http://teg.com.ua/leksichnij-povtor-shho-tse-take-prikladi-v-ukrayinskij-movi-i-literaturi/). The text itself refers to the literary devices in the Russian language, underpinned by quotes from the best-known Russian writers.

The purpose of such websites is unclear. Perhaps these are Russian-affected resources aimed at discrediting the Ukrainian language. It is not difficult to understand what will be the consequences of using such resources. These websites with bad translation are complete turn-offs. Due to it, users lose enthusiasm for exploring websites in Ukrainian or even view the Ukrainian language as a low-quality supplement to Russian.

Tracking such websites and responding appropriately to such things is an important task of our state's information security, where AI needs to be applied.

A. S. Dovbysh

To Section 8. National AI Ecosystem

To successfully implement the Ukrainian Strategy of Artificial Intelligence Development, it is necessary to concentrate Ukrainian scientific school of artificial intelligence for the creation of the

machine learning methods within the functional approach to modeling the cognitive processes of human natural intelligence. In this case, machine learning methods have to meet the basic requirements:

- to be adaptable to arbitrary initial conditions for the formation of an input mathematical description of the AI system;
- to perform the fuzzification of input fuzzy data in the process of machine learning, that is to say, to transform fuzzy recognition patterns that characterize the possible functional states of a computer with artificial intelligence into a crisp value;
- to be almost unsusceptible to the multidimensionality of the recognition features and the alphabet of recognition patterns;
- to perform machine learning according to the hierarchical structure, which allows building highly accurate decisive rules for the alphabets of high-duty recognition patterns;
- to perform automatic (without interactive mode) self-learning and retraining of the AI system in the process of expanding the alphabet of recognition patterns;
- to give a classification forecast on changes in the functional states of the computing system and the processes under study;
- to perform the optimal distribution of the resource of the computer and the distributed computing environment according to the generalized criterion “energy conservation is the quality of service”.

Since the Ukrainian Strategy of Artificial Intelligence Development lacks funding, one of the sources of funding for universities' scientific developments is grants given by IT companies. Unfortunately, in Ukraine, IT companies engage students and graduates to work in the IT sector refusing to pay compensation to the state for their training, which forces higher education institutions to act as beggars. It is necessary to submit a request to the Ministry of Education and Science of Ukraine to develop legal mechanisms regulating contractual relations between the university and employers. It is essential to set up a foundation to provide support for scientific research in the university departments and talented students and graduates, who will be involved in the implementation of the Ukrainian Strategy of Artificial Intelligence Development.

The scientific potential of Ukrainian talents is enough to create a computer with artificial intelligence, as long as there is financial assistance provided. The shreds of evidence of it are scientific results obtained at the Institute of Artificial Intelligence Problems of the Ministry of Education and Science of Ukraine and the National Academy of Sciences of Ukraine and at the Sumy State University on the modeling of cognitive processes inherent in humans, and creation of extreme learning machine methods within the functional approach, the functional efficiency of which exceeds the well-known intelligent information technology of data analysis.

To Subsection 2.1. Basic Concepts and Definitions

Clarification of terms “Human Intelligence” and “Artificial Intelligence”:

- **human intelligence is the ability to solve creative problems, formed in the process of interaction with the environment;**
- **artificial intelligence is the algorithm for the creative problem-solving performed by the artificial consciousness of the artificial personality (machine), created and controlled by human consciousness.**

Since artificial intelligence is the simulation of human natural intelligence, a machine a priori cannot create a decision-making mechanism better than human consciousness. Another thing is that human consciousness can create AI that can expand its functionality, for instance, by creating virtually unlimited memory or high decision-making efficiency. Such properties as self-multiplication, self-improvement, autonomous functioning, self-destruction, etc. are also created by human consciousness.

V.V. Kazymyr

To Introduction

The new era of technology, which came in the 21st century due to the rapid development of information technology, is based on cyber-physical systems. Nowadays, the physical world is merging with the digital world, forming a single digital ecosystem. The key success factor of that modification is the introduction of intelligent manufacturing systems.

In the future, AI costs are expected to rise as businesses strive to accelerate digital transformation and technological development. AI market is forecast to reach USD 99.94 billion by 2023, at a CAGR of 34.86% during the forecast period. Practical use of AI will be a major factor as businesses ensure they obtain income using AI to solve specific problems.

Considering the forecast, the existing potential, and challenges faced by the government, the manufacturing industry and the defense sector should be defined as priority areas for the development of artificial intelligence in Ukraine.

To Subsection 7.1. Artificial Intelligence and National Security

In supplement to cybersecurity, the importance of which has increased incredibly in recent years, the most important direction of research and implementation of artificial intelligence in the defense sector should be considered the creation and use of mobile intelligent autonomous systems. These systems will be designed with distributed control architecture, which is secure, reliable, and dynamically structured, instead of the centralized control architecture with predetermined supervision and situational centers.

The creation of mobile intelligent autonomous systems is one of the main concepts of the organization of heterogeneous national and international forces, known as “mosaic warfare” and “multi-domain operations”, which are being actively implemented by the Defense Advanced Research Projects Agency (USA).

The concept is called “mosaic warfare”. Like the ceramic tiles in mosaics, these individual warfighting platforms are put together to make a larger picture. The aim is to utilize multiple heterogeneous warfighting platforms and sensors to gain an advantage over adversaries. Therefore, the core idea of this concept can be expressed like that: to transform complexity into an asymmetric advantage.

The arrangement of distributed control mobile systems harmonizes with the concept of “multi-domain operations”. Confronting equal competitors means the need to protect forces from threats that can come from any domain – land, air, space, sea, and cyberspace. It is essential to transform multicomponent robotic systems into UAVs with swarm intelligence operating without central and external control.

A key role is played by unmanned aerial vehicles (UAVs), or drones. The rise in the procurement of military UAVs worldwide is one of the most significant factors. Thus, the UAV market is projected to grow from USD 19.3 billion in 2019 to USD 45.8 billion by 2025, at a CAGR of 15.5% during the forecast period. The increasing use of UAVs in various commercial applications, such as monitoring, surveying and mapping, precision agriculture, aerial remote sensing, and product delivery, is also contributing to the growth of the UAV market.

Based on the scope of application, the main directions of implementation of artificial intelligence in mobile systems, which include UAVs, are machine learning, computer vision, and pattern recognition, big data analytics, reliable communication systems, multi-agent control technologies, and establishment of autonomous robot communities.

The aim is an application of artificial intelligence (AI) in unmanned aerial vehicles (UAV) to make the efficient use of large datasets (for instance, aerial photographs), which is automated and almost uncomplicated. UAVs can reach their full potential only when the data collection and analysis process reaches the highest level of automation. However, it should be kept in mind that the fusion of UAVs and artificial intelligence makes sense only if it saves money and time, which is

especially important when used for military purposes. In some cases, traditional computer vision combined with machine/deep learning can still be a simpler and better solution.

AREAS OF ACTIVITY

of the Research and Training Center for Artificial Intelligence and Cybersecurity

1. Research:
   - machine and deep learning;
   - computer vision and pattern recognition;
   - data mining;
   - reliable communication systems;
   - multi-agent control technology;
   - autonomous operations;
   - mobile intelligent autonomous systems;
   - intelligent text processing;
   - voice and speech controlled by artificial intelligence;
   - artificial intelligence and cloud computing;
   - intelligent systems and healthcare;
   - Industry 4.0 technology trends;
   - intelligent design and manufacturing;
   - model-oriented management of intelligent manufacturing systems;
   - trustworthy Internet of Things;
   - intelligent monitoring and decision-making;
   - intelligent situational awareness and forecasting;
   - intelligent cybersecurity technologies of industries and organizations.
2. Training:
   - Doctor of Philosophy and Doctor of Sciences programs in specialties 122 - Computer Science, 125 - Cybersecurity, 126 - Information Systems and Technologies;
   - Master's Degree programs in Artificial Intelligence;
   - advanced training of professionals and personnel of cybersecurity centers on the use of the latest intelligent technologies.
3. Awarding Certificates to AI professionals.

To Subsection 7.4. Artificial Intelligence in Manufacturing Industry and in Power Sector

The global Intelligent Manufacturing Systems program, which was started at the end of the twentieth century with a series of research projects, has now become the core catalyst of Industry 4.0. Intelligent manufacturing systems, based on the comprehensive use of embedded computer systems, have led to the emergence of cyber-physical systems (CPSs) capable of merging real and virtual worlds. Currently, CPSs are applied in several fields such as autonomous robotics, augmented reality, manufacturing, horizontal integration and vertical integration, big data, cloud technology, simulation modeling, industrial Internet of Things, and cybersecurity. Moreover, computer models, which are the major artificial intelligence factor, are directly embedded in the control loop at all levels of decision-making: from strategic and tactical planning to technological processes control.

Considering the current intellectual potential, Ukraine can become a regional leader in these areas in the short run, ensuring comprehensive and high-tech engineering services primarily in the following areas:

– computer programming in the high-tech manufacturing industry, creation of new software products, including new technologies of Industry 4.0;
– design (electrical, mechanical, electronic, technological, construction, etc.);
– industrial automation, computerization, and intellectualization (including the commissioning of industrial zones);
– development and manufacturing of complex, small-scale, or unique products.

As for the national economy, Industry 4.0, filled with artificial intelligence solutions, is expected to foster manufacturing industry development, as well as defense industry development. However, the involvement of IT companies, science, and universities in the digital transformation of the Ukrainian manufacturing industry and power sector poses a great challenge. Moreover, labor shortage may lead to the shift to automation.

To Section 8. National AI Ecosystem

The essential component of the AI ecosystem is the supply of scientists, engineers, and pedagogical employees, who are entrusted with the following tasks:

- to conduct relevant and effective fundamental and applied AI research;
- to coordinate the scientific research on the development of AI in Ukraine with the needs of government and society;
- to support the participation of scientists in international exhibitions and conferences, to publish scientific papers in reputable international journals, to start a new paper or digital journals on AI problems;
- to start new educational programs and to improve existing ones that deal with AI theory and practice, as well as AI applications in various fields of knowledge;
- to develop standards for postgraduate education and bachelor's degree programs, taking into account the benefits of AI applications;
- to share your experience in AI systems development, which has been acquired during the implementation of Tempus IV and Horizon 2000 programs;
- to create AI awards to be presented at scientific festivals, startup competitions and forums;
- to encourage the talented youth to perceive and develop AI ideas at the Junior Academy of Sciences of Ukraine.

Ju. P. Kondratenko, O. S. Strjuk, O. V. Kozlov, Je. V. Sidenko

To Section 1. Paradigm

The economy of Ukraine faces fierce global competition simultaneously with high-risk investment challenges in advanced technologies, including ICT (Information and Computer Technologies). Moreover, outdated infrastructure, including equipment that is not suitable for digital transformation, as well as the lack of opportunities for scaling and diffusion of technological innovations stand in the way.

However, over the past decade, Ukraine has significantly strengthened its position as an active member of the global AI community.

According to the Deep Knowledge Analytics report (Artificial Intelligence Industry Landscape Overview 2018), Ukraine has been placed among the top three Eastern European countries in terms of AI companies number: Russia ranked No. 1 – 133 companies, Poland ranked No. 2 – 110 companies, Ukraine ranked No. 3 – 57 companies.

According to the Government AI Readiness Index 2020, which assesses the readiness of governments to deploy artificial intelligence, Ukraine ranks 57th out of 172 countries with a score of 49,901 (for comparison, the United States ranks the highest of all countries scoring 85,479). According to this rating, Ukraine has the following index scores: vision – 50, data availability –

66.56, governance & ethics – 51.27, innovation capacity – 41.53, size – 22.87, infrastructure – 41.35, human capital – 42.39. The highest score is 84.17.

Moreover, over the past few years, Ukraine has advanced significantly in publishing open data. Currently, Ukraine is ranked 31st in the Global Open Data Index[1].

Although Ukraine has not become an AI leader yet, it seems quite probable that Ukraine will bolster its position in the AI sector and attain the status of key AI player if the strategy is chosen correctly and modified in accordance with the challenges that beset the country.

It is urgent to attract foreign investors. Industrial policy and innovation policy should be integrated with sectoral policy and technology policy in order to promote the industrial transformation of the knowledge economy by strengthening the availability of high-tech sectors while fostering the modernization of low- and medium-tech sectors and their capability to incorporate new technologies. The capital allocated by the Ukrainian government for research and development is scarce when compared to top countries in terms of manufacturing output. In such high-tech areas as artificial intelligence, public and private investments are insufficient in Ukraine.

To Subsection 2.2. Main Directions of AI Research

Artificial general intelligence, a self-aware artificial agent capable of reasoning, is a primary issue of computer programming, but not computer engineering. In order to create a completely developed artificial intelligence, it is necessary to design fundamentally new software architecture, to craft an effective strategic plan through the use of computer programming and deep learning systems.

The performance of modern computer systems and supercomputers, which have long surpassed human intelligence in terms of computing capabilities, allows for efficiently complex mathematical operations. However, in spite of their high performance, computers are not intelligent agents. Performance is only a component of intelligence, and its high efficiency does not directly cause the emergence of intelligence.

As we see it, in terms of computer engineering, it is reasonable to put effort into software and algorithmic methods instead of the next-generation computer. These are new approaches and paradigms of computer programming, machine learning, and deep learning, new AI architectures, innovative algorithms.

The human brain is the most complete example of intelligence ever known to mankind. We believe that the human brain and mammalian brain are the optimal prototypes for the study of intelligence, as an example of natural engineering. However, since the phenomenon of intelligence is not fully explored, it is necessary to avoid restrictions and focus research efforts on the study of other intelligent biological agents, for instance, unicellular eukaryotes or viruses.

To Section 3. Aims and Objectives of the Ukrainian Strategy of Artificial Intelligence Development

The **aim** of the Ukrainian Strategy of Artificial Intelligence Development is the development and integration of artificial intelligence technologies both in the public and private sectors in order to improve competitiveness in Ukraine, ensure sustainable improvement of welfare and quality of life of the population, enhance public administration system, safeguard national security and national security and maintain law and order.

The **subject** of the Ukrainian Strategy of Artificial Intelligence Development is methods and means of AI development and integration in manufacturing, economy, transportation and infrastructure, science, healthcare, agriculture, ecology, defense industry, etc.

[1]Global Open Data Index. Tracking the State of Open Government Data. URL: https://index.okfn.org/.

It is necessary to determine the course of **popularization, support, and development** of the AI community: it will contribute to the engagement of professionals from other scientific fields, as well as stakeholders from various population groups, *regardless of age.*

It is necessary to create **a storage system** in order to accumulate organizations, companies, projects, and research groups specializing in artificial intelligence.

It is necessary to design an effective and permanent **AI data monitoring program**: news (both technical and ethical); tracking scientific discoveries and research with the subsequent *mandatory analysis*; regular information exchange with the global community, leading international organizations, and scientific institutions.

It is worth setting an ambitious goal for **Ukraine's leadership** as a country that can become one of the top 50 countries leading the artificial intelligence race. Considering the legacy of the Soviet Union (engineering education, scientific programs, and manufacturing) as well as Ukraine's leading position in the world IT industry, the leading position of our state in this field should be considered quite attainable even in the short term (10 years).

To Subsection 7.1. Artificial Intelligence and National Security
Prospects of Using Robots

Semi-autonomous or remotely-controlled robots are designed for mine clearance, reporting the presence of radioactive or toxic substances, detecting and studying potentially hazardous objects.

Tracked and wheeled unmanned military transport vehicles are already utilized by armed forces, allowing them to carry out complex tactical missions under extremely dangerous conditions. Phantom and Phantom-2 unmanned ground vehicles produced by SpetsTechnoExport armed with 12.7 mm caliber machine gun and RS-80 launcher are the perfect examples. These vehicles can be used for surveillance and reconnaissance, fire support, evacuation of the wounded, delivery, maintenance, etc.

Development of unmanned surveillance and reconnaissance aerial vehicles, and combat drones; fostering modifications that can significantly strengthen the military capability of Ukraine (Armed Forces of Ukraine, Security Service of Ukraine, National Guard of Ukraine, Ukrainian Air Force, National Police of Ukraine). It is essential to draw upon the experience of the United States (*RQ-1/MQ-1 Predator*) and Turkey (*Bayraktar TB2/TB3*), whose combat drones have already demonstrated a high level of efficiency in complex combat operations.

To Subsection 7.4. Artificial Intelligence in Manufacturing Industry and in Power Sector
Prospects of Using Robots

The integration of industrial robots is one of the main factors that drive economic growth. Industrial robots are used in a wide range of operations: welding, painting, pressing, casting, transportation and warehousing. In view of the fact that Ukraine has developed the manufacturing sector, the more intensive integration of robotics will contribute to the economic growth of the country. For Ukraine, it is beneficial to cooperate with the *International Federation of Robotics*.

Particular attention should be paid to the possibility of intensive integration of artificial intelligence systems and intelligent agents (robots) **in various industries**.

Robots can continuously perform actions without failures and develop more competent production models to solve problems associated with automation. They are also capable of correcting human mistakes and providing a higher level of quality.

Testing and application of intelligent control methods in automation systems of diverse mobile objects and robots in manufacturing enterprises of Ukraine is one of the promising directions of AI technologies integration in the manufacturing sector. The research work on the development and integration of intelligent control systems, as well as control devices of the

executive, tactical, and strategic levels, which are based on artificial neural networks, fuzzy systems, and hybrid neuro-fuzzy networks, is being conducted. It will contribute to the automation of diverse mobile technical objects and robots in the manufacturing industry, and improve their efficiency. New methods of synthesis and optimization of highly effective intelligent automatic control systems are also being developed, which are based on bioinspired evolutionary and multi-agent concepts, and global optimization algorithms.

Robots and mobile objects of the manufacturing industry include manipulators (technological, powered industrial, auxiliary, universal, etc.), multi-purpose mobile robots (examination, moving tools, and performing technological operations in inaccessible and dangerous environments), unmanned vehicles (unmanned cars, warehouse forklifts, drones, aerial and underwater vehicles, etc.), etc.

For instance, multi-purpose mobile robots with electromagnetic clamping devices that are capable of moving on inclined and vertical ferromagnetic surfaces are utilized to move various tools along specified trajectories in order to automatically perform technological operations like cleaning, rust removal, painting, welding, etc. in shipbuilding and ship repair, natural-gas processing, oil refining, and in other sectors. Mobile robots of this type are objects with an extremely complex mechanical design, which effectively apply neural, fuzzy, and neuro-fuzzy automatic control systems. Automatic control of robot movements on ferromagnetic surfaces with obstacle avoidance while ensuring high quality of a certain technological operation is one of the most complicated and crucial tasks of the robotic automation.

Artificial intelligence and robotics are influencing space exploration, which demonstrates the great potential for studying interstellar medium through innovative solutions and technologies: satellite data analysis systems, autonomous planetary rovers, autonomous space probes, intelligent automatic rocket control systems, smart system interfaces of manned spaceflights.

Currently, scientists are developing virtual assistants to aid astronauts. These assistants with mixed intelligent algorithms are designed to significantly accelerate and facilitate the execution of applied research tasks of different complexity levels. For instance, *CIMON* astronaut assistant has already been tested on the International Space Station (it reached the station in 2019).

Data analysis in space mission planning has always been a complex procedure based on large amounts of data and usually carried out by experts. Nowadays, artificial neural networks are used for analysis and forecasting, which make it possible to identify previously hidden patterns in the concealed data and utilize the knowledge acquired on the basis of such analysis more effectively.

Satellite technologies are also closely intertwined with intelligent systems, which makes it possible to process data and improve diagnostic systems through the use of artificial intelligence.

Artificial intelligence systems are also applied in space navigation. Analysis of large number of images recorded with telescopes enables the design of intelligent navigation systems for space exploration, discovering new objects and routes for space probes.

Artificial Intelligence becomes the leading phenomena in contemporary observational astronomy. Neural networks help to improve images recorded with telescopes, perform better statistical data analysis, create synthetic samples for datasets utilized to train specialized neural networks that are applied to solve various astronomical challenges (*Fader, Spatial GAN, Morpheus*).

Benefits of AI in Manufacturing. Over the past decades, AI and industrial automation have advanced significantly. A great deal of innovative approaches, such as smart sensors, and improvement of computer performance have been successfully integrated. AI helps aids machines to collect and retrieve large amounts of data; detect complex and hidden patterns; adapt to new trends through machine intelligence, learning, and natural language recognition. It also aids to make decisions based on data and data analysis, increase the efficiency of manufacturing processes, reduce operating costs, promote faster product development and ensure flexible adaptability.

Working 24/7. Since employees work in shifts to ensure rest time and meal breaks, AI-driven robots can continuously perform production line tasks. Enterprises can increase the production capacity and meet higher customers' expectations due to the increased intensity of production.

Workplace safety. With increasing use of AI components in production processes, fewer employees are engaged in dangerous, harmful and stressful work. In other words, with a decrease in the number of people and an increase in the number of robots performing tasks associated with health risks, the number of workplace accidents should decrease drastically. Moreover, AI gives ample opportunity for mineral exploration, as businesses and companies will no longer have to risk human lives.

Operating costs reduction. With increasing use of AI systems in manufacturing, businesses are significantly cutting operating costs. Instead of just hiring employees, companies and businesses should invest in AI. Nevertheless, AI systems need maintenance, which require plenty of costs.

Factors affecting the environment. Autonomous vehicles are potentially much less harmful to the environment. They can be programmed for the most efficient route and reduce downtime, which can lead to reduced fuel consumption and radically reduce greenhouse gas emissions. The same applies to heavy machinery used in manufacturing. AI can incessantly repeat a sequence of procedures with high accuracy, while humans are prone to accidental errors.

To Subsection 7.7. Artificial Intelligence in Agriculture

Prospects of Using Robots

The agro-industrial complex has always been an important component of Ukraine's economy, its strong point. The global population continues to grow, which poses a challenge to the entire civilized world, which intertwines with the challenge of providing high-quality food for human consumption.

In agriculture, it is necessary to widely use agro-industrial drones that help to control pests, detect the exact areas of crops, perform inventory tracking and auditing of land plots, recognize plant diseases, analyze crop yields, monitor and control land amelioration systems, automate planting and harvesting processes.

A perfect example of the unmanned aerial vehicles integration is the M-6-3 “Zhajvir” – a remote control drone made in Ukraine, designed for biological plant protection, cartography, aerial photography, and real-time video surveillance.

Innovative advances in this area are also carried out by the United States (*Harvest Automation*) and Australia (*Australian Centre for Field Robotics*), whose engineering solutions demonstrate impressive results.

To Section 8. National AI Ecosystem

Employee training in the AI ecosystem is currently not actualized. It takes place at the expense of professionals in various fields (mathematics, statistics, system analysis, etc.). Artificial intelligence was not included in Decree No. 266 “List of academic disciplines and programs of study” dated April 29, 2015. Therefore, it is necessary to put the AI degree program on the list and develop an appropriate training course. It is also necessary to focus on reinforcing the development of the dual education system.

As for scientific support, in accordance with the Resolution of the Presidium of the Higher Attestation Commission of Ukraine No. 13-08/9 dated September 20, 2000, the passport of the scientific specialty 05.13.23 “Systems and means of artificial intelligence” was approved. However, considering the date of adoption of this resolution, it is necessary to revise it and update the passport of this specialty.

It is necessary to develop an effective **retraining** system in higher education and *professional development* programs for professionals in various fields (engineering sciences, natural science, human sciences).

It is necessary to develop the concept of **clustering, accessibility, and transparency** of scientific AI projects, to create an opportunity for postgraduates and Ph.D. students to join the current *collective* specialized research of scientific groups in the field of AI.

One of the core factors driving the AI advancement in Ukraine is the systematic development of the specialized community, which could unite professionals and enthusiasts of any age and level of professionalism. The Ukrainian AI community has been developing spontaneously, almost regardless of the role of the government, and is situationally interacting with public organizations.

There was a need to create special (primarily digital) platforms for *strategic communication* among the participants of the AI community: a specialized project website (possibly with a forum and feedback templates), accounts in popular social networks for bilateral interaction with the community (*Twitter, Facebook, Instagram*).

It will allow engaging members of various AI platforms, startups, companies, and individual stakeholders (including grantors, sponsors and investors) in cooperation and fruitful interaction.

Utilization of *open source* and *crowdsourcing* methods for the implementation of crucial projects, both solely applied (mathematical, software, engineering) – when the product is open/ partially open and everyone can work on it after *registration* and *admission*, and organizational – when the community is collectively working on important program documents, conventions, methods, concepts, etc. Therefore, the core idea lies in controlled transparency and interaction.

The active AI community will contribute to the AI advancement in Ukraine in various areas. It will improve the position of Ukraine in the international arena, in particular by increasing the number of Ukrainian scientific articles published in prestigious scholarly journals and boosting citation counts of Ukrainian scientists' articles.

It is also important to coordinate efforts to engage Ukrainian professionals, enthusiasts, and the youth (as the society united by the AI) in the **AI for Good Global Summit** platform, which is one of the main platforms of the United Nations for dialogue on AI.

Advancement of the national database system should be based on a set of legal, organizational, methodological, and IT mechanisms that will ensure:

- normative and organizational regulation of data management, as well as control over the implementation of relevant measures;
- ascertainment and integration of a set of methods and means of financial support to activities aimed at creating and ensuring the functioning of the national database system;
- formation of principles, rules, and processes of public data management;
- formation of data ontology along with the semantic data model, descriptions of the configuration, relationships that exist among entities, meta descriptions and formats, data owners at different levels;
- building and functioning of IT infrastructure that guarantees monitoring and control over the integration of data management standards, and creation of information products of the database system.

Development of the national database system can also be based on the engagement of all individuals interested in projects, even if they are not subject experts. It can significantly accelerate and facilitate the accomplishment of this task. It is necessary to consider the possibility of building, populating, and administering such a database system remotely and on the basis of accessibility and involvement.

Fostering AI investment in Ukraine

It is crucial to ameliorate national and international funding system, to cooperate with leading tech companies, both international and national ones, which can allocate funds to educational and scientific AI programs in Ukraine. Moreover, it is necessary to persistently seek the allocation of funds from the government budget of Ukraine. It can also be effective to attract sponsors and patrons from non-specialized manufacturing and commercial companies, institutions.

In order to ensure the proper development of AI in Ukraine, funds should be allocated to:

– founding of new research institutes, modern centers and laboratories for the study of problems associated with AI;
– conducting state research projects in the main areas of AI;

- providing financial support for scientists and researchers working on AI. Ensuring decent (world-class) working conditions;
- increasing the number of AI professionals, and improving the quality of training;
- encouraging Ukrainian scientists to participate in the international academic AI conferences;
- organizing international scientific AI conferences held in Ukraine with prominent foreign scientists as participants;
- increasing the number of Ukrainian scientific papers on aspects of AI indexed in the scientometric databases Scopus and Web of Science;
- creating open access test environments and libraries for testing developed AI methods and algorithms.

To Section 10. Outline of the Ukrainian Strategy of Artificial Intelligence Development Addition to the Strategic Plan (by 2025)

Key steps for the Ukrainian Strategy of Artificial Intelligence Development execution.

1. Approval and adoption of the regulatory framework.
2. Creation of the supervisory board for monitoring the accomplishment of the tasks declared in the Ukrainian Strategy of Artificial Intelligence Development.
3. Defining prioritized course and objectives of the Ukrainian Strategy of Artificial Intelligence Development ranked from high severity to low priority.
4. Accomplishing the most prioritized and fundamental tasks.
5. Providing mechanisms for quarterly and annual control over the execution of the Ukrainian Strategy of Artificial Intelligence Development (reporting, optional examination).

The final step is the reassessment of the Ukrainian Strategy of Artificial Intelligence Development, its analysis on compliance with the actualities of 2025, and, if necessary, its effective modification.

The Ukrainian Strategy of Artificial Intelligence Development should be supplemented with additional midterm (annual) deadlines, before which Aim and Objectives of the relevant block must be completely accomplished. Each midterm period should be completed with an analytical report followed by an adjustment of the dynamic schedule. This component acts as a stimulus that will positively affect the intensity of the Ukrainian Strategy of Artificial Intelligence Development execution.

In order to execute the Ukrainian Strategy of Artificial Intelligence Development, it is necessary to take the following measures by 2025.

1. Creation of a regulatory framework that provides for the protection of economic and scientific data, as well as its storage in Ukraine.

2. Providing scientific and theoretical support for the execution of the Ukrainian Strategy of Artificial Intelligence Development.

3. Attracting financial resources for the development of AI in Ukraine.

4. Providing support for fundamental and applied scientific AI research. Fundamental and applied scientific AI research in Ukraine involves:

- long-term support to AI research;
- attraction of investors (individual entrepreneurs and legal entities) to artificial intelligence technologies;
- development of research infrastructures, and ensuring access to computing resources, databases and datasets;
- fostering international cooperation, including the exchange of experts and the participation of Ukrainian professionals in international AI projects and conferences.

5. Increasing the number of qualified employees in the AI market, and raising new technology awareness entail:

- designing and integration of educational modules within the framework of educational programs of all educational stages, advanced training programs and professional retraining for educating citizens of the country, who are developing competencies and skills in areas that contribute to the

advancement of artificial intelligence – mathematics, computer programming, information technology, mathematical linguistics, big data analytics, machine learning;
- establishment of standards for academic degrees, taking into account the prospects of AI utilization;
- encouraging beneficial activities in order to foster the admission of applicants to the higher education institutions of Ukraine for studying artificial intelligence;
- establishment of scientific schools of AI problems in universities and scientific institutions, as well as directing their work to integrate the achieved results;
- supporting the participation of scientists in international exhibitions and conferences, encouraging scientific papers publishing in the prestigious international journals, and starting scholarly journals on AI problems;
- supporting young scientists and their encouragement in scientific activities for the development and integration of AI;
- setting up laboratories in universities and scientific institutions for training students and conducting research on AI;
- engaging scientists and educators in international AI projects, including Erasmus+, DAAD, and Horizon Europe;
- sharing accumulated experience in designing AI systems, which was obtained during the execution of the TEMPUS, DAAD, and Horizon 2020 programs;
- creation of AI awards to be presented at scientific festivals, startup competitions, and forums;
- encouraging talented youth to perceive and develop AI ideas at the Junior Academy of Sciences of Ukraine;
- launching encouraging programs and grants for educational institutions of all levels with a focus on natural, mathematical, computer, information sciences, and mathematical linguistics;
- inclusion of the necessary elements of computer programming and computational thinking in the mathematics programs in public schools;
- increasing the number of AI study programs and state-funded places for students;
- engaging prominent experts and scientists who study the natural intelligence and functions of natural neural networks – neuroscientists, medical practitioners, cognitive psychologists, behaviorists, psychiatrists, and lawyers;
- stimulating employers to take measures aimed at employees to acquire competencies in the field of artificial intelligence and in related areas of its utilization;
- ensuring long-term financial support for scientists and researchers working in the field of AI, providing them with decent (world-class) working conditions;
- encouraging scientists to participate in commercial projects of top enterprises in the major areas of AI;
- creating conditions for prominent Ukrainian scientists and AI experts living and working abroad to come back to Ukraine;
- identifying technological priorities of research considering limited resources – in particular those that require little investments, while conferring a significant competitive advantage in global markets through mass use – on-device AI, new machine learning algorithms in resource-constrained systems, etc.

6. *Improving the digital literacy of the Ukrainian people.*
7. *Building a national database system, which provides for:*

- normative and organizational regulation of data management, as well as control over the implementation of relevant measures;
- ascertainment and integration of a set of methods and means of financial support to activities aimed at creating and ensuring the functioning of the national database system;
- formation of principles, rules and processes of public data management.

Addition to the Strategic Plan (2026 – 2030)

- Control over the execution of the Strategy and observance of all previous tasks.
- Accomplishment of all tasks, including the least prioritized.
- Auditing and monitoring the effectiveness of accomplished tasks of the Ukrainian Strategy of Artificial Intelligence Development.
- Analyzing and updating core tasks of the Ukrainian Strategy of Artificial Intelligence Development.

The last two years will be dedicated to analytical conferences on the assessment the Ukrainian Strategy of Artificial Intelligence Development.

D.V. Lande

To Subsection 7.1. Artificial Intelligence and National Security

Researchers in the field of AI have demonstrated significant technical progress over the past few years, much faster than was previously anticipated.

Existing capabilities in AI have significant potential for national security. Nowadays, experts believe that future progress in AI has the potential to be a transformative national security technology, on a par with nuclear weapons, aircraft, computers, and biotech.

Artificial Intelligence is changing the global environment of defense and security. It offers an unprecedented opportunity to strengthen our technological edge but will also escalate the speed of the threats we face. This foundational technology will likely affect the full spectrum of activities in support of three core tasks; collective defense, crisis management, and cooperative security.

In practice, technological changes alter the interests of the state. In this case, Ukraine has an interest in achieving technological leadership of Ukraine, which has the necessary base for it.

Advances in AI will affect national security by driving change in three areas: military, information, and economic.

Swarm intelligence, in particular the ability of the AI-enabled objects to function together, deserves a particular attention in the defense sector. This issue is closely related to the Internet of Things, which provides connection between AI-enabled objects. The task of controlling the swarms of intelligent unmanned aerial vehicles (drones) serves is a good example.

For instance, commercially available AI-enabled technology (such as unmanned aerial vehicles, in particular combat, short- and long-range unmanned aerial vehicles, cruise missiles with automatic target recognition) may provide access to a type of long-range precision strike capability. For example, existing machine learning technology could enable high degrees of automation in labor-intensive activities such as satellite imagery analysis and cyber defense.

In the information domain and cyber domain, AI will significantly expand the ability to collect and analyze data, respond to cybersecurity incidents, and create aggregated data. Therefore, more accurate information sources, as well as disinformation sources will be applied in the intelligence.

Those countries that develop a significant edge in AI technology will punch far above their weight.

As for economy, which is related to the national security, advances in AI could result in a new industrial revolution. In particular, advances in AI technologies can lead to a dramatic decline in demand for labor, which will reshape the relationship between capital and labor in economies around the world. In the cyber domain, activities that currently require lots of high-skill labor, such as Advanced Persistent Threat operations, may in the future be largely automated and easily available on the market. For information superiority, AI will dramatically enhance capabilities for the collection and analysis of data, but also the creation of data.

At the October 2021 meeting, Allied Defense Ministers formally adopted an Artificial Intelligence Strategy for NATO. The strategy outlines how AI can be applied to defense and security in a protected and ethical way. It sets standards of responsible use of AI technologies, in

accordance with international law and NATO's values. It also addresses the threats posed by the use of AI by adversaries and how to establish trusted cooperation with the innovation community on AI.

Artificial Intelligence is one of the seven technological areas which NATO Allies have prioritized for their relevance to defense and security. These include quantum-enabled technologies, data and computing, autonomy, biotechnology and human enhancements, hypersonic technologies, and space. Of all these dual-use technologies, Artificial Intelligence is known to be the most pervasive, especially when combined with others like big data, autonomy, or biotechnology.

The Strategy will be underpinned by the significant cooperation between NATO, the private sector and academia; a capable workforce of NATO technical and policy-based AI talent; a robust, relevant, secure data infrastructure; and appropriate cyber defenses.

Individual strategies will be developed for all priority areas, following the same ethical approach as that adopted for Artificial Intelligence.

Disruptive AI innovations can pose a global danger. Defense and intelligence community should invest heavily in "counter-AI" capabilities. Though outright bans of AI applications in the national security sector are unrealistic, the goal of safe and effective technology management must be pursued. The government should create formal organizations tasked with improving the safety of AI technology. It is also necessary to release a document on dual-use AI capabilities.

O.P. Mincer

To Subsection 7.3. Artificial Intelligence in Medicine

Artificial intelligence (AI) application is not only a pivotal factor in improving the delivery of care to patients. It is bringing forth revolutionary changes in medicine, biology, and education.

I. The Future of Artificial Intelligence in Medicine

Changes anticipated in medicine.

1. **Transformation of medicine into a broader social sphere, which applies all forms of medical information, including genomics, metadata, electronic health records, and biometrics for early and round-the-clock diagnosis.**

Healthcare is a multi-dimensional system established with the aim for the prevention, diagnosis, and treatment of health-related issues or impairments in human beings. The more data we have, the better we understand the biological processes.

Nowadays, humanity operates an incredible amount of data generated since the integration of efficient technologies like next-generation sequencing (NGS) and genome-wide association studies (GWAS) to decode human genetics. NGS-based data provides information at depths that were previously inaccessible and takes the experimental scenario to a completely new dimension. Instead of studying a single "gene" scientists can now study the whole "genome" of an organism in "genomics" studies within a given amount of time. Similarly, instead of studying the expression or "transcription" of a single gene, we can now study the expression of all the genes or the entire "transcriptome" of an organism.

The number of human genomes sequenced by 2025 could be between 100 million to 2 billion [Dash et al. 2019]. Combining the genomic and transcriptomic data with proteomic and metabolomic data can greatly enhance our knowledge about the individual profile of a patient – an approach often ascribed as "individual, personalized or precision health care". Unfortunately, healthcare and biomedical big data have not yet converged to enhance healthcare data with molecular pathology. Such convergence can help unravel various mechanisms of action or other aspects of predictive biology. Systematic and integrative analysis of omics data in conjugation with healthcare analytics can help design better treatment strategies toward precision and personalized medicine. It is the essence of the systems biomedical science.

The genomics-driven experiments e.g., genotyping, gene expression, and NGS-based studies are the major source of big data in biomedical healthcare along with EMRs, pharmacy prescription information, and insurance records. Healthcare requires a strong integration of such biomedical data from various sources to provide better treatments and patient care.

These prospects are extremely exciting and might turn out to be a game-changer in future medicine and health. Generally, it requires analyzing a large amount of data obtained from examination both for diagnosis and for choosing a treatment option. Intelligent analysis of this amount of data is impossible without the use of AI.

2. Improving the healthcare quality by:

- overcoming information asymmetry. Generally, patients face multiple issues. Such as solely healthcare workers are aware of diagnostic and treatment procedures performed. In other words, patients do not know what treatment they have received, and the healthcare quality remains vague. Potential patients and potential expert groups often conceal the true reasons for their actions and resort to all methods in order to obtain certain (own) results. On the other hand, patients do not provide essential information for determining a diagnosis or proper treatment. The use of AI makes it virtually impossible since it provides comprehensive information both to the patient and the doctor;
- ensuring **comprehensive (integral, transmural) care**, which may be seen as a response to the fragmented delivery of health and social services is an acknowledged problem in many health systems. The World Health Organization (WHO) provides the following definition: "Integrated Care is a concept bringing together inputs, delivery, management, and organization of services related to diagnosis, treatment, care, rehabilitation, and health promotion. Integration is a means to improve the services in relation to access, quality, user satisfaction, and efficiency" (Gröne and Garcia-Barbero 2002). It is a worldwide trend in healthcare reforms and new organizational arrangements focusing on more coordinated and integrated forms of care provision.

S. K. Ramazanov

To Introduction

The new global economy is characterized by five imperatives: social justice, harmonious globalization, maintenance of the biosphere, financial system stability, and convergence, formed and ruled by the sensible world government.

Such a transformation provides an opportunity for practical implementation of the new approach to

individual consciousness and collective mind within the framework of the formation of fundamentally new neoharmonic worldview, which is not boiled down to gain and capitalization – processes that occur in a single neo-technology space.

The essence of transition from an industrial society to information (post-industrial) society and subsequently to the knowledge-based (cognitive) society consists not only in global informatization covering all areas of human activity, and cognitive factors significance but also in emerging qualitatively new characteristics of the domain transactions: *"matter"* → *"energy"* → *"information"* → *"knowledge"*.

In other words, there is a transition to the neoimperatives of economic foundations of the existing civilization, and therefore the relevant reformatting of management mechanisms of various (economic, scientific, technical, etc.) aspects of the substantive activities as an additional element over natural and technical processes.

Therefore, social development is affected by the efficient socio-economic transformations in a technonatural environment: matter turns into energy, energy turns into information, information turns into knowledge, and knowledge turns into transformed matter and energy with the new quality of human consciousness; the process is repeated afterward.

With less attention paid to the human side of society hinders the formation of harmonious neoreality.

Under these conditions, the major task of the transition from an industrial society to information (post-industrial) society is not the advances in information and communication technologies as a part of scientific and technological progress, but the self-awareness of a human as a part (basis) of the convergent community "society" + "technonatural environment".

Consequently, it gives rise to the *divergent nature of the economic development*: the model of cognitive intellectualization of the economic mechanism of society development relating to the technonatural environment, including the mandatory dominant development of the human neoconstituent emerges instead of the "predator – victim" or "production – consumption (resources)" model.

Artificial intelligence (AI) is scientific knowledge and technology concerned with building intelligent machines, programs, services, applications, etc. It enables machines to perform tasks commonly associated with human beings.

Artificial intelligence has an impact on cultural identity and cultural diversity. AI positively affects the cultural and creative industries. However, it may lead to a significant disparity in the distribution of cultural content, data, and income inequality, which may adversely affect the diversity of cultural expression and the principle of equality.

According to top-level managers of the largest companies, AI will become the best tool for promoting and developing products and services over the next few years. Artificial intelligence could contribute an additional 1.2 percent to annual gross domestic product growth for at least the next decade, according to a simulation from McKinsey Global Institute. Overall, AI could deliver $13 trillion in additional global economic activity by 2030, putting its contributions to growth on par with the introduction of other transformative technologies. Nowadays, AI contributes US$1 trillion to the global economy. The institute's model expects about 70 percent of companies will adopt at least one form of AI by 2030, and that a significant portion of large firms will use a full range of the technology.

Nowadays, several challenges hinder the development of AI in Ukraine: lack of a clear AI strategy; poor infrastructure; poor awareness of AI advances among businesses; digital transformation failures; uncoordinated work on data; a lack of understanding by the company's management of certain aspects of AI implementation.

To Section 1. Paradigm

Transition to advanced digital technology, intelligent manufacturing technologies, robotic mechanical systems, Industrial Internet of Things (IIoT), new materials and methods for design, big data processing systems, machine learning, and artificial intelligence is a key challenge in the era of Industry 4.0 and Industry 5.0.

Nowadays, safety and sustainability require new scientific research, intelligent technologies, and systems, information technology, and innovations, in particular AI systems and technologies.

In an unstable world, AI research and development should be based upon fundamental and systematic interdisciplinary scientific developments and methodologies, considering new challenges. AI systems are nonlinear, complex, and constantly advancing. Therefore, our definition of AI, the principles and criteria for the synthesis of AI systems rest on modern fundamental research and other types of scientific research; these are clarifying and promising. AI technologies and systems should be designed and built on the basis of subsystems and components: scientific foundations, basic research, and software; hardware and technical support; software systems, platforms, and tools; social component (morality and ethics, culture, education, philosophy, and legitimacy).

Contemporary science is going through a paradigm shift: from a particular area of knowledge and sectoral composition of the economy to the fusion of sciences and convergence of technologies. Nowadays, a new scientific and technological structure has arisen based upon the integration of nano-, bio-, information, cognitive, and human sciences and technologies. It is worth noting that the strategic goal of convergence is the creation of bio-inspired anthropomorphic technical systems (principles of biology and the natural world).

Super technologies become a key driving force of sustainable development in the 21st century: artificial intelligence, nanotechnology, biotechnology, media technologies, cognitive technologies, and social technology. Specifically, it is the contemporary development of innovations. Therefore, the principle of intellectualization, integration, convergence, coevolution, and social technology should be integrated.

It is essential to consider modern principles of AI sustainability and safety AI; and the concept of the physical world and digital world harmonization, taking their harmonious hybridization into account.

To Subsection 2.2. Main Directions of AI Research

It is known that natural intelligence is a measure of human consciousness. Ukrainian scientists are already able to give a mathematical formalization of the evolution of consciousness. Therefore, an essential step to building AI is to design artificial consciousness, which drives decision-making, in accordance with the knowledge, laws, and rules of humanity, in particular spiritual and moral values.

AI technologies and systems should be designed and built on the basis of subsystems and components: scientific foundations, basic research, and software; hardware and technical support; software systems, platforms, and tools; social component (morality and ethics, culture, education, philosophy, and legitimacy).

As a part of the artificial intelligence theory, it is suggested to create a unified concept of knowledge bases to store structured information, resting upon the principles of relational and hierarchical databases, including additional, more complex principles of data communication and data selection, reflecting cause-and-effect relationships. It is important to develop the concept of characteristics of knowledge (similar to the characteristics of data).

Practical value in the scientific, technical and technological areas: building national automated knowledge bases (for example, the knowledge base to store mathematical models and relevant algorithms) and automated decision-making systems; **building algorithms to find analogies across multiple knowledge bases for generating new knowledge**.

Such structuring and automation may result in science, technology, and manufacturing advancement.

To Section 3. Aims and Objectives of the Ukrainian Strategy of Artificial Intelligence Development

Aim of the Ukrainian Strategy of Artificial Intelligence Development is to ramp up the development of artificial intelligence in Ukraine; to ensure sustainable and safe development of the country; to conduct scientific AI research; to increase the accessibility of information and computing resources for users; to enhance personnel training system in this area.

Key AI principles to comply within the process of the *Ukrainian Strategy of Artificial Intelligence Development* implementation:

- AI should benefit ***people*** and the planet by driving inclusive growth, sustainable development, and well-being;
- AI systems should be designed to respect ***rule of law***, human rights, democratic values, and diversity, which should be guaranteed, in particular, by being able to intervene in autonomous systems. Protection of human rights and freedoms provides for the right to work enabling citizens to gain knowledge and acquire skills to successfully adapt to the digital economy;
- there should be ***transparency*** and responsible disclosure to ensure understandability, and non-discriminatory access for users of AI-powered products to information about the algorithms of artificial intelligence used in these products;
- AI systems must function in a robust, secure, and **safe** way throughout their life cycles and potential risks should be continually assessed and managed, malicious use is unacceptable;

- there should be ***technological sovereignty***, the assurance of the necessary level of self-sufficiency in the field of artificial intelligence, achieved through the predominant use of domestic artificial intelligence technologies and technological solutions developed on the basis of artificial intelligence;
- there should be ***innovation cycle integrity***, the assurance of the close collaboration of research and development in the field of artificial intelligence with an actual sector of the economy;
- prioritized implementation and adaptation of existing measures aimed at the execution of ***government policies*** in the scientific, technical, and other fields;
- development of ***market relations*** and the impermissibility of actions aimed at the restriction of competition between organizations that engage in activities in the field of artificial intelligence.

Points to consider

1. The government should be a key regulator and initiator of the Ukrainian Strategy of Artificial Intelligence Development implementation. However, collaboration with developers, businesses, research centers, sharing experience, and international partnerships are factors necessary for the successful implementation of the strategy. It will regulate monopoly and ease the strain on state authorities.
2. As for the European integration, the introduction of tools for sensitive data monitoring, in particular health data, should be consistent with the law on data protection and privacy in the European Union. Nevertheless, artificial intelligence in healthcare and the diagnosis of COVID-19 is a promising direction for the introduction of AI.
3. Existing state programs and legislative documents in Ukraine have not formed a complete paradigmatic vision of AI development, which would include such components: a clear understanding of the purpose and scale of global technology transformation; setting Ukraine's position in the global distribution of innovations and outlining practical mechanisms for attaining the position.
4. Along with the fact that Ukraine has the potential to become a hub for the post-Soviet IT companies (as evidenced by the example of Belarus facing a brain drain in 2020), it should also be recognized that Ukrainian experts are engaged primarily in international projects as providers of additional services, and not leaders in processes. The government should stimulate the participation of Ukrainian professionals in the development of products that will support the national economy and will be designed for the needs and promising sectors of the economy – agriculture, renewable energy, space exploration, armament (including unmanned aerial vehicles).
5. The Strategy should promote existing regulatory documents, in particular, the Information Society Development Strategy and the Concept for the Development of Artificial Intelligence, considering Constantly Changing Technology and the growing responsibility (including moral) that lies with people who introduce AI technology for widespread use.

To Section 5. Global AI Standards

AI is one of the core factors in achieving the Sustainable Development Goals adopted by the United Nations.

In the EU's Ethics Guidelines for Trustworthy Artificial Intelligence, which may be considered the basis of the EU's AI policy, experts formulated ethics principles for trustworthy AI, published on April 8, 2019. As a recommendation, artificial intelligence systems are viewed as technical systems capable of processing information in a way resembling human intelligence, which typically includes such aspects as learning, recognition, forecasting, planning, and control.

First of all, AI systems are characterized by the use of models and algorithms that provide the ability to learn and solve cognitive problems such as formulating recommendations or decisions -

making in a real and virtual environment. Intelligent systems are able to function with varying degrees of autonomy by modeling knowledge and presenting the results obtained, as well as using data and calculating correlation dependencies. AI systems use several approaches and technologies: self-learning of a system that includes deep learning and reinforcement learning; automated reasoning, which includes planning, dispatching, knowledge representation, search, and optimization; cyber physical systems, in particular, the Internet of Things and robotics; control and recognition functions that combine the processing of data collected by sensors, as well as the work of performing elements in the environment of functioning of AI systems.

Moreover, along with the aspects of an ethical nature similar to those that arise within the framework of the use of any technology, artificial intelligence systems pose new challenges. Previously, intelligent systems were able to perform tasks that were only possible for intelligent beings. These features have allowed putting new tasks to ensure the support for relationships between individuals and society. In the long run, artificial intelligence systems will be able to compete with humans in terms of their ability to comprehend human experience and mimic human consciousness, which raises additional issues about the actual independence, uniqueness, and greatness of a human being, although today that issue is not relevant.

Finally, despite the fact that artificial intelligence-related issues of an ethical nature mainly relate to the specific effect of AI systems on humans and society, there is another set of ethical issues that relate to human interaction with intelligent systems, as well as the possible consequences to which such interaction can lead. The Recommendations state that both types of ethical issues are closely interrelated and are integral components of an ethical approach to AI.

To Subsection 7.3. Artificial Intelligence in Medicine

It is necessary to ensure the development and application of AI technology in modeling, predicting, and controlling the dynamics of infectious diseases, considering spatially distributed influences in pharmaco- and immunotherapy, as well as the use of neural networks, in particular genetic algorithms, in the tomographic diagnosis of biological objects.

A. A. Roskladka

To Section 8. National AI Ecosystem
State support for prioritized fields of study in Ukraine

The implementation of the Ukrainian Strategy of Artificial Intelligence Development without proper training of highly skilled AI specialists. Under Article 10 of the Law of Ukraine “On Higher Education”, educational institutions have to abide by high standards of education.

The analysis of the higher education standards of the bachelor’s degree obtained at the first level of education approved by the Ministry of Education and Science of Ukraine revealed that artificial intelligence is missing among these standards. According to the analysis, there are only four out of one hundred and eight fields of study, subject areas, competencies, and program results which include “data mining”:

- Degree program 113 “Applied mathematics”;
- Degree program 122 “Computer science”;
- Degree program 124 “Systems analysis”;
- Degree program 126 “Information systems and information technology”.

The Ukrainian Strategy of Artificial Intelligence Development outlines a range of areas for AI adoption. However, it turned out that it is not reflected in the normative documents, which educational institutions act upon in the process of degree program creation. The amendment process associated with the approved standards is rather difficult and time-consuming, so support from the government would be a more reasonable solution.

Specific methods of state support should be described in the Admission Requirements approved by the Ministry of Education and Science of Ukraine. Currently, the Admission

Requirements document contains a list of state-funded degree programs. However, in 2022 none of the four fields of study is included on the list. On the one hand, it seems favorable because it means a fairly high passing score for entrants over the past two years (the criterion for the elimination from the list of priority specialties). On the other hand, the lack of support from the state leads to the lack of interest in training AI specialists. It is contradictory to the Ukrainian Strategy of Artificial Intelligence Development.

Therefore, the following task should be included in the list of strategic objectives, which contains the task of recruiting sufficient numbers of skilled staff:

Degree programs (113 “Applied mathematics”; 122 “Computer science”; 124 “Systems analysis”; 126 “Information systems and information technology”) focused on studying artificial intelligent systems should be included in the list of prioritized fields of study provided with relevant state funding.

A. M. Serghijenko

To Subsection 2.2. Main Research Directions
Development of AI architectures

Three years ago, the computer architecture luminaries, John L. Hennessy and David A. Patterson [2019] declared the beginning of a new golden era for computer architecture (Fig. 1). A new golden era marks the end of the forty years of rapid development in software with minor advances in hardware. The inevitable period of new architectures advancement has begun.

Fig. 1. Materials of the lecture “A New Golden Age for Computer Architecture”

This change is driven by the slowing of Moore’s law and the impossibility to increase the energy consumption of computer chips. Consequentially, future advancements in IT may only be achieved through the transition to specialized architectures, in particular RISC architectures, and with more thorough programming and elaboration of algorithms.

It will have an impact on the development of AI.

1. In the future, the use of high-performance universal architectures, including universal architecture for artificial intelligence, will be ineffective.
2. Scientists began to discuss the artificial brain after experimental samples of the artificial brain reached 1011 transistors in them. Currently, the artificial brain is based on the universal architecture of the graphic accelerator and is used in systems such as ADAS. That technology costs about $104. There is no doubt that the increase in the number of transistors will not double the level of intelligence of the artificial brain, it will be increased only by a few percent. Nevertheless, the cost and energy consumption will double. Consequently, it is possible to significantly improve the intelligence of such a system only by creating an architecture that is designed for a specific type of artificial intelligence.
3. Due to the slowing of Moore’s law, the artificial brain hardware cost won’t be reduced over time with the same or slightly increasing productivity. Therefore, it will become unprofitable to replace it with a newer one in a couple of years, as it still happens with home and server processors. This factor, as well as the use of the artificial brain in high-risk autonomous vehicles and other robotic devices, requires the long service life of such a

device. Moreover, such a high-priced technology will be removed from old and damaged models for reuse (green planet!). Furthermore, there is a need to radically increase hardware reliability. However, this need contradicts the tendency to reduce the reliability of integrated circuits while reducing their design norms in the latest information system technology. The only way out is the specialization of architecture for such artificial intelligence.

Summary

The development of the universal Artificial Intelligence architecture and hardware components for it is futile.

Computer engineering of Artificial Intelligence will advance in the direction of finding new effective algorithms and specialized structures for their implementation. Moreover, more attention will be paid to the improvement of efficiency of common architectures programming adapted to the tasks of artificial intelligence, such as TensorFlow.

V. I. Slyusar

To Subsection 7.1. Artificial Intelligence and National Security

The tendency of shifting to robotics, which covers a wide range of areas, is especially discernible in the military sphere. The world's leading countries are making significant efforts to equip military units with robotic systems for various purposes and increase the effectiveness of their military use. The experience of military cooperation with the NATO member countries demonstrates that military analysts consider Artificial Intelligence (AI) to be a breakthrough technology for improving military readiness. The introduction of artificial intelligence is an important trend in the development of battlefield management systems and fire-control systems, including robotic platforms. [Stanley-Lockman and Hunter 2021].

As for controlling military affairs, artificial intelligence technologies are considered an important addition to the workforce in a range of directions, including expanding situational awareness and data exchange; coordination of divisions; distribution of goals; control of sensors and weapons; detection and identification of threats, reduction of reaction time; assessment of intentions; semi-autonomous weapons system; resource management, partial replacement of human decision-making, etc. In the long run, the optimal choice of a combination of sensors and weapons, depending on the threats, should be made with artificial intelligence, which is becoming more important both in solving problems of situational awareness and decision-making support.

In 2017-2018, NATO started the process of AI standardization. For now, several stages have been passed through. The first stage concerned terminology. At the initial stage, NATO experts used two alternative definitions of Artificial Intelligence (NIAG StudyGroup SG-238 GBAD Operations against the 21st Century Peer Nation Cruise Missile and Unmanned Aerial Systems (UAS)):

"AI is the capability provided by algorithms of selecting optimal or suboptimal choices from a wide possibility space, to achieve goals by applying strategies which can include learning or adapting to the environment";

"Artificial Intelligence (AI) refers to systems designed by humans that, given a complex goal, act in the physical or digital world by perceiving their environment, interpreting the collected structured or unstructured data, reasoning on the knowledge derived from this data, and deciding the best action(s) to take (according to pre-defined parameters) to achieve the given goal. AI systems can also be designed to learn to adapt their behavior by analyzing how the environment is affected by their previous actions".

The Bilateral Strategic Command (BI-SC) final report on Joint Air Power Capabilities (JAPC) turned to the definition of the NIAG SG-231: "Artificial intelligence (AI) is an ability of a non-biological system to achieve any complex goal through processes comparable to human cognitive processes such as perception, deduction, recognition, memorization, and learning".

The first of NATO's official definitions (NATO adopted) was included in the AJP-3.10 Ed. B, Ver. 1. Allied Joint Doctrine for Information Operations. In the project proposal dated May 2021 artificial intelligence is defined as a branch of computer science dedicated to the development of data analysis systems that perform functions commonly associated with human intelligence, such as reasoning, learning, and self-improvement.

Simultaneously with the approval of AI definitions, NATO experts have begun the process of agreeing on relevant acronyms. For instance, in the *Allied Joint Doctrine for Close Air Support and Air Interdiction, Study Draft 1*, it was decided to stop using AI for *Air Interdiction*, so that it remains an abbreviation for *Artificial Intelligence*. Nevertheless, the harmonization of acronyms is not completed yet.

Experts' views on possible military application of AI is a gradually expanding cluster of standards, which reflects certain aspects of the role and function of artificial intelligence in specific missions. It is noteworthy that these standardization documents already cover all domains of multi-domain operations – land, air, maritime, and cyberspace.

Moreover, the integration of relevant AI regulations gradually extends to all components of DOTMLPFI (Doctrine, Organization, Training, Materiel, Leadership, Personnel, Facilities, Interoperability). For instance, in the ATP-49. Use of Helicopters in Land Operations Doctrine Ed. G, Ver. 1 it is suggested to integrate AI technology in ground control stations for controlling unmanned vehicles (UAV) (Fig. 2), as well as a part of MUM-T, integrated with the helicopter team.

The ASCP-01 Ed. A Ver. 1 NATO Stratcom Training Standards (Annex F, page F-5) standardized requirements for the general competencies of information environment assessment specialists who have to be capable of understanding and applying artificial intelligence and machine learning technologies to assess the information environment: *Understand and apply Artificial Intelligence/Machine Learning in IEA*.

The roadmap for the implementation of the Federated Mission Networking spirals in the 2019 edition determined the goal of the 6th FMN spiral to improve the processes of analysis and decision-making by integrating AI. The 6th spiral implementation schedule envisages the formation of utilization and safety requirements that will begin in November 2022 and come to an end in 2024 with final specifications, including technical ones. The beginning of relevant artificial intelligence technologies utilization within the framework of FMN is planned for 2027 with their mass operational use in 2028-2029.

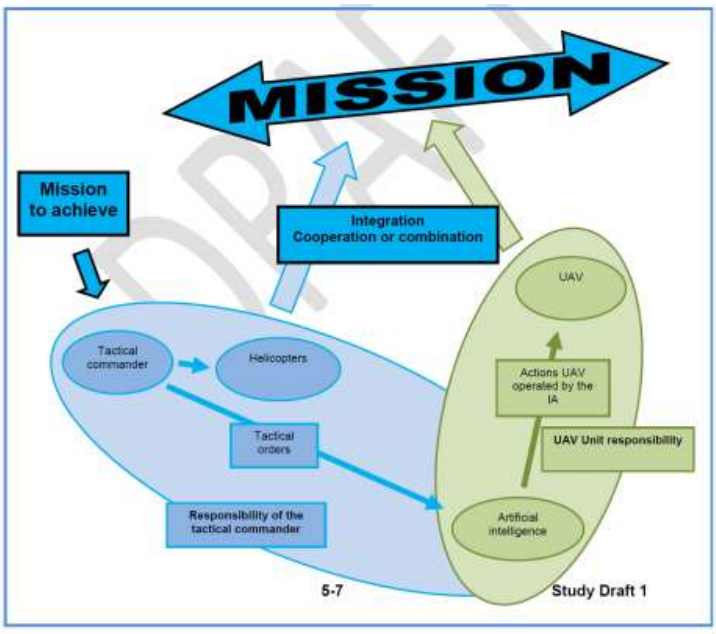


Fig. 2. AI in MUM-T (ATP-49(G)

Expectations for AI in medicine are reflected in *the AJMedP-5 Ed. B, Ver. 1 Allied Joint Doctrine for Medical Communications and Information Systems.* In particular, the paragraph "Automation and Artificial Intelligence" states that the automation of procedures and the use of current and future Artificial Intelligence will better enable command and control, particularly in Mass Casualty situations whether in combat or on humanitarian missions.

The fact that Artificial Intelligence can already significantly influence land activities is stated in *the ATP-3.2.1.1 Conduct of Land Tactical Activities, Annex D Considerations on countering UAS threat*.

However, the most radical approach is introduced in the AJP-3.10.2 Allied Joint Doctrine for Operations Security and Deception, Ed. A Ver. 1, which provides direction and guidance for the planning, execution, and assessment of operations security (OPSEC) and deception. For the first time, AI is on a par with human experts when it comes to decision-making. For the purposes of AJP-3.10.2, a decision-maker is understood to be a person or artificial intelligence responsible for decision-making within an adversary or population's hierarchy. Moreover, AI as a decision-maker may be at any level in any environment and may be capable of creating the required behavioral response.

The next step is the beginning of technical standardization of artificial intelligence tools, in particular, safety requirements for the use of AI in weapon systems, etc. NATO's first technical standard, which considers the use of AI, maybe the AOP 4452.

According to the presentation of the head of *the NATO AC326 SG/B: Ammunition. Systems Design and Assessment* at the meeting of *the CNAD Ammunition Safety Group (AC/326)* in June 2021, in the updated version of these guidelines it is planned to consider AI safety requirements in ammunition systems. The fact of the matter is, that the integration of AI modules into smart ammunition is considered an important trend in the development of arms. Such modules will be able to analyze combat areas, detect and identify the target in a specific area and opt for the effect specific to the identified target. In particular, AI-powered ammunition should distinguish an armored fighting vehicle from infantry, and create a cumulative effect in the first instance (HEAT, High-Explosive Anti-Tank), and shrapnel or nonlethal effect in the second instance (powerful electromagnetic pulse). A loitering munition or unmanned combat aerial vehicle (UCAV) equipped with the specified AI module will increase the ability to suppress or neutralize the enemy to reduce the number of volleys, and minimize vulnerability to enemy counter-battery fire, maximize the effectiveness of ammunition with minimal collateral damage.

Nevertheless, the analysis of the current NATO standardization mechanism reveals that the standardization of the military applications of AI should be carried out as part of the formation process of the System of Systems of Standards, S3 [Slyusar 2017]. S3 should be a hierarchical, multidimensional and multifunctional, consensual integration of the system-forming clusters of regulatory documents. The necessity for such a structure of the system of standards stems from the need to ensure the development, testing, and maintenance of the entire life cycle of the system of systems of weapons and military equipment through the use of AI, and to be a reflection of it. In this instance, the concept of NATO cross-domain standards [Slyusar 2018], which implies these standards to combine the descriptions of AI applications specificity for the benefit of the ground force, the air force, and the navy, for instance, in the form of separate sections or annexes, in a single document merits consideration.

Alternatively, some of the standards may be applied without changes in the armed forces, which must also be safeguarded and approved by the main groups of the Conference of National Armaments Directors (CNAD). This approach aims to avoid duplication in standardization, harmonize the AI standards in the armed forces, and provide an opportunity to coordinate the work of expert communities of the NATO's Conference of National Armaments Directors in related areas of the AI technologies standardization.

Key areas of the AI standardization in the security and defense:

- operational scenarios and common AI use cases;
- minimum requirements for AI-enabled systems;

- AI-enabled systems modes;
- a software architecture, main technical characteristics of AI-based systems, and big data transfer protocols;
- human-AI interfaces.

Considering common AI application scenarios, AI can perform several typical functions to aid an armored vehicle driver:

- improving stability and finding a safe path;
- detecting threats that impede movement;
- providing visual notifications for marking areas that call for closer observation;
- analyzing hyperspectral images of the territory to detect changes on its surface, which is a sign of concealed improvised explosive devices or landmines;
- detecting camouflaged targets in natural scenes, etc.

A comprehensive list should be created for all possible military applications of AI.

A comprehensive list should be created for all possible military applications of AI.

In terms of interface, it is important to note that as a means of interactions between humans and Artificial Intelligence, it is reasonable to consider AR technology, since the results of the information processing performed by the Artificial Intelligence are the most convenient to transfer to the operator through the use of visual, auditory and tactile symbols of the Augmented Reality. Correspondingly, it is also reasonable to set tasks for the AI system, especially since it is much easier to standardize AR symbols than to achieve full technical compatibility of systems developed by different manufacturers. In particular, the reverse interaction between a human and AI-based on augmented reality may be carried out by assigning zones to AI that are subject to analysis, using various variants of the graphical interface to input the source data, converting voice messages into commands for moving three-dimensional AR objects, their orientation, etc.

It is possible to establish interactions between several AI systems through the use of AR, in particular cloud services. For instance, a specially designed AI system can synthesize a three-dimensional terrain model based on contour two-dimensional images obtained from multiscopic images taken by scattered AI platforms. To maximize the potential of AR as an AI system interface, it is important to determine the requirements for appropriate functionality. In addition to that, it is necessary to standardize the design of AR symbols for the interoperability of the results of interactions between AI, operators, and other AI systems.

It is important to note that AI should be integrated into the generation of contour symbols of targets in targeting processes by transferring only the shells of targets as AR symbols, which will be superimposed on the real-world environment. It requires the deployment of large-scale work on the formation of appropriate datasets. Correspondingly, three-dimensional AR symbols should be formed, animated, and the effects of occlusion in the process of visualizing the color AR symbols on the display should be reduced through the use of AI. It is important that the optimal luminosity of AR symbols for different background objects is a rather urgent task. Depending on the position and spatial orientation combined into a network of combat platforms, the background may be different and quite often coincides with AR symbols in brightness and color. It leads to a partial or complete loss of AR systems' functionality.

With the aid of AI, this issue can be resolved by adaptively selecting the color and brightness of the AR symbol when applying it to the background image. AI tools should evaluate the background and assign the optimal color to the AR symbol, enable a dynamic change in brightness and color during visualization, or activate pulsation, rotation, and other animation effects. Correspondingly, the use of AI prompts the introduction of an auxiliary, translucent color layer, which would serve as a transitional buffer between the color palette of the background and the data visualization symbol. In this case, the adaptive choice of combining the colors of the auxiliary layer, background, and symbols of the AR should also be powered by AI.

AI algorithms can not only build the contour symbols of targets but also visualize models of their vulnerabilities, which are currently used for modeling and simulation. These visualized vulnerability models segment enemy objects into multiple hitting areas, providing a more efficient

choice to maximize the likelihood of neutralization or destruction of the target. The information about such hitting areas can be distributed as AR symbols between networked combat vehicles within the unit for the collective bombardment of the complex target. The level of segmentation of AR contour symbols varies according to the distance to the target. The state of such segmentation should be used as additional information about the current distance to the object of fire impact.

Available AI technologies are capable of generating images from the audio or text description, converting text reports and messages into annotations and AR symbols, or, if necessary, synthesizing audio or transforming them into audio symbols. In this instance, a top national priority is to develop

The Ukrainian language model will enable to develop intelligent assistants, generate realistic military exercise scenarios with enemy consistency, greatly facilitate data collection from unstructured texts, etc. In the future, on this basis, it will be possible to synthesize AR and the synthetic virtual environment through the use of AI, which will significantly improve the quality of training and military exercise.

Moreover, the synergy between AI and autonomy in the military creates several security challenges for the use of AI-based autonomous weapons systems, which is a major concern for NATO experts and all countries around the world. In particular, the real threats to the emergence of AI-enabled lethal autonomous systems on the battlefield and possible risks to the civilian population prompted a comprehensive review of the United Nations Office for Disarmament Affairs (UNODA) policy. Consequently, the activities of the United Nations Institute for Disarmament Research (UNIDIR) were also modified, and a The Group of Governmental Experts (GGE) on Lethal Autonomous Weapons Systems (LAWS) was established as a part of the United Nations Office for Disarmament Affairs [Slyusar 2021].

UNIDIR's series of regional table-top exercises were conducted to discuss different scenarios for the possible use of AI-enabled autonomous weapons systems. The main findings of this series of exercises are important for the formation of strategic approaches and therefore merit careful consideration.

The project brought together experts and diplomats to discuss the technical, military, and legal implications of introducing autonomy. The created scenarios serve as a tool to develop a more comprehensive understanding of the relevant operational and tactical context. Moreover, two methodological approaches were applied regarding the following:

- targeting process, including the different layers of autonomous weapons systems involved;
- the study of the impact on the decision-making process of different levels of human control over autonomous weapons systems depending on the type of targets, geographical and other conditions, taking into account potential threats to civilians.

Special attention was paid not to AI-enabled fully autonomous systems, which feature all steps of the targeting process without any human intervention, but to the grey zone when autonomy is used to perform a limited number of specific tasks that can be carried out technically. Furthermore, a number of issues that require consideration and regulation have been revealed.

Several assumptions were applied:

- technological developments were considered to be evolutionarily based on the uncertainty about the potential capabilities of revolutionary technologies (for example, in the long run, the introduction of quantum computing will drastically affect the development of AI), so it was important to focus on the current state of technology and realistic assessment of the gradual development of technologies;
- experts focused exclusively on AI-enabled physical autonomous weapons systems (AWS) capable of being deployed that achieve the kinetic effect, so the cyberweapons were out of scope; moreover, multidimensional systems used for intelligence, surveillance, and reconnaissance tasks were out of scope;
- AI-enabled decision-support systems that may be used for planning purposes were out of scope;

- the exercise focused on decisions to deploy LAWS, while political decisions to acquire or develop such technology were out of scope.

The analytical basis of the research is the infographic which illustrates the human element in decisions about the use of force published by UNIDIR in 2020 [Human element 2019]. This infographic is only the visible part of the iceberg since the decision-making process that leads to the use of force is complex and starts well before the actual use of force. First of all, this process starts with the political leadership that makes the decision that military intervention is required, then it goes through several phases of planning and evaluation, and results in the deployment of the weapons system.

Despite the attempt to speed up the exercises, a broad approach has been applied throughout the exercise. Beyond the visible part of the iceberg remained important decisions and key parameters that have a critical impact on the use of force. For instance, at the strategic level, the establishment of rules of engagement and the selection of targets, permissible or non-permissible use cases. At the operational level, the use cases are detailed, carefully analyzed, and approved. Decision-makers determine the best type of weapons systems to achieve the desired effect. Moreover, they assess the collateral damage by considering other critical factors. This data is further transmitted to the tactical level, where the mission is executed with the detailed planning of all necessary steps. Throughout all phases, the context is of paramount importance, taking into account parameters, circumstances, and constraints.

The tactical mission execution phase consists of the following steps:

– Find – navigate and maneuver on the battlefield to find the target based on available information, intelligence, and data collected in real-time.
– Fix and Track – once the target is detected, sensors will be used to determine and maintain positive identification of the target and to monitor the environment.
– Target – final checks before the engagement takes place include risk assessment, compliance check for rules of engagement and international law, and international humanitarian law.
– Engage – the attack is executed, and weapons are released. (An attack can also be suspended or canceled).
– Assess – the effectiveness of the attack is evaluated and decisions on future action are taken (including re-attack if necessary).

In addition, the exercise presented four different options for human control or involvement in a weapon's execution of each of the above steps:

– Full direct control – the system has no autonomy and remains under the full and direct control of the operator for the execution of the given task.
– Human in-the-loop – the system implements the given task with autonomy but requires human intervention to validate and implement specific actions.
– Human on-the-loop – the system implements the given task in autonomy under the supervision of human operator(s) who can intervene if necessary to correct or abort a specific behavior or action.
– Human off-the-loop – the system implements the given task with full autonomy, without supervision or intervention by a human operator(s).

In the course of the exercises, experts were asked to create an ideal control configuration in the form of a table for each of the scenarios (Tab. 1). The given version of Table 1 serves as an example. Moreover, 1 indicates the suitable level of control for each of the steps, and the lack of control is 0.

In the course of the exercises, while filling out the table, technical experts draw a conclusion, based on their understanding of the technical feasibility of applying possible levels of control for various tasks in different contexts. Military experts stressed a point of military expediency or achieving military superiority. However, legal experts focused on legal implications or legal considerations of the permissibility of lethal actions in each particular case.

Table 1. Control configuration

Step	Options for human control			
	Full direct control	Human in-the-loop	Human on-the-loop	Human off-the-loop
Find	0	0	1	1
Fix and Track	0	1	1	1
Target	1	1	1	0
Engage	1	1	1	0
Assess	1	1	1	1

Finally, experts were asked to reflect on and assess the relative relevance and influence of a range of factors in their decisions for each scenario:

- type of target (fixed or mobile, manned or unmanned, pre-planned/on-call/not planned, etc.);
- environment (e.g., urban or open, mountain, desert or forest, etc.);
- domain (e.g., air, land, maritime);
- type of mission and mission parameters (e.g., time of the attack, desired effect);
- assessment of risks to civilians or own forces;
- technical characteristics of the system (e.g., understandability, predictability, reliability); and
- other factors (which experts were asked to specify in their inputs).
- Four scenarios were used in the exercise:

Scenario 1

- Unmanned missile launcher.
- No military or civilian personnel.
- Launcher armed and ready to fire.
- Effect: destroy launcher.

Scenario 2

Armed UAVs.

- Active 24/7.
- Last known position from 12h before the mission is launched.
- Effect: neutralize UAVs.

Scenario 3

- Line of Communication (Road) used by enemy forces for re-supply of weapons and ammunition.
- Road also used by civilians and civilian houses in proximity.
- Effect: destroy LOC.

Scenario 4

- Enemy convoy in transit.
- Position unknown.
- Road also used by civilians.
- Effect: destroy convoy before it reaches city boundaries.

These scenarios were not intended to be representative of all the possible operational and tactical contexts. They were just a tool that was supposed to trigger discussion on something more specific and measurable. Analysis of scenarios shows that in two of them the position of the targets was known (Scenario 1 and Scenario 3), and in the other two, the position was unknown.

In addition, the scenarios proposed different combinations of other critical factors such as:

Target

- Fixed or mobile.
- Inhabited or uninhabited.
- Location known or unknown.
- Collateral damage and risk to civilians.
- Low risk or high risk of civilian casualties.
- Low risk or high risk of damage to civilian or dual-use infrastructure, some of which were included in no-strike lists (e.g., civilian housing).

The views of three categories of experts (technical, military, and legal experts) on the different scenarios provide enough evidence to conclude that when provided with a range of options for control, most experts converged towards options that would allow humans to retain a form of involvement. Experts rarely opt for full direct control or human off-the-loop configuration. Nevertheless, certain regional aspects and regional variations were identified. Experts from different countries had diverse views. Although, according to the aggregated data, it should be highlighted that there are many options and variations within and among expert communities. Therefore, it is very difficult to distinguish one specific trend that can be applied exclusively to one expert community.

Another important characteristic is the distribution of expert opinions on the permissible level of autonomy of AI-enabled weapons across the steps of the targeting cycle displayed as a dependency graph. Notably, for each of the steps, if the curve is plane, more variants of disagreements appear within the same group of experts. If there are peaks, more experts converge toward shared options. The analysis shows that in fact, the results of the exercises allow specifying multiple differences between the approaches of technical, military, and legal experts. However, for Scenario 2 in connection with the steps of Find, the distribution of opinions of different types of experts is very similar and is mainly reduced to the expediency of full autonomy of search systems.

O. Ye. Stryzhak

Introduction

The economic development of any country in the 21st century largely depends on the degree of representation of knowledge systems in the global market, which spread across socio-economic relations. This phenomenon manifests itself in the form of the knowledge economy, which is based on interdisciplinary processes of creation, processing, storage, distribution and use of knowledge. Consequently, the cognitive and communicative scenarios of interaction in all spheres of socio-economic activity of the country also depend on its ability to effectively process existing knowledge and comprehensively use already accumulated information resources. However, information resources that represent knowledge systems by the totality and nature of presentation belong to the big data. All of them are also characterized by multidimensionality, multiple latent connections, etc.

As evidenced by the global experience, tackling the issue of development and effective use of knowledge systems in various fields lies in the application of modern information technology implemented on the basis of AI as one of the key technologies of our time.

The Defense Advanced Research Projects Agency (DARPA) has stated that the 21st century marks the beginning of the transdisciplinary research age. It is possible to ensure the full implementation of this mega direction of scientific and technical development as a component of the knowledge economy on the basis of the use of all AI means. Thus, the formation of logical meta-frames is ensured, through which knowledge reflecting the results of transdisciplinary research may be integrated into various sectoral directions of the information society development and, as a result, will contribute to the development of the knowledge economy.

Such features of the modern stage of the knowledge society formation determine the relevance of the problem of creating intellectual tools and means capable of taking on at least part of the basic cognitive functions of a human. Therefore, the further development of the knowledge economy, especially in our country, largely depends on how effectively the achievements in the field of Information Technology and Artificial Intelligence will be implemented and used.

V.M. Tereshchenko

Section 1. Paradigm

Ukraine's place in the global AI ecosystem. Subject matter

Despite the fact that Ukraine has been an active actor in the field of fundamental research in a number of modern high-tech areas over a long period of time, the positions are lost for now. In particular, a lot of Ukrainian top universities graduates specializing in Information and Computer Technologies accept job offers from top foreign IT companies. Ukraine's industry faces fierce global competition, combined with difficulties in financing high-risk investments in complex technological areas, including Information and Computer Technologies. They are also hampered by the outdated infrastructure, including equipment that is not suitable for digitization and the country's productive capacity; and due to the scalability and technological diffusion issues. Long investment cycles are needed in key sectors of Ukraine, in particular energy-intensive industries.

Research and innovation are recognized as an important source of economic growth and competitiveness, but there is an urgent need for more investment in Ukraine, in particular in industry. There is a need to integrate horizontal industrial and innovation policies with sectoral and technological ones to promote industrial transformation to the knowledge economy by strengthening the presence of high-tech sectors, while promoting the modernization of low- and medium-tech sectors and their ability to learn new technologies. Ukraine's public investment in R&D in digital technologies is much smaller than in leading industrial countries such as the European Union, the United States, Canada and Asia (China, Japan, South Korea); and in such high-tech areas as artificial intelligence (AI), public and private investment in Ukraine is ten times smaller. China has developed a strategic plan to support $ 150 billion in AI technology, including the development of AI chips ending in 2025, which secures China's position as a global superpower in high-tech industries and focuses heavily on AI in ten strategic sectors.

The development of industry and information technology, on the one hand, enhances social integration, and on the other hand, the risk of dividing society by the level of qualification of workers with a high level in information and digital technologies and some conservatism of qualifications in other areas. There are also problems with the introduction of new technologies and their impact on the labor market and the nature of labor; skills mismatch and increased concentration of wealth. In Ukraine, there are significant differences in the level of economic activity and labor market efficiency, including technological specialization and investment in research and innovation. Thanks to the introduction of new technologies and automation, the number of highly skilled jobs is increasing. The highest differences in qualifications are in the professions related to information computer technology (ICT), manufacturing and construction. One third of Ukraine's workforce lacks digital skills. Lack of qualified people and talents risks slowing down investment. For example, 9 out of 10 manufacturers are trying to find the skilled workers they need. Similarly, more than half of companies looking for ICT professionals, particularly in the field of AI, report difficulties in recruiting them. Therefore, there is a need to reform the current education system, as well as to better anticipate and develop skills to equip the workforce with appropriate skill sets.

To Subsection 2.2. The main directions of research of artificial intelligence

The main directions of research and innovation

The main research and innovation priorities are grouped into two general categories: (I) Ensuring technologies that ensure control and economic independence; and (II) accelerating economic and social transformation.

Artificial intelligence technologies

Due to the increase in computing power, the availability of large amounts of data in new algorithmic concepts, intelligent devices in intelligent robots, artificial intelligence (AI) is being

formed as one of the most strategic technologies of the 21st century. How we approach AI will determine the world in which we live.

In the face of fierce global competition, Ukraine's AI research and innovation agenda will contribute to the successful development of all our citizens and businesses, while ensuring high ethical standards and an inclusive approach. Ukraine must take a prominent place in the field of information technology and, in particular, AI technology.

Object is for all citizens to experience the benefits of AI in everyday life - from optimizing traffic and autonomous driving to reducing everyday stress and significantly reducing the number of accidents, to truly intuitive AI-based systems that adapt to human needs. to support them in solving specific tasks, improving their working conditions and making the technology easy to use for everyone, not even AI experts. In addition, society as a whole will benefit from artificial intelligence solutions to optimize the life cycle of resources (energy, food, etc.) and make them more environmentally and economically sustainable - from production to distribution and use. Physicians will be able to seek the support of powerful machine learning, which requires large amounts of data, to help them make decisions about diagnosis and therapy. Firefighters will receive support from robots to approach dangerous areas of intervention. In general, progress in the field of artificial intelligence and robotics should be fully used to promote Ukraine in the markets of innovative solutions and technological breakthroughs in leading fields of science and industry; and bring all its potential benefits to other industries, such as health, agriculture, manufacturing, energy, transportation, and the environment.

The introduction of artificial intelligence and autonomous behavior algorithms in complex systems that are important for security and time, such as systems used in large transport networks, aviation, health and industrial purposes, is a technological challenge, but also a significant business opportunity for Ukraine. It is necessary to use human-oriented ethical and reliable AI, which will be crucial for its implementation, and the brand of AI, developed in Ukraine.

To subsection 7.5. Artificial intelligence in transport and infrastructure

Logistic. Development of technologies for detection and localization of objects using unmanned aerial vehicles

The development of technologies for detection and localization of objects using UAVs is one of the current and promising areas of application of artificial intelligence technologies. This makes it possible to solve a number of state, economic and defense tasks and, in particular, to create three-dimensional reconstructions of the area (buildings, landscapes), as well as to make accurate measurements with LIDAR and RGBD cameras.

Object. Use UAVs to detect obstacles and identify objects in the environment in real time.

Rationale for research and main tasks

Demand for technology for autonomous vehicles has increased with the development of IT and artificial intelligence. Requirements for autonomous driving, research on the detection / avoidance of obstacles and the recognition of surrounding objects - traffic signs and pedestrians have increased. The use of unmanned aerial vehicles has also become important in areas such as natural disaster monitoring, shipping and construction disturbances, intelligent flight and object recognition techniques.

Limited technologies available:

- *low accuracy of sensors due to limited characteristics;*
- *limited technology of synthesis of heterogeneous sensors;*
- *limitations of image recognition technology.*

Task. It is necessary to develop adaptive algorithms for assessing the accuracy of heterogeneous sensors (HS), which will assess the accuracy of each sensor by the characteristics of interference: brightness, depth, position, dynamics of change.

Object. To develop two-tier real-time object recognition algorithms based on YOLO and HS data that can speed up RoI search without losing accuracy. To avoid the limitations of available technologies, interference detection algorithms for the use of heterogeneous sensors and object recognition (RO) for real-time autonomous flight are proposed with the following two modules: interference detection module (MRP) using 1D-LIDAR sensors and camera, and also a two-level object recognition module (MRO) in real time, using data from heterogeneous sensors.

Research and development strategy

Based on the following strategies, developed new methods that provide both versatility for unmanned aerial vehicles and specialization in UAVs. • Development of core technologies to support any new adaptive heterogeneous sensor technology depending on different interference characteristics.

- Development of a strategy to overcome significant limitations of existing technology.
- Creating an open source technology development strategy that reflects new technological trends.
- Use of international infrastructure.
- Creating a business strategy based on technology sharing and business suitability.
- Creating a system of research and design through the analysis of the sequence of tests and data exchange.

Research plan

Stage 1: basic system design

- Analysis of sensor accuracy, collision risk measurement and training experiments for different obstacle characteristics.
- Development of an algorithm for detecting interference based on inhomogeneous sensors.
- Algorithm for recognizing multiple objects based on data from an adaptive sensor.

Stage 2: module optimization, adaptation and testing in different situations • Implementation and evaluation of UAV effectiveness

- Addition of heterogeneous sensor technology to autonomous operation of UAVs.
- Analysis and optimization of modules for embedded environments.

Expected use of the results of detection technologies and localization of objects using unmanned aerial vehicles

Real-time interference detection and object recognition technology, which is based on the convergence of data from heterogeneous sensors for unmanned aerial vehicles, can be used both in the unmanned vehicle and directly in the field of UAV. This work can be used in a variety of situations, including to prevent social disasters and to deliver goods by private companies.

- **PR:** press release, taking into account the key technologies of this service platform
- **Technical exhibition:** exhibition of technical exhibits to respond to various technical consultations related to task definition technology
- **Demonstration and pre-commercialization:** advancement through pre-commercialization based on this technology.

Development of integrated, smart, secure, affordable and inclusive mobility systems

Ukraine must maintain the competitiveness of its transport sector and manage the transformation of supply-based transport into demand-driven services, safe and sustainable mobility services. Relevant research and innovation initiatives will help prepare for such transformations. New digital technologies, such as big data (BigData), Internet of Things (IoT), artificial intelligence and advanced satellite navigation services (Galileo / EGNOS), offer great potential for the development of connected and automated transport and traffic management throughout the transport

network. This can provide significant benefits in terms of safety, environment, economy and social situation by reducing accidents caused by human error, reducing traffic congestion, reducing energy consumption and vehicle emissions, improving the efficiency and productivity of transport operations, improving working conditions, creating new jobs, and promoting social cohesion. To succeed in this transformation, Ukraine's aging (and not always sustainable) transport infrastructure needs to be prepared to function more efficiently and intelligently. The results of research and innovation will create the basis for future standards, creating European and global markets, as well as adapting and modernizing the overall regulatory framework. To maximize social, environmental and economic benefits, in addition to technological solutions, it is important to consider the following human and social aspects: analysis of mobility factors and patterns, representation of different social groups and inclusion of new solutions, capacity building and public acceptance.

Securiy and competitiveness of automated road transport system

Task. Implement the goals of joint, connected and automated road mobility at the national level.

Object: to outline public benefits, strengthen the competitiveness of Ukrainian industry and properly manage the long transition to a highly connected and automated transport system in a safe and secure way, promoting social integration and overall efficiency, taking into account personal mobility while reducing overall environmental impact.

Potential tasks and research topics

- Interaction of automated vehicles with the environment, physical and digital infrastructure, interfaces with other modes of transport.
- Technical and non-technical tools: smart sensors, 3D HD maps, advanced satellite navigation technologies, data analysis, artificial intelligence, ethics, confidentiality, security, responsibility for cybersecurity, user and public acceptance, management and international cooperation.
- Impact of automated road transport system on society and the environment (economic, environmental, social, educational, qualification aspects, employment).
- Large-scale cross-border demonstrations to gain insight into the capabilities of automated driving systems and their limitations, as well as for deployment.

Development of efficient and innovative transport infrastructure

Task. Innovative infrastructures will be vital for the implementation of the TEN-T network and the technological transition to effective reduction of greenhouse gas emissions. Thus, there is a need for new solutions to provide, despite the existing budget constraints, Ukraine's transport infrastructure. It can be maintained, upgraded and expanded to ensure efficiency. Climate change forecasting is crucial for the development of new types of innovative transport infrastructure for 2050, where the problem of sustainability and environmental impact is growing. Moreover, focusing on new modes of transport and customs is a key to improving connectivity and therefore increasing competitiveness and quality of service.

Object. Development and approval of new solutions to increase the efficiency, intermodality and safety of the transport system for passengers and goods. At the same time, reduce greenhouse gas emissions from transport operations and improve the environmental performance of transport maintenance and upgrades throughout the infrastructure life cycle.

Potential tasks and research topics

- To develop and to test new methods of supporting and modernizing transport infrastructure to increase safety, climate resilience and environmental impact (including habitat and biodiversity) and develop new solutions to ensure mobility.
- Support the development of transport infrastructure that will ensure the deployment of new and modes of transport and improve the integration of (national, regional) transport infrastructure and energy systems through the deployment of appropriate infrastructure.
- Integration of physical and secure digital infrastructure, including aspects of cybersecurity.

- To develop tools for information collection and data management to monitor infrastructure performance (asset utilization rate) and effective management of mixed fleets on road networks.
- To develop and test management, regulatory, public procurement models and new contract performance indicators and incentives to maintain and upgrade infrastructure.

Implementation. Potential challenges and research topics will be addressed through collaborative research and innovation.

Development of the future transport network and integrated traffic management

Task. The lack of timely information, reliability, multimodal coordination, safety, passenger comfort and the availability of collective mobility, which is exacerbated by inefficient freight traffic, leads to an increase in the use of individual transport. Overcoming system-wide capacity constraints will improve the management of passenger and freight traffic flows, ensuring uninterrupted mobility and door-to-door transport, which will lead to optimal traffic and circumvention of temporary capacity constraints.

Object. To develop and to prepare for the deployment of an advanced multimodal network and integrated traffic management system to ensure uninterrupted door-to-door mobility, increase safety, reduce congestion and emissions from transport.

Potential tasks and research topics

- Architecture and operation concept for an efficient, robust and adaptable multimodal network and traffic management system (NTM) using advanced digital technology solutions and satellite navigation services.
- Integration of service networks with cooperative and connected vehicles to improve traffic management and the overall higher percentage of information about mobile travelers.
- Verification of next-generation NTM multimodal systems (including intramodal optimization and interface development).
- Problems of data exchange: models of data exchange and use by different public and private stakeholders, the need for common approaches and rules;
- Optimization of the movement of conventional, automated and unmanned vehicles in the multimodal NTM system.
- Provision of co-modal freight transport services at the level of Ukraine, connected to global supply chains within a well-synchronized, intelligent and uninterrupted network.
- Include soft / active mobility provisions (bicycles + walking).

Implementation. Potential challenges and research topics will be addressed through collaborative research and innovation.

Multimodal freight logistics services and passenger mobility services

Task. New mobility services for people with disabilities are needed to ensure equitable access to new technologies. Public and private transport operators are developing their service models - blurring the traditional distinction between public transport and private mobility and between different modes of transport.

Object. Ensure the competitiveness of Ukraine in the field of logistics and mobility services, while reducing the impact of climate and environment in accordance with the Paris Agreement. To develop and to approve new, low-carbon approaches to the freight transport system and logistics operations throughout the life cycle. To develop and to approve people-oriented smart public transport and sustainable mobility services in all types of rural and urban areas.

Potential tasks and research topics

- New digital infrastructures, their interconnection and interaction with satellite navigation of Ukraine to increase the efficiency of logistics chains.
- To assess new business and operational models, their employment and social implications (eg the need for skills development and retraining), taking into account new digital and

space technologies, vehicles (eg unmanned aerial vehicles), new mobility models and new global trends.
- To assess the impact and opportunities of cooperative, connected and automated mobility on multimodal freight logistics based on digital technologies and satellite navigation services of Ukraine, open platforms and data standards / formats.
- To develop and define new management models for affordable, smart mobility services for all.
- Requirements arising from the future interaction of physical, digital, technical, social (health, education, etc.) and spatial systems.
- Adaptation of the data ecosystem / IoT to integrate new technologies from different sources (including non-transport) and integrate new mobility needs (models).

Implementation. Potential challenges and research topics will be addressed through collaborative research and innovation.

Improving transport safety - by mode and between modes

Task. Safety is a top priority of any transport system in the country. The basis of security research is technology, regulations and the human factor (individual and organizational aspects, including interaction with automation). The research process must take into account risks and systems, including vehicles, infrastructure (eg railway stations, airports and ports), the physical environment (eg weather) and various actors (eg. manufacturers, regulators, operators, users), and also all their interfaces. Specific issues for each mode of transport and synergies between modes of transport will be addressed, in particular on safety culture, data use and security / cybersecurity interaction. Particular attention will be paid to low-frequency incidents with high consequences (for example, passenger ship accidents) and emergencies that require rapid investigation to accelerate safety. Interaction will be used in research at the national, European and international levels, together with national authorities, agencies and international organizations, to improve rule-making, promote security and control.

Object. Contribute to a significant reduction in accidents and incidents, fatalities, injuries and environmental damage.

Potential tasks and research topics
- Construction, data analysis and exchange of security and security intelligence data.
- Understanding and predictive assessment of safety risks for system design, operation and efficiency.
- Human factors, including social behavior, new models of mobility, information perception, situational awareness, and interaction with automation.
- Smooth interaction between all users, their vehicles, infrastructure and physical environment in a secure system approach.
- New security technologies and solutions, taking into account emerging risks and opportunities (eg artificial intelligence).
- Improved preparation, verification, monitoring and implementation of safety norms, rules, standards, safety management systems and training, study of the potential of space technologies in Ukraine.
- Accident management and rapid response;

Implementation. Potential challenges and research topics will be addressed through collaborative research and innovation.

To Section 8. Scientific, personnel and material support of the national artificial intelligence ecosystem

The main **directions** of increasing the level of provision of the market of artificial intelligence technologies with qualified personnel and the level of public awareness about the possible areas of use of such technologies are:

- creation of an open organizational and technical ecosystem of topical fundamental and applied problems and tasks that require the use of artificial intelligence; use of the corresponding register of **problems and tasks as a top priority** for the choice of topics of diploma and dissertation works of the corresponding specialties and specializations;
- priority implementation of the **model of dual master's and postgraduate studies** in the field of AI using the experience of existing pilot projects of knowledge-intensive dual programs and involvement in planning and implementation of interested leading international companies with research branches in Ukraine;
- creation of normative and factual conditions for **stimulation of joint innovation-incubation activity (start-up infrastructure)** in the field of AI of teachers-researchers, students and business representatives at institutions of higher education of Ukraine;
- creating conditions for the return of leading Ukrainian AI scientists and specialists living and working abroad;
- identification of **technological research priorities taking into account limited resources** - in particular those that require **small investments**, while giving a significant competitive advantage in world markets due to widespread use - AI on devices (On-DeviceAI), new machine learning algorithms for systems with significant limitations in resources and so on;
- identification of ***priority related fields*** in applied physics, mathematics, materials science, neuroscience, mathematical linguistics, etc. - as real competition in the field of AI occurs, including in interdisciplinary areas for the creation of new computing architectures.

A.L. Fisunenko

To Section 1. Paradigm

Ukraine's place in the global artificial intelligence ecosystem. Basic decisions and measures

In order for Ukraine to play a leading role in the global AI ecosystem, it is necessary to identify such measures.

1. To create an open organizational and technical ecosystem of current fundamental and applied problems and tasks that arise in government and commercial organizations that are candidates for solving methods of artificial intelligence. To recommend the use of the appropriate register of **problems and tasks as a priority** for the selection of topics of diploma and dissertation works of relevant specialties and specializations.
2. To give high priority to the model of dual **master's degree and PhD in the field of AI**, involving in the planning and implementation of relevant training and research programs:
    a) experience of existing pilot projects of knowledge-intensive dual programs;
    b) interested leading international companies that have research branches in Ukraine.
3. ***Collegially,*** with the involvement of leading universities, state and commercial, Ukrainian and international research centers in the field of AI, determine the list of ***conferences and magazines*** that will be recognized for PhD (and above), and, conversely, the list of conferences and journals that are indexed by Scopus and other scientometric databases, but are "predatory" and should not be allowed for formal degree criteria. Accordingly, reduce the quantitative burden of PhD and doctoral criteria in favor of quality, which will be confirmed by the international community.
4. To stimulate partial employment of teachers in real commercial, state and international projects in the field of AI.

5. To create normative and factual conditions for stimulating joint **innovation and incubation activity (startup infrastructure)** of teachers-researchers, students and business representatives at universities.
6. To define **technological priorities of research** ***taking into account the limited resource***. For example, as modern data centers and computing clusters require significant investment, focus on areas that are **accessible and relevant in Ukraine and require little investment**, while giving a significant competitive advantage in global markets due to mass use: AI on devices (On-DeviceAI), new machine learning algorithms for systems with significant resource constraints and so on.

To identify priority related areas, not only in computer science and IT, but also in applied physics, mathematics, materials science, neuroscience, as real competition in the field of AI is including interdisciplinary areas to create new computing architectures.

To introduce the following key quantitative indicators for measuring the implementation of the Artificial Intelligence Development Strategy in Ukraine:

- quantity of presentations at leading conferences and publications in journals (according to the list of item 3).
- quantity of international patents in the field of AI
- quantity of masters, candidates and doctors of sciences specializing in AI and related (annual graduation and cumulative indicators)
- quantity of international conferences (IEEE, ACM) held by Ukrainian organizers.
- quantity of research projects with AI elements that have been successfully completed, implemented and used in companies and government agencies (annual indicator).
- quantity of immigrants specializing in AI in other countries.

Examples of the implementation of measures of the Strategy for the Development of Artificial Intelligence in Ukraine (2022-2030) in the form of applied developments and technologies

Intelligent technology for controlling a swarm of unmanned underwater vehicles

The project is aimed at solving the applied problem of navigation in environments with limited light supply and difficult radio signal transmission. When solving this problem, two problems are also solved: the first is the security and defense capability of the country, the second is the protection of nature from biological and chemical pollution of water bodies, which can cause man-made disasters.

The goal of the project is to create a universal hardware and software system for managing the tasks of a swarm of underwater robots with intelligent means of reconfiguring the interaction between them and the possibility of autonomous on-board navigation.

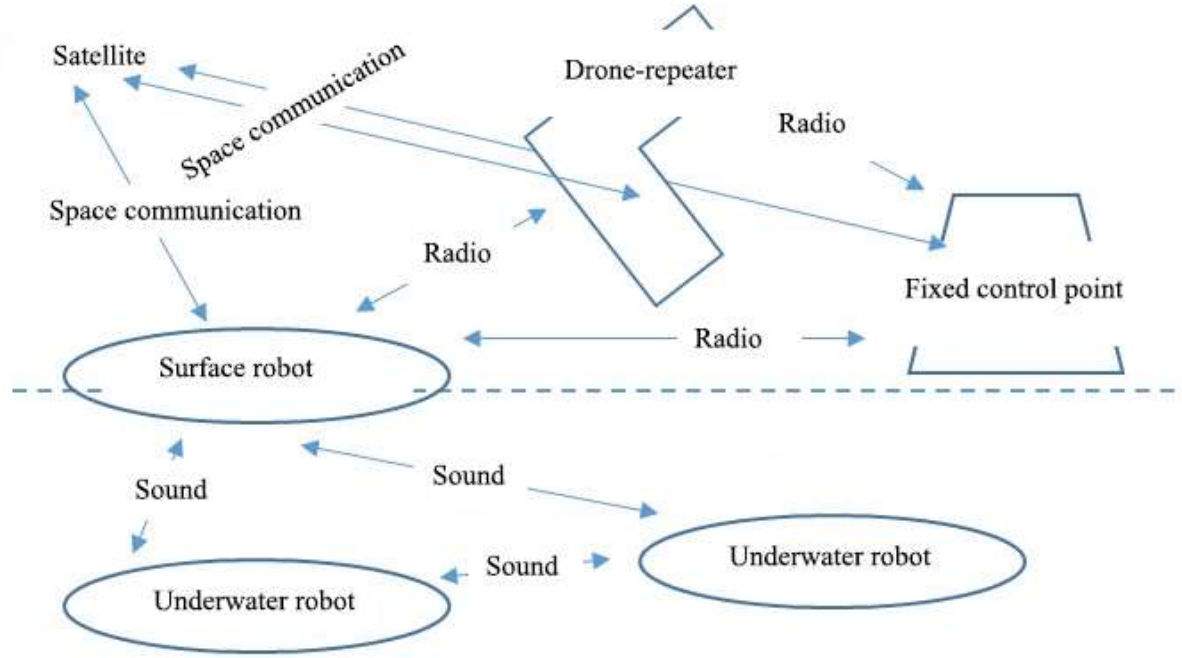


Fig. 3. – Conceptual structure of a universal complex of underwater robots

The architecture of the system includes 4 main elements: the operator's workplace (a multi-platform program), a central node of interaction (a server or a set of cloud services), a basic repeater (a hardware-software solution for exchanging data above and in the water surface), and an underwater drone. The proposed architecture allows operators to manually control selected underwater drones or assign tasks to groups of drones, combining them into a network-centric swarm. Drones perform data exchange with a basic repeater, but are able to interact with each other to implement swarm intelligence schemes.

The autonomous navigation subsystem of an underwater robot is being developed based on the processing and conversion of data from a set of onboard system sensors. The implementation of this subsystem consists in the preliminary development of methods of aggregation, filtering of data from sensors (sonar, camera, gyroscope, accelerometer, compass, altimeter, anemometer, thermometer, etc.) and creation of streaming data analysis models. A method of route analysis and planning is proposed, taking into account the factors that affect the increase in the error coefficient. This method will make it possible to create a map of the route based on the discrete data of the calibration buoy.

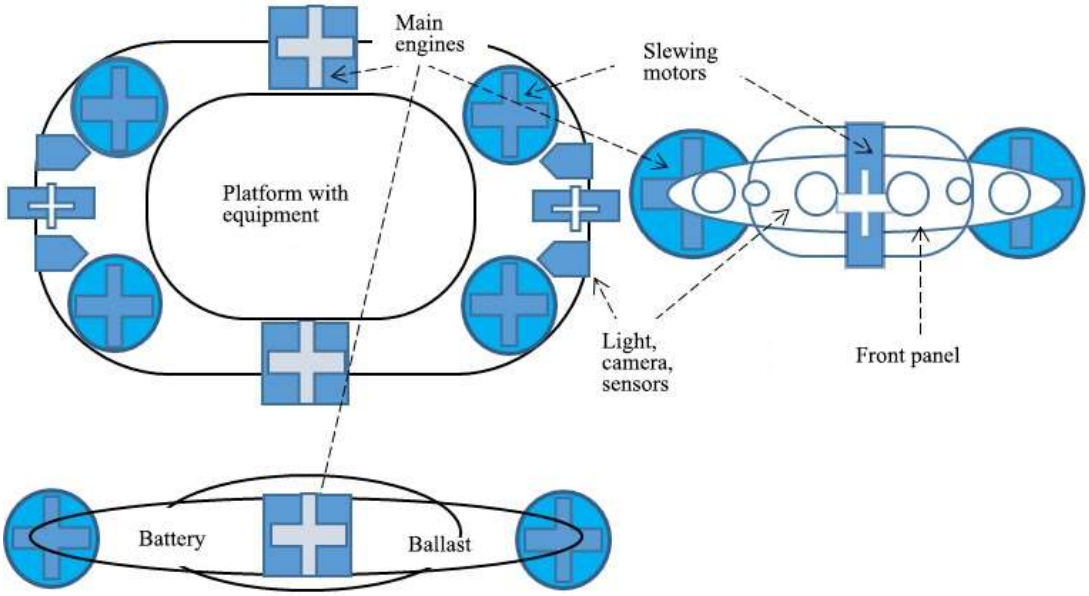


Fig. 4. – Sketch of an underwater robot model

It is proposed to create a method for classifying potentially dangerous objects and tracking a potentially dangerous target based on sonar and camera data, as well as temperature and depth data. Using machine learning methods, the system will be able to classify the behavior and parameters of the object. During the autonomous mode of operation, the system will make a decision to observe a suspicious object. In the process of observation, the system will also be able to reclassify the object.

A method of calibrating an autonomous underwater robot using calibration buoys with the implementation of data exchange protocols is proposed. This method is necessary to ensure a stable communication channel with the coordination center, as well as to ensure reliable navigation without the need for frequent pop-ups of the autonomous robot. As a buoy, it is possible to use a floating control station, which performs the general function of underwater robots and relays their signals to the control center.

State of development: prototypes of the repeater and drone are being created, research into the underwater communication system is ongoing, prototypes of the operator's workplace and the interaction node have been created, methods of the on-board autonomous underwater navigation system have been implemented under conditions of loss of communication or when performing tasks in silent mode.

A long-term defensive point with intelligent means of tracking and destroying ground targets

The project is aimed at solving an important problem of national security and defense, preserving people's lives by creating an intelligent system for recognizing and identifying moving targets in the ground space of operational surveillance, determining their coordinates, physical size, speed and direction of movement, followed by automated control of means of firing at damage.

The goal of the project is to create a prototype of an intelligent defense system that allows you to control robotic complexes remotely and remove a person from the contour of combat operations to reduce personnel losses and increase the effectiveness of small arms.

The idea of the project is to combine information from robotic video cameras with different spectrum ranges, means of distance measurement and knowledge about the processes of human visual perception of physical objects with known parameters, their location and behavior in space, ontological analysis of information about objects in the surrounding world. Such an approach, in combination with remote control systems for robotic mechanical military devices and decision-making systems in the tasks of managing defense devices, is relevant for increasing the state's

defense capability, creating innovative systems that remove people from the combat zone, reduce personnel losses, and contribute to the creation of new competitive types of weapons.

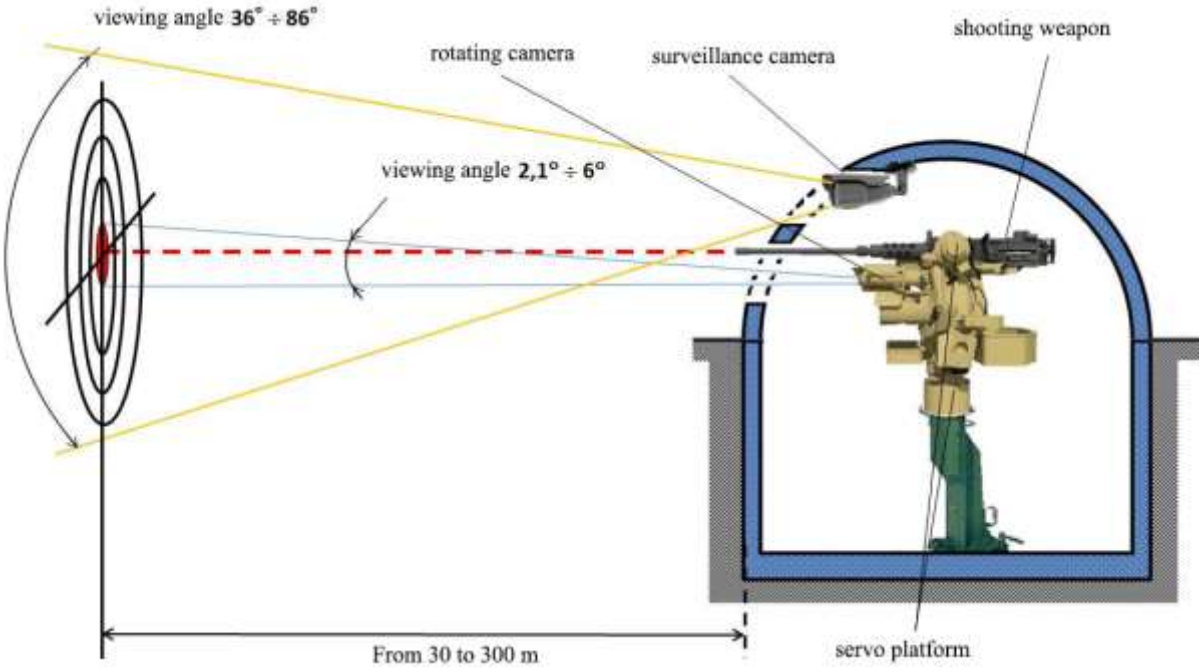


Fig. 5. – Scheme of an intelligent system of tracking and destroying ground targets

Hardware-wise, the system consists of a computing unit (single-board computer), which controls a rotary system with small arms, and receives video sequences from two cameras (at a minimum, the use of additional sensors is possible). The surveillance camera is fixed to the fixed common platform of the defense point. The rotating camera is aimed at a selective direction within the frame of the viewing camera and is placed on a servo platform, which in turn is fixed on a fixed common platform.

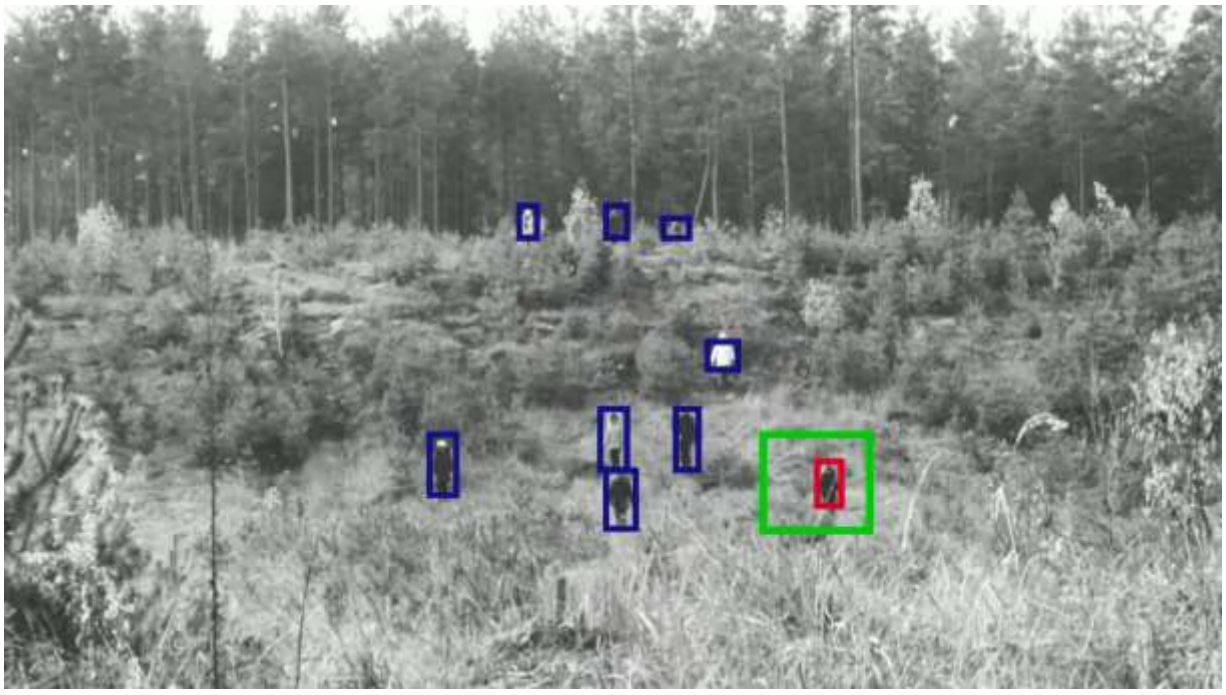


Fig. 6. – Simulation of the operation of the technology: tracking of moving objects (blue rectangles), aiming small arms at the current target (red rectangle) with its tracking by a rotating camera (green rectangle)

A simulator of the surveillance and rotating camera system has been developed based on the use of video captured by a fixed camera with a constant focal length. A software prototype of an intelligent fire system in an armored case with automated recognition and destruction of ground targets was implemented, which was tested on a simulator.

Technical characteristics of the object tracking system prototype:

- The number of target objects: limited by the resolution of the frame and the lack of overlapping objects from the viewing angle (up to 300 for a FullHD frame);
- The speed of target objects in the video stream in the image plane is no more than 25 pixels/sec;
- The minimum size of the object is 20x20 pixels (surrounding camera) and 10x10 pixels (rotating camera);
- Resource-efficient background selection: quasi-stable background (grass, forest, clouds);
- Surveillance camera: stationary placement in the direction of operative observation, viewing angle 86° ÷ 30°, resolution from 1920x1080 pixels, fast transmission of a video stream without compression and coding (HD-SDI/HD CCTV), progressive scan;
- Rotating camera: camera viewing angle 25° ÷ 17°, optical stabilization, resolution from 1280x720 pixels, fast transmission of video stream without compression. The real-time resolution of the rotating camera (frequency 25 frames per second) is 720x480 pixels;
- Operating modes: operator (user selects objects for tracking and damage), autonomous (tracking of all moving objects).

New and improved methods. The procedure for tracking the target object with a rotary camera, the procedure for correcting the direction of the rotary camera based on the comparison of the images of its video sequence with the images of the video sequence of the surveillance camera has been developed. On the basis of the developed search procedure between images of video sequences, a procedure for automatic calibration of the system of surveillance and rotary cameras is proposed. A method of formal description of images and video sequences in the form of a set of structural elements, properties of the function of modification of the description of tracked objects from frame to frame, which is necessary for tracking, has been developed. A procedure for detecting moving objects has been developed based on the selection of connected subsets of structural elements that have a similar interframe displacement. The developed methods of tracking target objects have been adapted for use on a video stream with a moving background inherent in a rotating camera.

A helmet for psychophysiological correction of the human condition in extreme conditions

The development is an intellectual system, which includes a set of methods of diagnosis and correction of the psychophysiological state and software and technical means for their implementation. Purpose: psychophysiological rehabilitation of a person in extreme conditions using a complex of methods; massage using innovative techniques and feedback control of the psychophysiological state.

The goal of the project is the development of theoretical provisions and practical implementation of means and methods of assessment and correction of human functional states in normal, extreme and emergency situations and environmental conditions, using feedback and adaptation mechanisms. The result is an intellectual system for adjusting the psychophysiological state of a person when making decisions in emergency situations, the features of which are autonomy, ease of use without the involvement of a specialist, modification of existing programs and creation of new ones. A scheme and methods have been developed for adjusting the functional working conditions of a human operator when making decisions at the level of performers of various ranks, including in military units. Informational models of the influence of psychophysiological and psychophysical characteristics on the intellectual characteristics of a

person when in situations of varying complexity and depending on different conditions of performance of assigned tasks are developed and described.

Fig. 7. – General view of the helmet and control unit on the demo stand (left) and testing the prototype helmet (right)

Principle of operation. Signals about the psychophysiological state of the body are sent to the intelligent system, the system controls the formation of appropriate feedback signals that purposefully affect the biologically active areas of the head surface with audio-visual accompaniment to increase the effectiveness of the effect. Basic types of programs: excitation or calming of the nervous system, software tools have also been created for the possibility of developing programs to increase attention during educational activities.

Components of the device: protective helmet, vibrocatuators (40 pcs.), microprocessor control system for vibration sources and sound accompaniment, virtual reality glasses ("Gear VR"), smartphone, stereo telephones, control panel, software and means of connection to a personal computer, means of autonomous power supply and recharging.

Available functions: selection of a program of the sequence of activation of vibration sources or creation of your own program; selection of audio and video accompaniment; control of the current physiological state; the possibility of saving and exporting information about the state of the body; expert system of selection and adaptation of procedures for psychophysiological correction of the human condition.

A chat-bot with artificial intelligence for the psychological rehabilitation of combatants

The goal of the project is to improve the effectiveness of the rehabilitation of combatants by means of trauma-focused cognitive behavioral therapy (TF-CBT) by automating these sessions using an intelligent system of a virtual interlocutor (chat bot).

Automation of elements of therapy is a way to solve the problem of quick provision of psychotherapeutic help. The leading chat bots available today have significant shortcomings: purposeful dialogue models (closed domain) implement separate TF-CPT scenarios without taking into account the user's characteristics and supporting arbitrary communication, which significantly reduces the therapeutic effect of using the development; open dialogue models (open domain) are close to natural communication, but due to the lack of forming a therapy scenario, they are used exclusively as a virtual interlocutor. Thus, current developments have a narrow range of tasks to be solved and cannot be used for autonomous rehabilitation of combatants.

The result of the project is a set of software that allows you to conduct a dialogue with the user in natural language by means of text or voice messages. The system takes into account the context of the conversation and implements TF-CPT methods to alleviate the consequences of being in stressful situations (in particular, combatants and military personnel). The specificity of the chatbot system lies in the need to ensure the required level of quality of responses to user requests, which are required to maintain dialogue and solve user problems. With this in mind, the structure of

the system includes a number of mechanisms that control the relevance of responses. The system is implemented in the microservice paradigm.

The work uses leading methods and technologies of machine learning: KeyBERT for identification of names, characteristics and events in the text, Cosmica for identification of emotions in expressions. Grammatical error correction using the BERT Gector model is included in the pre-processing of input information. DialoGPT is used to generate relevant answers and support dialogue, which is necessary for conducting psychotherapeutic sessions with the user in real time. Response quality is ensured by collecting clean, consistent data, fine-tuning the model, and integrating DialoRTP to evaluate the quality of chatbot responses and improve the existing dialog generation model by re-ranking generated response candidates.

A significant volume of possible training scripts on various topics and user requests complicates the task of configuring and training machine learning models with the required amount and quality of data for the desired topics of customers. In this regard, a feedback approach and a moderating mechanism with deferred regular retraining, taking into account the quality assessment and corrections of the moderators, are proposed for the organization of setting up and training the machine learning model.

To eliminate incorrect chatbot answers, which are possible after the use of different models, components and dependencies of various psychotherapeutic tasks set to the system, or insufficient volume of training data on the selected topic, and in order to improve the quality of answers, a context synchronization mechanism is implemented, which brings data to a single format supported by third-party models, and a mechanism for assessing the relevance of chatbot output data, which automatically evaluates, aggregates, accumulates results, and packs data for retraining the model.

State of development. The interaction of subsystems and machine learning models was designed and implemented with the help of a scheduler and a task router, which increases the efficiency of data processing due to the parallel processing of data by the mechanisms selected by the router. A web interface and a software prototype for dialogue in English have been created. The practical use of the developed system is currently expedient with constant moderation by experts of irrelevant chatbot responses during a psychotherapy session with users. The continuation of this work is the improvement of the context synchronization mechanism and the automation of the mentioned procedures, which require the involvement of the operator. This will allow in the future to abandon the moderation of user replicas and the vast majority of TF-CBT system session methods.

Conclusions

The Strategy for the Development of Artificial Intelligence in Ukraine is an important document that regulates the main areas of conducting fundamental research and obtaining new knowledge for the creation of breakthrough technologies in this field, taking into account Ukrainian realities. We consider the adoption of such a document an important state matter.

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Received 07.05.22
Accepted 05.06.22