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PARAMETRIC MODELING OF URBAN DEVELOPMENT

Abstract: *The article deals with parametric modeling, transforming the silhouette of the city. The examples of urban architectural dominants built in the last twenty years in different countries of the world are studied. The examples of parametric architecture that influenced the topological frame of the cities are analyzed. The basic principles of parliamentarism and the phasing of increasing importance in urban development are revealed.*
Keywords: *computer programs, parametric architecture, modern technologies in design, three-dimensional graphics, urban morphology.*

Introduction

Technologies of the end of the XX century and the beginning of the XXI century make us reconsider the approaches to architectural design and shaping. The world's leading architects are increasingly paying attention to the modern world, in which electronic devices are widely used. Many of architectural projects of the recent twenty years visually resemble the network of the cyber space or the architecture of a science fiction movie.

Conditionally architecture can be divided into two types: "digital", created with the help of a computer, and "pencil", designed without the use of the computer technology. Using a computer involves working with special programs; each of them is responsible for a certain stage of an object development [1]. The design of modern architectural objects increasingly involves the use of non-linear compositions, various forms of simulations that have an impact on the morphological structure of the city and often become the main species points. In cities with a relatively regular planning structure, these objects have an impact on the volume frame of individual areas, thereby changing the planning structure. The more there are elements of such buildings, the more influence they have on the city morphology. An example of these changes can be Dubai, London, Moscow, Kuala Lumpur, Singapore, Beijing, etc. In this regard, it is possible to trace the relationship between the development of modern computer programs in the field of architecture and morphological changes in the structures of modern cities [2].

Methodology

Thanks to the modern technology, where the main role is given to the use of computer programs, architects are taking a course on parametric, increasingly abandoning postmodernism and deconstructivism. This is due to the possibility of creating more advanced and natural forms, for which natural formations serve as a prototype [3,4]. Based on the parametric formation laid down in the first place it is not a direct imitation of some individual parts of the land terrain, flora or fauna; the creation of objects on a random basis depends on many external and internal factors. For example, rocks are formed by docking tectonic plates, rising up, they are exposed to wind, temperature, time, that in its turn forms the appearance, that is morphology. At the same time, these factors have a continuous impact, and changes occur constantly. It is possible to draw Parallels between these processes with morphology of both modern and ancient cities. The constant changes of the planning structure take place, changing viewpoints, new architectural dominant, older areas disappear and new border of the urban fabric occur.

Parametric architecture is based on discoveries in the field of mathematics, which in many cases help to describe the principles of natural forms with the help of algorithms. Diagram by G. F. Voronoi, a Russian mathematician (late XIX - early XX century), is used in many computer parametric programs and it consists of loci in the form of convex polygons, allowing to break the space or plane into areas, which form a set of points located closer to one of the elements than to all the others (Fig. 1). The examples of the diagram can be seen as in the nature as well in the architecture [5], (Fig. 2).

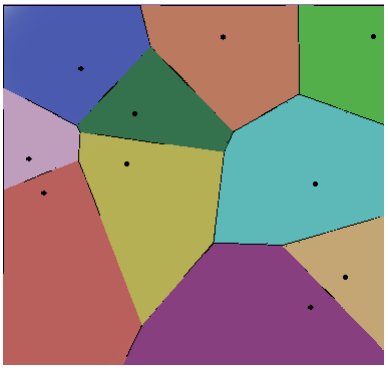

Figure 1. Diagram by G. F. Voronoi

Figure 2. Examples of G. F. Voronoi's diagram in the nature and architecture

The second parametric dominant is triangulations by B. N. Delaunay, a Soviet mathematician who developed G. F. Voronoi's ideas (the first half of the twentieth century) [10-11]. The essence of triangulation lies in a given set of points on the plane, where each point of the set, except for the vertices, lies outside the circle described around this triangle. Using this method, you can describe any natural algorithm, for example, "minimal spanning tree", in the construction of which the branches or connections connect the points of a certain set so that the sum of undirected graphs (edges) has a minimum "weight", where the weight is the sum of weights of all edges (Fig. 3). An example of finding the spanning tree can be the task of building a road network between several cities, where the cost of each road between the two closest cities reduces the total construction cost. In architecture and construction, this method is used for topological optimization for the construction of genetic algorithms, in which millions of possible parameters are calculated with a given end result for the selection of structures with a minimum weight and sufficient rigidity. This became available with the advent of supercomputers, and architectural and spatial forms are unique, reminiscent of its natural plasticity (Fig.4).

Measurement and analysis

One of the first objects using computer technology that served as prototypes of BIM technology, became the Museum. Guggenheim Museum in Bilbao by Frank Gehry in 1997 and

the tower of St Mary axe in London by Norman Foster in 2004 are the buildings that had a large impact on the morphological structure of the areas due to their unusual shapes. The end of the twentieth century can be considered as a starting point of the "computer" architecture application. Currently, a large number of buildings already in the style of parametricism rise in many of the largest cities in the world. Technologies have allowed carrying out a full transition of architecture to non-linear forms, setting new conditions for the formation of the space-planning structure of districts and cities. Ferrari world Abu Dhabi theme Park (Fig .5) is the main dominant in the formation of a new district. The road network is formed around the smooth shape of the buildings, with almost no straight lines. In Dubai, large areas have been built based on the planning structure that lay on the non-linear networks of streets, the forms of which have been influenced by the architectural objects and surrounding areas. At the sample of Dubai it is possible to trace new tendencies to street planning. The first parametric objects have been formed "separately" from the General urban development that sought to correct the geometry of the buildings and streets, which caused dissonance in the morphological frame, often found among European and Asian cities. The adjacent territory, designed in the same style, made adjustments to the formation of neighborhoods, but still had a nuclear character. The sprawling network of roads for subsequent construction has been formed under the influence of buildings and neighborhood nonlinearity. Today in Dubai, it is possible to observe areas with a new road network, in which large parametric objects are dominant, and in some areas a smooth structure is formed without the presence of parametric dominant. Similar planning decisions fit natural landscapes more naturally and do not look foreign (Fig. 6).

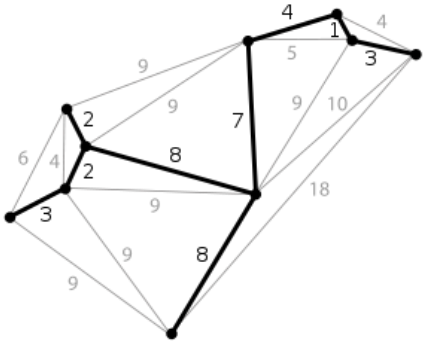

Figure 3. Triangulations
by B. N. Delaunay

Figure 4. Triangulations
by B. N. Delaunay in architecture

Figure 5. Ferrari world Abu Dhabi Park

Figure 6. Planning structure of Dubai district

Technological capabilities play a huge role in the design, the level of their development has risen to unimaginable opportunities, great promising prospects with new architectural environments based on individual principles have not yet been formed. Understanding the trend of the future, Singapore is one of the leading countries in the application of BIM technologies.

This is due to the fact that the introduction into the process of design and construction on the basis of computer programs has taken about a decade and a half, the purpose of which was the world leadership in the speed of the project examination and the issuance of building permits, as well as reducing the number of low-skilled workers (migrants).

The leader in the field of parametricism is the ZHA Studio. In the parametrization Manifesto, Patrick Schumacher examines the master plan for the Kartal-Pendik district of Istanbul, based on computer-assisted data processing, from the point of view of urban planning (Fig.7a). The objective of the project is to create a new city center in order to unload the historical part. With the help of dynamic tools of the program, the main points have been selected, which have been connected to the main highways by the main and auxiliary roads. The viewpoints of the "tower" have been located at the intersection of the road network, the height of which has been adjusted to take the topology of the earth marks into account so that there has been a correlation of the building height together with the total width of the entire building. For building blocks data have been set taking the insolation of the premises into account that has affected the availability and size of the spaces and atriums (Fig.7b). The model clearly shows the morphology of a new type of city, obtained with the use of modern technologies, taking various factors, depending on the terrain, the economy of the road network, the speed and time of communication between different parts of the district and the city into account.

A quarry has been included to the district, which becomes the main dominant in the system of urban parks (Fig.8). The spatial topological frame of the quarry has been taken into account in the morphological structure of the new district and has had a significant impact on the formation of the size of nodal "towers", creating a sense of organic unity not only in the landscape, but also in a combination of new and old buildings, giving easy urban navigation using nodal points.

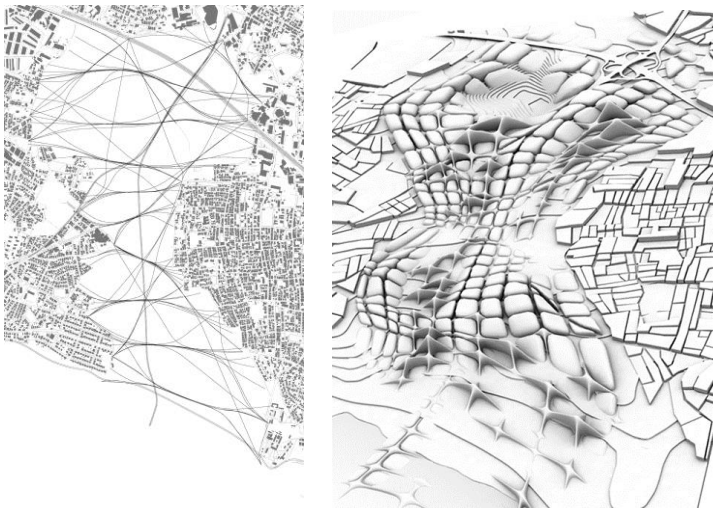

Figure 7. The master plan of the district Kartal-Pendik in Istanbul

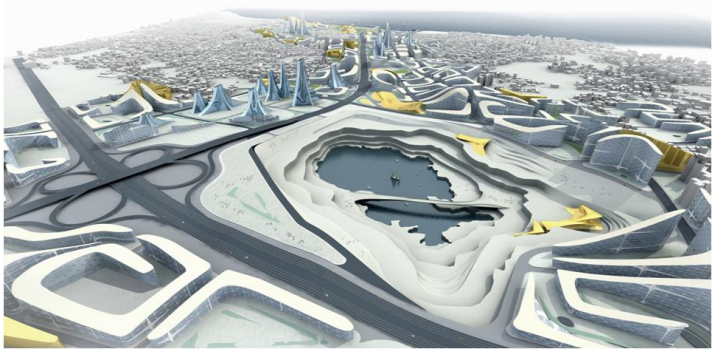

Figure 8. Cityscape with view of the quarry district of Kartal-Pendik in Istanbul

Conclusion

The influence of parametricism on the city's master plan still has a point character. It takes time to move such systems to higher levels in urban planning and designers ' minds. It is possible to trace stages of the parametrical architecture which is gradually exerting influence on an urban morphology of the cities. First, local single buildings are formed, which become a visual reference point, pressed into the format of historical buildings. To eliminate the foreignness of the characteristic type architecture, a larger area of land is allocated for new construction to develop the landscape in the same style. Gradually the importance, adaptability and functional sphere of architecture increases and there is a need to move from the locality to increase the territorial spatial structure of such buildings.

Simulation of natural shaping due to mixing various factors that affect the shaping is possible only with the help of powerful computers that have a significant impact on the work of the best architectural offices in the world. There is a gradual transition from postmodernism to parametricism, from traditional linear forms to new ones, giving complete freedom in design with maximum harmony with nature – the human natural habitat.

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