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CONTEMPORARY *D-DAY*: TECHNOLOGY INVASION OF ARCHITECTURE IN THE 21ST CENTURY – DOES IT HERALD THE END OR THE REVIVAL OF ARCHITECTURE?

WSPÓŁCZESNY *D-DAY*: INWAZJA TECHNOLOGII NA ARCHITEKTURĘ W XXI WIEKU – ZAPOWIEDŹ KOŃCA CZY ODRODZENIA ARCHITEKTURY?

A b s t r a c t

Currently, we are dealing with the invasion of intelligent technologies into architecture, threatening its existence as a discipline representing humanistic and technical values in equal measure. While the architecture of modernism managed to survive during the first mass invasion of mechanical technologies, the current invasion may mean the end of architecture. The aim of the research was to determine the impact of mechanical technologies of the industrial era and smart technologies of the post-industrial era on the development of architecture. The research was based on a critical analysis of the manifestos of futurologists and architects, and on a comparative analysis of contemporary trends at the interface of technology and architecture. The basic threats related to the invasion of technology into architecture were defined, and its consequences were presented in the form of the emergence of specific thinking strategies and design patterns of spatial structures.

Keywords: architecture of beyond-modernism, architecture of modernism, mechanical technologies, smart technologies, spatial patterns

S t r e s z c z e n i e

Obecnie mamy do czynienia z inwazją inteligentnych technologii na architekturę, zagrażających jej istnieniu jako dyscypliny reprezentującej w równym stopniu wartości humanistyczne i techniczne. O ile architekturze modernizmu udało się przetrwać w okresie pierwszej masowej inwazji mechanicznych technologii, o tyle obecna inwazja może oznaczać koniec architektury. Celem badań było określenie wpływu mechanicznych technologii epoki industrialnej i inteligentnych technologii epoki postindustrialnej na rozwój architektury. Badania były oparte na krytycznej analizie manifestów futurologów i architektów oraz na analizie porównawczej współczesnych trendów na styku technologii i architektury. Zdefiniowano podstawowe zagrożenia związane z inwazją technologii na architekturę, a także przedstawiono jej konsekwencje w postaci pojawiania się określonych strategii myślenia i wzorców projektowania struktur przestrzennych.

Słowa kluczowe: architektura po-modernizmu, architektura modernizmu, mechaniczne technologie, inteligentne technologie, wzorce przestrzenne

1. INTRODUCTION

Architecture of the information age of the 21st century creatively develops the ideas of modernism, which in their assumptions were an expression of fascination with the technological development of the industrial era and referred to significant scientific discoveries in the first half of the 20th century.[1] These ideas expressed the need for architecture to follow the progress of civilisation towards a better future and had a significant impact on the way architectural forms were shaped. The language of modernist architecture patterns was an expression of order and rationality of the spatial structures, sincerity and economy of the materials used, standardisation and typicality, as well as universality and timelessness of architectural forms.[2] This way of defining the language of spatial expression can equally describe the world of architecture and the world of technology.

Modernism laid the groundwork for the emergence of such styles in architecture as *high-tech* (post-modernism) or *smart-tech* (beyond-modernism), proclaiming that form should follow structure (*form follows structure*) and the source of spatial structure should be material and technological innovations that take precedence over aesthetic attitudes in shaping architectural forms.[3] The difference between the modern and beyond modern view of architecture is revealed only in the degree of affirmation of the technology itself and thinking about its effects on the natural environment. Technological civilisation of the twentieth century. The twentieth century has disturbed the fragile balance in the natural environment and caused threats to the development of humanity, while the current civilisation believes that technology can become a remedy for the problems it has created.

In the shadow of this discussion of the impact of technology on the human living environment, there is another dispute between civilisation and culture. This dispute is a clash of two different worlds: technological and humanistic (prototypes vs. archetypes), material and spiritual (patterns vs. symbols), or objective and subjective (universalism vs. individualism). From the point of view of the theory of architecture, this dispute seems more important than the one concerning the conflict of technology and the natural environment because it is at the very core of the problem that defines the way of thinking about shaping the spatial setting of human life. If, in the process of creating an architectural form, technological values win in the confrontation with humanistic ones, architecture will lose its symbolic, aesthetic and ethical dimension, which threatens its further existence in the form as we know it. Therefore, in the era of the invasion of smart technologies into architecture, it is important to take a critical look at the seemingly unquestionable directions of civilisation development and the threats associated with it, as well as to search for solutions that will allow maintaining human control over the design process and at the same time contribute to the formulation of a new architecture paradigm that will legitimise the contribution of new technologies to architectural work while preserving the symbolic and humanistic dimension of architecture.

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[1] L. Mies van der Rohe, *Technology and architecture* [in:] U. Conrads (ed.), *Programs and manifestoes on the 20th-century architecture*, The MIT Press, Cambridge 1990, p. 154.

[2] Le Corbusier, *Towards a new architecture: guiding principles* [in:] *ibidem*, p. 60.

[3] M. Tafuri, *Towards a critique of architectural ideology* [in:] M.K. Hays (ed.), *Architecture theory since 1968*, The MIT Press, Cambridge 1998, pp. 20–21.

2. PURPOSE, SCOPE AND RESEARCH METHODS

At the beginning of the 21st century, we are dealing with a great acceleration of civilisation development and the invasion of intelligent technologies in all areas of life, including architecture, threatening its existence in its current form as a discipline representing humanistic and technical values in equal measure. A similar event took place at the beginning of the twentieth century, although in this case we were dealing with the invasion of mechanical technologies of the industrial era. And while the architecture of modernism managed to survive during the first mass invasion of technology, and even turn this threat into success, due to the skilful transformation of the phenomenon of machines into the modern aesthetics of industrial purism, the current invasion of AI technologies[4] and GNR (*Genetics – Nanotechnology – Robotics*)[5] carries much greater threats, as it may mean the end of architecture.

The aim of the research was to determine how the mechanical technologies of the industrial era and smart technologies of the post-industrial era have influenced and will influence the development of architecture, and how the phenomenon of these technologies has affected and will affect the strategies of thinking about architecture and the way of shaping architectural forms. The research was based on a critical analysis of the most important manifestos of futurologists and architects of the 20th and 21st centuries, and on a comparative analysis of contemporary trends at the interface of technology and architecture. The basic threats related to the invasion of technology on architecture were defined, and its consequences were presented in the form of the emergence of specific thinking strategies and patterns of designing spatial structures in two key moments in the history of modern architecture:

- *D-day* of the 20th century: invasion of mechanical technologies on architecture,
- *D-day* of the 21st century: invasion of intelligent technologies on architecture.

The necessary actions to be taken to manage smart technologies were then defined so that the architecture is not completely dominated by technology.

The term *D-day* is most often used to refer to military events and covert military operations marking the moment of invasion of enemy forces. This term also sometimes appears to describe breakthrough events, the consequences of which were not fully known to the parties to these events, but which changed the course of history and involved the application of new thinking strategies and the use of innovative technologies, giving one of the parties an advantage. It is in this second sense that the threats of technology's invasion of architecture are analysed.

3. *D-DAY* OF THE 20TH CENTURY: INVASION OF MECHANICAL TECHNOLOGIES ON ARCHITECTURE

The entire twentieth century can be generally called the era of modernism, with its phases: *pre*- at the turn of the 19th and 20th centuries and *post*- in the second half of the twentieth century.[6] Modernist architecture responded to civilisation changes resulting from the scientific

[4] N. Bostrom, *Superintelligence: Paths, dangers, strategies*, Oxford University Press, Oxford 2014.

[5] R. Kurzweil, *The singularity is near: When humans transcend biology*, The Viking Press, New York 2005.

[6] C. Jencks, *Modern movements in architecture*, Penguin Books, New York 1987.

and industrial revolution, which had their origins in the Age of Enlightenment. The scientific revolution brought with it objectified thinking strategies, referring to the theoretical and generalised foundations of knowledge about the nature of reality, while the industrial revolution concerned the practical implementation of knowledge into the existing reality and its transformation through the use of the latest tools and technologies. The industrial revolution, the era of machines, steam and electricity (first and second industrial revolutions)[7] – introduced new materials and technologies into architecture, which contributed to the emergence of industrialised and prototypical construction, the appearance of techno-aesthetics and industrial design, being the expressions of the aesthetics of machines, and also initiated the process of a permanent future-orientated technological revolution; a revolution that continues to this day.

The expansion of the mechanical technologies of the industrial revolution into the architecture of modernism resulted in the emergence of new thinking strategies and design patterns of the spatial structures, such as: massness and universality, linearity and prefabrication, techno-aesthetics and high-tech, futurology and spatial mega-structures, as well as mobility and flexibility.

Massness and universality

Industrialisation was associated with the mass production of not only objects, industrial and consumer goods, but also apartments, buildings, and urban infrastructure networks. With the emergence of the category of mass in industrialised construction, a tendency appeared in architecture to search for a universal spatial pattern of house and city for a mass consumer.[8] As a result, this led to the uniformity of spatial patterns and their subordination to the principles of functionality and technological and economic rationality and enforced the simplicity and flexibility of architectural solutions. Massness also meant the export of technology and the international architectural style, which replaced regional architecture and contributed to the creation of McWorld. The mass industrialisation of architecture and the spread of terms such as production, standardisation, and economic and technological efficiency of spatial structures made architectural form a commodity that was subject to the rules of the market, forcing it to be functional, optimised, interchangeable, cheap and meeting the preferences of the statistical consumer.

Linearity and prefabrication

The concept of linearity, horizontal and vertical, of spatial structures in architecture, promoted, among others, by Russian futurists (e.g. arch. Lasar M. Chidekel, Mikhail Masmanyan, Konstantin Melnikov),[9] referred to the idea of the factory production line, which so significantly revolutionised the method and efficiency of industrial production. Prefabricated building elements of spatial structures began to be produced on factory lines, which was intended to speed up the construction time of buildings and make this process independent of weather changes on the construction site. In addition to linearity, prefabrication technologies also imposed a specific way of thinking about the spatial structure in terms of modularity, prototyping, and standardisation of both building elements and the tools for their production.

[7] K. Schwab, *The fourth industrial revolution*, Portfolio Penguin, London 2017, pp. 6–13.
[8] R. Banham, *Theory and design in the first machine age*, MIT Press, Cambridge 1980.
[9] S.O. Chan-Magomedow, *Pioniere der sowjetischen Architektur*, Verlag der Kunst, Dresden 1983.

Techno-aesthetics and high-tech

The Industrial Revolution resulted from an explosion of technological discoveries and inventions initiated by scientists and engineers at the turn of the 19th and 20th centuries. Inventions were accompanied by great fascination of artists and architects with the aesthetics of machines. Many architects referred in their manifestos to the need to follow the spirit of time (*Zeitgeist*) and exploit the means of expression associated with mechanical technologies, liberating architecture from the influence of cultural individualism.[10] The universal and timeless language of technological patterns was completely adopted by high-tech architecture in the second half of the 20th century, according to which form should follow structure and innovative material and technological solutions (Ill. 1). The precursors of this trend were such architects as Norman Foster, Renzo Piano, and Richard Rogers[11] (Ill. 2). The concepts of high-tech architecture were set in the context of a permanent technological revolution, determining the form, and architects played the role of inventors whose task was to discover new fields of technological exploration with each object they designed, crossing the boundaries of possible structural and spatial solutions in architecture, thus contributing to the progress of civilisation.

Futurology and spatial mega-structures

Filippo Tommaso Marinetti's Manifesto of Futurism paid tribute to the racing car as a form more beautiful than the Nike of Samothrace.[12] Futurism, although primarily an artistic movement, was also an important trend in modernist architecture, contributing to the creation of future visions of architecture in the aspect of civilisation development driven by technological progress. Many architects continued the ideas contained in the manifesto, searching for a vision of the city of the future and announcing the expansion of architecture in the form of spatial mega-structures into areas previously uninhabited and unfavourable for human life (e.g. Submarisle – arch. Richard Buckminster Fuller, The Spatial City – arch. Yona Friedman).[13] The functioning of these megastructures was possible only thanks to the use of innovative technologies in terms of building construction and operation. Visions of spatial megastructures were the expressions of the technology itself, rather than the aesthetic and formal decisions of architects.

Mobility and flexibility

The futurists' manifesto announced the death of "Time and Space" and the birth of the absolute in the form of "omnipresent speed."[14] Demands for the design of mobile spatial structures, expressing the idea of flow and movement, were also promoted by the Archigram group. According to them, architecture was no longer just a metaphor for a machine (e.g. "a house as a machine for living"),[15] but should be a machine in the sense of a mechanical technological structure (e.g. Walking City – Archigram, Plug-in-City – Archigram).[16] This

[10] L. Mies van der Rohe L., *op. cit.*, p. 154.
[11] A. MacDonald, *High tech architecture: A style reconsidered*, The Crowood Press, Ramsbury 2019.
[12] F.T. Marinetti, *The founding and manifesto of futurism* [in:] Italian Futurism, https://www.italianfuturism.org/manifestos/foundingmanifesto/ (access: 23.05.2024).
[13] N. Spiller, *Visionary architecture: blueprints of the modern imagination*, Thames & Hudson, London 2006.
[14] F.T. Marinetti, *op. cit.*
[15] Le Corbusier, *op. cit.*, p. 60.
[16] N. Spiller, *op. cit.*

involved a paradigm shift in the operation of the spatial structure from a static to a dynamic way of functioning in relation to the whole structure or to its components. Mobile, technologised spatial structures, in addition to problems related to their structural complexity, also faced the problems of minimising the energy consumption needed to keep objects in motion, reducing the usable space to a minimum, and the spatial flexibility of the structures.

There are many interesting visions and concepts of architecture of modernism, which are expressions of the invasion of mechanical technologies on architecture, as well as architects' fascination with technology itself. The quintessence of architecture completely dominated by technology can be considered the designs of Richard Buckminster Fuller, from the Manhattan Geodesic Dome, through the Dymaxion House, to the Dymaxion Dwelling Machine, as an emanation of the spirit of technology. Dymaxion meant combining the idea of "dynamic, maximum, and tension" in one word.[17] Fuller's visions were an expression of the ideal and logical world of geometry, defined by the principles of mathematics and physics, while at the same time referring to the world of technology, i.e. the efficiency, economics, and aerodynamics of dome structures manufactured from prefabricated elements. The idea of the dome, as a form universal to the concept of house and city, was an expression of the complexity of technological structures, the desire for maximum concentration of cubic capacity, the ability of the structure to internal conversion, rationality, and modularity of construction, and heralded the fusion of technology and ecology, abandoning the cultural heritage of architecture in favour of technology. The Manhattan Geodesic Dome concept was a design challenge for the builder and technologist rather than for the architect, and its functioning was entirely dependent on the reliability of the technical infrastructure systems supporting the life of living organisms under the dome. Fuller's visions, at the time of his contemporaries, could seem to be close encounters with alien technology, because they differed significantly not only from traditional architecture but also from the modernist language of architectural forms.

The era of industrialisation contributed to the fusion of technology and architecture, reducing the importance of the cultural dimension of architecture and leading to the globalisation of the architectural language using the universal language of technology. From that moment on, the idea of the prototype dominated over the idea of the archetype. At the same time, this fusion led to a significant degradation of the human living environment, giving architects the right to unlimited transformation in accordance with the logic of technological progress. As a result, this led to many negative phenomena related to the loss of not only biodiversity, but also architectural diversity, in the sense of local – cultural and technological – strategies of human adaptation to environmental changes.

4. *D-DAY* OF THE 21ST CENTURY: INVASION OF SMART TECHNOLOGIES ON ARCHITECTURE

The scientific and information revolution at the turn of the 20th and 21st centuries (third and fourth industrial revolutions)[18] is associated with the discovery of new energy sources (nuclear energy, renewable energy) and the development of smart technologies (informa-

[17] P. Gössel, G. Leuthäuser, *Architecture in the 20th century*, Taschen, Köln 2005, vol. 2, p. 363.
[18] K. Schwab, *op. cit*., pp. 6–13.

tion technology, nanotechnology, robotics, genetic engineering) and their implementation into the human living environment. With the advent of the post-industrial era, scientists and visionaries began to look for technological solutions that could prevent the negative effects of the civilisation development of the industrial era. This required a change in thinking strategy, that is, a shift from mechanical to ecological thinking, and a search for new sources of inspiration drawn from the world of nature rather than machines. Many of the current technologies are modelled on very effective survival strategies of various plant and animal species and on the ways they adapt to the changing natural environment. What further distinguishes the revolution of mechanical technologies of the industrial era from the revolution of intelligent technologies of the post-industrial era is that in the former case, we were dealing with the transformation of primarily the material (*hardware*) world, while in the latter case we were dealing with the transformation of the material (*hardware*) and information (*software*) worlds.

The expansion of the smart technologies of the post-industrial revolution into the architecture of beyond-modernism resulted in the emergence of new thinking strategies and design patterns of the spatial structures, such as: optimisation and efficiency, intelligence and self-steering, eco-aesthetics and smart-tech, Internet of spatial structures and information mega-network, as well as adaptation and interactivity.

Optimisation and efficiency

Optimisation of spatial structures in terms of energy efficiency is a key objective of design strategies today, driven by the need for energy efficiency and protecting the environment from the effects of excessive greenhouse gas emissions. The present technologies of the post-industrial era that use renewable energy sources (geothermal energy, biocompost, wind turbines, solar and photovoltaic panels, etc.) completely redefine thinking about the way a building (*hardware*) operates, which is no longer just an energy consumer, but is first and foremost an energy producer. The spatial structure is tightly integrated with the energy acquisition and circulation system, and the primary goals of this system are to maximise energy yield and minimise energy losses. The role of technical infrastructure in architecture is growing significantly today compared to the previous period. The criteria for assessing the correctness of architectural solutions are also changing; energy efficiency criteria of buildings dominate over aesthetic ones. There is another additional factor that forces the optimisation of structures due to the robotisation of building construction processes. The elimination of the human factor, as well as the total mechanisation and automation of construction in the near future, will have an impact on the way architectural forms are shaped, due to the need to subordinate them to the requirements related to specific construction robot technologies (this has already been partially initiated in the industrialised construction of the industrial era). Efficiency in architecture is also related to the achievements of the information revolution, i.e., thanks to software, the architect gains access to tools for controlling and optimising the geometric, structural and technical order of the designed buildings. These tools, on the one hand, open up a new field of shaping architectural forms, and on the other, mostly determine their shape.

Intelligence and self-steering

Energy production and its circulation in spatial structures involve the use of intelligent systems for monitoring and controlling energy flow, its collection, and transfer to the municipal power grid (*hardware*). The monitoring systems consist of a network of sensors, processors, and computer programs that control the operation of these systems. Due to the unreliability of technology, it is necessary to introduce additional alarm systems to protect against the effects of possible failures. Today, the technical systems of smart buildings are controlled by the users themselves, but in the near future they will probably be controlled solely by artificial intelligence, which will mean a total human dependence on their reliability. Taking control of spatial structures by artificial intelligence raises the question of whether the degree of complexity of the structures created in this way will not be so complicated, they can ultimately be designed solely by artificial intelligence, as the architect may not be able to cope with their complexity. Additionally, the introduction of the generation of intelligent materials (nanomaterials) into architecture on a larger scale will significantly increase the amount of information circulating in the spatial structure in the near future. The problem of the invasion of artificial intelligence into architecture concerns not only spatial structures, but also the creative process itself. The source code of architectural software is increasingly supported by artificial intelligence, which means that copyright is becoming blurred and shared between the architect, programmer, and artificial intelligence. The smarter the software, the easier communication with it and the more intuitive the field of exploration for the architects' imagination, but at the same time there is no certainty whether the decisions they make are not determined by an external player, so the question arises who controls the creative process.

Eco-aesthetics and smart-tech

The post-industrial era inherited all the consequences of the development of the industrial era, associated with the development of industry and migration of people from agricultural areas to cities, which gave impetus to the unlimited growth of urban agglomerations. The negative phenomena that accompanied this process are the source of various pro-ecological movements, proclaiming the need to improve urban living conditions and save existing natural resources. A response to these demands was the emergence of the concept of the so-called green architecture, which included not only solutions for green roofs or facades, but also proposed the exploration of the organics of spatial structures in reference to forms found in nature (Ill. 3). Eco-aesthetics has become such a popular trend in contemporary architecture that even artificial intelligence, in the images it creates regarding the vision of a human-friendly city, presents them as vertical gardens established on terraces and roofs of buildings with fluid and curvilinear shapes. Although contemporary architectural visions representing eco-aesthetics differ from the techno-architecture of the previous era, they share a common core, which is technology. Most pro-ecological solutions in architecture require the use of many intelligent technologies (*hardware*) that sustain the life of greenery and control systems, e.g. irrigation, spraying, organic waste disposal, soil aeration and fertilisation, etc., as well as the use of the genetic engineering achievements, producing appropriate plant species that can be integrated into the architecture. Therefore, we can say that behind eco-aesthetics there is actually *smart-tech*, which is a continuation of *high-tech* of the industrial era (Ill. 4). Digital architecture also mostly follows eco-aesthetics, thanks to various functions of architectural programs (*software*), enabling not only the creation of any organic forms (e.g. evolving and liberated forms), but also their control in terms of the stability and rigidity of their structure.

Internet of spatial structures and information mega-network

The networking of architecture with the advent of the Internet of Things will create a completely new quality, both in the way buildings and entire urban organisms will function. As Rem Koolhaas writes:

> The tech world's gradual colonisation of architecture is taking place without the collaboration of its host. As technology triumphs, architecture is simply left behind. The 'Internet of everything' is drastically changing many fields, but architecture, because it is a five-thousand-year-old discipline, is especially susceptible to the radical yet surreptitious shifts catalyzed by a network of wired objects creating an immersive, inescapable environment.[19]

Everything will be connected to everything, which means that there will be not only new players (programmers, operators, administrators, network service providers) on the architectural market, but also decision-makers and regulators who will define the performance parameters of spatial structures mainly in terms of their energy, information, and economic optimisation, diminishing or ignoring the cultural and aesthetic values of these structures. As Rem Koolhaas notes:

> The effects of the new technologies infiltrating architecture unfold even more blatantly in the smart city, which projects the data gathering and feedback loops of the Internet of everything at an ever-broader scale. […] prominent figures in the field of technology staked their claim to the urban realm, traditionally the domain of architects. This transfer of authority has been achieved through a clever strategy: By calling their city smart, they condemn *our* city to being stupid.[20]

We will be dealing with an electronic ecosystem in which buildings will play a role similar to servers connected to the worldwide network in the peer-to-peer model; each building will be able to be both a server and a client, and architects will become space programmers.

Adaptation and interactivity

The networking of architecture may contribute to the dissemination of the concept of architectural objects as interactive structures that respond to the needs of users. Buildings would act as an interface, allowing users to make changes in the functional and spatial organisation of structures through specific commands or sensory interaction with objects. Currently, many experiments are being carried out related to the design of interactive structures, many of them related to the design of houses (e.g. HomeLab – Philips; Smart House – Microsoft; Responding House – MIT). In these cases, the interactivity of architecture does not only concern the mutual relations of structures with users but also with the environment, in the sense that the building can adapt to changes occurring in the environment and respond to specific external stimuli. The possibility of making functional and spatial changes in structures in real time carries certain limitations in shaping forms, because the mechanism of their operation is more important than their appearance. The concept of a building as an interactive interface significantly expands the definition of architecture to include issues related to information architecture.

[19] R. Koolhaas, *The smart landscape: Intelligent Architecture*, Art Forum 2015, https://www.artforum.com/print/201504/the-smart-landscape-intelligent-architecture-50735 (access: 1.06.2024).

[20] *Ibidem*.

The architectural visions of beyond-modernism are mostly a continuation of the trend initiated by modernism, in the sense that architecture follows the latest scientific discoveries, becoming an expression of the potential and possibilities of modern technologies. However, there is an important difference between them, which is that while modernist and beyond modernist visions at the conceptual level show a similar fascination with technologies, at the level of materialisation of these visions modernist buildings in the way they function are closer to traditional construction, while intelligent buildings beyond modernism are increasingly approaching the way mechanical devices function, depending on the circulation of energy and information in them.

The contemporary threats to architecture resulting from the invasion of intelligent technologies are associated with the dictate of informational thinking strategies, forcing rationalism and objectivity of the design process and optimisation in the way of creating, functioning and operating spatial structures, completely disregarding cultural values. Hence, artificial intelligence and robotics are very close to taking control of architecture, as they are characterised by better efficiency and effectiveness in optimising spatial structures and generating variant solutions for their adaptation to the changing parameters of the environment. Information technology means the global formatting of culture according to the rules invented by Big Tech policymakers and programmers; rules that are often the basis for legal regulations and tools for their enforcement. These regulations will be a significant limitation in the way architecture and its goals are defined in the near future and perhaps will contribute to negating its current role.

The information revolution of the post-industrial era is accompanied by pro-ecological movements trying to find a remedy for the environmental destruction caused by the industrial revolution. At the declarative level, these movements postulate a turn away from technology and a return to nature, but in reality many proposed solutions for environmental reclamation involve the use of the next generation of technology, e.g. obtaining energy from alternative sources or genetic engineering to recreate extinct species. So, we are dealing with a fusion of ecology and technology that further marginalises cultural aspects in architecture. Perhaps this will result in a reversal of the negative effects of the industrial revolution in the future, but the global scale of the adopted project will mean that all spatial interventions will have to fit into this project and meet its standards in order to be effective, thus providing a field of choice in the process of architectural creation will be limited to insignificant decisions.

Since the information revolution is still ongoing and artificial intelligence is only in the first phase of its development, not all threats to architecture that now appear on the horizon will actually occur. Therefore, it is now important to use the potential of new smart technologies to try to save the cultural dimension of architecture by incorporating humanistic values into thinking strategies that are used to develop algorithms for architectural software.

5. SMART TECHNOLOGIES: IN SEARCH OF LOST ARCHITECTURE

The fundamental challenge in the confrontation of architecture with smart technologies is not the technology itself, but the thinking strategies behind it. In order to have an effective impact and to give these technologies a shape acceptable to architects, one should work at the source of their creation. In other words, it is necessary to articulate arguments and define principles relevant to architecture, which should be embedded in the way these technologies operate, in their *modus operandi*, as well as influence the criteria and parameters used in defining the algorithms of architectural computer programs.

The thinking strategies formulated by the Design-to-Production group, underlying the algorithmic design of spatial structures, define four rules of conduct, such as organisation, optimisation, simplification, and materialisation.[21] Using this description of information management in the creative process, one should try to include in this process concepts and phenomena important from the point of view of architecture, as a discipline representing not only the information-material but also the symbolic-aesthetic dimension.

Organisation

The data organisation rule is the first essential step in encoding the architectural language, that is, translating the architectural form into the informatics language. This requires understanding the spatial structure, dividing the structure into component parts, assigning specific parameters to these parts, and standardising them. And these last steps are a big obstacle in trying to translate symbolic-aesthetic values into the language of informatics, because parameterisation is possible primarily in the case of measurable phenomena and works well in the description of physical phenomena, but it is difficult to assign specific parameters to symbolic-aesthetic phenomena, which additionally are characterised by a high degree of subjectivity. The very definition of beauty in architecture causes many difficulties, and an attempt to standardise this concept by assigning specific parameters to it would necessarily end in failure. A way out of this trap could be to extend the architectural program with a block programmable by architects, in which, using a text or sketch, they would enter their intentions, how the forms should interact, and what goals they should pursue, so that in the next phases of the process these intentions could become one of the important criteria for optimising the spatial structures. Interpretation and codification of architect texts or drawings would probably be carried out with the participation of artificial intelligence, but it should be a kind of dialogue in which the architect has the last say.

Optimisation

The optimisation rule involves transforming the original organisation of the spatial structure and searching for the best solutions in terms of the efficiency of the structure's operation, for example, functional, structural, energy, material, economic, infrastructural or informational. Similarly to the data organisation phase, optimisation requires specific criteria and parameters in order to be able to perform specific transformations according to them and evaluate the degree of their effectiveness, which is very difficult and sometimes impossible in the case of symbolic-aesthetic values. Therefore, in order to include the possibility of optimising a structure for its symbolic-aesthetic values, it would be necessary for the programme to monitor how much the optimised variant deviates from the original assumptions, maintaining a continuous discourse between what is effective and what is intentional, what is technologically optimised and what is symbolically declared. The architects would have a decisive voice in this discourse, assigning specific weight functions to the best variants

[21] A. Ferre, T. Sakamoto (eds.), *From control to design: Parametric/algorithmic architecture*, Actar-D, Barcelona 2008, pp. 181–182.

when choosing optimized forms. In addition, they could introduce their own modifying functions into the program, which optimize the structures in terms of the original assumptions regarding shaping the form. This possibility already partially exists thanks to text or visual scripts of computer programs, such as: Grasshopper 3D, Autodesk Dynamo, Rhino, Visual Basic.NET, Revit, etc.

Simplification

The rule of simplification involves striving for maximum simplicity of the structure's components and their connections. From the point of view of technology, this is a key thinking principle that guides all its products and which in IT takes the form of the KISS (*Keep It Short and Simple*) formula. After the optimisation phase, the selected variant is reviewed for excessive complexity in search of the perfect solution to reduce the components or their connections. This phase poses a particular threat to architecture, especially to the freedom of expression of architectural forms, because it leads to the creation of repeatable prototypes. If everything in a given variant is optimised and reduced to the maximum degree of perfection, then any other solution that deviates from the ideal pattern will be burdened with original sin, as it will involve, for example, higher costs or energy consumption; therefore, its usefulness will always be questioned. In architecture, there is an equivalent of the rule of simplification, i.e. the principle formulated by Mies van der Rohe, *less is more*, but this is only one of many possible points of view on shaping architectural form. Therefore, it seems that the simplification phase should be either optional in architectural computer programs or, similarly to the optimisation phase, it should be possible to confront a specific solution with the original assumptions so that architects themselves can decide on the degree of simplification of spatial structures.

Materialisation

The data materialisation rule means sending the final version of the spatial structure design from the architect's computer directly to the construction site, where specialised robots are tasked with building the object in accordance with the program instructions. This phase involves translating the architectural language of CAD programs (*computer-aided-design*) into the machine language of CAM (*computer-aided-machine*). The robotisation of the construction process is currently progressing very rapidly, and it is not yet clear to what extent the requirements regarding the specificity of construction robots will affect the design method and whether architects will have to take these requirements into account at a very early stage of conceptualisation of the idea. However, it can be assumed that this will not have such a significant impact on the creative process, as a similar situation has already occurred in the case of industrialised and prefabricated construction.

The invasion of smart technologies on architecture carries many threats, as it mostly eliminates non-measurable symbolic and aesthetic values from the design process, strengthening measurable material values related to the construction, energy and economic efficiency of spatial structures, and forces the optimization and simplification of architectural solutions. To avoid losing the cultural phenomenon of architecture, it is necessary to include the possibility of encoding symbolic and aesthetic values in the way smart technologies operate, so that they are reference points for decision-making.

6. CONCLUSIONS

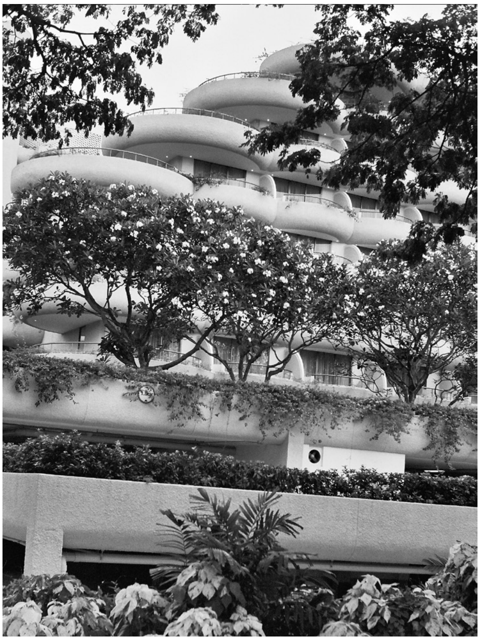
The current benefits of the information revolution for architecture can be seen primarily at the level of architectural software, which has introduced a new quality to the design process, opening up additional possibilities in the creation of architectural forms and allowing for better control of how the components of spatial structures work. Thanks to architectural software algorithms, new generations of architectural forms related to parametric or generative design have appeared. Information technologies have also enabled the creation of a platform for Integrated Design Process, which is a place of cooperation and coordination of all construction industries involved in design and executive works in architecture.

However, several threats to architecture have emerged at the same time related to the excessive dependence of the design and decision-making process on software, especially with artificial intelligence elements embedded in it. The algorithms of computer programs are mostly determined by the directions of transformations of spatial structures. While in the case of shaping the form, the architect can still independently decide which variant is better, in the case of choosing the most optimal solution in terms of energy and economic efficiency, the algorithms will decide about it. The architect will not be able to verify the choice made due to the complexity of this problem and its multifaceted nature. Taking control of the entire decision-making process within integrated design by artificial intelligence may result in the architect being completely eliminated from it.

Witnesses to the revolution rarely have full insight into the consequences that this revolution brings for the future, so it is difficult to answer the question of whether the current invasion of smart technologies on architecture is an announcement of its end or revival in some other form. However, we can try to define whether the events we can observe today form a trend. It seems that the march towards increasing rationalisation and technologization of architecture, initiated in the industrial era, will continue. The fusion of technology and ecology will put more and more pressure on architecture to become part of the solution to the problem of environmental degradation, imposing on it requirements typical of the operation of technical systems, subordinated to the rules of efficiency, optimisation, and simplification. Architecture's dependence on technology will therefore increase rather than decrease, although new generations of technology related to superintelligence, genetic engineering, biotechnology and nanotechnology will emerge over time. Additionally, the perception of architecture and users' expectations regarding the way it functions are also changing. Perhaps in the near future, users will require the same degree of interactivity and access to information from architecture as in smartphones, which will make architectural objects become something like interfaces in the urban mega-network, and architects will no longer be architects of space, but will become architects of the network.

Ill. 1. Techno-aesthetics: Nakagin Capsule Tower, Tokyo – arch. Kisho Kurokawa, photo by Ada Kwiatkowska.

Ill. 2. Techno-aesthetics: Lloyd's Building, London – arch. Richard Rogers, photo by Ada Kwiatkowska.



Ill. 3. Eco-esthetics: Green housing architecture, Singapore, photo by Ada Kwiatkowska.

Ill. 4. Smart-tech: Torre Glòries, Barcelona – arch. Jean Nouvel, photo by Ada Kwiatkowska.

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