THESAURUS OF PARAMETRIC FORMATION PARADIGM
ARCHITECTURAL SPACE

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Abstract. The realities of the existing ecological crisis raise the question of the need to create new methods in the approach to the design of an architectural habitat adapted to the surrounding nature. The paper discusses the principles and approaches of biomimetic design of the architectural environment, taking into account the ecological state of nature in Ukraine. At the same time, we are talking about the creation of a completely isolated, self-sufficient, self-contained ecosystem that will fully meet all the necessary requirements for the biological functioning of the human body and includes the natural environment with residential objects harmoniously embedded in it. The solution to these questions is possible with the integrated use of modern design methods in an adaptive architecture environment.

1 Introduction
The rapid development of technology leads to the inevitable change in the space around us. At the dawn of his existence, man sought to adapt to his environment, used natural shelters, existed in unity with nature. However, from the moment the first artificial dwelling was created, he became convinced of the possibility of protecting his existence by isolation from the environment. In our opinion, this was the source of the contradictions between man and nature, the depth and scale of which increased with the development of human civilization. In the middle of the twentieth century, these contradictions acquired a global, deadly nature for humanity [1, 2].

Destructive processes, already launched by nature on a planetary scale, began to cause concern not only among esotericists and members of religious sects but also among the governments of most countries of the world [3]. The increasing frequency, destructive power, and, most importantly, the factual impossibility of a long-term forecast of the occurrence and prevention of climatic collisions are causing increasing concern.

The central and eastern part of Ukraine is currently in illusory security, but the state of strategic waterways of the state, the critical pollution of small rivers (water resources), the ongoing process of burning and decay of peat deposits and the forest fires provoked by them are already causing great concern. Recent information about smog hanging over the capital of the state, the global coronavirus pandemic, the threat of activation of seismically dangerous zones, which are geographically tightly close to Ukraine, require a very serious and responsible attitude to the issue of environmental degradation of our habitat. Professional environmental analysts generally raise the question of the survival of the human race on our planet in the framework of the familiar and necessary conditions of existence [4, 5].
One of the important environmental problems is the rapid growth of urbanization and the global technicalization of society, which entails an increase in the imbalance between nature and the human environment. The adaptation of man to an artificial urban environment contributed to the transformation of his perception of nature itself as a resting place, and not a living environment. Figure 1 shows a diagram that characterizes the degree of environmental pollution of cities in Ukraine.

A distinctive feature of our time is the ever-growing dynamism of society, associated with the high pace of development of new technologies, expanding the scope of people’s activities, increasing migration, population mobility, etc. According to sociologists, the structure of modern society has not finally formed and is in very complex dynamics, there is a fuzzy and vague social boundary, mobility of the vertical section of society when a person under the influence of various factors can change his social status at different periods of life.

![Figure 1. Indicators of environmental pollution of Ukrainian cities (according to the Central Geophysical Observatory) [6]](image-url)
Since the issue of caring for the environment on a planetary scale looks like a utopia, a local solution to the problem of human survival in an already unfriendly environment is necessary.

Prerequisites for the creation of ecosystems
The realities of the existing environmental crisis raise the question of the need to create new methods in the approach to designing an architectural habitat adapted to the surrounding nature. Unfortunately, this new habitat can no longer be called simply the term “housing” in the usual sense of the word. It should be a completely isolated, self-sufficient, self-contained system that will fully comply with all the requirements for the biological functioning of the human body.

We are talking about creating a new ecosystem, which includes the surrounding natural environment with harmoniously embedded residential objects in it.

Such an ecosystem should be considered as a model of aggregates and relationships between its components:
- the functioning of all artificial objects of the system should be carried out in a closed cycle;
- creating a cycle of continuous wastewater treatment to reuse them as a renewable resource;
- disposal of solid waste using non-energy-intensive technologies and their reuse as raw materials for new building materials, fuels, fertilizers;
- providing water and food in the required amount utilizing mainly domestic resources;
- the energy supply of all technological processes due to alternative renewable energy sources.

At this stage of the creation of the project, in our opinion, the need arises to pose and resolve the following issues:
1. an adaptation of architectural objects to the environment due to the variability, flexibility, mobility of the architectural form, where continuous in time transformation becomes one of the types of their existence;
2. reliable life support due to the most economical consumption of available natural resources, environmentally friendly disposal of waste through their processing and reuse;
3. the correct choice of tools and methods at all stages of the design of such complex systems;
4. the selection of a reliable contractor for the implementation of the design and construction phases with the provision of their modern building materials.

The solution to these questions is possible with the integrated use of modern design methods in an adaptive architecture environment.

Adaptive architecture as a means of ecosystem formation. The search for an architectural form depends on the functional purpose of the structure and the area of the construction site. In our study, we focused on the natural environment.

In connection with the tendency of a steady increase in air temperature in Ukraine, the usual geographical boundaries of climatic zones are changing: the zones of arid territories from Odesa and Kherson regions are expanding towards the center of Ukraine (Fig. 2), the amount of precipitation in the Carpathian region and all western regions is growing (Fig. 3).
One of the promising areas in the field of shaping in adaptive architecture is biomimetics - a method of creating architectural objects when borrowing ideas from wildlife. With a biomimetic approach, architects do not just copy natural images but carry out a detailed analysis of the principles of the living world and the harmonization of natural and architectural environments [7].

Inspiration in nature was found by many famous architects and designers - Alvar Aalto, Antonio Gaudi, Bruce Goff, Buckminster Fuller, Gustave Eiffel, Zaha Hadid, Imre Makovets, Rudolf Steiner, Santiago Calatrava, Hugo Hering, Fry Paul Otto, Frank Lloyd Raynitez, and etc.

Architects have long used biomimetic principles in many structures. At the same time, they do not just copy the external form of natural analogs but take into account the nature of their structure, specific properties. Examples of this are shown in Fig. 4.

Biomimetic design principles can solve a number of urgent problems in architecture: the artificial habitat becomes more resistant to external influences, more comfortable and convenient for humans, and less harmful to the environment, more expressive. The formation and development of adaptive abilities of the artificial environment based on the study of ontogenesis and phylogenesis of living organisms occupy a special place when using biomimetic principles (Fig. 5).

The biomimetic concept of shaping is based on the possibility of practical associative application of
the ideas of nature in architectural design to create effective ecosystems harmoniously integrated into the environment. Much attention is paid to the study of evolutionary processes during which living organisms adapt to changing environmental conditions. Since biomimetic design at different levels of the ecosystem takes into account organizational, production, and technological life support strategies, it refers to sustainable architecture.

| Construction | Natural analogue | The nature of the analogy | The nature of borrowing |
|--------------|-----------------|--------------------------|------------------------|
| High-rise pipes | Stalks of cereals | The sclerenchymal strands of the plant stem play the role of longitudinal reinforcement. The internodes of the stems are rings of rigidity. Oval vertical voids are located along the walls of the stem. | Subconscious: The complete analogy was determined after the pipes were created. |
| Eiffel Tower | Human shin bone | Spongy tissue structure in the femoral head. The relationship between the formation of bone structure and external stress. | Conscious: Anatomy professor Hermann Von Meyer identified a network of ossicles with a strict geometric structure in the femoral head. Engineer Carl Cullman has theoretically substantiated load distribution. Natural load distribution using curved calipers was used by Eiffel. |
| Funicular Nordpark, Innsbruck, Austria, arch. Zaha Hadid | Sea clam shell | The layered structure of the shells ensures their resistance to external influences. | Conscious: The use of layered composite materials allows the use of complex architectural forms and ensures their structural reliability |
| Vertical bionic city-tower arch. Maria Rosa Cervera and Javier Pioz | Cypress | The shape and structure of the cypress crown, the structure of the root system. | Conscious: based on the growth and development pattern of cypress, the heat-regulating function of the skin for the outer cover. |

**Figure 4.** Examples of the use of biomimetic principles in architecture

If we consider the systematization of the borrowing of biomimetic principles, now it is worth
highlighting the system developed by Janine Benius, an American researcher in the field of biomimetics, and supplemented by Pedersen Dawn. This scheme consists of two cross-systems, one of five types of borrowing - form, design, material, process, and function - and the other of three different levels of borrowing - the organism, behavior, and ecosystem. It turns out that this system allows you to comprehensively evaluate the borrowing of natural characteristics in an architectural project.

Types of borrowing reflect the elements of wildlife that are studied, analyzed, and used with the necessary characteristics. Borrowing levels reflect which particular object or group of objects has been studied. At the level of the organism, living organisms are studied, their structure, behavior, and vital functions. At the level of behavior, what has been done by a living organism, for example, to build a house or other structure, is investigated.

![Figure 5. Biomimetic design principles](image)

At this level, the shape of the natural object, the design features, the qualitative characteristics of the material, the principles of its functioning are also investigated. The third level, which involves the study of the ecosystem, explores complex natural systems, that is, the interaction of various living organisms and the environment itself as, on the one hand, the conditions for their interaction, and, on the other, its result. The third level is the most difficult to study and requires close cooperation of natural scientists and architects to achieve maximum effect. But at the same time, it is most effective in achieving a sustainable and comfortable architectural environment that can exist in harmony with nature.

**Biomimetic design solution analysis**

The artificial environment is becoming increasingly responsible for global environmental and social problems associated with the huge amount of waste, materials, and energy, as well as the greenhouse gas emissions associated with the habitats that people have created for themselves [8, 9]. It is becoming increasingly apparent that changes need to be made to how the created environment is created and maintained. Simulating the complex interactions between the living organisms that make up ecosystems is a robust perspective for human habitats.

By the end of the 20th century, architectural composition finally got rid of the classic constraints of a global geometric prototype, symmetry and proportion. The compositional process can now be almost completely open to the final configuration of the project.

Computer technology has radically changed the nature of design, consistently shifting the emphasis from 2D drawings to 3D information models. Modern design includes comprehensive linking and
comparison of information not only in the development and design of an architectural object, but also in the process of forming its original image.

The parametric approach requires new design thinking and deep knowledge of computer programs. This approach is necessary to create complex geometric and fundamentally new, unexpected shapes. The symbiosis of the architect's creative thinking and the capabilities of digital virtual reality modeling technologies allows us to take a fresh look at rethinking the role of form in architecture in the context of creating a comfortable and safe spatial environment.

A distinctive feature of the activities of researchers and practitioners in the framework of the parametric orientation is:
- the use of methods of interactive computer design and morphogenetic methods of modeling the architectural form;
- the application of complex computational geometry using advanced design techniques such as Tel-script or Rhino-script (Figure 6) and parametric modeling [10-12];
- creation of architectural forms capable of responding to changes in conditions without current human control, with the correction of structural and planning decisions.

![Figure 6. Examples of creating complex geometric shapes using Rhino-script](image)

Geometric modeling is the process of sequential creation of the structural geometry of an architectural object, based on the specification of an information array. Geometrization of an object, spatial design in three-dimensional modeling are necessary components for solving problems of parametric architecture, which can be used in the practice of designing various objects and which make full use of modern information technologies.

Conclusions

The discourse proposed in this article is still a theoretical prerequisite for the creation of ecosystems based on the use of biomimetic design, which requires testing their ability to function in a sustainable and even restorative manner. The use of systemic biomimetics to simulate the functioning of ecosystems will allow for a deeper understanding of the nature of interaction in the "man-environment" system.

The main challenges faced by parametric architects are:
1. lack of customer knowledge;
2. insufficient funding;
3. difficulties in production (many manufacturers are not ready to solve complex non-standard tasks)
4. difficulties in mastering the software product.
Parametricism opens up wide opportunities for introducing innovative developments in architecture in related areas of knowledge, technical capabilities of new structures and materials, while it is necessary to work with complex information models of architectural objects based on computer technologies.

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