UDC: 004.93 DOI: https://doi.org/10.15407/jai2022.02.008

ARTIFICIAL INTELLIGENCE SYSTEMS AND TECHNOLOGIES - MAIN DRIVERS AND CATALYSTS OF SUSTAINABLE DEVELOPMENT IN THE CONDITIONS OF INDUSTRY 4.0

S. Ramazanov
Kyiv National Economic University named after Vadym Hetman, Ukraine
54/1, Peremogy Ave., Kyiv, 03057
SRamazanov@i.ua
https://orcid.org/0000-0002-8847-6200

Annotation. The Ukrainian Strategy of Artificial Intelligence Development was developed with such aspects as existing scientific establishments in AI field, high literacy rate, and yet limited financial resources taken into account. The information obtained from various ministries and institutions, in particular of such sectors as security, defense, science, education, various industries, marketing, logistics, demonstrates that without the introduction of artificial intelligence systems, further development of these sectors would not be effective. The approach to the development of breakthrough technologies in specific sectors and industries of Ukraine, in particular in the field of science and education, has been determined. The analysis of the available findings of fundamental, applied and experimental research on AI, which would ensure the development of breakthrough technologies has been performed. In unstable contemporary world, AI research domain grounds on fundamental scientific developments and methodologies, considering a fair amount of new challenges, therefore today we are in need of intelligent information and innovative technologies and systems, in particular artificial intelligence systems and technologies. The main scientific and technological driving force of the XXI century is the development of supertechnologies, namely: artificial intelligence, nanotechnology, biotechnology, mediotechnology, cognitive technologies, and human science technologies. However, it is important to take into account the principles of intellectualization, integration, convergence, coevolution, human science technologies. Moreover, it is crucial to formulate the terminology, definitions, principles of analysis and synthesis based on systemic and synergistic approaches, innovative, information, convergent technologies, taking into account the design of the viable, safe, and sustainable development against the backdrop of Industry 4.0.

Keywords: systems, technologies, artificial intelligence, principles, Industry 4.0.

"There could hardly be any doubt that in the future the considerable part of the laws of our world would be comprehended and employed by automatic human assistants. However, it is undeniable that all of the essential attributes of thinking and cognition processes would always be inherent in human. Our history proves the plausibility of this statement.

...Humanity is not simply all human beings considered collectively. The intellectual and physical capacity of mankind is defined by not only human muscles and brain, but also by all the material and spiritual values created by human. From this perspective, no machine and no set of machines, which is ultimately the product of the collective activity of humans, could be "more intelligent" than humanity as a whole, because with such a comparison, a machine is placed on one side of the scales, and on the other side there is the whole humanity in conjunction with the machines created by it, which, naturally, include the machine in question.

It should also be noted that historically, a human would always give a final assessment of intellectual as well as material values, including those values that are created by machines, so that in that regard the machine would never be able to surpass a human.

Therefore, it can be concluded that from solely informational perspective, cybernetic machines not only can, but must necessarily surpass a human, and in a number of still relatively narrow industries, they are doing it nowadays. However, from socio-historical perspective, these machines are and always will remain nothing more than human assistants and tools."

Academician V.M. Glushkov. On the "intelligent" capabilities of artificial intelligence.

Introduction

Artificial intelligence (AI) is a scientific knowledge and technology of developing intelligent machines, programs, services, applications, etc. It enables machines to perform tasks commonly associated with human prerogative.

According to top-level managers of key market players, AI will become the only and best tool for promoting and developing products and services over the next few years. According to analytical model, AI could contribute an additional 1.2 percent to annual GDP growth at least over the next decade. Overall, AI could deliver additional economic output of $13 trillion by 2030, putting its contributions to all sectors on par with the introduction of other transformative technologies. Nowadays, AI contributes $1 trillion to the global economy. Analysts expects about 70% of companies to adopt at least one form of AI by 2030 in order to scale up their performance, and a large number of top companies is expected to use a full range of innovations in order to strengthen the businesses.

Nowadays, several challenges hinder the development of AI in Ukraine, namely: lack of clear AI strategy; infrastructure issues slowing the adoption of AI; lack of awareness of fundamental AI advancements among businesses; low level of digitalization of the companies slowing the adoption of AI; uncoordinated processing of data; lack of understanding of certain aspects of AI adoption among managers of the companies.

Essentially, government agencies have to make quick decisions that would enable them to keep up with AI processes and influence the evolution of AI technologies.

Particular attention should be given to the development of strategies, programs, laws, and tools in order to regulate the AI field, which would allow to solve social, legal, moral, and ethical problems; as well as to the issues in training workers with necessary qualifications, building an investment strategy, and financing relevant developments.

It is also important to emphasize that AI is one of the main driving forces in achieving sustainable development goals (The Sustainable Development Goals (SDGs)) [1-27].

Relevance and importance of the strategy

The abovementioned statements serve as an evidence of relevance and importance of designing comprehensive and strong concept in order to create Ukrainian Strategy of Artificial Intelligence Development 2022-2023.

Transition to advanced digital technology, intelligent manufacturing technology, robotic and mechatronic systems, Industrial Internet of Things (IIoT), new facts and methods of software construction, 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, safe and sustainable development require new scientific research, intelligent information technology and innovative technologies and systems, in particular AI systems and technologies [11-27].

Scientific novelty

In unstable contemporary world, AI research domain should be based on fundamental scientific developments and methodologies, considering a fair amount of new challenges arising. AI systems are nonlinear, complex, and evolving systems. Therefore, our definition of AI, principles and criteria for the synthesis of AI systems is based mainly on modern fundamental and other research, and is clarifying and promising. AI technologies and systems should be designed and constructed on the basis of the following subsystems and components: scientific foundations, fundamental research and software; hardware and technological foundations; software systems, platforms, and tools; social and human science (moral, ethical, cultural, educational, philosophical, and legal) foundations.

The abovementioned components of AI technologies and systems, and their interactions with the external environment can be represented as a complex nonlinear self-developing system in the form of the structure (Fig. 1) [26].

AI TECHNOLOGIES AND SYSTEMS			
SCIENTIFIC FOUNDATIONS, FUNDAMENTAL RESEARCH AND SOFTWARE	HARDWARE AND TECHNOLOGICAL FOUNDATIONS	SOFTWARE SYSTEMS, PLATFORMS, AND TOOLS	SOCIAL AND HUMAN SCIENCE (MORAL, ETHICAL, CULTURAL, EDUCATIONAL, PHILOSOPHICAL, AND LEGAL) FOUNDATIONS.
Subsystem	Subsystem	Subsystem	Subsystem
1.	2.	3.	4.

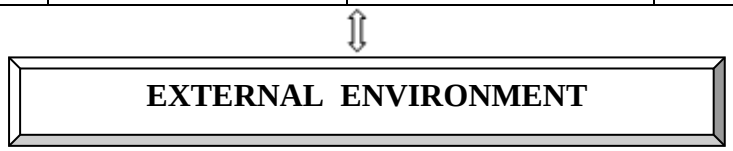

Fig. 1. The structure and subsystems of AI systems and interactions with the external environment.

The Ukrainian Strategy of Artificial Intelligence Development puts forward a global scientific and technical project to create a next-generation computer – an artificial personality with artificial intelligence. To this end, it is proposed to use the knowledge obtained from studying of the human intelligence. Knowledge of functional, psychological, neurobiological, chemical schemes of the human brain should be the basis of the algorithm for building a universal computer with artificial intelligence.

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

Proposals for outlining the area of breakthrough technologies in Ukraine

The Ukrainian Strategy of Artificial Intelligence Development was developed with such aspects as existing scientific establishments in AI field, high literacy rate, and yet limited financial resources taken into account. The information obtained from various ministries and institutions, in particular of such sectors as security, defense, science, education, various industries, marketing, logistics, demonstrates that without the introduction of artificial intelligence systems, further development of these sectors would not be effective. The approach to the development of breakthrough technologies in specific sectors and industries of Ukraine, in particular in the field of science and education, has been determined. The analysis of the available findings of fundamental, applied and experimental research on AI, which would ensure the development of breakthrough technologies has been performed.

Contemporary science is going through a paradigm shift: from field-specific knowledge and sectoral composition of economy to fusion of sciences and convergence of technologies. Nowadays, a new scientific and technological structure has arisen based upon 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).

Supertechnologies would become a key driving force of sustainable development in

the 21st century: artificial intelligence, nanotechnology, biotechnology, media technologies, cognitive technologies, and human science technologies. Specifically, it is a contemporary development of innovative technologies. Therefore, the principle of intellectualization, integration, convergence, coevolution, and human sceince technologies should be integrated.

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

In the EU's Ethics Guidelines for Trustworthy Artificial Intelligence, published on April 8, 2019, which may be considered as the basis of the EU's AI policy, experts formulated ethics principles for trustworthy AI. In this document artificial intelligence systems are viewed as technical systems capable of processing information in a way resembling the operation of 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, namely: self-learning of a system that includes deep learning and reinforcement learning; automated reasoning, which includes planning, dispatching, knowledge representation, search and optimization; cyberphysical systems, in particular the Internet of Things and robotics; functions of control and recognition, which integrate processing of data, collected with sensors, and functioning of actuators in 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. It is down to the intelligent systems that turned out to be able to perform tasks that only living beings were capable of performing, in some instances exceptionally humans. These features have allowed to set a number of new tasks for AI systems in order to ensure the support of society and humans. In the long run, artificial intelligence systems would be able to compete with humans in terms of their ability to comprehend human experience and mimic human consciousness, which poses additional issues in 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 that are manifested in influence on our perception of both technology and human, to which such interaction could lead. The Guidelines state that both types of ethical issues are closely interrelated and are integral components of an ethical approach to AI.

Artificial intelligence has an impact on the cultural identity and cultural diversity. AI could positively affects cultural and creative industries, however, on the other hand, it could lead to the concentration of production of cultural content, data, and, therefore, income in the hands of a very small group of market actors, which would potentially negatively affect the diversity of forms of cultural expression and guarantee of the principle of equality.

Thus, intelligent information and innovative technologies and systems, in particular, artificial intelligence systems and technologies are required in this day and age.

Proposals for introducing the scheme (chain) of scientific results in manufacturing and market

I approve of the schemes proposed in the Ukrainian Strategy of Artificial Intelligence Development for the implementation of scientific, applied, experimental research for the introduction of

new and existing technologies for various industries, economic reproduction, and production of goods.

Capacity of workforce scientific potential of Ukraine to create a computer with artificial intelligence, as long as there is financial assistance provided

Separately developed components of a computer with artificial intelligence, designed as intellectual property, are assembled into one high-tech product. To preserve human resources in the state, it is advisable for Ukrainian scientists to participate in various international projects financed from abroad and not related to the global project.

The use of international experience in research, where a large number of scientists from different establishments, ministries, higher education institutions, academies take part, should be supervised by one coordinating scientific and educational center. Such a center should be created in Ukraine. Simultaneously, the state should create an integrated system for ensuring the development and implementation of AI in the production of goods and services with the trademark "Made in Ukraine". A number of scientific schools have been established in scientific institutions and higher education institutions of Ukraine that study the field of AI. It is the principal direction of study for the Institute of Artificial Intelligence Problems of the Ministry of Education and Science of Ukraine, and the National Academy of Sciences of Ukraine.

It is important to ensure the fulfilment of the aims of the Strategy with the qualified employees as the main driving force, which requires the following measures: development of the regulatory framework for training qualified AI specialists by means of integration of educational modules and programs at all educational stages; development and adoption of mechanisms to stimulate professional training in AI field in higher education institutions and conduction of scientific activities in this area; encouragement of the talented youth and young scientists to participate in scientific activities for the development and integration of AI; setting-up of laboratories in universities and scientific institutions for training students and conducting research on AI; engagement of scientists and educators in international AI projects, including Erasmus+, DAAD and Horizon Europe; improvement of the quality of natural science education, its integration with humanitarian education by launching encouraging programs and grants for educational institutions of all levels with a focus on natural, mathematical, computer, information sciences and mathematical linguistics; allocation of funds for the creation of free courses (online) in Ukrainian on artificial intelligence on platforms such as Prometheus, Coursera and Udemi, including those designed for a teenage audience; increase in the number of AI study programs and state-funded places for students;

engagement of prominent experts and scientists who study the natural intelligence and functions of natural neural networks – neuroscientists, medical practitioners, cognitive psychologists, behaviourists, psychiatrists, lawyers; legislative stimulation of employers to take measures aimed at employees to acquire competencies in the field of artificial intelligence and in related areas of its application; introduction of mechanisms to stimulate the work of scientists and researchers in the field of AI, providing them with decent (world-class) working conditions; establishment of scientific schools of AI problems in universities and scientific institutions, as well as directing their work to integrate the achieved results; setting-up of a separate department of artificial intelligence in the sections of physical, technical and mathematical sciences of the NAS of Ukraine; provision of proper conditions for prominent Ukrainian scientists and AI experts living and working abroad to come back to Ukraine.

By 2030, Ukraine shall implement world-class educational programs to train highly qualified specialists and managers in the field of artificial intelligence. Ukrainian educational organizations should occupy leading positions in the world in certain areas in the field of artificial intelligence. The shortage of specialists in this field must be eliminated, in particular by attracting leading

foreign specialists who possess academic degrees.

Therefore, it is crucial to formulate the terminology, definitions, principles of analysis and synthesis based on systemic and synergistic approaches, innovative, information, convergent technologies, taking into account the design of the viable, safe, and sustainable development against the backdrop of Industry 4.0. [21-28].

In unstable contemporary world, AI research domain grounds on fundamental scientific developments and methodologies, considering a fair amount of new challenges arising.

I consider research on the functioning of human brain and cognitive modeling to be important tasks, therefore it is reasonable to select the human brain, in particular consciousness and intelligence, as a functional prototype for creation of the computer with artificial intelligence.

The main goal of the Strategy: Synthesis of controlled and "good" AI systems!

General conclusion

Ukrainian Strategy of Artificial Intelligence Development 2022-2030 is up-to-date, it has international scientific novelty and practical value for the sustainable and safe development of the country.

References

1.The Brookings Institute analyzed national strategies for the development of artificial intelligence (AI). (n. d.). Retrieved October 10, 2020: https://www.brookings.edu/research/how-different-countries-view-artificial-intelligence/

2.Concept of development of artificial intelligence in Ukraine. Project (2020). Order of the CMU. https://thedigital.gov.ua/storage/uploads/files/

3.Krakovetskyi, O. (n.d.). Review of national strategies. Retrieved 01, October 2019: National Strategy for the Development of Artificial Intelligence for the period up to 2030, p. 490, Decree of the President of the Russian Federation (2019).https://www.tadviser.ru/images/8/86/000120191 0110003.pdf

4.Subetto, A. I. (2008). Doctrine of Spiritual and Moral System of Noosphere Man and Noosphere Education (Kostroma: N.A. Nekrasov KSU).

5.Chubatyuk, Y. (n. d.). Ukrainians are not inclined to trust apocalyptic scenarios in the context of artificial intelligence development, a survey shows. Retrieved 10, October 2020: https://rus.lb.ua/tech/2019/01/15/417108_protivostoyat _ugrozam.html.

6.AI WATCH report 'defining ai': An operational definition and taxonomy of all ai different approaches. (2020, May 28). https://ai-regulation.com/ai-watch-report-defining-ai-an-operational-definition-and-taxonomy-of-all-ai-different-approaches/

7.Dawson, S. F., Kevin C. Desouza, and Gregory S. (2020, June 17). How different countries view artificial intelligence. Brookings. https://www.brookings.edu/research/how-different-countries-view-artificial-intelligence/

8.Ramazanov, S. K., Babenko, V., Honcharenko, O., Moisieieva, N., & Dykan, V. (2020). Integrated Intelligent Information and Analytical System of Management of a Life Cycle of Products of Transport Companies. 12(3), 26–33. https://doi.org/10.22059/jitm.2020.76291

9.Ramazanov S. K. Cybernetics, synergetics and digital economy: yesterday, today, tomorrow. – P. 310-313 // Collection of materials of the National Scientific and Research Complex "Digital Economy" - Kyiv: KNEU, 2018.-407 p.

10.Ramazanov, S., Antoshkina, L., Babenko, V., Akhmedov, R. Integrated model of stochastic dynamics for control of a socio-ecological-oriented innovation economy (2019). Periodicals of Engineering and Natural Sciences, vol. 7, no. 2, pp. 763-773. http://dx.doi.org/10.21533/pen.v7i2.557.

11.Ramazanov S.K., Stepanenko O.P., Cherniak O.I., Tishkov B.O. Models and technologies of forecasting and the problem of designing the future: analysis of the state and some results. – P. 164-191 // Actual problems of forecasting the development of socio-economic systems: Monograph / Edited by O.I. Cherniak, P.V. Zakharchenko - Melitopol: 2019. - 456 p.

12. Ramazanov S.K., Stepanenko O.P., Tishkov B.O., Honcharenko O.G. Problem of forecasting and innovation economics control based on integrated dynamics model. – P. 91-106 // «Information systems and innovative technologies in project and program management» [Text]: Collective monograph edited by I. Linde, I. Chumachenko, V. Timofeyev – Riga: ISMA, 2019. – 339 p.

13. Information and innovative management technologies in ecological and economic systems. Monograph. Corrected and supplemented edition. Under the editorship of Prof. S. K. Ramazanov - Kyiv: KNEU named after V. Hetman, 2020. 464 p.

14. Ramazanov S.K. Future Production Systems (Green Innovation Economy of the Future). // ACCESS Journal: Access to Science, Business, Innovation in Digital Economy ISSN 2683-1007 (Online)2020, 1(1), P.6-8.

15.Sultan Ramazanov, Mariana Petrova. Development management and forecasting in a green innovative economy based on the integral dynamics model in the conditions of "Industry - 4.0". // ACCESS Journal: Access to Science, Business, Innovation in Digital Economy (Online) 2020, 1(1), P. 9-31.

16.Ramazanov, S., Babenko, V., Honcharenko, O., Moisieieva, N., & Dykan, V. (2020). Integrated

Intelligent Information and Analytical System of Management of a Life Cycle of Products of Transport Companies. Journal of Information Technology Management, 12(3), 26-33.
doi: 10.22059/jitm.2020.76291.
URL:https://jitm.ut.ac.ir/article_76291_
81fc65ca9e7647cc2f978481f587e8de.pdf

17.Ramazanov S., Honcharenko O., Makarenko M. The problem of sustainability of the development of an integrated technogenic system in an innovative economy and "Industry 4.0". – P. 240-270 // «Intelligent computer-integrated informatation techology in project and program management» [Text]: Collective monograph edited by I. Linde, I. Chumachenko, V. Timofeyev – Riga: ISMA, 2020. – 324 p.

18.Ramazanov S.K., Tishkov B.O. On the evolution of intellectualization processes: experience, problems, development strategies, singularities and risks / S.K. Ramazanov, B.O. Tishkov. – P. 340-349. Access mode: https://cutt.ly/ThklRuN /VII International Scientific and Practical Conference "Strategies, Models and Technologies of Economic Systems Management (SMTESM-2020)". - Khmelnytskyi, October 8-9, 2020.

19.Ramazanov S.K., Tishkov B.O. Education, science and innovative technologies in the era of Industry 4.0. digitalization and artificial intelligence. P. 293 - 295 / International scientific and practical conference "Social and labor sphere in the coordinates of the new economy and global socio-economic reality: challenges, ways of development". November 11-12, 2020 - Kyiv KNEU, 2021. - 362 p.

20.S.K. Ramazanov, A.I. Shevchenko, E.O. Kuptsova. Artificial Intelligence and Problems of Intellectualization: Development Strategy, Structure, Methodology, Principles and Problems. - P. 14-23 // Artificial Intelligence: IPAI of MES and NASU, №4 (90). - 74 p.

21.Sultan Ramazanov, Vitalina Babenko, Oleksandr Honcharenko. Information technologies for the industrial management of objects in an innovative economy under conditions of instability and development of Industry 4.0. p. 147-170. // Advanced Trends in ICT for innovative Business Management (1st ed.). CRC Press. 2021. – 298 p. https://doi.org/10.1201/9781003028932/

22.Ramazanov S.K., Slobodianiuk M.E. On the problem of economic stimulation of the development of artificial intelligence. - P. 16-17. // Modern information technologies and systems in management [Electronic resource]: collection of materials of the III Intern. - Practical conf. of young scientists, graduate students and students (Internet conference). April 15-16, 2021 - Kyiv: KNEU, 2021. 232 p.

23.Ramazanov S. K. Financing and investing in the development of technologies for creating artificial intelligence systems in Ukraine. Journal of Economic Reforms. 2022. № 3 (47). p. 43-48.

The article has been sent to the editors 25.10.22
After processing 23.11.22