Formation of Sustainable Development of the Architecture of the Future in the Context of the Information Paradigm

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Keywords: Global information system, Society 5.0 strategies, Big Data technology, Smart city, Integral space, Sustainable development, Architecture of the future

Abstract: The article discusses ways to form sustainable development of the architecture of the future in the context of the information paradigm. The purpose of the article is to identify trends in the formation of an integrated information space interactively connected with the living environment. The theoretical platform of the information paradigm and the prerequisites for its emergence are substantiated. The evolution of sustainable development of architecture is determined in the context of the "Society 5.0" strategy, using information technologies of cybersecurity, artificial intelligence and robotics. The use of "Big Data" technology in the formation of the "Smart City" concept in terms of intelligent automated control systems is considered. The tools of interactive technologies for the formation of the architecture of the electronic era have been identified: a global information system of interaction in architectural design with the development of a new holistic hybrid communication environment. It is noted that the integral space and the global information and communication environment have a complex relationship with the intensification of means of communication. The results of the study can be useful for the theory and practice of shaping the living space of the future, as they open up completely new possibilities for its architectural design.

1 INTRODUCTION

The rapid progress of information technology and telecommunications that has emerged throughout the world contributes to the fact that information is becoming one of the main economic resources for the development of society. Information networks form a new global information and communication environment for life, communication and production, and also create opportunities for the creation and development of network structures in various areas of public life. In a dynamically changing society, the role of architecture is being transformed in the context of the new strategy "Society 5.0" and information technologies such as "Big Data".

New information technologies are changing the idea of architectural design, as the capabilities of technology are being integrated with the corresponding human needs. In connection with the global information system as an integrated information space, interactively connected with the living environment, innovative approaches to providing information and organizing its consumption can be introduced when creating appropriate architectural objects.

The role of architecture in a dynamically changing society is transforming. Computer technologies used in architectural activities have significantly changed the possibilities of designing of vital activity objects. Information design is becoming the leading direction of architecture, which uses concepts such as interactivity, a virtual reality, parametric design (Saprykina, 2017).

With the advent of new technologies, the formation of a new aesthetics began, the so-called free form, where the ideas of dynamism, fluidity and synergy become the dominant and active elements of shaping in architecture. The implementation of this in practice is possible thanks to digital technologies and cybernetic mechanisms. As a result, architecture has the ability to change, which allows the structure, form and function of an architectural object to acquire interactivity and automation properties. Происходит

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моделирование объекта как некого организма, основанного на идее самоорганизации эволюционирующей системы (Gogolkina, 2018).

In this regard, it is of interest to consider the evolution of the formation of the architecture of the future in the context of the information paradigm of the development of society on the basis of objective methods developed in information science, which studies space and spatial organization of information and information systems (Saprykina, 2018). Due to the relevance of this problem, it seems appropriate to consider new approaches to the formation of the information space of the future as a separate category of the architectural environment in the context of the following areas.

2 MATERIALS AND METHODS

2.1 Theoretical Platform of the Information Paradigm and the Prerequisites for its Emergence

2.1.1 Evolution of Sustainable Development of Future Architecture in the Context of the Strategy "Society 5.0"

The declining amount of the planet's internal resources and the sharp drop in living standards necessitate a qualitatively new approach for the further development of society. An effective solution in this situation is the creation of an interactive and intelligent system for managing the country's economic development (Baitenov, 2020). In this regard, to improve the quality of human life, the recently emerged "Society 5.0" strategy is to solve social problems through the integration of the digital environment and the physical living space. It should be noted that the previously created strategies "Society 1.0 and 2.0" were based on and associated with the development of agriculture. At the next stage of the industrial revolution, the "Industry 4.0" strategy emerged, associated with the construction of smart factories and the penetration of innovative technologies into all spheres of life (Sawyer, 2017).

The model of a "super-smart" living environment within the framework of the "Society 5.0" strategy proposes the creation of integrated intelligent systems in all areas of activity in the context of sustainable development. According to the developers, this will be realized through the use of components that apply technological advantages in the following systems: robotics, drive technology, biotechnology, human interface technology, materials and nanotechnology, light and quantum technology, innovative methods of measurement, information and energy transfer (Vorozhikhin, 2016).

Many technologies that have already changed industrial production play an important role in solving social problems and transforming society to create comfortable conditions for its existence in the future. In these developments, in order to create a mutually agreed upon development of the economy and society, the main attention is paid to the rational development of energy, environmental conservation issues, the development of automation of organic farming and livestock breeding, and the qualitative development of industry. The logic of development of the vital activity environment determines an alternative understanding of architecture as a new spatial system (Balatsky, 2007).

Creating a "smart", safe and comfortable human environment is one of the objectives of the "Society 5.0" strategy as a super-intelligent society, with the aim of its technological and social development. The strategy is aimed at solving global crises that arise simultaneously with the acceleration of the pace of social life and the merging of material and cyberspace. This leads to the emergence of new opportunities for movement, automation of life support and transport systems, as well as the need to form completely new spatial typologies (Kurcheeva, Bakaev, Klochkov, 2020).

An example of this concept is the project "*House of the Future Inspired by the Matrix*" (author Kuangyi Tao) 2011 (USA), responding to emerging modern problems of overpopulation, lack of resources, etc. Using the concept of "cell body" development, a house design is proposed that is based on a system of energy and information exchange controlled by its inhabitants. The main infrastructure of the house frame is created from an alloy of memory plates, which can be located at a distance from each other. The overlay computer network used in this project operates by analogy with the work of the heart shell. The proposed material is electrically sensitive and is capable similar to cardiac muscles can expand or contracting by the various electrical stimulation. Such material reacts to changes in the object's program, for example, more intensive filling in a room leads to the expansion of its shell and an increase in space. The spatial concept of a house is similar to a living organism, capable of independently organizing and functioning depending on the changing needs of its inhabitants (Tao, 2011).

It is predicted that in the near future, many professions not related to creative search will be eliminated and replaced by automated systems in order to save resources. Architecture can provide innovative approaches to achieving the goals and initiatives of the Society 5.0 strategy. Ensuring the continuous growth of social sustainability in times of crisis becomes possible through the formation of a living space as an alternative ecosystem.

2.1.2 Use of Big Data Technology in the Formation of the Smart City Concept

Architecture as a system for the formation of artificial space is influenced by the innovation revolution taking place in the world in the context of the development of scientific and technological progress, new areas of knowledge are being attracted to architectural research, which makes it possible to form a completely new urban space that provides quality of life. Therefore, society faces the problem of ensuring sustainable coexistence of cities with the environment without causing critical damage to it.

This paradigm is implemented in the concept of forming a “Smart City” as a new integrated living environment, which includes a set of environmental problems aimed at searching for new forms of urban space using innovative engineering technologies. The new trend of a sustainable city as a complex system of metabolic processes will require a deep rethinking of the ways of its planning and management (Saprykina, 2018).

In this regard, for the integrated formation and management of a Smart City, it is advisable to use Big Data technologies in urban planning, territorial zoning, as well as in solving transport problems, security issues and social comfort. It should be noted that the concept of using Big Data can also help in solving issues of human life safety and improving transport and pedestrian communications using intelligent automated control systems (Volynskov, 2017).

At the present stage of the scientific and technological revolution, science is transforming into a leading element of the productive forces, and scientific activity is turning into a leading branch of social production. One example of the manifestation of this trend is the project “*Inform City*” (author V.I. Bodyakin) 1992 (Russia), which is a self-developing socio-economic and architectural structure. Its main task is complete information support and management of the regional infrastructure. In Inform City, in addition to the main information and management task, the entire range of production, household and leisure issues can be comprehensively solved, and many modern acute environmental problems can also be solved along the way. The project technologically merges three important areas of development: the cultural and historical component, high information and progressive socio-economic technologies. Such architectural and information facilities can have an intercontinental, regional and national level in terms of capacity with scientific, information, coordination, management and production content. Information and dispatch management and technology centers do not require a large number of service personnel and can be located at a considerable distance from each other. These new forms of providing information and organizing its consumption may well be introduced when creating appropriate objects in the global system of electronic architectural information centers (Bodyakin, 1993).

The development of information technologies for transmitting information makes it possible to create new opportunities for accessing it and servicing it, which cannot be implemented and used without powerful information centers for storing, creating and using these resources. In this regard, the use of space communication potential, which is closely connected with the information system, is of particular importance. To use an information resource, a different technological level is required, improvement of means of storing and transmitting information, as well as its full interactivity (Gogolkina, 2018).

An example of the implementation of such an approach is the project proposal “*Data Skyscraper as the Sustainable Data Center in Iceland*” (authors V. Mercuri, M. Merletti) 2016 (Italy), which is designed to host various servers used by many types of companies for store and process all the information data created on a daily basis.. Modern data centers consume a lot of electricity and have a large “carbon footprint”, and equipment must be constantly cooled to avoid overheating. The proximity to the Arctic Circle allows using the cold and fresh sea breeze to cool servers, avoiding the cost of a traditional cooling system. From the outside, the center is a cylindrical tower, on the outer façade of which all hardware components are mounted. In addition, the tower façade is a flexible and continuously evolving system that changes, if necessary, the density and position of equipment elements, which allows you to freely change and increase the height of the tower (Mercuri, Merletti, 2016).

According to some researchers, the use of information storage and processing centers in the future will make it possible to create complex objects and systems in almost all parts of the city, where engineering equipment will become part of its infrastructure network using Big Data technology (Gnevanov, Ivanov, 2018).

These trends are further developed in proposals for the creation of a secure archive to preserve the world's heritage and the world's most remarkable achievements. This is because, over the centuries, many cultural relics, works of art and manuscripts have been destroyed in social and economic conflicts. An example is the project "*Data Cemetery Skyscraper*" (authors Joanna Targowica and Mateusz Binkowski) 2017 (Poland), which is based on the concept of an ever-changing world that needs a new kind of environmental object in order to perpetuate the cultural impact of people on society. The proposed architectural object is presented as a memorial tree that, due to its structural integrity, can survive harsh environmental conditions and natural disasters. Denser branches are a sign of natural disaster, war or epidemic, thinner branches represent peacetime. Information data stored inside the diamond memory is guaranteed against destruction, so the "cloud" archive, according to the authors, will be the greatest achievement of humanity and, especially, after a global cataclysm (Targowica, Binkowski, 2017).

2.2 Tools of Interactive Technology for Forming the Architecture of the Electronic Age

2.2.1 Global Information System of Interaction in Architectural Design

To identify trends in the development of the information space of the architecture of the future, it becomes advisable to consider the general direction of creating objects located in the operational field of architecture and urban planning, which use the latest information technologies and resources. This concept allows not only to understand the importance and necessity of updating the global information system in the context of the theory of knowledge, but also to determine general approaches to its formation (Ptichnikova, 2020).

New information technologies are changing our understanding of architectural design, which is a multi-level system, which necessitates the development of a new holistic hybrid environment for architectural design. The result is a hybridization of object, space, and process and design environment. A communication environment emerges, which includes means of presenting a project idea, tools for managing the project process and information support systems. The main principle of the hybrid architectural design environment is interaction through a computer, rather than interaction with a computer (Asanovich, 2007).

In accordance with the demands of the time, the information space is being allocated into a separate category of the architectural environment, based on the analytical systematization of factors and the optimal use of the ever-increasing capabilities of modern digital technologies. In this case, there is a shift in emphasis and modification of the phenomenon of architecture away from its materialization into virtual, unreal architecture. Information approach in architecture appears as the relationship of two spaces: architectural and information. Incorporating the digital world into the real world requires consideration of a model of interaction between these two spaces and a model of the language of communication, as well as a model of the architectural design process (Asanovich, 2007).

The use of this approach is especially necessary when creating a system of connections between participants in the design process using digital technologies in the development of buildings of complex geometry. This requires the creation of a unified system for integrating data obtained during the design process into ordered models that allow a complete picture of the object. These models contain all the data regarding building geometry, function, materials, maintenance and much more.

With the advent of new technologies, the formation of a new aesthetics began, the so-called free form, where the ideas of dynamism, fluidity and synergy become the dominant and active elements of shaping in architecture. At the same time, architecture has the ability to change, which allows the structure, form and function of an architectural object to acquire interactivity and automation properties. The object is modeled as a kind of organism based on the idea of self-organization of an evolving system. The development of architectural and urban planning objects in the future lies in the plane of parametric and generative design. These methods are based on the creation of a mathematical model that allows changes to be made to the parameters of an object and the relationships between them, as well as to a general algorithm that serves as a basic template for creating a specific object (Saprykina, Saprykin, 2012).

An example is the complex spatial structure of the future metropolis "*Cybertopia: Future of an Architecture Space, Death of Analogous Cities*" (by Egor Orlov) 2015 (Russia), which is formed and organized simultaneously in digital and physical space, while a completely different topography of the city is expected. The entire complex is formed by a frame structure on which cranes, components and entire blocks move. Some of the housing stock may be fixed into the structure immediately after construction is completed or deliberately left as a potential opportunity for further transformation and change in the future. The residential sector of the skyscraper is a constantly growing and developing spatial complex. A series of frames and spatial elements, 3D printed or formed by drones, act as structures for subsequent local integration and modification. The central axis of the complex contains a monorail on which a printer moves, which prints and in some cases erases spatial structures. At the author's suggestion, huge airships dock at the complex and immediately become part of this object, its organic connection and spatial cell. After being saturated with objects, the airship sets off on its next voyage and, upon arrival at a new port city-metropolis, is connected to the new structure for an indefinite period, as an additional spatial block (Orlov, 2015).

These design methods involve the creation of an integrated space that interacts interactively with its environment and has the ability to adapt depending on changing conditions. The combination of real and virtual elements of the space itself allows it to be in constant motion and change. This is due to the fact that currently the living space, which ensures the formation of people's daily lives and their interaction, is undergoing significant changes under the influence of the development of information technology.

2.2.2 Integral space and global information and communication environment

The development of electronic communication and information systems makes it possible to significantly reduce the dependence between spatial proximity and the performance of many functions of daily life. This is due to the currently actively developing ultra-fast and ultra-long-range means of communication. At the present stage of social development, the formation of communication connections as the most important elements of the sociocultural space is of global importance. They influence the formation of the entire system of spiritual values and needs of humanity. An information resource becomes a socially integrating factor (Dutsev, 2020).

The global information and communication environment radically changes the conditions for cultural exchange and interpersonal communication in the city, and also erases spatial, temporal, social, linguistic and other barriers. This leads to the possibility of creating new forms of virtual communities, united only by their own sociocultural preferences. The information space of the city, as part of the sociocultural space, provides new opportunities for the development of personality and to the city's putting forward new demands on the individual consciousness and behavior of the inhabitant, which are unthinkable without that mental property designated as "information activity" (Dutsev, 2020).

Human progress is symbolized by modernization and globalization, but for all the conveniences they bring, they also absorb the key components of life: people's senses, sensory information and emotions. The "*Sensory Skyscraper*" project (authors V. Mercuri and M. Merletti) 2016 (Moldova, China) is a multifunctional laboratory for scientific research on human feelings, perception, rehabilitation of sensory information, rehabilitation of the effects of experience, motivations and expectations, etc. This lab is a cube that creates a combination of 6 pyramids that reflect how the human brain works to process different senses. Within each pyramid there are certain patterns that show functional sectors, each of which represents an open space for different types of perceptions and feelings. The pyramids can move separately and vertically, since the cubic shape is controlled by magnetic force, and the mobility of the pyramids is completely fixed. Magnetic energy is invisible and strictly controlled without harming the environment, so the object looks like an object floating in the air (Sharkov, 2015).

The intensification of communication through information technology leads to the emergence of a virtual parallel environment as a model of an alternative to the social world. Virtual space is able to repeat all the trends of real space, which is used in various fields of activity. So, in order to restore disappeared natural artifacts and entire agglomerations that have not survived to our time, with incomplete historical documents and the absence of recording the features of the natural landscape, the creation of cyberspace makes it possible to create a virtual model of this situation.

In this regard, the proposal of the skyscraper "*Memory Cube Skyscraper*" (by Keyi Shen, Zichao Zhong, Dingyu Li, Jian Yan, Yuan Zhang) 2019 (China) intends to play the role of a historical set designer and simulator of a real picture of landscape images for future people. The skyscraper carries out image simulation by collecting material parameters of the physical state, such as wind, wind speed, temperature, humidity and other basic environmental parameters. With these physical parameters, the simulation is no longer a simple display of an image, but allows people to experience the most authentic feelings on an educated stage. This building will be both a data storage center and a stage simulator for displaying historical attractions (Pincer, Chang, 2016).

Wireless connections make not only people mobile, but also things. As more and more people's lifestyles are connected to the Internet, the use of "flying robots" could easily become a common part of daily life in the future to meet the emerging demand for incorporating advanced drone technology.

As an example of this trend, a skyscraper project for landing unmanned drones "*The Hive: Drone Skyscraper*" in New York (authors Hadeel Ayed Mohammad, Yifeng Zhao Chengda) 2016 (USA) was developed. The facility is a central control terminal housing docking and charging stations for personal or commercial drones in midtown Manhattan. Modules on the skyscraper's "living façade" are designed for nine different types of drones. To ensure a secure landing on the vertical chassis around the tower, the drones are attached parallel to the façade, and to maximize surface area, two overlapping layers are proposed - outer and inner. Flickering lights on each station module help to fulfill navigation conditions and also indicate the fullness and capacity of the building (Shen, Zhong, Li, Yan, Zhang, 2019). Good wireless connectivity is especially important in areas with poor roads and undeveloped areas. People's activities increasingly rely on mobile communications across geographically dispersed spaces.

3 DISCUSSIONS OF THE RESEARCH RESULTS

As a result of the study, the areas of use of information technologies in architectural activities that have significantly changed the possibilities of designing architectural objects have been considered in scientific and design developments. This made it possible to identify tools for their formation and identify some concepts for solving this problem in the following areas.

1. Theoretical platform of the information paradigm and the prerequisites for its emergence:

• *The evolution of sustainable development of architecture in the context of the Society 5.0* strategy is associated with a new vision of a sustainable spatial living environment using information technologies of cybersecurity, artificial intelligence and robotics. Ensuring the continuous growth of social sustainability in times of crisis becomes possible through the formation of a living space as an alternative ecosystem.

• *The use of "Big Data" technology in the formation of the "Smart City"* concept as a new integrated living environment is implemented through the use of intelligent automated control systems to ensure safety, solve transport problems, security issues and social comfort. Information technology allows the successful development of cities without direct spatial dependence on developed infrastructure, that is, without the creation of large transport highways and energy networks.

2. Tools of Interactive Technology for Forming the Architecture of the Electronic Age:

• *The global information system of interaction in architectural design* is associated with the development of a new holistic hybrid communication environment, which includes means of presenting a design idea, tools for managing the design process and information support systems. These design methods involve creating an integrated space that interacts interactively with its environment and has the ability to adapt to changing conditions.

• *Integral space and the global information and communication environment* radically change the conditions for cultural exchange and interpersonal communication in the city, and also erase spatial, temporal, social, linguistic and other barriers that influence the formation of the entire system of spiritual values and needs of humanity. The intensification of communication through information technology leads to the emergence of a parallel virtual environment as a model of an alternative to the social world, which is able to repeat all the trends of real space.

4 CONCLUSIONS

Thus, the typology of architecture is replenished with new types of architectural objects, which are scientific and information denominators of the era. Traditional architecture can no longer meet the needs of dynamically developing scientific progress, which uses the latest information and technology developments. Intellectual information resources have a small material and resource component and energy intensity, as well as dynamism, easy replication and social integration.

Architecture must become interactive, responsive and adaptable to the needs of each person. In the architect's work, concepts of the future are created and innovative ideas for using information design methods in architecture are materialized. This has grown into a rapidly developing branch of architecture with the potential to dominate contemporary art in the near future. The results of the study can be useful for the theory and practice of shaping the vital activity space of the future, as they open up completely new possibilities in architecture.

ACKNOWLEDGEMENTS

The work was carried out with financial support from the Fundamental Scientific Research Program of the Ministry of Construction and Housing and Communal Services of the Russian Federation and the Russian Academy of Architecture and Construction Sciences of 2024. Research project 1.2.3.2 "Strategic resources for regulate of the instability of the residential environment: archetypes of sustainability."

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