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TOWARDS ARCHITECTURE THROUGH TECHNOLOGY?

KU ARCHITEKTURZE PRZEZ TECHNOLOGIĘ?

Abstract

Nowadays, AI can analyze more data in a shorter time than any human can. At the same time, its structure analysis exceeds the possibilities of intuitive perception of forces. Verification of feasibility becomes a domain that is, if not unattainable, indeed difficult for humans to achieve. At the same time, modern technologies make it possible to carry out these projects with a precision that guarantees maximum consistency of design and execution. For the first time in history, the development of technology allows architects to significantly break away from the limitations of constructing form. Will technology replace the human designer? Will it free us and allow us to focus on design's ideological and artistic aspects? The following article presents some emerging problems, describing their current state and possible development.

Keywords: architecture, augmented reality, artificial intelligence

Streszczenie

Obecnie sztuczna inteligencja może analizować więcej danych w krótszym czasie niż jakikolwiek człowiek. Analiza jego struktury przekracza równocześnie możliwości intuicyjnego postrzegania sił. Weryfikacja wykonalności staje się dziedziną, jeśli nie nieosiągalną, to w istocie trudną do osiągnięcia przez człowieka. Jednocześnie nowoczesne technologie pozwalają na realizację tych projektów z precyzją gwarantującą maksymalną spójność projektu i wykonania. Po raz pierwszy w historii rozwój technologii pozwala architektom znacząco wyłamać się z ograniczeń formy konstrukcyjnej. Czy technologia zastąpi ludzkiego projektanta? Czy nas uwolni i pozwoli skupić się na aspektach ideowych i artystycznych designu? W poniższym artykule przedstawiono kilka pojawiających się problemów, opisując ich obecny stan i możliwy rozwój.

Słowa kluczowe: architektura, rozszerzona rzeczywistość, sztuczna inteligencja

1. INTRODUCTION

We live in a time of not so much a digital revolution, but rather a revolution related to the possibilities of constituting digital images in the real world. The rapid development of information technology is changing many areas of our lives – including architecture. AI-assisted design, prototyping, and the possibility of individualized prefabrication allow for the implementation of many ideas that go beyond the classic understanding of how structures work. Not to mention the process of developing and introducing new or significantly modified

materials into the construction industry that follows these changes. This expansion of the possibilities of shaping objects inevitably entails profound changes in the perception of architectural forms.

Technology, however, does not change its basic property – a certain ethical ambivalence. Its use has always been both beneficial and dangerous for humanity. Although, of course, the risks in the case of technology in construction are quite limited, and in the following article their description is mainly limited to the humanistic aspect, they undoubtedly exist. And technology, such as the concept of Yin and Yang, always has two complementary faces.

By helping to implement bold concepts and accelerating and minimizing construction costs, new technologies can be the answer to many social problems. Technology can enable the introduction of compositional arrangements different from the traditional ones, shaping a new perception of beauty in architecture, to push the boundaries of our imagination and sense of aesthetics. However, it may lead to excessive unification of solutions, depriving them of their individual features in favor of typical – modular solutions. Solutions that are so convenient to use in combination with computer design based on object libraries. Finally, it can ultimately lead to the exclusion of the human factor from the process. This is already the case with AI applications that not only take on the role of creating visualizations or optimizing projects, but also offer project preparation from concept to BIM models without the participation of an architect.

Therefore, it can potentially, under the cloak of digital infallibility, offer solutions that are implicitly limited by algorithms. In return, it does not offer the element of enlightenment that is characteristic of the human mind – that elusive spark that stands behind the achievements of brilliant artists and architects in history. That which has often been the basis of exceptional projects, in which knowledge met inspiration and intuition.

At this stage, this final assessment is of course difficult, if possible at all, to say the least. On the one hand, the development is rapid and arouses understandable enthusiasm. Optimism is also fueled by the fact that new barriers are being crossed. On the other hand, the scale of implementation in architecture is so small and fresh that it seems difficult to assess the impact. In addition, the whole issue also functions in the face of strongly critical tendencies that increase the minimization of human influence and indicate that progress is not always beneficial and inevitably brings losses. Not once justified, but just as often resulting from a natural fear of the unknown and not always understood. In a word, from human nature.

Regardless of the final assessment, as well as the positions adopted in relation to the present, attempts to describe the issue of modern technologies and their impact on our reality seem valuable and necessary to set future goals and prepare for possible consequences.

The following article is not able to describe the entirety of such a complex issue – it only signals many of its aspects. However, it is a contribution to the discussion, focusing on architecture and the direction it takes, shaped by modern technologies.

2. TOWARDS OTHERNESS AND UNKNOWN WATERS

In architecture, the question of standing out or surprising the recipient is not a new issue. It has existed since the semiotic character of architecture began to be understood, even instinctively. The implementation of this postulate took various forms. From illusory painting to reaching for surprising forms and technical solutions. The need to arouse emotions in

the viewer seems to have accompanied architecture from the very beginning of its history. Traditionally, the border between understanding and purely emotional reception ran through the threshold of education. People with a field of study, knowing the secrets of these solutions, could decipher the artist's intentions through the filter of their own knowledge. In this way, he made the perception of architecture similar to the interaction with the art of magic, where the architect-juggler spread his arcana in front of the audience, trying to charm them. Only partly on his talent depended how many people followed the prepared path, allowing themselves to be enchanted. Some, inevitably, chose to try to understand. Discovering the workshop – and deriving satisfaction from a conceptual understanding of the means used. Just like the audience, who is trying to understand the mechanisms of the magician's illusion to which it is subjected.

The end of the twentieth century was characterized by a significant increase in the approach to architecture through the prism of surprise. Most of the well-known projects of star architects were based on the assumption of a certain uniqueness and otherness behind this concept. Even if often, the projects resembled decorations dressed for completely standard buildings (as in the case of the design of a Gehry's housing estate from Frankfurt) or were made using methods straight from the Middle Ages – such as the façade of the Guggenheim Museum in Bilbao. Undoubtedly, however, in contemporary architecture it was a period in which the tendencies of individualism in architecture gained new power.

At the same time, it seems that only the 21st century has brought the tools and materials to achieve this effect to such an extent that knowledge and intuition no longer allow us to describe reality through simple intellectual schemes but require the computing power of machines to trace the forces acting on the elements. Digital technology has made it possible for a new perspective on buildings and style not only to be the domain of theory and conceptual drawings. This trend is probably best seen in the realization of various types of pavilions, designed with parametric tools. Partly made using CNC technology or 3D printing from materials such as concrete or steel. However, it also found its dimension in larger projects, such as the CCTV headquarters, the implementation of which was possible only thanks to the analysis of forces in individual parts of the building and the introduction of structural elements with dimensions and arrangement corresponding to the directions and magnitude of forces acting on a specific part of the building.

3. TOWARDS THE LIMITS OF IMAGINATION

Modern technology has not only made it possible to implement the above examples. At the same time, it did something more. By interfering with the very technique of the design process, it has perfected this element at the meta-design level, adapting it to the demanding construction process, and thus gave architects powerful tools that could unleash their imagination. This group includes, of course, all BIM solutions[1], programs that enable mold modeling, optimize it, introduce parametric design issues, as well as all solutions that allow you to generate, from prepared models, ready-made technical documentation existing in

[1] S. Hel Al-Dhaimesh, N. Taib, *Review paper: Investigation of augmented reality – BIM benefits in design process in the AEC industry*, "Informatica" 2023, no. 47, pp. 111–126. DOI: 10.31449/inf.v47i5.4671.

every major BIM software on the market. Also, tools that have become an important element of communication with other participants – including in particular with investors, on whose recognition the implementation of architectural concepts depends. VR, AR and XR technologies also allow the designers themselves to understand the project, to an extent incomparable to the previous methods, regardless of the complexity of the form, by giving them a verification tool such as the ability to assess the already made object itself, in the real world, but without a fraction of the expense needed to make it.[2]

This creates the potential to redirect the architect's effort related to documentation technology to other aspects of his work. Freeing him not only from hundreds of hours spent on preparing plans, but even from any work related to it, or partially (for now), from verifying their correctness. However, the precise use of this technology, paradoxically, also requires some effort. Therefore, it is not unequivocally certain whether freeing architecture from the technological constraints of its design representation will translate into the implementation of the postulate of its greater relationship with art. Currently, one can even risk a thesis that this is rather unattainable.

It seems that most of the advantages of digital design, in market conditions, are visible in economic optimization, not in the release of creative potential. Leading to a significant unification of projects – especially in cases where they are aimed at an unknown recipient, which helps avoid excessively risky – in this case – individual aesthetic and functional solutions.

Of course, in each case, the key element is the efficiency in using the tool and knowledge of the goal the designer is striving for. This only emphasizes the importance that should be placed on education in this area and the development of general principles that should be followed, which can provide a framework for the creation of algorithms of conduct and assessment.

4. TOWARDS THE ILLUSION

The development of digital technologies and the possibilities offered by 3D printing allow for the creation of concept presentations that are both informative and visually impressive. The latter aspect can also be a double-edged weapon. The attractiveness of visualizations – including those created at lightning speed by AI applications – can be a veil behind which the substantive deficiencies of the project are hidden. This problem has been noticed and attempts are being made to develop standards that would bring visualizations closer to the reality of implementation, while making it possible to compare various proposals in a near-objective way.

The importance of visualizations for non-professionals is obvious. And there is a significant part of truth in the saying that you buy with your eyes. The modern world also seems to suffer from an over-reliance on the sense of sight, which is also raised in writings on the theory of architecture – such as by J. Pallasmaa.[3]

Visualization excellence is also a problem from the point of view of the possibility of misleading potential investors, not only as to the potential effect. Realistic visualizations placed on websites, presenting buildings that were never actually completed, indicate the

[2] 10 benefits of augmented reality for architecture [in:] Proven Reality, 22.01.2024, https://provenreality.com/augmented-reality-for-architecture (access: 20.05.2024).

[3] J. Pallasmaa, *Oczy skóry. Architektura i zmysły*, Instytut Architektury, Kraków 2012.

designer's experience, which has no justification. In the traditional approach, this is a potential problem, because it was the ability to transfer one's concept from the area of ideas to reality that was historically an important element of the investor's decision in terms of his trust in the designer and the proposed solutions. Of course, the more the implementation turns into the simple execution of the model, reducing the traditionally functioning element of the contractor's interference in the process, the less important this problem will be. In this case, it will be more important to be efficient in preparing the model, which will then be assembled in a way that is one hundred percent consistent with the digital version, following the example of industrial production. A version verified by AI in advance.

5. BEYOND UNDERSTANDING

Of course, modern designs generally cannot do without computer programs that calculate the forces and cross-sections of the elements. They speed up the process and allow designers to take the tedious calculations off their shoulders. Until recently, however, schemes remained within the range of describable solutions, which could be determined based on the designer's experience. However, both advances in parametric design and the use of AI allow for the formation of schemes whose effectiveness can only be determined by the analysis of complex models and are beyond the ability of an experienced designer to determine.[4] This opens up the possibility of realizations in which buildings seem to defy gravity and physics in a way that was previously unimaginable.

Unlike architects from the beginning of the 20th century, these solutions are not only in the realm of dreams. The accuracy of modeling and the possibility of prefabricating individual elements, exactly as in the design – with precision and repeatability unattainable for the products of human hands alone – allow us to boldly cross new boundaries. Leaving basically the only barrier – the financial one.

The freedom provided by complex technological processes, hidden from the user behind the mask of friendly interfaces, allows you to create layouts that are far from the usual patterns and rules of composition. And so, paradoxically, *the wise man of the glass and the eye* allows *feeling and faith* to speak more strongly, creating diversity depending on the individual views of the designer.

However, this is not a completely unmanageable style. It is also not without reason that there are voices that this stylistic freedom provided by computers can be considered the birth of the style of the new Baroque. Many of the solutions used follow wavy lines referring to various types of images of movement. And even the apparent minimalism of forms actually consists of complex arrangements of elements that make up the living tissue of the building structure.

6. BEYOND REALITY

As it was written above, the basic problem that the designer had to face quite recently was to present the ideas that were born in his head both to himself and to investors or contractors.

[4] A. Picon, *Digital culture in architecture. An introduction for design professions*, Birkhäuser, Basel 2010, p. 130.

Full success depended and still depends not only on having the technologies to transform the dream into an actual body of the object, but it also starts with whether it is possible to present the concept in a way that is understandable to people often not related to the design process. In the next step, the essence of the process is to transform the sometimes-expressive drawings, whose important role is the role of persuasion, convincing people to one's vision, into drawings of a more universal nature, enabling the precise execution of non-existent matter with the use of technology limited in its principle. And all this while minimizing the interpretative influence of the people making the material object. In addition, of course, the verification role was also important in the first stage – enabling the confrontation of one's own ideas.

This huge scale of responsibility explains why the drawing part has been considered important since the dawn of the field. Of course, its verbal development was of great importance, and the expressed need to have the ability, at least to express oneself correctly in speech and writing, finds its place already in the work of Vitruvius.[5] However, it was the visual form of communication, especially in the twentieth century, that took the lead in architectural communication, and drawing even become the language of architecture. All this in order to develop tools that allow the constitution of the "architect's dream" in the way that the execution technologies allowed – of course also affecting the design itself.

Since Miligram and Kishino coined the concept of mixed reality in 1994[6], attempts have been made to implement it in various fields, including architecture. Although it encounters many difficulties and the implementation is not as fast as expected, it is undoubtedly one of the technologies that can enable the implementation that almost perfectly reflect the original ideas of the architect. It can also potentially allow to obtain solids with geometries that cannot (or rather are difficult) to reproduce using popular and more traditional techniques.

Apart from the fact that there are various methods of implementing the idea of design in augmented reality, for the purposes of this article, only two main stages should be noted, where it can allow you to combine imagination with implementation.

The first stage – design – has already been partially mentioned. In this field, AR offers two solutions that have not been seen before. The ability to design an object – model its body – in combination with a view of the context of its implementation or on a principle analogous to creating a mock-up – under the designer's eye, with unprecedented accuracy and detail, often using a completely intuitive interface. Effectively eliminating the excess of simplifications related to, for example, the use of symbols or the need-to-know complex program commands.

In this respect, solutions using glasses and phones are particularly interesting (which opens up the field for use by virtually everyone).

The second aspect is the possibility of using AR during construction – simplifying documentation to visually understandable elements that clearly show down to the level of individual bricks or blocks the layout to be constructed. Thus, eliminating possible errors and discrepancies with the design.[7]

Currently, it is difficult to determine whether these methods will be used on a wider scale. However, regardless of their purely business advantages – simplification of the process and

[5] Vitruvius, *O architekturze ksiąg dziesięć*, Prószyński i S-ka, Warszawa 1999.

[6] P. Milgram, F. Kishino, *A Taxonomy of Mixed Reality Visual Displays*, "IEICE Transactions on Information Systems" 1994, no. 12, pp. 1321–1329.

[7] D. Bain, *Digital transformation: practice adoption* [in:] The RIBA Journal, 1.06.2018, https://www.ribaj.com/intelligence/bim-augmented-reality-virtual-reality-practice-management-software (access: 24.05.2024).

reduction of costs – for the architect they undoubtedly mean the possibility of achieving intentions that in traditional techniques were limited by the imperfections of tools and their users, bringing the process closer to a more natural method based on a gesture, on the one hand, and on following a strictly defined and calculated path on the other.

7. BEYOND MAN

> *Generative design in architecture and construction will pave the way for productivity. Generative design in architecture and construction involves the use of computers to model building strategies – not only to describe structures, but also to co-create them.*[8]

It is hard to disagree with the above thesis. It is also hard not to notice that solutions of this type – no matter how strongly related to the use of AI – have the potential to both speed up work and eliminate human errors and enable the creation of very complex objects. The analysis of a huge amount of data is also perceived as beneficial for optimization – both in terms of pro-environmental design and the local context, or basically any context. Undeniably, it is a potential tool to improve the technical side of the project, and probably also has the potential to create visually interesting buildings. There are already tools that make it possible to generate a building model that can form the basis of BIM documentation (e.g. the Architechtures platform) by simply providing boundary parameters. Even at the conceptual level, it is possible to find generators (e.g. Midjourney) which, if they do not create useful models themselves, generate images that can turn verbal description into graphic interpretation – and thus allow for the creation of a medium needed for communication between participants of the design process or verification of one's own design idea.

8. TOWARDS DIGITALIZATION OF WORKMANSHIP

Of course, the digital revolution does not bypass the construction site either – although this process is also not instantaneous and at this stage it comes down to laboratory solutions or to larger-scale solutions, but limited to digital tools and quite simple robots and digitally controlled devices. A significant part of them are also modifications of classic equipment with solutions that enable control with greater precision, whether by adding GPS systems or generally increasing the role of AI in machine controllers.[9]

However, regardless of specific solutions, the fact is that the computer takes over many of the tasks of humans on the construction site. The benefits of this fact are quite widely recognized – increased safety, precision and savings in time and materials. An important

[8] P. Bernstein, *Generative design in architecture and construction will pave the way to productivity* [in:] Autodesk, 13.07.2022, https://www-autodesk-com.translate.goog/design-make/articles/generative-design-architecture?_x_tr_sl=en&_x_tr_tl=pl&_x_tr_hl=pl&_x_tr_pto=rq (access: 4.03.2024).

[9] Digital Construction Site: Innovations at digitalBAU 2024 [in:] DigitalBAU, https://digital-bau.com/en/discover/topics-news/digital-building-site/ (access: 1.06.2024).

economic aspect is also the extension of working time – robots are not subject to time restrictions.[10]

Examples of projects using robots are, so far, few. But they will undoubtedly change. An already existing example can be DFAB House / NCCR Digital Fabrication or the Elytra Filament, Skilledln Office or ICD-ITKE pavilions, which showed that the production of utility structures with the help of mechanical workers is not a sci-fi issue. Their forms can both correspond to classic ideas about the building and implement parametric designs, supporting the digital revolution in design.

For designers, these trends have a twofold meaning. On the one hand, greater precision, even with complex layouts, consistency within BIM – all this means that projects can be more individual, and their implementation is closer to the design intentions.

On the other hand, these trends mean the need to describe your own ideas more precisely in digital files. The margin for errors, but also for spontaneous changes on the construction site is reduced. The response to the unforeseen is becoming more and more difficult, as the construction is becoming closer to the implementation known from the production lines. The prefabrication of individual elements speeds up the construction process and enables solutions that, thanks to the precision of workmanship and optimal use of materials, give freedom of creation. However, they take away the element of indeterminacy. Decisions made on the construction site and implemented as a result of modifications of real solids, following the example of Oscar Niemeyer when he built Brazil, are becoming a thing of the past. The process itself becomes more of a laboratory than a chaotic experience. Any errors in assumptions become a much bigger problem. The latter is of course beneficial from the investor's point of view as a whole, but it distracts the designer from the execution of his work. Offering, in exchange for its perfect reproduction, a lack of understanding of the process of creation – a characteristic of laboratory work in which the effect is only the result of the concretization of conceptual assumptions. In a sense, this leads to a further process of shift from the architect, as the Byzantines perceived him according to Jan Knothe, to the engineer.[11] From someone who knows how to lay a stone through practice, to someone who can calculate which stone needs to be placed to fulfill its purpose. From the architect's point of view, this also shifts the problem from the aspects of building to the prefabrication of a 1:1 scale model.

9. SUMMARY

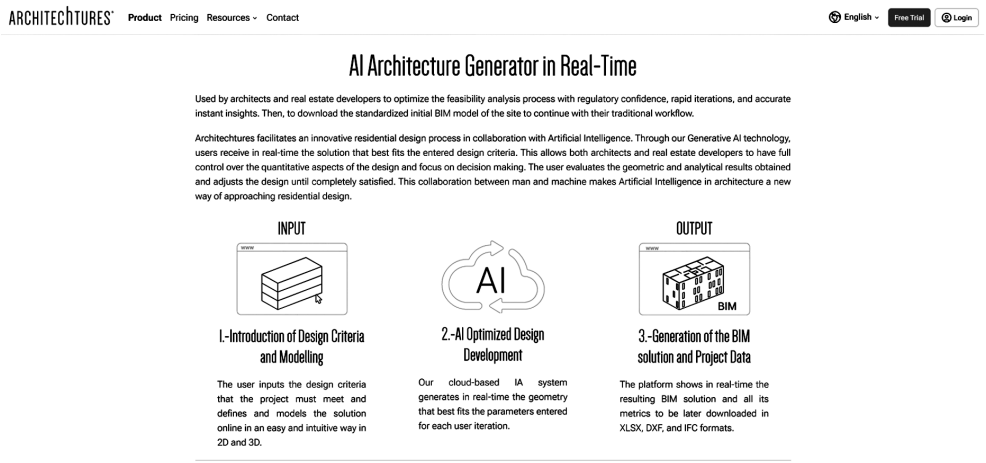
As it was said at the beginning, it is not possible to describe the effects of the phenomenon precisely and certainly. The issue itself is broad, many teams deal with it, and their work creates complex systems of dependencies. Focusing only on the use of AI, it is clear that the potential ranges from a tool that is very useful, especially in pro-ecological projects, complicated and inscribed in a network of interdependencies difficult to describe by humans, requiring the analysis of a lot of data, to a potential solution that replaces the architect or at least strongly modifies his position and scope. The situation is similar, although perhaps less

[10] J. Loring, *What is digital construction? 7 best practices* [in:] Hitachi Solutions, https://global.hitachi-solutions.com/blog/digital-construction/ (access: 13.05.2024).

[11] J. Knothe, *Sztuka budowania*, Karakter, Kraków 2015, p. 217.

extreme, with many other techniques. Their use brings a lot of good, but we must remember that all technology hides its dark side, and its use never leaves the world unchanged. Bringing architectural visions to life in an unlimited way through technologies and materials has been a dream for many designers, but many great projects have been created precisely as a response to limitations. Full freedom does not have to mean better solutions. As long as architecture remains a manifestation of human activity, its imperfections and struggles with limitations, as in the case of its creators, are often its most valuable manifestation. Like in the Japanese art of Wabi Saba, which celebrates the imperfection of recreated human handicrafts, beauty often lies in imperfections. In uniqueness – a factor that is difficult for a machine to introduce. Time will tell whether we will be able to preserve this human element, whether we will adapt to machine perfectionism, and whether it will be a gain or a loss for architecture in particular, and in general for the civilization and culture, of which architecture is a manifestation.

Ill. 1. Microsoft's HoloLens solution, source: D. Bain, *Digital transformation: practice adoption* [in:] The RIBA Journal, 1.06.2018, https://www.ribaj.com/intelligence/bim-augmented-reality-virtual-reality-practice-management-software (access: 24.05.2024).



Ill. 2. A platform that enables design with AI, source: Architectures – AI Architecture Generator. Building Design, https://architechtures.com/en (access: 24.05.2024).

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[5] Digital Construction Site: Innovations at digitalBAU 2024 [in:] DigitalBAU, https://digital-bau.com/en/discover/topics-news/digital-building-site/ (access: 1.06.2024).

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