

THE INFLUENCE OF PARAMETRISM AND ARTIFICIAL INTELLIGENCE ON THE ARCHITECTURE OF THE FUTURE

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Abstract. Articles, reports, studies of a number of scientists in the field of parametric design were analyzed. The work of leading architects using parametricism and the latest technologies in design, such as Zaha Hadid, Santiago Calatrava, Patrick Schumacher, and others, is highlighted. Ways to solve and implement complex spatial modeling processes thanks to parameterization and the use of artificial intelligence are determined. A number of computer programs that are active have been analyzed used in design, creation of virtual reality, and 3D simulations. The methods of using software tools that involve algorithmic calculations for the generation of forms in the design and optimization of structures are disclosed. It has been proven that the use of the latest technologies ensures efficient and accurate design, and reduces the time for project development. That is, parametrics has a key role in the creation of innovative programs and affects the future architecture and organization of space as a whole. With the help of technologies are created digital models of the object. Digital models are stored in a system that allows you to provide the maximum level of security of designer and project data. And for achievement maximum efficiency and convenience in designing architects at various stages parametric design uses artificial intelligence, which allows them to get interesting architecture of the future. Based on the experience of leading architects in the field the introduction of parameterization in the design and use of artificial intelligence is emerging. There is a reason to believe that in the future it is necessary to promote parametricism, to develop AI comprehensively and use it in practice. Also, all of the above must be conveyed to the young generation of architects to influence the architecture of the future.

Keywords: artificial intelligence (AI), blockchain, augmented reality (AR), virtual reality (VR), architectural digitalism, architecture of the future, new technologies, generation, innovative projects, authorship.

Statement of the objective. In the 21st century, the customer sets before the architect more complex tasks related to the creation of complex and innovative forms of buildings and structures. This, in turn, requires a large amount of time and resources from the architect to implement these ideas. Therefore, there is a problem of lack of time and the complexity of the shape of the design object [1].

The architect comes to the aid of parametrics, which offers solutions for solving these problems, including the use of optimization algorithms, geometry generation and the use of information technologies [2]. Parametric design affects the architectural process, making design more efficient and accurate, and also reduces data processing time and improves the quality of work as a whole [3].

In addition, the use of parametric design affects the design process. With the help of parametric design, the architect creates more complex and innovative forms, which could hardly be done by conventional means [4].

And by applying blockchain and artificial intelligence (AI) at the end of the work, the architect gets maximum accuracy and design efficiency [5].

Analysis of recent research and publications. The problems of using parametric design in work have been and are currently being actively addressed by many scientists, such as Polyakova O. V., Kysil S. S. and Shmelyova O. E. ("Computer technology for analysis and design of the object

environment from the perspective of visual perception”) [6]; Bulgakova T. V. (“Computer design of the object environment based on modeling of visual perception”) [7]; Kuznetsova I. O. (“Modeling of visual perception of objects of design, decorative and applied and fine arts.” Author’s abstract [8].

It is worth paying attention to the work of Polyakova O. V., Kesil S. S. and Shmelyova O. E. [6] on the study of parametrics from the perspective of perception of the object environment through the technology of computer analysis.

T. V. Bulgakova in his dissertation on the topic: "Computer design of the subject environment based on modeling of visual perception" proves that the use of parametrics by modern architects in their work is the key to success in designing the architecture of the future [7].

Foreign scientists Mohammadreza Pourjafar and Behzad Sarmast in their study "Parametric Design in Architecture: Challenges and Opportunities" conduct an analysis of the principles of parametric design and its use in the work of architects [8].

Architects around the world are successfully implementing parametric tools, innovative technologies, and AI inventions to achieve maximum efficiency and ease of design. The most famous architect in the world, Zaha Hadid, created her architectural masterpieces thanks to parametricism. Patrick Schumacher and Santiago Calatrava also actively use the parametric approach in their projects.

John Fraser has been researching the evolution of parametricism in architecture for 30 years. In his works, the author considers the computer as an architect's assistant in the use of environmental modeling data [9]. But, despite the large number of articles, dissertations, researches in the field of parametric design, the full stop has not yet been put in this topic. There is still no theoretical base that would allow for a comprehensive pedagogical approach for teaching digital design in architecture. Therefore, for the full use of parametrics in design, further research on the topic of parametricism is relevant, but already taking into account the additional use of AI in practice to improve the architecture of the future.

The purpose of the research is a scientific view of parametric architecture, analysis of modern design, analysis of the use of innovative technologies of artificial intelligence and creation of virtual reality. Also, the identification of disadvantages and advantages when using these technologies in the design process at its various stages. Using AI to achieve the best result in a project. Parametrics in the work of the architect now plays a major role, which suggests that parametricism, AI and the latest technologies should be used to achieve the maximum effect.

Analysis of the recent research and publications. The influence of parametricism and artificial intelligence on the architect and on the architecture of the future as a whole is integral to the evolution of architecture. Customers, in their desire to do something incredible and unique, push architects to improve design tools, to learn new programs, new technologies, and ultimately to use artificial intelligence (AI) in their work. But the fact is that it is not possible to learn one program and use it at work. It is impossible to understand parametricism and create parametric architecture at will. It needs to be constantly studied, promoted and improved.

Parametric architecture is a modern style that combines architecture, sculpture, mathematics and design. This is a style that creates a complex model with a beautiful design solution. When creating parametric architecture, modern computer programs are used, such as: Grasshopper, Dynamo, Revit, ArchiCAD, Fusion 360, 3ds Max, and others. These programs provide the ability to create complex parametric models that can be quickly modified and optimized. This allows an architect or designer to quickly and efficiently solve design problems and increases the quality of his project.

Let's delve a little deeper into antiquity. The construction of the Cathedral of the Holy Family by Antonio Gaudi would probably have been completed by now if this great architect had used the tools of parametricism (Fig. 1). But, unfortunately, the construction of the cathedral, which began in 1882, is still ongoing, and parametricism as a style emerged only at the end of the 20th century. It is known that Gaudi looked for inspiration in books about nature, as if intuitively drawn to the future style of parametricism. Modern architects and designers who continue the construction of the Holy Family Cathedral according to Gaudi's drawings already use the tools of parametricism in work.



Pic. 1. Cathedral of the Holy Family, architect Antonio Gaudi, Barcelona, Spain

Despite the lack of opportunities to use parametric design, Antonio Gaudi created a large number of architectural monuments during his lifetime, which are still admired by mankind. The most famous of them: Park Güell, House of Batllo, House of Vicenza, El Capriccio.

The leading Spanish architect, currently existing and working, Santiago Calatrava, is known for the original forms of his buildings and innovative technical solutions for their constructions. The main feature of his work is the use of parametric design - a method that allows the author to create complex structures and images. An architect and designer in one person, Santiago Calatrava uses computer programs that are based on mathematical algorithms.

With the help of parametric design, Calatrava created the Al Amilo bridge in Seville, which consists of a complex steel structure and has an ergonomic design (Pic. 2).



Pic. 2. Al Amilo bridge in Seville, architect Santiago Calatrava, Spain

The Palace of the Arts of Queen Sofia, the Subisuri Bridge in Bilbao, the Congress Hall in Oviedo, the Oculus transport hub of the World Trade Center in New York are a small part of Santiago Calatrava's works created through the use of parametric design. Only thanks to parametric

design, the author created many complex forms and structures, taking into account the requirements for the strength of structures, and the challenges of ergonomics and aesthetics.

It is safe to say that Calatrava is one of the leading architects who successfully uses parametric design to create impressive and innovative buildings and structures.

Architects and designers are often attacked by competitors for using parametric modeling. The fact is that buildings created on the example of natural forms with an almost complete rejection of classic angles are always a risky process. The famous British architect of Arab origin, Zaha Hadid, held the pressure of more traditional architects like no other. In 1980, she founded her own architectural office, which became famous many years later for its bold and innovative projects. This architect is the only woman - the architect is known all over the world for her hard work and her innovative and bold projects. Her future projects have already been implemented and are still subject to criticism by some artists.

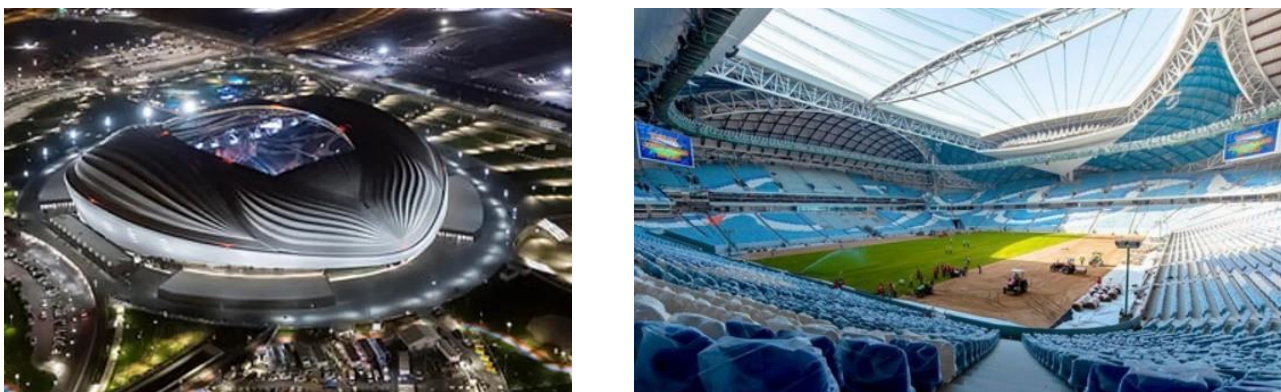
It is difficult to single out the main works of Zaha Hadid for example, because they are all unique. And yet, the most interesting ones include: Changsha Meixihu International Culture and Arts Center China, super skyscrapers in Shenzhen China, a 40-story hotel designed by Zaha Hadid architects for the city of Macau in China, towers with the highest atrium in the world, national the stadium in Tokyo, the Opus Hotel in China, and the house of the future (Pic. 3).



Pic. 3. House of the future, architect Zaha Hadid, Spain

Patrick Schumacher, a famous architect and philosopher, joined Zaha Hadid's architectural office in 1988. Schumacher and Hadid worked together for more than 30 years. The use of parametric modeling brought these two architects together. As a result, the world saw a completely new, fresh look at how modern buildings and the architecture of the future as a whole should look. In the office of Zaha Hadid, Patrick Schumacher was responsible for the realization of complex forms and structures. Thanks to the hard work of this genius and his ability to use the latest computer technologies in his work, many projects that have been gathering dust on the shelves of Hadid's architectural office for years have come to life. Mathematical analysis, formula algorithms, programming and computerization gave impetus to the implementation of the existing buildings and structures designed by Zaha Hadid architects.

Under the leadership of the tandem of Hadid and Schumacher, such projects were implemented as: Interior "Bridge Pavilion", Zaragoza, Spain; Interior "National Museum of Art of the XXI Century (MMXXI)", Rome, Italy; Riverside Transport Museum, Glasgow, Scotland; Guangzhou Opera House, Guangzhou; Interior of Heydar Aliyev Center in Baku, Azerbaijan; "Galaxy SOHO" complex, Beijing, China; Sheikh Zayed Bridge, Abu Dhabi, UAE; Pavilion Bridge, Zaragoza, Spain; The football stadium in Al-Wakra, Qatar (Pic. 4), and many others.



Pic. 4. Football stadium in Al-Wakra, Qatar, architects Zaha Hadid and Patrick Schumacher

After the departure of Zaha Hadid, many conceptual developments remained, made thanks to the use of parametric technologies, here are some of them (Pic. 5).



Pic. 5. Conceptual designs by Zaha Hadid

The list of architects, designers and scientists who are engaged in parametricism and have made a lot of efforts to develop this style does not end with these outstanding architects. Greg Lynn, with degrees in philosophy and architecture, does not have a lot of implemented projects, but he is a pioneer in the theory of architectural digitalism. His name was included in the list of 100 most influential innovators of the 21st century (Time magazine). There are many young architects who work in parametric architecture and make great strides in this direction in creating monumental buildings, namely: Slovenian Irena Predalic, Romanian Bogdan Zaha, Polish Dennis Brezina, Serbian Branko Svarcer, Bulgarian Kaloyan Erevinov, Czech Jakub Klaska, and Ukrainian Yevgenia Pozihun. By the way, Zhenya graduated from our Odessa Academy of Construction and Architecture and defended her master's thesis at the ABS department 15 years ago.

But it is necessary to remember the scientists and developers thanks to whom computer programs, technologies and artificial intelligence were created, because if it were not for their work,

architects would not have the opportunity to implement their ideas and influence future architecture. Thanks to the enormous work of programmers working in the field of creating architectural programs, such as: Grasshopper, Dynamo, Revit, ArchiCAD, Fusion 360, 3ds Max, and others, architects and designers have the opportunity to effectively and efficiently solve design problems and implement their ideas. sometimes even insane.

Thanks to the latest technologies, such as virtual reality (VR) and augmented reality (AR), it is easier for the architect to communicate with his client. With the help of AR, the architect creates a virtual model of the building and offers the customer, using a smartphone, to view the building in real time. 3D simulation is used in the first stages of design, when the building has not yet been designed. Also, at the first pre-design stage, the architect can conduct a stress test of the first ideas, using AI in the transformation of text into images. For example, an architect, before starting design, can dictate several different text queries to AI generation, such as Adobe Firefly, to get a concept of an unconventional look of the future project. The machine will come up with an interesting idea, because technology "thinks" with different materials than a person. The most creative designer or architect has prejudices regarding the possibilities of architecture and structures, the machine "sees" it differently, it does not have a spiritual part that can evaluate the created from the point of view of beautiful - not beautiful. AI creates new connections and identifies unforeseen connections, creates patterns and potential that are not in our perception.

AI not only changes the way we think about designing buildings, but also transforms the approach to architecture. Machines become co-participants in the human design and projecting process.

1. *Algorithms as new architect tools.* The future of architecture is closely related to the use of AI algorithms. For example, generative design, which allows architects to create complex forms that were previously impossible without modern computer tools.

2. *Ethical challenges.* Potential issues with authorship and responsibility. If a project is created by artificial intelligence, who is its real author? Can we trust a machine to make important decisions that affect a person's life and needs?

3. *AI as a partner in the creative process.* AI can become a real partner in the creative process of a person, and not just be a tool in his hands. Architects use AI to create innovative projects. For example, the IBM VOTSON product allows you to quickly process large amounts of data and find unexpected relationships in raw data.

4. *Prediction of future trends.* AI will change not only the design process, but also the environment in which we live. The concept of «smart house» (Pic. 6) has long been part of the lives of residents of some wealthy countries of the world, but with the advent of AI, this concept will soon become commonplace for many countries and their citizens. Using AI to analyze and manage urban processes.



Pic. 6. «Smart house», a set of functions

«We must accept that AI is capable not only of imitating human creativity, but also of creating new, unexpected forms of architecture that we could not even imagine» - a quote by Neil Leach, from the book «Architecture in the Age of Artificial Intelligence: An Introduction to AI for Architects» [5]. This suggests that AI is not a threat to humanity, but a tool for expanding the boundaries of our understanding of architecture. That is, AI is capable not only of automating routine design processes, but also of providing new opportunities for the architect's creativity (Pic. 7).



Pic. 7. Houses created by Midjourney AI product

Interesting and complex projects can be implemented thanks to the use of modeling and engineering in parametric structures.

«We need to learn to cooperate with machines, not fear them. It is in this cooperation that we will be able to reach new heights in design and construction» - quote by Neil Leach, from the book «Architecture in the Age of Artificial Intelligence: An Introduction to AI for Architects» [5]. This results in a partnership between man and technology. Only through such cooperation will we be able to use all the possibilities of AI for the benefit of architecture and humanity.

The combination of different aspects and tools in parametric architectural design and environmental design gives the architect an improvement in his creativity and efficiency in further design, as well as in increasing the quality and innovation of projects.

In turn, the combination of innovative technologies, such as artificial intelligence (AI), virtual reality VR technologies and blockchain using NFT, together with parametric design allows to create more complex and innovative projects that meet the needs of the modern market.

Conclusions. Therefore, the implementation of parametrics in architecture and design is effective for achieving optimal solutions in design that meet the requirements of modern times. And the use of artificial intelligence can significantly simplify and improve the design process.

Among the projects that can now be realized with the help of parametric design and artificial intelligence are residential and office buildings, public hubs, roads and infrastructure.

With the help of parametric design, it is possible to create a virtual environment that will meet the requirements of users and the style of the project.

With the use of virtual reality, you can create virtual tours of existing museums, which will allow people with disabilities to visit them without leaving their apartment.

Thanks to the application of blockchain technology (a distributed database in which blocks are stored in the form of a chain), the authorship of the project owner is preserved.

When designing architecture, you can use virtual reality in real time in a three-dimensional format.

Therefore, the use of digital technologies in architectural design allows you to efficiently and accurately develop projects, preserve copyright and creativity, and simultaneously be in two worlds - real and virtual, which facilitates and speeds up the design process.

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ВПЛИВ ПАРАМЕТРИЗМА ТА ШТУЧНОГО ІНТЕЛЕКТА НА АРХІТЕКТУРУ МАЙБУТНЬОГО

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Одеська державна академія будівництва та архітектури

Анотація. Проаналізовано статті, доповіді, дослідження ряду науковців в галузі використання параметричного проектування. Висвітлено роботу ведучих архітекторів використовуючих в проектуванні параметризм і новітні технології, таких як Заха Хадід, Сантьяго Калатрава, Патрік Шумахер, та інші. Визначено шляхи вирішення та реалізації складних просторових процесів моделювання завдяки параметризації і використання штучного інтелекта. Проаналізовано ряд комп'ютерних програм, які активно використовуються у проектуванні, створенні віртуальної реальності, та 3D симуляціях. Розкрито методи використання програмних інструментів, які залучають алгоритмічні розрахунки для генерації форм при проектуванні та оптимізації конструкцій. Доведено, що використання новітніх технологій забезпечує ефективне і точне проектування, причому зменшує час на розробку проекту. Тобто, параметрика має ключову роль у створенні інноваційних програм та впливає на майбутню архітектуру та організацію простору вцілому. Завдяки параметризації реалізуються складні просторові процеси в моделюванні, на допомогу якій приходять інноваційні технології. За допомогою технологій створюються цифрові моделі об'єкта. Цифрові моделі зберігаються у системі, яка дозволяє забезпечувати максимальний рівень безпеки даних проектувальника і проекту. А для досягнення максимальної ефективності та зручності в проектуванні архітектори на різних етапах параметричного проектування використовують штучний інтелект, що дозволяє їм отримати цікаву архітектуру майбутнього. Спираючись на досвід провідних архітекторів в галузі впровадження параметризації у проектуванні і використанні штучного інтелекта виникає підстава вважати що і надалі потрібно пропагувати параметризм, розвивати ШІ і всебічно використовувати його на практиці. Також все перелічене потрібно донести до молодого покоління архітекторів з метою впливу на архітектуру майбутнього.

Ключові слова: штучний інтелект (ШІ), блокчейн, розширена реальність (AR), віртуальна реальність (VR), архітектурний дигіталізм, архітектура майбутнього, новітні технології, генерація, інноваційні проекти, авторство.