Using Bagua Trigrams in Parametric Design for Creating Planning Structure

D S Tceluko, A A Kim

1Lecturer, Architecture and Urbanistic Department, Pacific National University, Tihookeanskaya St., 136, Khabarovsk, 680035, Russia
2Senior lecturer, Architecture and Urbanistic Department, Pacific National University, Tihookeanskaya St., 136, Khabarovsk, 680035, Russia

E-mail: dima123117@gmail.com, ant.kim@mail.ru

Abstract. The article is devoted to the combination of traditional and modern methods of designing landscape complexes in China, on the example of the project of the planning structure of the campus of the Pacific National University (PNU). The traditional and modern gardens of China are considered, the basic principles of the formation of space are revealed. Feng Shui and parametricism are described as the main approaches in design. The technology of combination and application of the described methods is described in detail. Using the Voronoi diagram, Delaunay triangulation, and Bagua trigrams, the planning structure of the recreation zone was created and the main functional zones were determined. With the help of modern analogues created architectural elements, the location, shape and color of which is selected using traditional design principles. The importance of using modern technologies and the experience of traditional architecture is shown.

1. Introduction
The design process in architecture is not a systematic or procedural process. There is a process of creation and discovery that continues in the generation and testing of creative ideas. Taking into account the various limitations, architects use a wide variety of scientific knowledge as well as individual experience and beliefs in the process. Currently, the architectural space unites and binds a large number of vital functions, but the issues concerning its formation are still the subject of scientific debate.

There are a large number of tools, theories and techniques for the formation of space, each of which uses different algorithms, aims to interact with different elements and eventually creates a unique result. An excellent example in which tradition and modernity are combined is China. Many theories of the formation of space have been created over many millennia of cultural formation, many of which have found their application today. This is especially evident in landscape architecture. An excellent example in which tradition and modernity are combined is China. Many theories of the formation of space have been created over many millennia of cultural formation, many of which have found their application today. This is especially evident in landscape architecture.

Modern gardens in China can be divided into two groups: using traditional methods of creating parks and proponents of parametric design. The first actively use the experience of classic Chinese garden and park complexes. The architectural elements are easily to read, the combination of modernity and tradition is evident both in the general planning decisions and in separate park scenes such as the Park...
on the site of the shipyard, the city of Zhongshan, the park of Xiaoyuan, Tianjin, Houtan Park, Shanghai. The second group actively uses parametric methods in all stages of design. Study of the object’s relations with the architecture, surrounding landscape and pedestrian paths are the main tasks for architects, but the centuries-old traditions of creating a park in them are kept to a minimum: Tourist Center, Rizhao City, Heavenly Water Park, Qingdao City Park, Earthen Pond, Qingdao City [1, 2, 3, 4, 5, 6, 7].

However, it cannot be said that these two groups are completely different from each other and use radically opposite design principles. In each of the gardens, you can recognize the national Asian motifs and the interpretation of the classical sets of elements for the Chinese garden, despite their different presentation. As a result of a combination of tradition and modernity, new, unique planning schemes were born.

2. Feng shui
One of the oldest methods of space formation, actively used today is Feng Shui - the Taoist practice of symbolic development (organization) of space. This teaching helps to properly distribute the positive energy of Qi and prevent the accumulation of negative energy of Sha on the site. The name Feng Shui refers to the two most important forces of nature - wind and water [8].

In the VII-XIII centuries, the period of active development of Feng Shui began. During the days of the Tang Dynasty, two main schools of Feng Shui appeared, which were later called the Compass School and the Form School. The School of Compass in its works relied mainly on astrological and astronomical definitions. The school of the Form considered it more correct to analyze a particular plot, to construct its animal-landscape codes, to adapt and transform general principles for particular deviations, rather than astronomical investigations. It was the Form school that had a great influence on Chinese landscape art in the medieval period [9].

The next stage of rapid development of Feng Shui came in the XVI-XVIII centuries. The peculiarity of this period is the combination of scientific knowledge of geography, geology, mechanics and other natural sciences with mystic-natural-philosophical knowledge. What essentially strengthened and adapted the Chinese geomancy to new knowledge. From the period of the early Middle Ages, Feng Shui transmission began in other countries, which subsequently influenced the layout of many cities in East Asia [10]. An important group of symbols for Feng Shui is five elements or five elements. The elements are characterized by five basic forms of movement: up and down, outward and inward, and also in a circle. Each element has its own element. Five elements interact with each other according to the cycles of creation and destruction (restraint) [11].

3. Parametricism
Feng Shui is actively used in our time, not only in traditional Asian buildings, but also in modern architecture. However, with the development of science and technology, new digital design methods appeared. In the XXI century, Chinese landscape architects actively demonstrate their achievements in the field of avant-garde trends. On the other hand, design organizations from various countries find the Chinese market very attractive. The country with the largest population on the planet, an actively developing economy and vast territories that are very favorable for the development of landscape complexes according to the climatic characteristics and the way people live cannot be overlooked by this business. As a result, there are a lot of branches of famous companies, many of the foreign architects are actively involved in the projects. All this makes it possible for designers to communicate closely and communicate with each other, which in turn improves the overall quality of projects and introduces new global trends in the modern Chinese landscape architecture in the concept of creating a public, administrative and personal garden, its functional content, planning and structural organization. and besides all this, the use of the newest technologies of computer design. Under the influence of these factors, serious transformations are now taking place in Chinese landscape art [12, 13, 14].

One of the most popular styles in landscape architecture is parametricism - this is a global style of architecture. It is an advanced trend in avant-garde architecture. It is used both for large-scale projects (Zaha Hadid Architects, General Plan Kartal-Pendik, Istanbul, Turkey, 2006) and in small architectural
form and design. The roots of parametricism go to the methods of constructing digital animation of the late 90s, when, using calculations and calculations, three-dimensional animation was created. But it was completely formed at the beginning of the XXI century. One of the leading companies in this style is Zaha Hadid Architects. The architect of this bureau, as well as the scientist, Patrick Schumacher, published more works on the topic of parametric design, where he described the history of the origin of the style, the basic principles and design stages on the example of implemented projects [15, 16].

4. Creating a planning structure

At the heart of digital design is always the abstract idea of representing space - a breakdown into specific zones. The purpose of this work is to use Feng Shui, and the nominal Bagua trigram, as the basis for the design, the place for the project was chosen as the campus of PNU. By itself, this tool is not able to create a specific planning structure, and only indicates the location and connection of different volumes, but their content and external presentation does not have to be done in the traditional form, for this modern analogs of Chinese parks and digital design methods were used. But the initial configuration depends on the site, its content and environment, therefore, first of all, the territory was analyzed and terrain features were identified. Often sketches are not similar to the future image of the project. It is not uncommon to find an idea taken from painting and transformed into a form. Zaha Hadid used the work of the Russian artist Kazimir Malevich, bringing forms and images from the paintings into the volumetric space [15].

Mathematical diagrams, formulas and patterns are often used at the preliminary design stage. Russian mathematician Georgy Feodosiyevich Voronoi is the author of the diagram, which divides the field relative to points in a given space. This diagram is closely related to the Delaunay triangulation. If you connect the points of the Voronoi region with edges to each other, the result will be a Delaunay triangulation. These principles are applied as in the division of space into functional zones or town-planning blocks, to create small architectural forms and individual interior details and create constructive schemes.

One of the first people who applied computer calculations in architecture was Fray Paul Otto. In 1972 he was invited to design a hipped roof over the Olympic Stadium in Munich. Finding a source of inspiration in natural forms, namely in the web, Fry Otto designed the canopy, which is one of his most complicated structures. Part of the calculations for the hip roof was performed by a computer.

4.1 Territory analysis

After analyzing the territory, it is possible to identify a number of features and issues of relief and planning structure of the campus, which should be taken into account during design. The whole area was divided into 3 main zones: the north - here is a large ravine, in which water accumulates, the central - open space and the south - consisting of two open areas. Pedestrian traffic analysis, climatic, functional areas analysis and analysis of green areas were carried out.

4.2 Formation of planning structure

When creating a garden planning structure used both traditional and modern techniques. Planning layout is made in the program Grasshopper. In its original form, the scheme is a cloud of points, distributed by the program and having a mathematically calculated layout. Based on the given points, the Delaunay triangulation is applied. Due to the flexibility and variability of the features of parametric design, it is possible to create several geometric schemes of a garden, reflecting connections and spatial types. A symbolic analysis was performed, during which the entire territory of the PNU campus was divided into 9 sections in accordance with the Bagua trigrams. Based on the data obtained, the main prospects for further project activities were identified. After combining the parametric model and the concept developed on the basis of traditional garden design methods, we obtain the planning solution of the project (Fig. 1).
Figure 1. Construction of a geometric scheme.

The garden has a focus on passive recreation. The choice is due to the absence of a recreational zone in this part of the campus of PNU. Also, there are sports areas, where there are various kinds of simulators and places for recreation.

The free planning of the garden is largely due to its compensatory function in the spatial structure of the quarter. The garden plan symbolizes the flow, with its course and quiet creeks, through which energy flows smoothly. It begins from the left wing of the main academic building of Pacific National University, gradually dissolving into the space of the student campus.

The southern part of the park is located in the phoenix zone. The layout is dominated by the elements of the peaked shape, which are the symbolisms of the element of fire. On this part of the campus there is one area for active recreation, as well as two zones for passive recreation. The red color of the benches and the interactive stand is also a reference to the fire element.

The central part of the garden is located in the area of the snake. The layout is dominated by round shape shapes, which are symbols of the elements of the earth. There are four types of paving, yellow paving, is a reference to the element of earth. In the western part of this zone, there is an analogue of the triumphal gate - pailou. This element, as well as the layout of the central part of the garden, has a rounded shape and yellow color.

The northern part of the garden is located in the area of the turtle. The element of this territory is water. A wave garden is located in the central part of the plot. Initially it was a ravine in which water accumulated after rain or melting snow. To solve this problem, it was decided to create a drainage system. Since this area of the campus will become more habitable, then the slope should be strengthened by terracing. There are two types of pedestrian ways on the area, the first is made in a more traditional style, the second track is at the foot of the slope. This element is located just in the place where water usually accumulated, its configuration is also not accidental, it has several bends and is analogous to winding bridges that were laid over water in the Chinese garden. At the top of the slope, along the path there are two viewpoints. In the southern part of this zone is an observation deck. To solve the transportation problem of the quarter, in the north of the campus multi-level parking is designed.
5. Conclusions
The presented project on campus of PNU is the quintessence of traditional and modern elements and design principles. A comprehensive analysis of the territory was carried out, which allowed identifying the main problems and set the main design tasks. The lack of recreational and sports areas in this part of the campus, the chaotic system of placing footpaths, swamped territory and the lack of decorative landscaping are the solution of these problems are priority issues when creating a project. The five-step geometric scheme uses the principles of a point cloud, Delaunay triangulation, and Bagua trigrams. The project of the park is divided into three zones in accordance with a symbolic analysis of the territory, produced using Bagua trigrams. Each zone was designed in accordance with the rules of Feng Shui. The general style corresponds to modern analogues. The elements of the park were created in accordance with the analysis of similarities and differences between traditional and modern elements of landscape gardening complexes.
This study demonstrates only a small part of the potential of the process shown. Combining traditional and modern design principles is able to create new, unique planning structures using the convenience of digital design and the experience of traditional methods.

6. References

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