ARTIFICIAL INTELLIGENCE: AN ERA OF NEW THREATS OR OPPORTUNITIES?

Monograph

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12. ARTIFICIAL INTELLIGENCE IN ARCHITECTURE AND EDUCATION: POTENTIAL, TENDENCIES, PERSPECTIVES

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Today, we are witnessing a new technological revolution, which is unfolding on the basis of the use of artificial intelligence (AI). It finds its implementation in all spheres of social life, economy and construction. As the founder and head of the Institute of Artificial Intelligence Problems in Ukraine, scientist Anatoliy Shevchenko, notes, a new type of society (Society 5.0) is actually being formed. Its production chains, logistics and social infrastructure will be based on the use of artificial intelligence [1]. Scientists face an important task of developing the concept of preventing risks associated with the use of AI, developing a legal framework for AI systems, and improving the transparency system when using AI. It is also important to comply with the norms of international humanitarian law, information security and the confidential use of data related to the use of AI systems in all sectors of the economy, including in construction and architecture.

According to Ukrainian scientists, foreign approaches to the use of AI cannot be effectively implemented in Ukraine. The modern specifics of our country determine the formation of alternative ways of AI development taking into account the leading world practices [1].

In this context, there is a need for scientific and pedagogical workers who are able to perceive, generate and practically implement AI technologies in the educational process. Today, the modernization of the learning process through the use of new technologies in education, including AI, is one of the modern directions of education development. Therefore, the direction of research related to the training of highly qualified teachers in the direction of using AI and involving them in the educational process in order to improve knowledge, skills and abilities is considered relevant.

As you know, artificial intelligence is a product of scientific thought of representatives of different countries. Therefore, the deepening of international cooperation is an essential condition for the development of this industry. In recent decades, the study of AI has been devoted to a significant number of publications and research. First of all, this issue is studied by those individuals who form the technological component of the development of the whole world. Among them are Elon Musk [2], Stephen Hawking [3], Mark Zuckerberg [4], Jeff Bezos [5]. These questions also concern specialists who work in leading laboratories and institutes for the development of AI as such. The scientific works of foreign and Ukrainian scientists are the theoretical basis of research. In their works, they analyze the future and the role of AI for the development of science, economy, and industry. These are the works of D. Markoff [6], N. Bostrom [7], M. Ford [8], D. Lanier [9], S. Romazanov [10], and others. Regulation of academic integrity and copyright when using AI is no less important. The works of many Ukrainian scientists, including V. Strelnyk [11], M. Stefanchuk [12], O. Petryshyn [13], and others, are devoted to this. To date, not many scientific works have been devoted to the study of the use of AI in architecture. It is necessary to note the works of O. Polyakova [14], A. Konotopenko [15], O. Nikolaieva [16] and K. Khorolska [17].

Today, there is a process of realization by architects of the exceptional potential of AI. The use of neural networks in architectural education and professional activity provides architects with opportunities, advantages and perspectives that were unimaginable before. Modern architects use AI to optimize the design process, create innovative forms and structures, and increase the energy efficiency of buildings.

So, when designing buildings, the first task is to create a concept. A neural network makes it possible to solve this task at a potentially high level. For this, architects use generative artificial intelligence – an AI tool that is able to create new content based on a request (input data). Several types of generative artificial intelligence can be distinguished: text generation (GhatGPT, Bing, Bard Rytr, Moonbeam, etc.); image generation (Dall-E, Midjourney, Stable Diffusion, Adobe Firefly, Replicate, Lexica, etc.); sound and music generation (AIVA, Ecrett Music, ORB Composer, Jukedeck, etc.); multimedia generative artificial intelligence (ImageBind Meta). The latest generative AI simultaneously considers six types of data (text, image, audio, perspective, thermal data and motion data using sensor devices).

Architects in their professional activities more often use generators such as DALL-E 2, Midjourney and Stable Diffusion. The quality of the images they produce can be stunning. So, for example, Stable Diffusion makes it possible to create a detailed, accurate image from a simple text description. This technology allows architects and designers to bring their concepts to life with an extremely high level of detail. It is a powerful tool for visualizing ideas, concepts in a short time (fig. 1).

Figure 1. Creation of visual concepts of the Tree House Project using Stable Diffusion

Zaha Hadid, an architect with a world name, can be cited as an example of the use of AI in professional activities. Thus, the president of the studio Patrick Schumacher notes that the use of AI is encouraged when creating visual concepts of objects, especially in competitive works and in projects at the idea generation stage (fig. 2). These image generators give interesting hints, new types of architectural forms, volumetric and spatial compositions [19].

Figure 2. Buildings created using image generators (DALL-E 2, Midjourney, Stable Diffusion) in Zaha Hadid Architects

Currently, there is no method of directly implementing generative neural networks such as Midjourney, DALL-E 2 and Stable Diffusion into real architectural practice. It is only possible to use them as a means of quick conceptualization or sketching. This greatly helps the architects' imagination and fantasy.

The creativity of the Egyptian designer Hassan Ragab is an interesting example. He explores new architectural forms as conventional building material. Hassan Ragab creates conceptual architectural works using the Midjourney image generator, studies the nuances of inputting raw data, freely mixes architectural styles with extraneous materials of biological origin (feathers, plant structures), smoke, etc. (fig. 3). Ragab believes that in the near future neural networks will learn to create 3D geometry, not just images on a plane [20].

Figure 3. Experiments with the use of artificial intelligence in architecture. Designer Hassan Ragab, Egypt

Elements of AI are already confidently entering our living space. Today, kinetic buildings and structures, interactive interiors and urban spaces are in the active field of vision of architects, urban planners and designers. The possibilities of introducing AI into the design of the internal environment of architectural objects have expanded. Among them is the Poem Pavilion at the Dubai Expo 2020 exhibition (by Es Devlin, Great Britain). It presents a "message to the cosmos", consisting of numerous poems. Visitors enter the building under the cone through the illuminated "Labyrinth of Inspiration" (fig. 4, left). Thanks to AR (augmented reality), the maze turns the passage into an exciting adventure. Another example is the Digital Art Museum (Tokyo, Japan, 2015), which completely erases stereotypes about museum buildings. Here, visitors can interact with virtual images and museum exhibits. There are no static objects in such an ultra-technological museum. The space is filled with interactive projections, multimedia illusions, light, color and sound. The project completely changes people's perception of museum standards and demonstrates an aesthetic combination of technology and nature (fig. 4, right). In addition, the projections and exhibitions with which people can interact are constantly changing - from multi-colored projections on bamboo groves to dancing with ghosts, entering the cluster of light and shadow... The museum is divided into five interconnected zones. The first zone – "Endless World" - is an interactive area of computer landscapes with waterfalls and forests. The second is the "Forest of Athletics" simulation area, where visitors are encouraged to engage in various physical activities such as jumping on a trampoline or rock climbing. The third zone is a space with an aquarium filled with digital fish "Future Park". The fourth zone is called "Lamp Forest". The fifth zone is "Tea House", where visitors can drink tea from virtual cups. The border between people and nature is blurred in this museum. These objects embody the 21st century and push architectural students to new creative ideas.

Figure 4. AI elements in the formation of interactive interiors

Therefore, the use of AI in architectural design at the idea generation stage makes it possible to obtain clear, detailed images and a realistic representation of the

future building. It should be noted that AI is definitely a useful tool for architects and designers at the conceptualization stage. On the other hand, abuse of this resource in the educational process deprives students of the opportunity to independently create ideas, relying only on their own intelligence. This can gradually lead to a certain degradation of a person (the student of education) as a creative personality. If a person completely transfers his creative activity to ChatGPT, then he may begin to decrease certain intellectual qualities, such as: the ability to think, analyze, understand, plan, perceive independently. A person loses analytical thinking skills, becomes dependent on technology. In addition, the issue of copyright (academic integrity) regarding the use of AI in the field of architecture remains unresolved today. Therefore, it is important to maintain a balance regarding the use of neural networks in the education of architectural students, understanding the advantages and disadvantages of this process.

The next step, which is solved by AI, is the development of detailed building models using text prompts and special BIM CAD tools. AI software allows you to analyze, predict, model, calculate and test implemented solutions. Such digital solutions allow architects to develop a project with the subsequent possibility of editing, deleting and making corrections. The neural network also makes it possible to analyze various parameters and factors. Among them are climatic conditions, site geometry, project estimate, consideration of customer requirements, etc. In general, all this allows an architect to make informed decisions and, as a result, to design effective and functional buildings.

In the architectural educational environment, when studying disciplines in both face-to-face and distance formats, there is an opportunity to use the following new technologies and trends:

– *elements of artificial intelligence (AI),* in particular – the inclusion of the computer game "Urban planning game" in classes for the development of spatial thinking, the formation of an understanding of one's project decisions in the perspective of the city development and its spaces, the construction of virtual new cities with full infrastructure, creative thinking and improvement of language skills (professional terminology in English);

– *elements of virtual reality (VR)* – creation of the illusion of reality using the computer program 3ds Max and Google maps for the possibility of virtual visits to urban spaces, evaluation of their architectural, planning and landscape solutions "on the spot", clarification of problems and search new solutions for improving the architectural environment of the city;

– *elements of augmented reality (AR),* in particular – the use of the above-mentioned computer programs 3ds Max and Google maps for the construction of new architectural objects and verification of the results, virtual visualization of the new object in the existing environment, finding out the possible results of such solutions.

Therefore, the use of AI in architecture has the following advantages:
  – saving time and resources – the possibility of using AI generators is one of the key advantages;

- implementation of architects' own concepts with unsurpassed detail and precision;
- a powerful tool for visualizing unprecedented ideas in a short time;
- assistance in the processing of raw data and the implementation of an architectural project;
- minimization of errors and maximization of building efficiency with minimization of damage to the environment.

However, it should be noted that along with the numerous advantages of implementing AI in architecture, there are also certain concerns about the significant changes that may occur in the profession. So, for example, Chilean designer Sebastian ErraZuriz believes that 90% of architects may lose their jobs because AI will take over the design process [23]. Architecture studio Wallgren Arkitekter and Swedish construction company BOX Bygg have created a parametric design tool called "Finch" that can design floor plans adapted to site constraints [24].

Another area of use of AI in architecture, which has been around for several decades, is building management and the improvement of the concept of "smart building" or "intelligent building". These terms mean buildings connected by systems with artificial intelligence. They can control various aspects of the building, such as energy consumption, resource conservation, temperature, security, reducing operating costs, providing a clear control and management interface. This not only improves the efficiency of buildings, but also improves the comfort and safety of users. The system must be able to recognize specific situations occurring in the building and respond to them accordingly. One of the systems can control the behaviour of others according to pre-developed algorithms. In addition, the automation of some subsystems provides a synergistic effect for the entire complex. This allows the building to have high characteristics of functionality and flexibility, while at the same time restraining the cost of construction and operation. The automation of a smart home is similar to a children's Lego constructor. It is based on the same principle, according to which, having a certain set of elements, you can create a building of any configuration and complexity.

An interesting example is the construction of a city in Chongqing (China), which will be completely controlled by a neural network. The Gloud Valley project was developed by the Danish architectural firm Bjarke Ingels Group (BIG). Construction should be completed in the middle of the 21st century. In this futuristic place, AI technology will anticipate people's needs and meet them with the latest machines, devices and software. The goal of the Cloud Valley AI City building project is to unite people, technology and nature. The compositional form of the city is based on the shape of the relief, which is formed as a result of the decomposition of rocks. Under the clouds and between the mountains, AI City is where Terminus and the world's leading technology companies strive to advance the future of AI and robotics and create the foundations of a new sustainable development. According to BIG, the green carpet on the roof, forming the building's valley and mountain, will be a gesture of the meeting of technology with nature and at the same time the largest

night-time digital screen in China. Gloud Valley is the first project in the high-tech zone, which will become the newest innovation center of China. It will be a city where people, technology and nature flourish together with spaces designed for all kinds of life (fig. 5) [25].

Figure 5. The urban campus in Chongqing, China will be completely managed by artificial intelligence (AI). Architecture firm Bjarke Ingels Group (BIG), Denmark

Sourse: Ravenscroft T. (2019) They build a city in China with artificial intelligence that will "read" the minds of its inhabitants

Another type of use of AI in architecture is the construction of buildings using a 3D printer. European and Eastern countries have such experience. Ukraine is also gaining this experience. So, in the city of Lviv, with the help of a 3D printer, the Danish company of Mikell Brich is building a school in which 100 pupils will be able to study. The advantages of this technology are the absence of the need for internal and external finishing works, saving time and resources [26].

These technologies are also introduced into the educational process of students of architectural specialties. They perform practical modeling tasks using 3D printers. Thanks to this, students get to know modern methods in the work of an architect. 3D modeling tools, supplemented by AI, open up incredible opportunities in the educational process of future architects with the possibility of their further use in professional activities. This will make it possible to improve not only the work of architects, but also the cooperation between the customer and the architect. The

customer will be able to receive offers, information and the best project solutions in one place. This will make it possible to improve the entire design process and introduce a joint approach focused on "collective intelligence", and not only on artificial.

So, the prospects for using AI in architecture include:

− opening of new opportunities for construction, architecture and design. The use of new tools that open up unlimited possibilities for creative imagination and self-expression;
− change of the entire design process and introduction of a joint approach focused on "collective intelligence";
− the need to integrate into AI information about the environment, places where construction is planned, environmental conditions, project financing and other "more pragmatic things".

Artificial intelligence today evokes the greatest number of multifaceted, sometimes contradictory emotions. This is the active promotion of technologies related to its further development, and it's almost complete denial. It is obvious that the rapid development of the neural network creates both additional opportunities and threats for its users. In addition, AI pushes the average person to become more aware and responsible. Nick Bostrom, a professor at the Faculty of Philosophy at Oxford University, in his book "Artificial Intelligence. Stages. Threats Strategies" concludes about the inevitability of the development of intelligence – both artificial and human. The only question is in which direction this development will be directed [27].

Currently, there is no unified approach to understanding the nature of artificial intelligence in the technical, particularly in the architectural sphere. This causes some uncertainty in the legal, social, moral and ethical fields. There is an ongoing dialogue between different groups of lawyers regarding the legal aspects of the advantages, benefits, threats and risks of the development of artificial intelligence. As well as a discussion about the need to develop new mechanisms for the implementation of legal responsibility and compensation for damages in the conditions of the artificial intelligence use. It is obvious that it is difficult or almost impossible to stop the development of artificial intelligence. Nevertheless, the creation, implementation and use of artificial intelligence must undoubtedly be socially oriented. This process should correspond to the interests of human security, preservation of his personal space, will and self-awareness.

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