INFORMATION PROGRESS AND TECHNOLOGY TRANSFORMING THE WORLD

Monograph

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Introduction. We live in an era when artificial intelligence (AI) with its current development pace has become impossible to ignore. Today, it is a very powerful tool in our everyday life, even if we are not fully aware of it. AI has become ubiquitous. As architect Neil Leach says, AI has colonized our homes, hiding behind apps like Siri, Alexa, Cortana and Google Assistant. It helps support a range of household processes such as paying services and bills, influencing the control of home appliances, giving us advice on ChatGPT, suggesting music tracks on Spotify and movies on Netflix, etc. AI is tightly woven into the fabric of our cities, making them more efficient and sustainable and much more [1]. We don't notice AI because it doesn't look like a robot. It is an algorithm that is invisible to us, but which controls the environment around us. And the impact of AI on our life in many fields is growing every day.

Scientists devote a lot of scientific research to AI. Today, there are a sufficient number of them and they relate to various sciences and fields of human activity. The architectural field is no exception. But today, architects, both practitioners and scientists, do not pay due attention to the study of this issue. Architectural activity does not use AI on a daily basis until now. However, the number of aspects that are already reliably known is increasing. Meanwhile, as researcher Tamas Lukovich points out, there are several university design schools that are actively researching AI and its implications. These are Harvard, Stanford, Michigan and Washington Universities in the USA or University College London, Hartford, ETH Zürich, University of Applied Arts in Vienna and Gdansk Technical Uni in Europe. In addition, there are countries such as China and the United Arab Emirates. Several years ago, separate specialized ministries for the study of AI were created in them.

There is also USA-funded research on artificial intelligence and its impact on architecture [2].

According to Ukrainian scientists, foreign approaches to the use of AI cannot be effectively implemented in Ukraine. The modern reality of Ukraine determines the formation of alternative ways of AI development, taking into account the leading world practices [3]. In this regard, there is a need for the development of scientific potential and pedagogical personnel capable of perceiving, generating and implementing AI technology both in practical activities and in the educational process. Today, the Institute of Artificial Intelligence Problems of the National Academy of Sciences of Ukraine is successfully operating in Ukraine. He deals with general theoretical and applied problems in the field of AI, intellectual property issues. The institute conducts practical research and design studies, introduces modern computer technologies to medical and biological studies of the functional capabilities of the human brain, to the field of education and psychophysiological studies of human intellectual activity, etc.

Literature review. Scientists from different countries are studying artificial intelligence. Therefore, international cooperation in this field is an important condition for development. In recent decades, a significant number of scientific publications and studies have been devoted to the study of AI. First of all, these are robots that form the technological component of the development of AI throughout the world. Among the authors are Elon Musk [4], Stephen Hawking [5], Mark Zuckerberg [6], Jeff Bezos [7]. It is also necessary to note the leading specialists who work in laboratories and institutes for the development of AI. These are scientists who work in the institutions named above: Harvard, Stanford, Michigan and Washington Universities in the US or University College London, Hartford, etc. [2]. The theoretical basis is also the scientific works of foreign scientists, who in their works analyze the future and the role of AI for the development of science, economy and industry. These are the works of J. Markoff [8], N. Bostrom [9], F. Martin [9], J. Lanier [11] and others. A number of works are devoted to the study and real use of AI in architecture [12, 13]. Articles by Ukrainian scientists studying this issue are useful [14, 15]. The authors of the article are also involved in scientific research in this field [16, 17].

Result. Thanks to the rapid development of generative artificial intelligence in the early 2020s, global changes took place in the social life of society. Neural networks capable of creating content quickly gained popularity on the World Wide Web. They are not only fast and efficient, but also convenient to use and do not require programming knowledge. Most of them are capable of processing simple text queries in different languages.

Although this technological breakthrough is relatively recent, self-learning machines have already become the subject of controversy and even cause for panic in some circles. Even developers cannot predict the true potential of their creations. And the speed of their progress is still alarming. That is why the development of the

new chatbot model ChatGPT-ChatGPT-5 intelligence was stopped. This caused a specific ethical debate on the topic of human "aging".

Today, AI is gradually being introduced into the architectural profession, showing impressive results at almost all stages of work: from idea generation, planning to construction. Today, architects use various types of generative artificial intelligence in their professional activities, such as:
- text generation (GhatGPT, Bing, Bard Rytr, Moonbeam, etc.);
- image generation (Dall-E, Midjourney, Stable Diffusion, Adobe Firefly, Replicate, Lexica);
- multimedia generative artificial intelligence (ImageBind Meta), which simultaneously takes into account six types of data: text, image, audio, perspective, thermal data and motion data using sensor devices.

To create architectural projects, AI uses various methods and algorithms to create unique and creative solutions. These are deep neural networks, genetic algorithms, recurrent neural networks, graphic algorithms.

Deep neural networks (DNN). The use of deep neural networks is a tool for creating architectural and design projects. These networks are trained using a large dataset. It contains images and descriptions of architectural styles, their features and characteristics. After training, the neural network can create new images. They imitate a certain architectural style or direction. For example, 3D models of buildings and their interiors can be created based on the use of a given style or trend.

Genetic algorithms is a method that is often used to find optimal solutions for complex problems. It uses the principles of genetics and natural selection. In architecture, the method is based on evolutionary design. Here, artificial intelligence creates random architectural designs and then selects the most successful ones based on predetermined quality criteria. Similar to natural selection, this process is repeated several times. This allows artificial intelligence to find the best architectural solutions. The use of the method of genetic algorithms is effective when optimizing the layout of the premises of the building or determining the most successful building project.

Recurrent neural networks (RNN) are a class of artificial neural networks in which connections between nodes form a time-oriented graph. This creates an internal state of the network that allows it to exhibit dynamic behavior over time. Unlike feed forward neural networks, RNNs can use their internal memory to process arbitrary sequences of inputs [18]. Recurrent neural networks are especially valuable when creating architectural designs that involve a sequence of actions or decisions. They facilitate the step-by-step solution of tasks in the process of architectural design, which includes various stages of design. This also applies to detailing, selection of building and finishing materials.

Graphical algorithms. In architectural practice, such algorithms are used as a method of modeling or drawing to create an ideological and visual component of architectural projects. For example, convex hull algorithms determine the optimal composition and shape of a building, taking into account given constraints. These

algorithms can also be used to create detailed 2D or 3D models of a building and the environment around it.

So, the process of creating an architectural project using AI is interesting, complex and multifaceted. This requires a fine interplay of methods and algorithms that can be adapted and optimized depending on the task at hand. These methods and algorithms allow architects to achieve new innovative solutions.

In addition, it should be noted that today AI is introduced into architectural programs in order to facilitate and improve the work of architects. An example is Autodesk Dreamcatcher architectural software, created by one of the leading software companies, Autodesk. This software uses AI to create architectural concepts. Dreamcatcher is able to analyze raw data and project criteria. After that, it creates many options of architectural solutions that meet the given parameters. For example, the program can form optimal forms of buildings taking into account restrictions on materials or maximum energy efficiency and environmental friendliness. This allows architects to conduct an accurate analysis of various options and choose the most successful project.

It is also necessary to note the Genesis project, which was developed by GPT-3 Studio. It uses a text generation model using deep neural networks and allows you to create a detailed description of the architectural project based on the provided characteristics. For example, by specifying the required dimensions of the building, functional requirements for it, desired compositional and stylistic features, Genesis is able to create a detailed description of the given project with all the specifications and necessary details. This allows you to quickly get a holistic view of the future project.

Rapid application development (RAD) is a concept of creating means of developing applications, software products and pays special attention to the speed and convenience of programming, creating a technological process. Since the end of the 20th century, RAD has been widely distributed and approved. Today, the concept of RAD is also often associated with the concept of visual programming. The main principles of RAD work include: minimization of development time, creation of a prototype to clarify the customer's requirements, and cyclical development (each new version of the product is based on the evaluation of the previous versions) [19].

In addition, scientists from the University of Illinois improved the RAD program for working on architectural projects. The program uses artificial intelligence to generate and evaluate architectural designs. This program is able to analyze the initial data for the project, such as climatic conditions, site topography, user needs, project estimates, etc. After that, based on the given initial data, the program offers an optimal architectural solution. For example, the RAD program can offer the best option for the distribution of windows on the facade of the building in order to optimally use natural light and save energy. As a result, it helps architects create comfortable and energy-efficient buildings.

As you know, AI can not only design, but also help build buildings. An example is the use of a 3D printer in construction. Artificial intelligence and 3D printing are a fast synergy. The combination of artificial intelligence and 3D printing

creates an intriguing opportunity to produce excellent results in much less time. From initial idea to quality control, AI has the potential to optimize and improve every step of the 3D printing process.

Figure 1. "House Zero", built using 3-D printing technology by ICON and Lake Flato Architecture Studio, Austin, USA, 2022. Photo by Casey Dunn [20]

Sourse: ICON's House Zero – 3D-printed Home Pushing Boundaries of Sustainable Architecture & Design (2022)

The accumulated experience of 3D printing of buildings is available in many countries of the world. So, the world's first residential building printed on a 3D

printer using a new energy-saving technology was built in the city of Nantes in France in 2018. An interesting example is the modern residential building "House Zero" located in East Austin (USA). It was built in 2022. The house is 3D printed using ICON's next generation Vulcan building system and designed by Lake Flato. The company is known for her environmental projects. The house combines the aesthetics of a mid-century modernist ranch. It has an interesting architecture and an energy-saving design that emphasizes the digital possibilities of construction (Fig. 1). Jason Ballard, ICON co-founder and general director, says House Zero demonstrates a new architectural language that uses robotic construction. It makes it possible to provide what is most needed: comfort, beauty, dignity, sustainability, accessibility and hope [20].

Ukraine is also gradually gaining this experience. A pilot project in Ukraine is the construction of a school in Lviv with the help of a 3D printer by Mikell Brich's company. 100 students will be able to study there. Traditionally, a 3D printer can print a school in a week, and build the walls of a three-story building in three weeks. The delay in construction is due to the realities of war. This is bringing an international team to a country where war is going on; delivery of all necessary materials that can be destroyed by shelling; obtaining construction permits; construction delays caused by shelling, blackouts, curfews. Nevertheless, today the walls of the new school have been erected. Completion of construction and opening of the facility is planned for January 2024 (Fig. 2) [21].

Figure 2. The process of building a school using a 3D printer in Lviv, Ukraine, 2024. [21]

Sourse: Building new things with new technologies: how a school in Lviv was printed by a 3D printer (2024)

It should be noted that Ukrainian scientists are also working on improving construction with the help of a 3D printer, using AI. An example is the Ukrainian company 3D UTU. She invented the first domestic construction 3D printer. The Ukrainian-made 3D printer erects the building significantly faster than with conventional construction. Such a house has high noise absorption rates, the possibility of complete autonomy and rounded corners. The filling of the walls can be different depending on the needs. Light weight (2.1 tons), innovative precision and speed of movement, and innovative design make it easy to move the printer around the construction site. And the time to expand or collapse the printer takes up

to 3 hours. This 3D printer combines a precision mechanism, a mixing system, and proprietary software to provide high-precision, high-speed printing. To start construction, apart from the equipment itself, only electricity, water and a special concrete mixture from the company "Henkel Bautechnik" and TM Ceresit are needed [22]. This technology makes it possible to build reliable and energy-efficient houses. In 3D construction technology, the microclimate in the premises is preserved thanks to the insulation circuit. Concrete works as an energy accumulator. It is also possible to create various building forms.
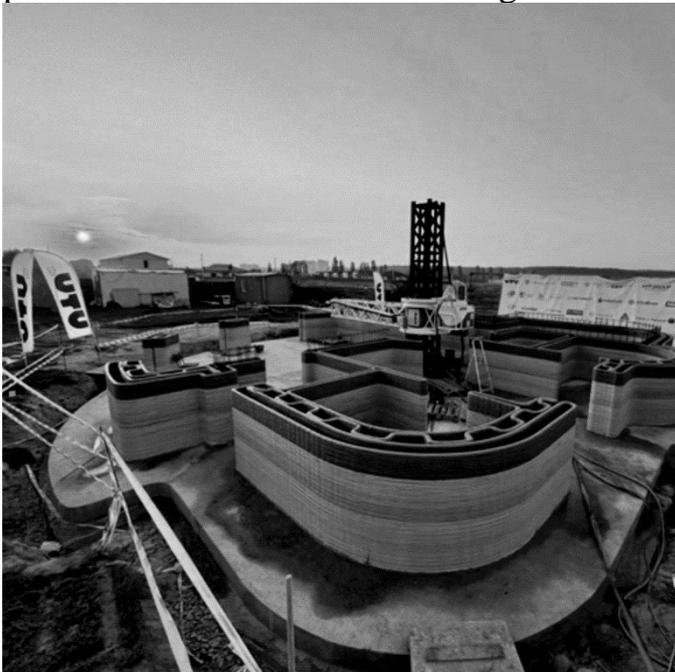
3D printing of a house

Exterior of the house

Living room

Safe room

Bedroom

Figure 3. The house for the family of the fallen hero Yaroslav Berezov, erected with the help of a 3D printer. Developed by Ukrainian company 3D UTU. Location - village Mykhailivka-Rubezhivka, Kyiv region, Ukraine, 2024. Photo by dev.ua [22]

Sourse: "We are not warm, but very warm". The story of the first 3D house in Ukraine for the family of a fallen defender (2024)

In Ukraine, the 3D UTU company built the first residential building for the family of the fallen soldier Yaroslav Berezov with the help of a 3D printer. The house has an area of 130 square meters. The rounded walls of the house, 60 cm thick, were printed in 58 engine hours and 72 tons of special cement-sand mixture were used. The printer printed the exterior and interior of the building at the same time, which simplifies exterior and interior finishing works. The printing itself was carried out by 4 workers: an operator and helpers. The planning of the house takes into account all regulatory requirements for housing and modern ideas about a comfortable environment. It has a spacious common room, a kitchen-studio, three bedrooms, two bathrooms and utility rooms with all the necessary communications. One of the rooms has an increased level of security and will serve as a shelter for the family from debris during missile threats. The window in this room has a unique mounting system, armored glass and unique fasteners. The building received a class B energy efficiency certificate (Fig. 3) [22].

Therefore, Artificial Intelligence is rapidly developing, changing various aspects of our daily existence. 3D printing is no exception. Construction of buildings with the help of a 3D printer is a fast and effective technology for Ukraine in the realities of the ongoing war.

The use of AI in architecture has such advantages as: saving time and resources; implementation of architects' concepts with high detail and accuracy; assistance in processing raw data and execution of architectural projects; minimization of errors; maximizing the efficiency of the house while minimizing damage to the environment; visualization of the most daring ideas in a short time.

However, it should be noted that despite the numerous advantages of implementing AI in architectural activity, there are also certain fears about the significant changes that may occur in the profession. So, for example, some famous architects and designers, such as Neil Leach, Sebastian Errazuriz, believe that the majority of architects and designers may lose their jobs due to the fact that AI will take over the design process.

Analyzing the rapid progress of the development of the neural network, it should be noted that architects will soon face the task of adopting a new course of development of AI technologies, studying them and using them in the profession to improve and facilitate work. So, the English design studio ArchiTAG actively incorporates AI into the work process. She teaches students and architects the professional use of the latest technologies in architecture (Fig. 4). An example is the educational course "Augmented intelligence: increasing human creativity with the help of AI and 3D printing" developed by the ArchiTAG studio. This innovative pilot project is a joint project with Monday.com Tech School. It engages high schools across New York City in a social impact project designed to shape the future of design and technology [23].

Figure 4. Examples of architectural projects created by the architectural studio ArchiTAG with the help of AI, England [23]

Sourse: Creative uses of AI (2023)

Another important question raised by scientists in relation to AI is the question of copyright. Since the architectural field is a creative activity. The discussion on this issue continues. But researchers come to the opinion that a work of architecture created with the help of artificial intelligence technologies is definitely an object of copyright. According to Nikolaieva O. notes that an architect as the person of copyright is a professional with an appropriate level of education and additional certification on the one hand – and with a certain creative, original thinking on the other. Therefore, the creative nature of an architectural work as the person of copyright will always be available. Including if it is created with the help of AI. Indeed, artificial intelligence of a certain level is able to remove a person from some creative processes. However, architectural activity as such, which is particularly socially important and involves increased responsibility, will always require human participation. Thus, it is in line with ensuring human rights when using artificial intelligence [23].

Conclusion. So, human imagination, sense of style and aesthetic perception combined with the analytical capabilities of AI create a symbiosis that promotes innovative design. It becomes an integral part of modern architecture, providing new opportunities, optimization of processes and innovative approaches to architectural design in general.

Artificial intelligence today causes many discussions and conflicting emotions, from its active promotion and further development to its almost complete denial. Currently, there is no single approach to understanding the nature of artificial intelligence. This causes its legal, social and moral and ethical uncertainty. The discussion on this matter continues. It is obvious that it is almost impossible to stop the development of artificial intelligence. This process should be socially oriented and correspond to the interests of human safety and preservation of personal space.

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