PARAMETRIC DESIGN OF QUASI-NATURAL WATERSCAPE GARDENS BASED ON BIG DATA TECHNOLOGY

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Abstract: In order to better design the water scenes of garden, the natural water scenes of garden parameters are designed by combining the big data technology, the water scenes of garden generation rules are collected by the pseudo-natural principle, and the garden landscape parameters are designed by combining the regular production characteristics with the big data technology. In order to ensure the rationality of the principle landscape design, the pseudo-natural water scenes of garden parameters are standardized, and the standard parameters are input into the Grasshopper auxiliary simulation software, so that the optimal design scheme of the pseudo-natural dynamic correlation water scenes of garden view is automatically generated. Finally, through experiments, it is proved that the landscape simulation effect of pseudo-natural water scenes of garden parametric design based on big data technology is more satisfactory than that of traditional design simulation results.

1. Introduction

"Quasi-nature" means to simulate nature, which means to create a landscape environment like nature by artificial means. The "simulation" here has a double meaning, not only the similarity of "shape", but also the interpretation of "law". The design of "quasi-natural" waterscape gardens starts from the interpretation of the generation rules of natural waterscape gardens, and combines the current topographic conditions to simulate the natural forms and ecological processes to generate a quasi-natural waterscape garden view system. Natural waterscape gardens adapt to different forms of topography and landform[1]. They are part of natural water network system and have a set of complete water ecosystem. The artificial waterscape coupled with the natural system helps to maintain the integrity and systematicness of the regional water system. The traditional design method of "quasi nature" has 3 kinds, respectively: The GIS to landscape, through the calculation of precipitation, watershed analysis, collect water quantity calculation, the formation of water form to complete the scene design, high accuracy, but long time consuming; Logic construct landscape, form - water - the water, although the structure is simple, but slightly lower precision; Water balance, water balance equation, the quasi natural water garden for water catchment area of rainwater collect optimal value, thus to provide reference for waterscape garden water design, this method can present the waterscape garden, high precision but spend more money[2]. The design of "quasi-natural" waterscape gardens emphasizes "rational" water: taking advantage of the existing shape of mountains and the potential of water, minimizing the disturbance to the site, forming a new view of waterscape gardens or optimizing...
the existing water system through combing. However, the three methods mentioned above have problems such as water imbalance\cite{5}. Waterscape landscape view is often the most attractive node in the landscape environment, and is also an important part of landscape planning and design. Thus to meet the requirements of the above, put forward based on the technology of large data quasi natural waterscape garden parametric design, and the design algorithm simulation experiment, the experimental results show that the design of quasi natural waterscape garden "comes from the nature, higher than the natural", is not only a natural waterscape garden art of abstract and processing, and to be able to accord with a variety of waterscape garden form concentrated rendering of natural law, generate beautiful landscape, satisfy people's needs for recreation.

2. Parametric Design of Quasi-natural water scenes of garden Based on Big Data Technology

2.1 Landscape Design of Quasi-natural water scenes of garden

Natural waterscape is formed by precipitation, which must satisfy two necessary conditions: precipitation and depression\cite{4}. So it is very important to design water network system in waterscape garden. Water network system is mainly composed of four parts: one part is intercepted by vegetation surface, this process is called interception; Some is absorbed directly into the soil, a process called osmosis; Other parts are stored in small depressions and depressions on the surface, a process called impoundment; The rest of the rainwater flows along the surface, creating surface runoff and eventually collecting into water bodies such as channels, rivers and ponds\cite{5}. The amount of water in a catchment area is determined by the catchment area area, precipitation per unit area and surface interception. According to the classification of runoff, the surplus water of the last time will be collected to the next level, and the water bodies with different elevations will form a "water network system" through the streams. Therefore, in the natural state, the water body is not a single existence, but in the water network system, according to the situation of the topography, it is represented by lakes, pools, rivers, streams, pools, terraces, waterfalls and other forms\cite{6}. As the name suggests, a catchment is an area where water is collected, also known as a catchment basin or basin. It is also closely related to the topography. Precipitation tends to gravitate toward lower areas. The highest ridge in the terrain naturally becomes the "watershed", and the design of water network system is shown in figure 1.

![Fig. 1 water network system design](image)

It can be seen from the above figure that the catchment area presents a nested grading system according to the grading of runoff. The high-level catchment area is composed of a series of lower-level catchments, whose catchment amount is the sum of the catchments of the upper level and the area of the catchment area of the lower level. Sufficient catchments and depressions are necessary for artificial waterscape\cite{7}. Catchment water comes from natural precipitation, and depressions are hollow areas of the earth's surface formed by artificial damming or excavation. In order to minimize the disturbance to the natural environment and control the amount of engineering, the appropriate topography area is usually selected by combining with hydrological analysis, and the depressions are created by rational dam-building and local topography carding. The volume of water that the
depression can hold is the storage capacity, that is, the volume of water. On the one hand, the reservoir capacity is directly related to the volume of the depression; on the other hand, it is restricted by the height of the dam. Water quantity is positively correlated with dam height. In addition, the form of waterscape is also the key to the design of natural waterscape. The two-dimensional form of waterscape, namely the water surface form, is the horizontal section of the intersection of water and terrain. The shape of water surface is affected by both topography and water volume. It can be seen from the generation law of natural water body that there is a dynamic correlation among "water amount, water form and dam height", which is the key element of parameterized design of pseudo-natural water scene and the generation basis of parameterized design logic.

The parameterized design logic of pseudo-natural waterscape corresponds to the law of natural waterscape generation. From the perspective of system, based on the dynamic correlation of "shape -- dam height -- water volume", the parameterized model is constructed. For the realization of the quasi natural water scene design, the parameterization of team building logical model by the data processing module "dam", "terrain data processing module", "water formation and water volume calculation module", "earth data calculation module" and "water form the evaluation module" five modules, functions are: determine the dam site, optimization of terrain, water body, water quantity and water form the optimization and the calculation. Among them, "dam data processing module" and "terrain data processing module" are used to process the terrain and other basic data input externally, and the data are transformed into data types that Grasshopper software can use. The three modules of "water body generation and water quantity calculation module", "earthwork data calculation module" and "water body shape evaluation module" will calculate and visually express the obtained data, and carry out the evaluation of water body shape and the optimization design of man-machine interaction. "Water generation and water quantity calculation module" is the direct expression of the logical relation of "form -- dam height -- water quantity", and also the core of the design of quasi-natural waterscape. The design logic of its waterscape parameters is shown in the figure below.

The realization of parameterized design of quasi-natural waterscape needs to complete the following two preliminary works: site selection of waterscape and establishment of water body form database. First, the site selection of waterscape was based on Arc GIS software platform to build a parametric site selection process. Secondly, according to the design demands, areas with catchment potential are screened out and the location of the water system is determined. The number and location of the water surface are designed according to the topography, runoff and catchment conditions of the area. Thirdly, according to the annual precipitation of the design site, the runoff coefficient of the underlying surface and the reduction coefficient of runoff, the runoff volume in the potential catchment area is calculated. The second task is to establish water body morphology database. The
The water body morphology database contains the water body morphology data of dozens of scenic and environmental lakes with high public recognition. The specific morphological indicators include: area, longest axis, nearness, shape rate, compactness, shoreline development coefficient, etc. The "water form evaluation module" in the parameterized design logic model of simulated natural waterscape is associated with the database. The purpose of the database construction is to provide a basis for the evaluation of water morphology. In other words, the index interval value in the database is used as the criterion to judge whether the water morphology is beautiful or not in the parameterized design of pseudo-natural waterscape, which is an important parameter of water landscape design. In addition to natural water features parametric design logical model for single water, for water network system made up of several bodies, on the basis of the parametric design of single body model, based on the relationship between the amount of water in each level in the same watershed water will be a single water body of parametric design model, further generate parametric design model of the whole water system.

2.2 Parameter Design of water scenes of garden Landscape Model

By means of Rhino Grasshopper software running in the environment, calculation set compilation and data calculation are carried out. On the one hand, the calculation set of Grasshopper is programmed by algorithm, which enables accurate and efficient calculation of data. On the other hand, Grasshopper can accurately calculate and output various types of data, making the data effectively connected and avoiding errors in the manual calculation process. In addition, with the help of Rhino software, the calculation results of Grasshopper can be presented and fed back in real time for the convenience of regulation and optimization. Based on the design logic described in the previous paper, parameters were selected according to the preliminary analysis and evaluation research results of waterscape location, water volume, site topography, water body shape indicators, etc., and the preliminary research data were taken as the initial constant input model. This paper adopts Python language based on Grasshopper software platform to design the parameterized logic of simulated natural waterscape. 5 sub modules of algorithm and model building, according to the characteristics of the design logic and the actual situation of waterscape design, selection of the optimum calculation, write the "high dam - water", "water - terrain" algorithm, "water - earth volume" algorithm, "water form" five algorithm, and its associated combination to natural water features parametric design model was constructed. Based on the writing of the "high dam - water" algorithm as an example to further illustrate use Grasshopper software to natural water features parametric design model algorithm written: based on the water of site selection and calculation of access to water data, the data needs to be associated with the terrain data to determine the height of the dam, but because of the "volume - height" type algorithm is too complex and constraints, more difficult to cover by a single algorithm; Therefore, in view of the relationship between "dam height and water amount", the entity difference set algorithm in Grasshopper software is adopted to compare the water amount required for water generation with the site water amount. By adjusting the input dam height data, the water demand and the site water amount are basically equal and kept within the error range. Thus, the dam height is determined by backward inference. The algorithm is as follows:

\[ i - O = \Delta S \quad (1) \]

Where I and O are the total water input and total water output in the water system respectively, and \( \Delta S \) is the change of water storage in the water system. Formula (1) is the general formula of the water balance equation in the water system. Specific total input and total output of water are analyzed for different water systems, and the corresponding water balance equation is obtained

\[ W - W - \Delta = \Delta S \quad (2) \]

\[ W - (Q + W + W + E + W) = \Delta S \quad (3) \]

The algorithm rules above are as follows: the terrain surface is cut from the preset water cube to obtain the water body (entity) for volume calculation and contour extraction of the two-dimensional shape of water body; According to the analysis results of water site selection and dumping point, the
dam building point (point set) can be obtained. Based on the contour line, the dam base line can be drawn. The datum level is scaled at the center of the datum line to ensure its fit with the terrain, and the computational surface of water (water surface) is obtained. Based on previous calculation module has access to relevant data of terrain (terrain surface), input dam elevation (absolute height) parameters, calculation for water required extension can get on the water (water volume) is proposed to calculate body in natural water is composed of a series of "single" water, therefore at the completion of a single water body design on the basis of the construction of a water system is also required. Based on the parameterized design model of a single water body, a parameterized design model of the water system was established by associating water volume with multiple water bodies located in the same water collection area. In the preparation of the algorithm, the tree data structure in Grasshopper software is needed to realize the synchronous processing of multiple single water bodies. In other words, the single water body data is adjusted into a tree data structure, and multiple water body data are generated through the adjustment of water quantity parameters. Generated by Rhino software for parameterized regulation to natural waterscape design results in real-time, water volume, high dam and water form together to form a set of parameter modification plan, and feedback to the dam body module and the terrain data processing module, after a lot of the optimized parameter adjustment and form, the final output stream landscape design results.

2.3 parameter design of waterscape landscape model

There are many scattered small water surfaces in the interior of waterscape gardens, which fail to form a water network system. The planning and design of the waterscape garden proposed to fully connect the existing water bodies of the site to form a water system and optimize the water form to generate a sustainable water environment, so as to provide a good microclimate environment for plant growth while shaping diverse water scenes. The design model of waterscape garden is shown in the figure below.

Fig. 3 waterscape garden design model

It can be seen from the design model of waterscape gardens that the first step of the design needs to carry out site selection research of waterscape, analyze the hydrological situation of the site, and the data obtained from the research will serve as the basic value of the next step of parametric design.
Firstly, the design uses ArcGIS software to carry out hydrological analysis of runoff, river network, catchment area, dumping point and so on on the flower park site, and according to the analysis results, it is determined to create the pseudo-natural waterscape in the beauty chong area. On this basis, further hydrological analysis was carried out, and sites with potential for waterscape construction were screened based on the topography, so as to determine the scope of water catchment, the position of water system and the location of dam construction corresponding to each single water body. The water morphology evaluation module was used to evaluate the water morphology. According to the water morphology database, when the longest axis, near-circle ratio, shape rate, compactness, shoreline development coefficient and other morphological parameters were located in the index interval, the water morphology could be determined to meet the design requirements. If the water body shape index does not meet the requirements, the terrain control points can be adjusted in Rhino software through man-machine interaction to optimize the water body shape. At the same time, the water form evaluation module can conduct real-time evaluation and feedback on the optimized water form, so that the water solution meeting the design requirements can be obtained after many iterations. By adjusting the dam height and controlling the topography, a number of quasi-natural waterscape design schemes can be generated by means of parameterized design models. In addition, based on the tree data structure model of the water system, the single water body in the water network system is related to each other, and the sum of its water amount is the total water amount of the designed water system. The design of the pseudo-natural water system can be realized through the regulation and secondary distribution of the total water amount.

3. Analysis of experimental results

Due to in the implementation of the waterscape garden setting is different, need to water form such as link in the process of project monitoring, to accord with a variety of waterscape garden form concentrated rendering of natural law, in order to further verify the accuracy of the method, therefore the method using Grasshopper software water simulation experiment, the experimental parameters shown in the following table.

| nomenclature       | Data type     | Control mode | Number/shape |
|--------------------|---------------|--------------|--------------|
| Site terrain       | surface       | Manual control | Sa           |
| Dam elevation      | Floating point Numbers | Manual control | 21.3        |
| Dam shape          | curve         | Manual control | C₄           |
| Water body         | entity        | Automatic control | B₄          |
| Water contour      | curve         | Automatic control | Cₜ₄         |
| Amount of water    | Floating point Numbers | Automatic control | 396.85      |
| Dam slope          | Floating point Numbers | Manual control | 0.248       |
| Dam body           | entity        | Automatic control | Bₐ₄         |
| Earthwork quantity | Floating point Numbers | Automatic control | 3.5         |

After setting up the experimental parameters, different water scenes of garden landscapes were simulated according to the design results of garden parameters. As the ultimate effectiveness of garden landscape is based on the satisfaction of the masses, this paper chooses the washing of the masses as the starting point and randomly selects 1,000 volunteers to evaluate the satisfaction of water scenes of garden. In order to verify the universality of this method, three experiments were carried out. In order to investigate the test results more intuitively, the design results proposed in this paper were recorded as observation group and the traditional design results as control group for comparison. The results are shown in the following figure.
Can be seen from the results, the experimental group of waterscape garden design parameters on the satisfaction was better than control group, experimental group of water, water form, quantities of multi-factor as a whole design and dynamic regulation, to accord with a variety of waterscape garden form concentrated rendering of natural law, generate beautiful landscape, satisfy people's needs for recreation.

4. Conclusion
The parameterized design of simulated natural waterscape realizes the simulation of natural waterscape scientifically on the basis of interpreting the natural law and assisted by computer and other scientific technical methods and means. Is proposed with the Grasshopper software parametric design of natural water features, by using the method of parameterized can be implemented in the dynamic regulation of overall design, the design scheme of data can be real-time rendering with form and feedback, and through that is associated with water form such as database, can achieve fine control of water regulation and quantities in the form of, in more than one seek comprehensive optimal design scheme, both beautiful and economic.

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