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Analysis of the Priorities and Perspectives in Artificial Intelligence Implementation

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***Abstract*— The paper analyzes the priorities and perspectives of artificial intelligence (AI) implementation. The main components of the paper discuss the national AI strategies, the world's and NATO's priorities in AI's implementation, methodological aspects for creating the Ukrainian AI strategy and key priority areas for its implementation. Special attention is paid to perspectives of: a) applied AI's R&D for medicine and country's defense; b) AI academic consortia for education; c) the conscience paradigm approach to AI design; d) organoid intelligence; f) polymetric sensors for modern industrial AI systems; g) optic, color and quantum computing for the design of AI systems.**

Keywords*— *artificial intelligence, priorities, perspectives, implementation, research, analysis, tasks, proposals

I. INTRODUCTION

Artificial intelligence (AI) availability and effectiveness of its adoption will be a criterion for accessing the rank of economic development. The attractiveness of countries and regions, the concentration of skilled workforce [1], high-tech enterprises, educational institutions, material and financial resources, and cultural heritage will depend on the level of AI implementation.

Methods and means of AI are widely used [1-3] in robotics and automation, national defense, space industry, state administration, etc. Deep learning architectures are effectively used in different fields [1] including autonomous vehicles, computer vision, natural language processing (NLP), recommendation services, bioinformatics, medical image analysis and generation of new functional samples.

Current AI technologies become true amplifiers of research and scientific discovery. For example, researchers have decreased, based on using AI, a daunting quantum problem from 100,000 into only 4 equations [1] providing the same accuracy. AI implementation can lead to revolutionary results. Among the most promising AI directions [1,4,5] are: NLP and language models (Megatron-LM, XLNet, ALBERT, Meena); large language models - LLM (ChatGPT, GPT-4); generative adversarial neural networks (GAN); image generation models (DALL·E, Midjourney, Stable Diffusion); systems of artificial/computer vision; intelligent robotics and others. The AI plans, concepts, and strategies often highlight healthcare, military, agriculture, and manufacturing as perspective fields for transformation by AI means.

The aim of this paper is to analyze the main priority areas of AI implementation in the world and particularly in Ukraine, to discuss the research perspectives on the development of AI and its components and to form some attractive proposals for AI implementation in the important fields of human activity.

The rest of this paper is organized as follows. Sections 2, 3 and 4 present an analysis of the national AI strategies and the world's, NATO's and Ukraine's priorities in AI implementation. In section 5, the authors discuss new world-level research trends, tendencies, tasks and proposals in AI development. The paper ends with a conclusion in Section 6.

II. ANALYSIS OF THE WORLD'S PRIORITIES IN AI'S IMPLEMENTATION BASED ON NATIONAL AI STRATEGIES

According to experts' predictions for 2030 [1], the use of AI will increase GDP in China by 26%, North America by 14% and Europe by approximately 10%. More than fifty developed countries [6], which represent 90% of Global GDP, have already created national strategies for AI development with a formulation of goals, tasks and priorities in the AI area.

It is necessary to underline that current national AI strategies are presented in different forms, styles and shapes, particularly as AI detailed strategies, roadmaps, acting plans, conceptions, or executive orders. Each national strategy focuses on priority areas for AI implementation considering the corresponding country's economy, the structure of industrial and agriculture sectors, transformation in education, science, etc. Canada and Japan are the first countries [1,6], which developed corresponding National AI Strategies.

Table 1 presents the analysis of priorities and/or goals of AI implementation in selected countries from different continents.

Experts predict [6] that AI can provide an increase in cumulative GDP by 2030 by about 16%.

TABLE I. AI IMPLEMENTATION PRIORITIES PER COUNTRY

Country	Priorities/Goals of AI Implementation
Australia	AI Roadmap: health, infrastructure and natural resources.
Austria	The strategy outlines areas for which AI will be critical: (1) research and innovation, (2) society, (3) ethics and labor market, (4) qualification and training, (5) AI governance, (6) security and law, (7) AI in the public sector, (8) infrastructure for industrial leadership positions, (9) AI in the economy.
Belgium	The AI strategy includes 7 goals: policy support on ethics, regulation, skills, and competencies; provide AI cartography; co-animate Belgian AI community; collect EU funding and connect EU ecosystems; training in AI; implementation AI technologies to the industries; new products and services based on AI technologies.
Chile	The AI plan is based on 3 main pillars: (a) enabling factors (including human capital, fiber optic networks, and computing infrastructure); (b) development of AI in the country; (c) ethics, standards, security, and regulation.
China	AI plan consists of initiatives and goals for R&D, industrialization, talent development, education and skills acquisition, standard setting and regulations, ethical norms, and security.
Czech Republic	Main objectives: (a) concentrate research on developing responsible and trusted AI; (b) promote digital transformation, especially among small and medium-sized enterprises; (c) enhance economic development; (d) and ensure equitable distribution of AI benefits.
Denmark	The AI strategy has 3 goals: to make businesses the best at using digital technologies; to have the best conditions in place for the digital transformation of business; providing the necessary digital skills to people. The strategy concentrates on AI, big data, and the Internet of Things.
Estonia	4 key goals: (a) advancing the AI update in the public sector, (b) advancing the AI implementation in the private sector, (c) developing AI R&D and education, and (d) developing a legal environment for the AI introduction.
France	4 main components of AI plan: (1) a network of five leading research institutes, (2) an open data policy, (3) a regulatory and financial framework, (4) ethical regulations.
India	AI Strategy aims to: (1) enhance the skills to find quality jobs; (2) invest in research and sectors that can maximize economic growth and social impact; (3) scale Indian-made AI solutions to the rest of the developing world.
Japan	2 main goals: (a) "dramatically increase" young researchers in AI by increasing funds to priority fields; (b) unify data formats and standards throughout various industries.
Kenya	Priority AI areas: financial inclusion, cybersecurity, land tilting, the election process, single digital identity, and overall public service delivery.
Lithuania	AI is planned for implementation in the public sector for crime prediction, developing better services for citizens, and improving internal government processes.
Netherlands	The AI roadmap focuses on building up AI talent, taking a friendly human-centric approach to AI design and implementation, integrating ethics in AI frameworks, R&D investment, and balancing the role of man and machine.
Norway	AI strategy focuses on: (1) building up expertise through education, research, and innovation; (2) using AI in the public sector; (3) exploiting commercial opportunities, including enablers such as regulation and data access. (4) infrastructure and enabling technologies (e.g., 5G, high-performance computing); (5) ethical principles, protection of data, and security.
South Korea	3 main objectives: growing AI talent (special training programs and AI graduate schools), developing AI technology (by funding major projects in health, public safety, and defense), and investing in infrastructure (creating AI semiconductors for autonomous vehicles).
Sweden	Main focuses of AI strategy: (a) training more skilled AI professionals; (b) increasing applied and fundamental AI research; (c) creating a legal framework to ensure the development of AI applications that are ethical, safe, reliable, and transparent.
Tunisia	The main goal is in creating an AI ecosystem for equitable and sustainable development and job place creation.
UAE	9 priority areas for AI implementations: transport, health, space, renewable energy, water, technology, education, environment, and traffic.
USA	Focuses of AI strategy: investing in AI research, unleashing AI resources, setting AI governance standards, building the AI workforce, and protecting the US AI advantage.

National AI strategies have developed also in Argentina, Columbia, Finland, Indonesia, Israel, Italy, Mexico, New Zealand, Poland, Portugal, Vietnam, Switzerland, South Africa, and other countries.

III. PRIORITIES OF AI'S RESEARCH AND IMPLEMENTATION FOR NATO

In conditions of rapid technological development, AI has become an integral component of modern warfare and national security. NATO member states have recognized the significant potential of AI to transform their defense strategies, streamline operations, and enhance military capabilities [7,8]. The NATO Science and Technology Organization published "Science & Technology Trends 2023-2043" across the Physical, Biological, and Information Domains with the priorities of AI development and implementation for 2023-2043 years.

AI is seen by NATO analysts as a technology to improve operational awareness by processing and integrating data from various sensors, platforms and intelligence sources in real-time. AI tools can help a more complete understanding and prediction of potential risks, adversary intentions, and the impact of various strategic decisions as well as detecting anomalies or suspicious activity, informing decision-makers on potential dangers, and laying the groundwork for a faster and more targeted response. AI can also be used to model the behavior of adversaries, giving NATO countries a better understanding of their actions and reactions in various scenarios.

The use of AI as part of the NATO Defense Planning Process (NDPP) is very important. The proposed NDPP (Fig. 1) may be considered as a key mechanism that manages the development of NATO's military capabilities, ensuring the Alliance's readiness and ability to respond to new security challenges. AI can significantly improve NDPP by increasing planning efficiency, providing better insights and optimizing resource allocation. The following set of priorities can be considered when using AI to support NDPP.

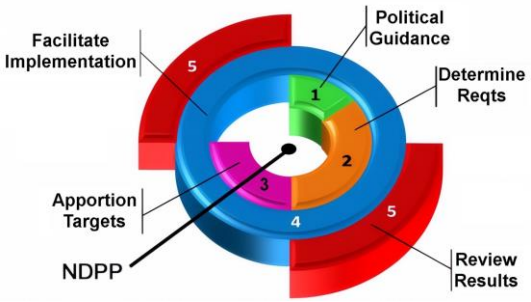

Fig. 1. Structure of NDPP - NATO Defense Planning Process (own source).

- AI technologies are an organic ecosystem for analyzing NATO's current capabilities and more effectively identifying weaknesses. An effective tool that can help analysts in this process is large language AI models.

- AI can be used to optimize the formation of forces and their readiness, ensuring the efficient distribution of personnel, equipment and other resources. AI-based algorithms allow analysis of personnel skills, equipment availability, and deployment history to determine the most appropriate force composition for specific missions.

- AI can help to predict future needs, allowing NATO countries to better plan the resources and capabilities they need. Effective allocation of resources and optimization of military forces are vital to maintaining NATO's strategic advantage.

- AI can support NDPP by improving training and education programs for NATO personnel. AI's main role in this area is to help develop individual training plans, ensuring that personnel are properly trained to perform their duties within the Alliance. The integration of AI with virtual reality technologies is particularly promising.

- The war in Ukraine revealed significant problems of NATO in the field of interoperability and interchangeability of weapons and military equipment. By identifying potential problems or obstacles to cooperation, AI can help NATO countries address these challenges and ensure that their military forces work together seamlessly during operations. Moreover, AI can facilitate the development of common standards, protocols, and architectures that facilitate greater integration and cooperation among Alliance members.

- A condition for the successful implementation of the NDPP is effective logistics and management of the necessary supply chains. AI can help optimize these processes by analyzing data on resource availability, transportation networks, and demand patterns.

- AI can assist in the development of autonomous vehicles and drones that can be used to solve logistics tasks, thereby reducing the need for human intervention in high-risk situations.

AI-based systems can analyze vast amounts of data to detect cyber threats and intrusions, respond in real-time, and even predict and prevent future attacks. In addition, AI can support information operations (disinformation campaigns and psychological operations) to counter hostile narratives and influence target audiences. AI has enormous potential to revolutionize military strategies and capabilities. NATO plans [7,8] to realize this AI potential to strengthen collective security through cooperation and collaboration among NATO Allies to confront complex challenges and threats.

IV. The Stages of AI's Strategy Creating and Key Priority Areas of AI Implementation in Ukraine

The field of AI in Ukraine is also developing rapidly. According to LinkedIn, there are currently more than 2,000 software development companies specializing in AI in Ukraine. Over the past few years, Ukraine has made significant progress in terms of publishing open data. Currently, Ukraine ranks 31st in the world ranking concerning the Global Open Data Index [9].

As a first step, Ukraine created the Conception for AI Development and Implementation, approved by the Cabinet of Ministers of Ukraine on 2 December 2020 [10]. This Concept defines the purpose, principles and tasks of the development of AI in Ukraine as one of the priority directions in a scientific and technological perspective.

In the second step, it is necessary to create a detailed Strategy for the development of AI in Ukraine. In 2020, the Institute of Artificial Intelligence Problems (IAIP) of the Ministry of Education and Science of Ukraine (MESU and the National Academy of Sciences of Ukraine (NASU) started the project "Creating Strategy for the Development of AI in Ukraine" [2] involving many Ukrainian scientists in the AI field. The stages of creating the AI strategy were defined as follows: analytical review and comparative analysis of different national programs for AI development; formation of a generalized vision of the activities of analytical AI centers; identification of promising ways of development of AI in Ukraine; formation of the terminology and basic principles and directions of further research of Ukrainian AI scientists; determination of priority areas for AI implementation in Ukraine, formation of a list of necessary legislative, organizational and investment measures for the implementation of the identified directions for the development of AI in Ukraine. The developed AI strategy is based on the national characteristics and interests, the necessity to extend AI research, and to implementation of recent AI tool developments in different fields of the Ukrainian economy. IAIP involved over 300 different organizations, in particular, the majority of ministries of Ukraine, research and higher education institutions, and commercial organizations for the determination of the priorities in AI implementation. Unfortunately, the Russian aggression on Ukraine is a serious obstacle to the final approval of the AI Strategy at the state level.

Let us focus on the tasks, proposals and priority areas for the development and implementation of AI in Ukraine [2] according to the developed AI Strategy.

Tasks in Science and Education. Appropriate development of educational centers is planned for the possibility of training personnel in the AI field. Transdisciplinary clusters must be created to monitor the development of students and the compliance of educational programs with society's challenges. In educational activities, intellectual platforms can be used to create conditions for meaningful filling of the educational process and personal development. Much attention must be paid to the development of basic digital skills, such as data analysis, programming, design, development, and support of technologies, which will increase the general level of digital literacy of society, adapting it to familiarization with new AI technologies.

Proposals for Medicine. AI in medicine must be focused on increasing the quality and length of life of the citizens of Ukraine. The main AI tasks should include: the formation of a national electronic health care platform, ensuring the exchange of data of the Internet of sensors and their use at the local, regional and national levels, the implementation of deep learning in scientific research in the medical field, improving the protection of personal medical data, improving the regulatory framework and ethical control of the use of AI related to health care, the introduction of intelligent robotic, autonomous medical technologies, increasing the competence in the field of AI of students and employees of the medical industry.

AI Tasks in Industry and Energy Sector. The implementation AI solutions must be directed toward creating fully automated industrial plants; enterprise management; control of nodes and aggregates of the enterprises and optimization of technological processes; information analysis, planning, and forecasting in energy security; flexible management of energy consumption; planning supplies, production processes, and making financial decisions; continuous monitoring of critical malfunctions, recognition of defects, prevention of sudden equipment failure, predictive maintenance/repair of equipment and forecasting of its resource; determining the priorities of AI research within the limited resources.

Telecommunication. The AI implementations, first of all, must be aimed for: the development of mobile communication infrastructure, the use of AI to solve typical operators' problems (dealing with customer churn, forming flexible tariff plans, fraud detection), as well as the implementation of AI systems for geographic targeting and analysis. Mobile communications infrastructure must be designed to facilitate the development of AI-based applications, services, and products.

Transportation and Social Infrastructure. The AI implementation must be planned with the aims of creating autonomous vehicles and fully automated infra-structure facilities; intelligent traffic management; creation of an early warning system for the need to replace and repair infrastructure elements; forecasting traffic flows and optimizing routes of public transport systems; increasing the safety of transport; development of multimodal freight logistics services and passenger mobility services, inclusive mobility systems.

Agriculture. The application of AI in agriculture has great potential for improving yields, reducing costs, and improving product quality. Several directions of AI application can be planned: prediction of weather conditions and climate changes, optimization of irrigation and fertilization systems and regimes, monitoring of plant conditions, soil analysis, and automation of sowing, harvesting, sorting, and packaging of products. The integration of AI into national and international weather and climate change data analysis systems is expected, which will allow farmers to more effectively plan crop selection strategies, sowing campaigns, and manage yields.

Proposals for Ecology. An urgent task is the development of intelligent situational centers that can use a geo-information system and AI robotic systems to control swarms of unmanned aerial vehicles to assess the consequences of destruction and search for victims in the event of man-made, natural disasters, or hostilities. This avoids risks to people in hazardous areas and reduces monitoring costs. Autonomous monitoring for optimal use of nature and restoration of land and water resources is seen as another direction of using AI robotic systems. Such tasks as reclamation of land and neutralization of pollution of water bodies can be performed without direct human participation.

National Security and Defense. AI technologies can be used for military goals but AI research, developments and implementations should be agreed upon with high ethical and moral principles.

Besides, the priority areas for AI implementation in Ukraine according to [10] are economics, cybersecurity, information security, public administration, justice, legal regulation and ethics.

V. Discussion of Some Perspective Proposals in Contemporary AI Research and Implementation

Let us discuss some perspectives, tendencies and authors' proposals in research for AI software and hardware solutions and analyze the peculiarities of corresponding results of AI implementation in the selected and very important areas of human activity: healthcare, defense, and education.

A. Perspectives of applied AI's R&D for healthcare

AI continues to be a high research interest in healthcare [11, 12]. For example, the models, created using a computational system Virtual Epileptic Patient (VEP), have been developed as part of the Human Brain Project (HBP), a ten-year European initiative focused on digital brain research [13]. The achievements in machine learning (ML) and NLP can improve the accuracy of medical diagnoses [14], predict patient outcomes [15], streamline healthcare workflows [16] and improve medical imaging [17].

Task 5.A1. AI will be widely used to identify potential drug candidates and accelerate the drug discovery process [18]. By analyzing medical data, AI algorithms can identify patterns and make accurate predictions, aiding in the diagnosis of rare diseases and the development of personalized treatment plans. For example, Spotify founder and CEO Daniel Ek have launched a new health-tech startup "Neko Health", which aims to offer full-body scanning to help doctors detect and prevent diseases. The non-invasive treatment will take about 15 minutes, the examinations will collect over 50 million data points about the skin, heart, vessels, respiration, inflammation, and more [19] using AI technology, and the company expects its diagnostic ability to improve over time.

Task 5.A2. AI can also improve the efficiency of healthcare delivery by providing patients with personalized advice and optimizing hospital operational procedures, such as predicting patient admission rates and scheduling maintenance. Additionally, AI can optimize resource allocation and reduce costs by predicting medical equipment failure and improving the allocation of healthcare resources [20, 21].

Task 5.A3. The current state of AI in medicine has demonstrated promising results in improving diagnosis and treatment, enhancing patient care and experience, and optimizing healthcare operations. Ongoing research [22] and development efforts in applied AI for medicine are focused on addressing challenges such as bias and standardization while exploring new applications of AI in medicine. As AI continues

to evolve, it is essential to ensure that its use in healthcare is safe, effective, and equitable. This requires collaboration between researchers, clinicians, policymakers, and patients to develop guidelines and standards that ensure the ethical and responsible use of AI in healthcare.

B. Applied AI's R&D for the country's defense

AI promises to change the traditional approach to national security. One of the most important aspects of defense research is situational awareness, the ability to identify, process and understand information in real-time. Applied AI has become a tool for providing an unprecedented level of situational awareness for decision-makers and strategists. Key areas of focus include advanced surveillance technologies, predictive analysis, and adaptive communication systems. Advanced AI-based surveillance technologies have revolutionized the way military forces gather and process intelligence.

Task 5.B1. Using computer vision, these systems can automatically analyze huge amounts of data from various sources, such as satellite images and drone footage [23, 24], data from various sensors, video surveillance cameras [25], etc. This enables rapid identification of potential threats and accurate assessment of enemy movement, ultimately leading to more informed and effective strategic planning. This will allow commanders to quickly find out the current situation on the battlefield and quickly respond to its critical changes. Thanks to the well-developed technology of image synthesis based on textual descriptions, it will finally be possible to realize the military's dream of automatically displaying and updating the operational situation on maps (Fig. 2). It is quite possible to supplement this process with the function of converting voice into text and then into images and synthesis of 3D virtual reality scenes (Fig. 3). It is quite realistic to implement the reverse process when AI is used to synthesize the texts of draft combat orders based on the results of updating the local tactical symbols on the commander's combat map.

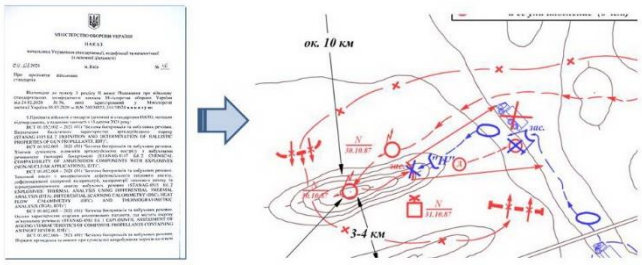

Fig. 2. Transformation of combat reports into an operational graphic situation on maps.

Task 5.B2. Another area of LLM's implementation is (a) the analysis of moods in units and among the population to identify potential threats and (b) the use of machine translation to facilitate communication between soldiers who speak different languages. AI algorithms excel at identifying patterns and making predictions based on large data sets to predict threat outcomes and strategies. By analyzing historical data in separate time series and tracking information in real-time, AI-powered predictive analytics can help military leaders make more informed decisions that effectively save lives and resources.

Task 5.B3. AI plays a crucial role in the increased resilience and adaptability of communication networks. NLP and ML algorithms can detect and counter cyber threats, such as hacking and blocking attempts, and ensure secure and reliable communication channels. In turn, neural network technologies of coding and demodulation of signals allow for an increase in the bandwidth and immunity of radio data transmission channels. This aspect is especially important due to the widespread use of autonomous systems and robotics in modern warfare, the control of whose actions requires the stable functioning of communication channels.

Task 5.B5. Robotic systems based on AI significantly change the rules of warfare, reducing risks to human lives and expanding combat capabilities. UAVs have become an indispensable tool in multi-domain operations. Equipped with AI, UAVs can perform a range of tasks, from reconnaissance and surveillance to targeted attacks with fire damage. Drones can work in swarms, in which collective AI should increase their efficiency and ability to overcome enemy defenses in conditions of heavy fire resistance and radio-electronic warfare. Similar ground, surface, and underwater robotic systems based on AI are developing to assist in a variety of military tasks, such as mine clearance, search and rescue, and logistical support.

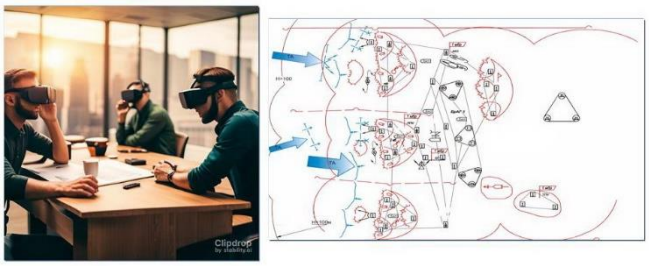

Fig. 3. Transformation of voice commands into symbols of the graphic situation on the maps (synthesized by the Stable Diffusion XL neural network according to the text description).

Task 5.B6. As the digital realm becomes an increasingly critical battlefield, AI is seen as a valuable asset in cyber defense and information warfare. The role of AI in identifying vulnerabilities to counter disinformation campaigns and a secure digital landscape is constantly expanding. AI-driven cybersecurity systems can effectively detect and neutralize cyber threats in real-time. These systems can quickly detect patterns and anomalies, responding to ongoing attacks before significant damage is done. It is necessary to note that a possible future cyber war may be a clash of several AIs that explore opposite goals and act in concert against the opponent's AI system.

Task 5.B7. Disinformation campaigns pose a significant threat to national security in the era of information wars. AI-based tools can help detect and counter such threats by analyzing various sources, including social media and news outlets.

Fostering talent and encouraging collaboration between academia, industry, and the military is critical for fully realizing the AI potential in defense research and development.

C. AI perspectives in education based on the academic consortia

Education is the key sector that allows nations to realize their AI ambitions. This problem can be solved by training students in the framework of academic and academia/industry consortia. Academic consortia of the universities can

significantly help in AI cadres' preparation. Exchange students and high-caliber professors, implementing the cross-registration procedure, and sharing computers, libraries, and other resources and facilities [26-28] in the framework of AI academic consortia can provide high-quality training the specialists in all universities which are members of the corresponding academic consortia.

Task 5.C1. AI academic-industry consortia (AIAIC) that united universities, research institutes, education centers and industrial or agricultural enterprises can promote the high-speed implementation of AI innovation solutions and start-up results in the industry, agriculture, and public sector.

For example, United Ukrainian University (UUU) is an innovative online education platform from Coursera and edX for Ukrainian universities [29] with the features: a full cycle of training with the help of the EDU intelligent bot; catalog of educational programs consisting of 6,000 courses (Coursera, edX, Cognitive Class, Intela-EDU, Progressive EDU Foundation); virtual reality training; gamification of learning.

Another example of AIAIC deals with introducing the idea of Ship Knowledge Center 5.0 (SKC) in frames of University-Industry Educational Consortia, when one must first define a critical practical engineering skills map. Appropriate innovation projects are on the go within Ukrainian Maritime Cluster in cooperation with advanced SEA Europe members [30]. A prototype of such SKC has been operational in the National University of Shipbuilding (NUS) since 2009. Then the Accelerated Training Program (ATP) developed in Aker Yards Design Ukraine office was relocated to Maritime Instrumentation Department Training Center (MID-TC) with appropriate hardware and software. Initial ATP was modified to the current needs of Ukrainian shipyards and design offices by MIC staff. Last decade the NUS faced a new specific challenge. While many students have successfully executed key training tasks concerning the design and engineering provision of ship hull manufacturing, very few have been ready to replicate the acquired skills across solving other seemingly similar practical engineering tasks. And, despite the accelerated adaptation of graduates to full-scale development of 3D models of ship structures and systems (an essential part of a ship's digital twin), junior specialists still have to additionally develop their knowledge to gain unique skills to deal with specifics of different types of vessels, building shipyards, digital modeling software, ship-owners' and operators' requirements, dominated weather on maritime routes, classification bodies and industrial standards, etc. Also, the role of the university's faculty is minimal in covering the gap between the horizon of their practical knowledge and the vast set of ROE (Return of Experience) system data at engineering, manufacturing and service entities [31]. In addition, universities historically are not present in the "normal" links of the shipbuilding value chain.

Task 5.C2. Thus, there is an urgent need to develop the next level of University-Industry Educational cooperation in the frames of the Industry 5.0 Paradigm. De facto, the first revision of SKC-4.0 was already tested and is operating in three MID-TC laboratories on an irregular basis (short-term projects) within Framework Agreements between the NUS, Aker Yards Design Ukraine (AYDU), Marine Design Engineering Mykolaiv, C-Job Nikolayev, AVEVA, CADMATIC, Schneider Electric and AMICO Group. The industry supports the development of the training center's material base, equipping it with new generations of workstations, internet connection and join updating of training programs and extracurricular courses, including multimedia instruments of online education and practical training. And they are the first employers of MID TC graduates, who grow in their professional careers very fast and now are working as lead engineers in several countries and international shipbuilding groups. Proposed in the "Shipbuilding Proto-Cluster Mykolaiv" project structure of SKC-5.0 should have more participants from EU shipbuilding supply chains and AI instruments developers on a de jure basis, supported by international grants and funds for dual green and digital transition of an industrial revival of Ukraine after the war.

D. The conscience paradigm to AI design

Special attention to future research in AI should be paid to creating AI based on the consciousness and conscience paradigm [2, 32, 33]. A person who has lost consciousness also loses intelligence. In other words, human intelligence originates from consciousness.

Let us further assume that AI is conscious, reasonable, and adheres to ethical, moral, and legal norms [2]. Therefore, it is necessary to connect the study of AI with a natural phenomenon – human intelligence. Fig. 4 shows the developed functional model of a new-generation computer system with embedded AI, which is a basis for further research on AI in a personal context. During its creation, knowledge can be used to build a real scheme of conscious activity, with a system of control over the decisions made.

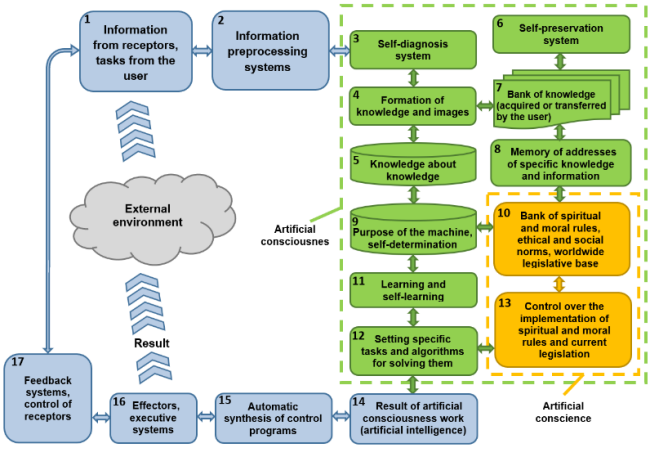

Fig. 4. Functional model of a new-generation computer system with AI.

E. Research and perspectives of organoid intelligence

Recently, there has been growing interest in combining organoids with AI to enhance their functionality and create "organoid intelligence" (OI) [34]. By analyzing large datasets of organoid behavior and responses, researchers can gain new insights into organ development [35, 36] and the nature of disease pathology, which would be difficult to achieve with traditional experimental methods. By studying organoid responses to various stimuli (drugs, genetic manipulations) researchers can develop models that accurately predict how organoids will respond to new stress factors.

Computer vision algorithms can be used to analyze microscopic images of organoids and identify patterns of cellular organization or differentiation (Fig. 5). These algorithms allow the monitoring of organoid development in real time, providing scientists with valuable insights into the dynamics of organoid formation [37]. US researchers [34] explore the potential of biocomputers and plan to use

organoids (clusters of 50,000 brain cells grown from stem cells), which will eventually lead to OI systems.

The human brain outperforms machines for solving certain tasks. While AI beat Lee Se-dol, the world champion in Go in 2016, this AI was trained on data from 160,000 games, equivalent to playing for over 175 years. Biological systems such as the human brain are also much more energy-efficient than data farms, using only a few watts of power compared to the thousands of megawatts used by data centers. OI could allow for the study of personalized brain organoids developed from samples of patients suffering from neural disorders.

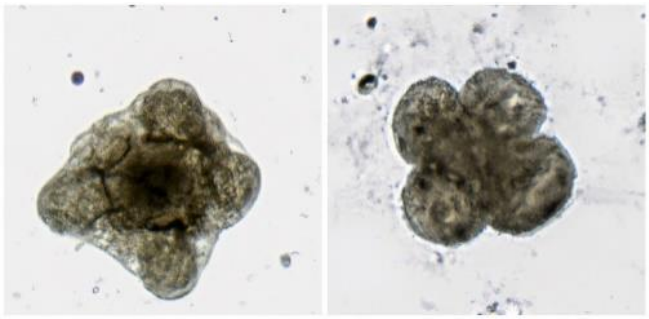

Fig. 5. Intestinal organoid (synthetically generated by authors using the DALL·E AI system).

By developing complex and physiologically relevant organoids and advanced AI algorithms, and promoting collaboration between experts in different fields, it is possible to maximize the potential of the OI's approach.

F. Polymetric sensors for modern industrial AI-based systems

Future AI research closely deals with the development of new sensors and sensor systems, based on various physical principles, with extended functional possibilities and improvement of technical characteristics. One of the perspective directions in this area is polymetric sensory systems (PSS) [3, 38, 39]. The special research will be focused on integrating digital polymetric and multivariate sensors (PMS) [40-42] into modern industrial AI-based systems to increase production entities' overall efficiency and provide their dual, green, and digital transformation.

The innovation in the PSS-approach lies in combining three key elements: certified and market-proof sensors; a secure and resilient data transport and storage system; and proven data analysis instruments for operations anomaly detection and failure prediction. By integrating these elements into a single system, critical infrastructure operators can more effectively monitor and protect their objects and detect potential issues before they become pressing problems.

The use of certified digital sensors ensures the accuracy and reliability of the collected data. At the same time, the secure data storage system protects the data from unauthorized access, tampering and even physical attacks. Finally, the data analysis for operational anomaly detection allows operators to quickly identify potential issues and take corrective actions before they cause damage or disruption (ship capsized under storm conditions, floating dock damaged because of pump or valve failure, maritime oil or gas transshipment terminal not operating, environment spoiled, production processes are interrupted, low-quality products are produced, enterprises suffer losses and pay fines, the nuclear power station is at risk of fire or even explosion, etc.). Such an integrated approach represents a significant advancement in critical infrastructure monitoring and protection, providing greater security, reliability, sustainability, and efficiency.

Critical features of the proposed approach different from the nowadays level include:

(a) Integrating certified digital sensors, secure data storage, and data analysis for anomaly detection into a single system represents a comprehensive solution that addresses multiple aspects of critical infrastructure monitoring and protection. In contrast, many other solutions focus on some parts of this solution.

(b) Proposed solution focuses on data security as a critical component of critical infrastructure functioning, using recognized advanced AI, ML, and IIoT instruments, building a resilient sensor network in combination with resilient data transport and data storage that can withstand cyber and physical attacks with implemented numerous redundancies. If one part of the system is down, other modules and the system can operate.

G. Optical computing, color optical computing and quantum computing for the design of AI hardware

The main goals for the development of new hardware solutions for AI realization deal with extending memory storage and increasing the speed of information and signal processing. Among perspective approaches for future implementation in the hardware of real AI systems are optical, color optical and quantum computing [43-45]. Optical computing allows (a) the creation of hardware for AI systems with faster computation compared with existing computer systems and (b) maximizing communication speed between different parts of computer systems. Color optical computing may allow us to get robust computations and robust communications providing reliable and high-accuracy computations in the conditions of noise as the main disturbances in signal and information processing. Quantum computers promise to solve problems that are beyond the reach of classical machines, by harnessing phenomena such as quantum superposition, in which an object can exist in two simultaneous states: spinning both clockwise and anticlockwise. For years, two leading approaches have enabled physicists to make progress, partly by cramming devices with more and more qubits, the quantum equivalent of a computer’s memory bits.

CONCLUSIONS

This paper consists of a detailed analysis of the priority areas for AI implementation in different countries, based on their national AI strategies, in NATO countries and in Ukraine. The paper also focuses on some advanced research directions, which may have a significant influence on the development and implementation of new AI solutions.

The authors analyzed, developed, formalized and justified priority proposals and tasks for future successful AI investigations and implementations, particularly, in healthcare and medicine (*Tasks 5.A1-5.A3*), defense (*Tasks 5.B1-5.B7*), education (*Tasks 5.C1-5.C2*), as well as in perspective sensor systems, organoid intelligence and advanced AI hardware components. The proposed approach for creating a new generation of computers with embedded AI based on moral and ethical principles has very high expectations and its creation is an important task for future research. The designing of AI systems raises questions about accountability, transparency, and potential unintended consequences.

AI developers from different countries (a) should work together to establish common ethical standards and principles [46] governing the use of AI in defense, medicine, and other fields as well as (b) AI research should be directed to minimize bias, improve explanatory power, and ensure the technology's compliance with international humanitarian law and human rights principles.

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