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Research Article

Application of Computer 3D Modeling Technology in the Simulation Design of Modern Garden Ecological Landscape

Zhiyong Tian

College of Arts, Henan University of Animal Husbandry and Economy, Zhengzhou 450000, Henan, China

Correspondence should be addressed to Zhiyong Tian; 81413@hnuahe.edu.cn

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Modern landscape design not only needs creativity but also needs auxiliary tools that can predict the design effect, so as to ensure that the deficiencies can be found through the renderings before the landscape is completed, and targeted rectification can be carried out. At present, the research of landscape planning and design assisted by virtual reality technology in China is basically in its infancy. The rapid development of information-based computer technology, powerful 3D modeling, and solid rendering and animation functions have created a good environment for landscape design, so landscape design is inseparable from the help of computer-aided design technology. However, the conventional method to model and simulate the landscape is rather time-consuming. Based on the research on the application of computer-aided design technology in landscape design, the computer-aided design technology is briefly explained, and the application of computer-aided landscape design is explored step by step.

1. Introduction

The garden landscape is relatively long such as the palace garden landscape in the West and the classical garden in China. More often, only some limited thoughts can be expressed, and they cannot be fully conveyed and expressed to others. On the one hand, with the progress and development of science and technology, landscape architects are gradually liberated from primitive and inefficient tools and labor, especially the rapid development of computer technology, the efficiency of hardware, and the rapid update and iteration of software, garden landscape engineering design is also gradually getting rid of the shackles of paper and pen, especially with the emergence of drawing software technology, a fundamental breakthrough has been made in the working methods and efficiency of designers, and they are freed from heavy drawing tasks. On the other hand, with the rapid development of the economy and society, environmental problems have become more and more prominent [1–3]. Whether for a country or for an individual, the expectations and attention to garden landscapes have reached an unprecedented height. The country has successively formulated garden cities and gardens. The standard of the county seat has now been upgraded to require the construction of an ecological garden city and encourage and support the construction of urban garden landscape belts, green corridors, and greenways across the country to meet people's demands for green, green mountains, and clear waters. These have laid a solid foundation for the great development of the garden landscape. In recent years, computer-aided technology has made great progress, the existing assistive technologies and platforms have been optimized, and some of them have become special technologies for landscape design, such as sketch masters [4–6].

The application of computers to engineering design is called CAD technology. At present, the application of CAD technology in landscape design is mainly in drawing pictures and is a part of auxiliary calculation [7, 8]. Among them, AutoCAD is the most popular computer-aided design software used at home and abroad. With its colorful drawing functions, smart editing functions, and superior user interface, AutoCAD enjoys a good reputation among engineers and technicians and is generally welcomed by everyone. In particular, AutoCAD software also provides a variety of editing tools and interfaces, making it convenient for users to complete secondary development and

manufacturing on the basis of this software. In addition, AutoCAD software enhances the functions of 3D modeling and image processing, and also has a powerful set of additional tools, supports ActiveX automation programming interface, has powerful network drawing functions, supports a variety of image access formats, and is compatible with different CAD systems. Graphics can be transferred further [9–11]. Computer-aided technology has a good application in all aspects, especially in the field of landscape planning and design, there is a broader prospect, and landscape designers need to strengthen the study and application of this aspect.

With the popularization of the internet and the advent of the electronic information age, virtual technology has been applied to all walks of life. However, with the continuous development of virtual technology, its drawbacks are gradually discovered by people [12]. The purpose of people applying this technology is only to meet their own needs, to have a more detailed and comprehensive observation of the real environment, and to avoid some omissions in the observation of the environment caused by some objective factors, rather than to use the virtual environment to replace it. The real environment place, but due to some technical problems, such as the running speed of the equipment and the quality of modeling, not only can it not restore the real scene but also distort the image and cause information loss, resulting in an unsatisfactory user experience [13–15]. Therefore, in order to improve this problem, people have invented a new technology-augmented reality technology. As a kind of virtual technology, augmented reality technology combines computer technology with real situations to generate a very realistic 3D virtual environment, so that users can experience it through various sensing devices. Today, this technology has been used in technology, entertainment, medical, and military industries, and has good developmental prospects [16, 17].

In the past, the frame of the garden design was expressed by hand-drawing. With the progress of the times and the development of computer software and hardware technology, the new technology of 3D drawing became more and more popular. This does not mean that 3D drawings can completely replace traditional manual drawings, but they are better applied to garden design separately. That is, we use manual drawing in the early stage of design and use 3D drawing when drawing high-quality drawings. The 3D has made technical improvements to Editable Poly with almost every upgrade, so its capabilities go beyond editing meshes to become the primary tool for polygon modeling [18–20]. It takes a brand-new perspective to do landscape planning and design, modeling, virtual tour, and other technologies that can be combined with the real landscape, complement each other, better express its design ideas, and design intentions.

The requirement for designers is to be proficient in 3D drafting-related software, as shown in Figure 1. At present, the overall requirements for designers are getting higher and higher, and the use of software to express design intentions is far from meeting the design requirements. It is also necessary to coordinate various related software to exert their respective functions and characteristics. With the rapid development of the times, the requirements for design and drawing personnel in various fields are also getting higher and higher. Designers themselves are also dissatisfied with only relying on 3D drawing software to achieve depapering operations. They are more inclined to use 3D software to improve their work quality and devote their energy to more meaningful work [21, 22].

Driven by the development of information technology, the efficiency of landscape design has been improved. In order to more accurately express the intention of landscape design, the field of landscape design has already entered a new era. The application of CAD technology to assist landscape design has long been the general trend. Therefore, as a landscape designer, you need to dare to try and apply more, and you need to master the functions and characteristics of CAD, so as to ensure that this technology becomes a good tool for expressing your design intentions [23, 24]. At the same time, in the development of science and technology, all kinds of software are constantly innovating, and this part of the software has many shortcut commands, so designers also need to strengthen the mastery of shortcut commands to improve work efficiency. Landscape engineering design is the science and art of the analysis, planning, layout, design, transformation, management, protection, and restoration of landscape engineering. Built on the basis of artistic esthetics and natural science, it is the product of their combination. The use of land according to local conditions is the key to garden landscape planning and design. Scientific and artistic esthetic planning, utilization, and analysis of land, topography, landforms, etc. are carried out, and perfect solutions are obtained to create more in line with people's esthetic needs and ecology. This study focuses on computer-aided technology, introduces the contemporary mainstream computer-aided software and platforms, and also expounds on the application in the planning and design process of landscape engineering. First of all, it gives an overview of the developmental history of garden landscape design and also introduces the process of the gradual combination and application of computer-aided technology in landscape planning and design. The basic concepts of modern garden landscape planning and design can include the scheme of garden planning and design and the computer-aided technology garden design technology [25, 26]. Therefore, first of all, it gives an overview of the development history of garden landscape design and also introduces the process of the gradual combination and application of computer-aided technology in landscape planning and design, the basic concepts of modern garden landscape planning and design, including the introduction of garden planning and design thinking, and the current situation of designers using computer-aided technology and related design software.

2. Mathematical Modeling of Garden Landscape

Due to its complexity and diversity, garden landscape design has not had a relatively unified and authoritative definition in the academic world. The landscape itself has dual attributes of geography and ecological type. From the perspective

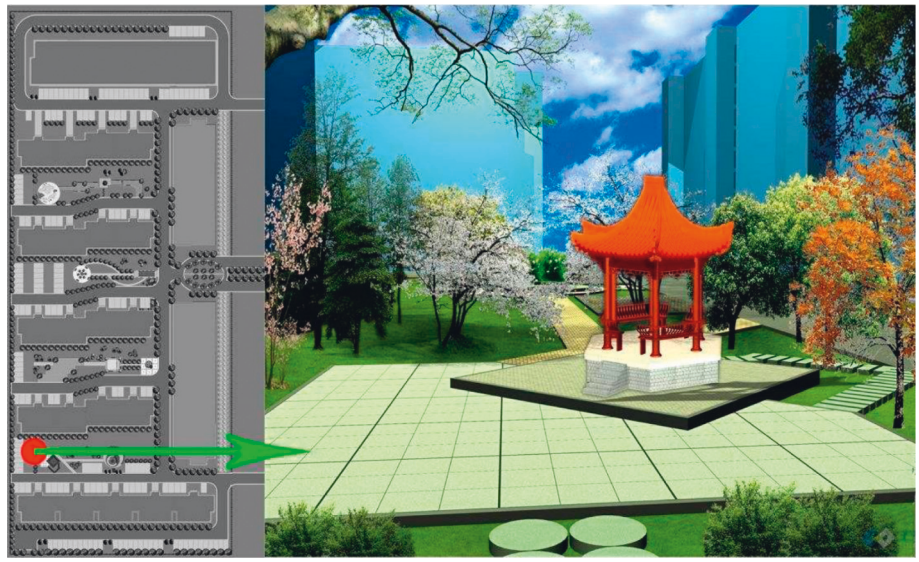

Figure 1: 3D-assisted garden drafting.

of geography, more attention is paid to the entire landscape such as topography and landforms. From an ecological point of view, more attention is paid to the collocation and relationship between plants and nonplants in the landscape, and it is more willing to treat the landscape as a self-circulating ecological system; on this basis, garden landscape planning and design are considered to be "complex objects on the land. It is a complex natural process and the imprint of human activities on the earth; garden landscape engineering is the carrier of various functions (processes), so it can be understood and expressed as follows: landscape, the object of the visual esthetic process; habitat, the space and environment in which humans live; ecosystem, an organic system with structure and function, with internal and external connections; and a record of the human past, the expression of hopes and ideals, the language, and spiritual space on which identification and sustenance are based." Garden landscape reflects the meaning of visual esthetics, which has the same meaning as "landscape." This meaning is also recognized by the literary and art circles and the vast number of landscape architects.

It is this cross-cutting and multidimensional characteristics that make landscape architecture rich in connotation and more extension. This study focuses on computer-aided technology, introduces the contemporary mainstream computer-aided software and platforms, and also expounds on the application in the planning and design process of landscape engineering.

This study takes the plants in the garden landscape as an example to carry out mathematical modeling. It can be seen from the concept of string replacement that the initials and productions in the Lindenmayer system (L-system) are described by strings. It boils down because L-systems are a formal language. To connect the L-system with the plant simulation, so that it can represent the structure of real plant branches, it is necessary to assign a specific geometrical meaning to each letter in the L-system. In order to vividly illustrate it, the concept of turtle shape can be introduced. Postprocessing usually uses PS software and finally uses a color laser printer to print out the renderings.

We can extend the turtle-shaped interpretation of the L-system from 2D to 3D. First, three vectors H, L, and U that describe the current direction of the turtle shape are given. They represent the forward, left, and upward directions of the turtle shape, respectively. They are all unit lengths and are perpendicular to each other, and satisfy the following equation:

$$H \times L = U. \tag{1}$$

The rotating turtle shape can be represented by the equation as follows:

$$[H', L', U'] = [H, L, U] \times R, \tag{2}$$

where R is the 3×3 rotation matrix. The matrix representation of the rotation angle a with respect to the vectors H, L, and U is as follows:

$$R_H(a) = \begin{bmatrix} \cos a & \sin a & 0 \\ -\sin a & \cos a & 0 \\ 0 & 0 & 1 \end{bmatrix}, \tag{3}$$

where a is the variable.

$$R_L(a) = \begin{bmatrix} \cos a & 0 & -\sin a \\ 0 & 1 & 0 \\ \sin a & 0 & \cos a \end{bmatrix}, \tag{4}$$

$$R_U(a) = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos a & -\sin a \\ 0 & \sin a & \cos a \end{bmatrix}. \tag{5}$$

The plant images generated by the determined L-system are relatively simple, and the plants generated according to the same L-system are very similar. If we put these plants in

the same picture (producing a picture of a forest), there would be significant, artificial regularity. In order to avoid this, it is necessary to introduce differential changes between different species, which can change some details of the plant on the basis of maintaining the overall structure of the plant. These changes can be accomplished by randomizing the turtle interpretation or engineering system. Simply randomizing the turtle interpretation would have limited effect because it only changed the external geometry of the plant's morphology, such as the length of the stem and the angle of the branches, but not the underlying topology of the plant. Correspondingly, if this randomness is applied to the production, it can not only affect the geometric appearance of the plant but also change the topology of the plant. We have also made great strides in the development of computer-aided technology in recent years.

A random L-system is an ordered quaternion as follows:

$$G = \langle V, \omega, P, \pi \rangle. \tag{6}$$

An example of a simple random L-system is as follows:

$$\begin{aligned} &\omega: F \\ &p_1: F \xrightarrow{0} .33\ F[+F]F[-F]F. \end{aligned} \tag{7}$$

Although L-systems with turtle-shaped interpretations can produce a range of objects, from abstract fractals to plant-like branching structures, their modeling capabilities are limited. A major problem is that all line segments are integer multiples of unit steps. This leads to some simple figures, such as right-angled isosceles triangles, and cannot be drawn correctly because the slope of its hypotenuse and right-angled sides is an irrational number $\sqrt{2}$. Taking a rational number approximation provides only a limited solution, since the unit step size must be the common denominator of all line segments in the model. Thus, even a simple internode model of a plant requires a large number of symbols. In order to solve this problem, a method combining mathematical parameters and L-system notation—parameter L-system—is introduced. In the process of postprocessing, the artistic effect should be comprehensively considered, so various special filter functions in the computer-aided design software can be used to correct the artistic effect in time.

The parameter L-system extends the most basic concept of parallel rewriting, from words consisting of only characters to words with parameters. The parameter L-system operates on parameter words, which are module strings consisting of characters with parameters. Characters belong to character set V, and arguments belong to the real number set R. It consists of characters AEV and parameters as follows:

$$a_1, a_2, \ldots, a_n \in R. \tag{8}$$

The module composed of the above formula is denoted as follows:

$$A(a_1, a_2, \ldots, a_n). \tag{9}$$

Every module belongs to a collection as follows:

$$M = V \times R^*, \tag{10}$$

where $R*$ is the set of all finite parameter sequences, and the set of all module strings and nonempty strings is denoted as follows:

$$M^* = (V \times R^*)^*, \tag{11}$$

$$M^+ = (V \times R^*)^+. \tag{12}$$

Therefore, according to the above model, the probability can be obtained and is shown in Figure 2.

3. Computer-Aided Garden Landscape Design

Landscape architects can absorb and introduce more intentions and understand different landscape configurations through the human-computer interaction function of the virtual reality system, so as to modify and improve their own design schemes. In specific operations, designers can break through the limitation of two-dimensional plane thinking, observe landscape works from plane to 3D, multidimensional, multiperspective, better grasp the space, and achieve a more intuitive understanding of the design scheme. More importantly, based on the support of technology, landscape architects can break through the limitations of traditional design methods and expressions, and make garden landscapes more artistically pursued. The description of landscape details and the perfect presentation of effects by virtual reality technology further stimulate the designer's inspiration and intention, and enhance the originality of the landscape design scheme. Of course, the landscape design is not limited to the places where the surface can be viewed.

In addition, there is a rich spatial environment design and expression, and the multidimensional composition of landscape architecture. These characteristics are reflected in the combination of factors such as culture, space, time, nature, and society, and provide conditions and foundations for creating the overall atmosphere and special artistic conception of the garden landscape space environment. The 3D scene formed by virtual reality technology can fully express the multidimensional spatial form of the garden landscape. Compared with traditional computer-aided animation production, virtual reality is more powerful in real-time sculpting and interactive functions. Landscape designers can more easily control scene elements, such as weather, season, morning, and evening backgrounds, and can create virtual spaces that cannot be achieved using traditional expressions. In the virtual reality landscape space, different scenes can be switched in real time, and different observation angles or different observation sequences will produce different scenes and experiences.

The prerequisite for realizing virtual reality technology is to have a 3D model, and the construction of virtual space and landscape is based on a large number of 3D models. Therefore, the models are required to be of various types, with realistic effects and easy operation. In this way, a virtual scene with rich content and smooth operation can be established. The reason why the requirements for virtual

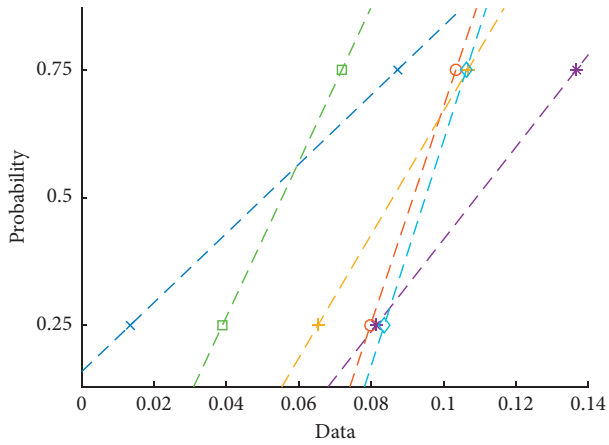

Figure 2: The probability calculated by the proposed method.

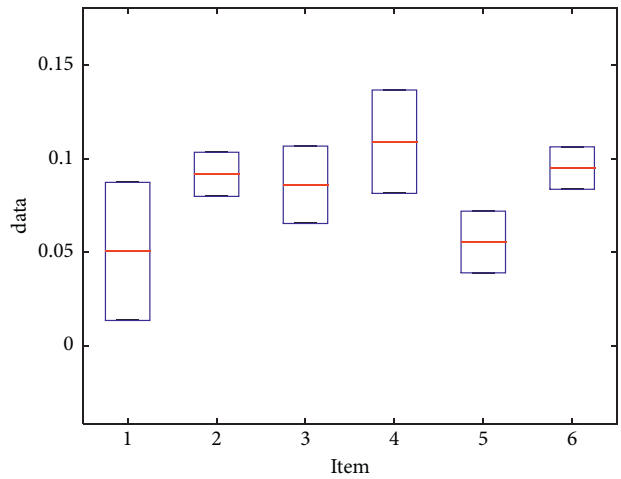

Figure 3: Data evaluated by the proposed method.

tours are high is because the audience can choose any viewing angle to watch by themselves, which requires the quality of the virtual rendering model to be very high, any small surface must be handled without flaws, and even the difference between the front and back of a leaf must be one side with veins and the other side not. In order to achieve a real-level virtual effect, when modeling, special attention should be paid to the processing of light and dark effects, to enhance the 3D sense of the 3D model, and to highlight the content of the environment in which the landscape modeling is located. The data predicted by the proposed method are plotted in Figure 3, which shows the validation of the proposed method. It is also necessary to consider the adjustment of the temperature, humidity, and other elements in the local area through CAD technology, so as to achieve the purpose of noise reduction and pollution reduction, and ensure the perfect landscape design.

Immersion, that is, experience, is the advantage of virtual reality technology compared with traditional graphic image creation. In order to allow users to have a good experience as immersive, it is necessary to integrate people's vision, hearing, and touch into virtual reality. From the very beginning, simple display screens and headsets initially solved the problems of vision and hearing. Later, the emergence of VR-specific headsets strengthened the above two sensory experiences. Recently, the use of finger nerves has appeared in Europe to bring part of the tactile sense into the virtual world. With the replacement of technology, the virtual modeling of the garden landscape will bring users an experience that is indistinguishable from the real one.

3.1. Application of Construction Drawing Production. When we carry out landscape planning, we generally formulate corresponding construction drawings and renderings, which reflect a certain design concept. Its objects are generally buildings and landscapes in the city, including residential areas, squares, pedestrian streets, parks and natural landscapes, and other spatial forms. Here are some applications of the corresponding computer image production technology for construction drawings. Hence, in order to verify the drawing production, the predicted value vs item is shown in Figure 4.

The previous construction drawings were all hand-painted by design engineers. The process was tedious and tedious, requiring a lot of calculations, and wasting time, and the accuracy of the final product was also flawed. During the construction process, it was also necessary to confirm and repeatedly modify it. CAD developed by Autodesk company has been widely used all over the world; due to its simple operation and professional design, designers can fully control it in a short time. Designers communicate with customers in advance, conceive products, and complete them in the shortest time, which improves work efficiency and is now a necessary computer software tool in the industry. At present, software widely used in landscape planning and design includes CAD, sketch master, and geographic information system. They are simple operation, easy to use, low cost, and good effect to improve the quality and efficiency of landscape planning and design.

3.2. Rendering and Application of Renderings. The renderings are the final architectural effects that will be presented in the production of landscape gardens. In the process of production, designers must first consider the overall color matching, the structure is complete, and it can give people a good feeling. When designing, different drawing software should be used for various terrain buildings in order to better complete the whole work.

(1) Modeling of basic terrain building design. The $3d_{max}$ is the basic terrain of landscape design and the software of choice for architectural modeling. Every year, some new designs are added according to the user's experience, and the functions are becoming more and more perfect. The best product we have experienced is MAX2014. The newly added graphite modeling tool can basically meet the production of complex models. When applied to landscape design terrain, we only need to use two-dimensional images

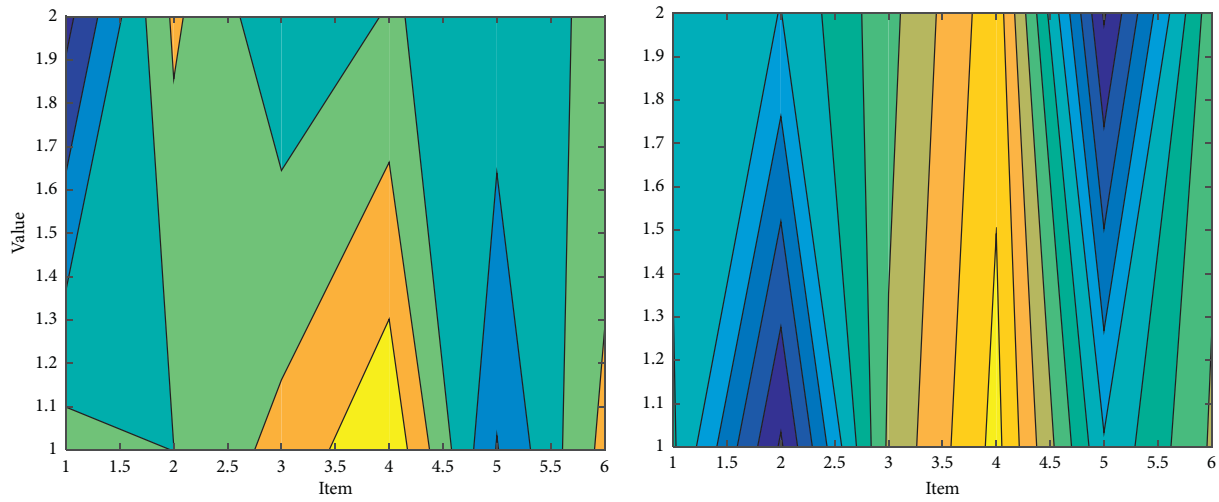

Figure 4: Value vs item.

and basic commands to achieve Conception, the effect is perfectly presented, and the operation is simple.

The English name of Sketch Master is SketchUp. In recent years, there is a trend of catching up and surpassing $3d_{\max}$. At present, some designers are using it, especially in the field of landscape garden design, which is favored by a large number of designers. Its advantage lies in the display and production of landscape terrain. There is an independent interface, and the production and rendering can be independently completed.

(2) Mountains and slope terrain. Terrain with slopes is a part of our design that we often have to make, and making it in software is a bit cumbersome. What we commonly use now is a terrain production tool using the max synthesis panel, which can draw terrain slopes of different heights, which is difficult to use. But the controllability is poor.

(3) Green plants. What we often use in this regard is a forest plugin called Forest, which is used to create distant landscape trees for buildings. It can instantly create up to 10,000 trees and control their heights while optimizing the rendering of the scene. The latest version of the update now adds 3D functionality. Similar in function to it is a plugin called V-Ray.

(4) Building auxiliary facilities. The auxiliary facilities of the building include bridges, characters, vehicles, etc., which can be directly imported into the existing model in a relatively simple way, saving time. The later stage plays an irreplaceable role in the entire landscape design. The commonly used software is Photoshop, which has a relatively powerful color correction function, and some less frequently used ones, such as fusion and nuke, will be used in the postproduction of some film and television dramas. In order to explain the modeling method, the prediction is shown in Figure 5.

Landscape designers use computer-aided rendering technology to present realistic visual effects and visual experience, so that both the owner and the designer can better feel the advantages and disadvantages of the design, so as to facilitate mutual communication and improvement. Computer-aided rendering technology has provided assistance in all aspects of landscape planning and design, and also brought some realistic and obvious role design demonstrations, providing users with a sensory visual sense, which is used in the design, procurement, approval, management, etc. Intuitive information is used to help designers and managers understand designs more easily. Taking the rainwater collection system of garden landscape design in Xinghua Park as an example, from the performance diagrams and examples, it is easy to see the materials used, the process of rainwater collection, and even the latest concept of garden landscape design, sponge city, in specific design and application. First of all, it can be seen that the ecological permeable ground is laid, the permeable bricks are laid on the roads in the park, and the reasonable sidewalk slope is set; although it is only a design scene, we can also feel the comfort of someone stepping on it. Collection of road rainwater-green space is obviously three to five centimeters lower than roads, and rainwater is more likely to penetrate into drains; road pavement is made of flat teeth, so it is easier for rainwater to flow into roadside drains when it rains; sidewalks paved with pebbles or stone blocks form a permeable surface; pipes for collecting rainwater are laid under the park according to the terrain, and underground cisterns are constructed; and after a series of rainwater collection and storage measures, it is finally connected with the municipal pipe network to form a large sponge patch. The predicted value is shown in Figure 6.

Virtual reality simulation landscape technology is the mainstream technology of computer-aided landscape performance, and its main features are multiperception, experience, interaction, and imagination. Through the rendering of the virtual reality platform such as Lumion, and the modeling software such as Sketch Master, the landscape effect of our design can be simulated. The use of virtual reality

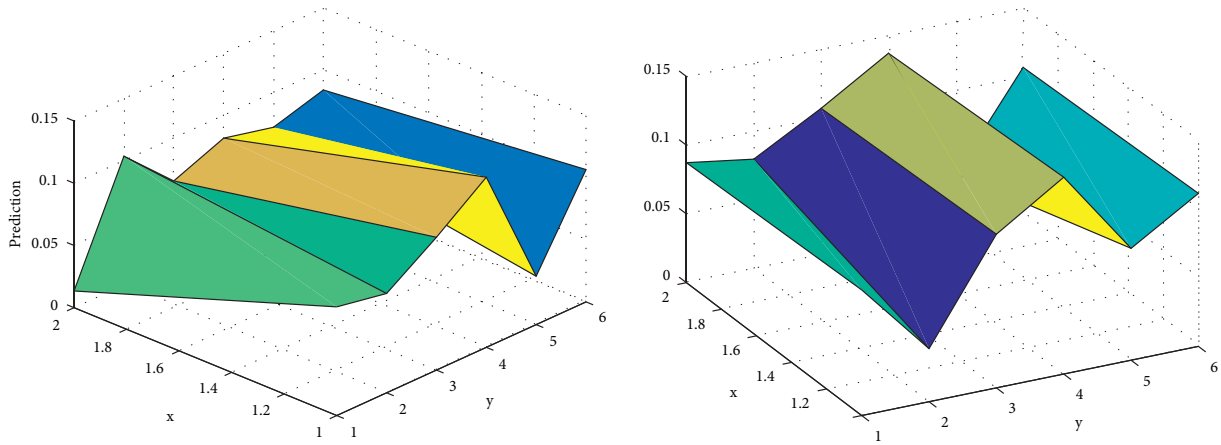

Figure 5: Prediction.

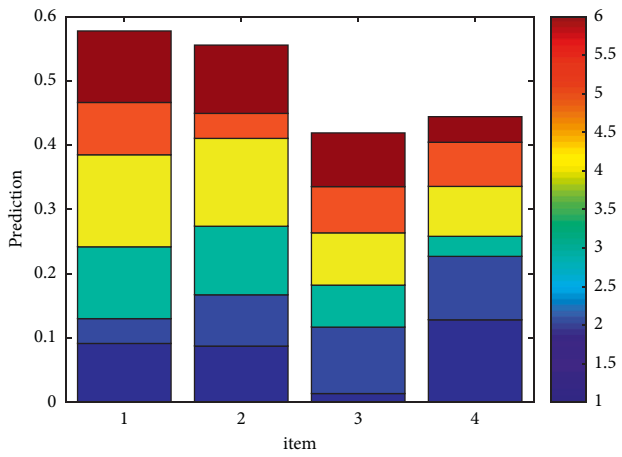

Figure 6: Predicted value.

technology can quickly establish the intended high-quality landscape of the design plan, and express it to users and landscape designers in a timely manner through hardware equipment, improve the owner's participation and sense of creation in the design, and help designers discover their own designs in time. Whether it conforms to your own design ideas, you can use the virtual landscape platform to interact with the owner in time, so that the final design result is also conducive to the owner's acceptance. We avoid the large-scale modification and rework of the past, resulting in a waste of time and resources. Using rendering technology to achieve "photo-level" renderings, we fully express the positioning of the landscape architect for the park and also interpret to people what is new Chinese classical in a 3D, intuitive, and vivid way, as shown in Figure 7 below. In the landscaping of virtual gardens, flowers and plants are mainly arranged at the edge of the entire layout to reflect the naturalness. In the current landscape design, special attention is paid to the collocation of flowers and plants with other plants. Taking the landscape engineering design of Xinghua Park as an example, there are basically no particularly large and gorgeous flowers, but in harmony with vine plants, the choice of coreopsis, iris, purple gold flowers, etc. form a local large-scale "flower sea" effect. In rendering production and expression, we should pay attention to layering, medium and long-term perspective, and light and shadow effects.

As an important landscape element in landscape design, plants occupy an important proportion in landscape shaping. In landscape design blueprints, they play the role of creating atmosphere and improving quality. In the design process, the addition of plants is performed later. According to the overall positioning of the park and the zoning planning and layout, the conventional practice is to separately plant trees, shrubs, and grasses. Sometimes, in order to obtain a comprehensive landscape effect, they are also mixed and planted, and the advantages of using computer-aided technology for layout can be clearly reflected here, because the software can easily carry out the matching of regions and the increase or decrease in the number of plants, and the continuous correction is scientific and reasonable. Through the real-time imaging capability of the virtual reality platform, landscape designers can get the effect of plant configuration for the first time and achieve their design intentions through changes in species, arrangement of locations, increase or decrease in quantity, etc. Of course, as a garden landscape design, teachers cannot completely rely on the computing technology to assist the platform, but also need to be familiar with the local tree species in the area, and understand the biological collocation of trees and shrubs. For example, it is very good in terms of computers and esthetics, but in actual construction, it is difficult to survive, or this kind of plant configuration cannot show the landscape effect of virtual reality in the local climate environment. Therefore, the requirements for landscape planners are very comprehensive, and they can be skilled in operating mainstream computer-aided platforms, Sketch Master, Lumion virtual rendering platform, and large-scale landscape planning geographic information system and other technologies and platforms, and have enough esthetic ability and ecological knowledge to meet the sensory experience demands of owners and audiences, and plants, soil, climate, and other natural properties and configurations are very familiar. The predicted fluctuation is shown in Figure 8.

Figure 7: Simulated landscape.

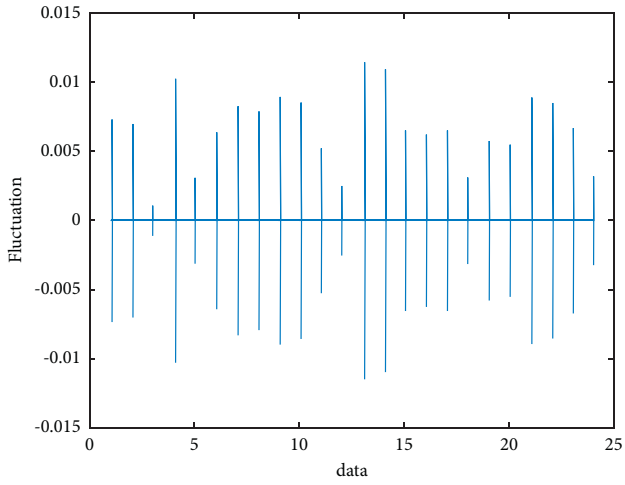

Figure 8: Predicted fluctuation.

4. Conclusions

Computer-aided technology, especially the virtual reality platform, can provide users with a beautiful virtual landscape and an immersive experience. In the process of interacting with the virtual scene, landscape architects can discover their own works. If there are any defects or inconsistencies with their own design intentions, they should be changed and improved in a timely manner. The computer-aided plane software can accurately draw the landscape construction drawings. In the actual project construction, the landscape can be constructed according to the drawings and standards, so as to ensure that the actual results are consistent with the design effects and improve the quality of the landscape.

The research on the realistic graphic rendering of the virtual plant model, the intelligent modeling of various plants, and the various natural factors affecting the growth of plants is not deep enough, and the established system is still far from the actual plant growth process.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest or personal relationships that could have appeared to influence the work reported in this paper.

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