Research on Landscape Architecture Modeling Simulation System Based on Computer Virtual Reality Technology

Sha Li[1], Bo Peng[2]

[1]College of Architecture and Engineering, Guangzhou city Construction College, Guangzhou 510925, China

[2]Architectural Design Institute, Shenzhen Municipal Design ＆Research Institute Co., Ltd, Shenzhen 518000, China

Abstract. This paper develops a three-dimensional garden landscape design simulation system based on virtual reality technology. The landscape design data collection module uses files to read and write landscape design data. Use the resource library to store the basic materials required for 3D landscape design. The system realizes the functions of 3D solid modeling, 3D real-time virtual presentation of design scenes, rendering and animation production, and construction drawing. After the landscape architecture simulation system generates construction drawings, it uses the coordinate matrix method of three-dimensional graphics processing technology to render the three-dimensional texture of the model. The system realizes three-dimensional landscape design through the statistical budget and engineering data of the data statistics module. The system simulation results show that the system can effectively realize the garden landscape design of the community, and the visual effect of obtaining the garden landscape scene is better.

Keywords: computer; virtual reality; garden landscape; landscape simulation modeling.

1. Introduction

With the rapid development of information technology, the landscape industry has been more and more deeply applied to information technology. From the gradual popularization of computer rendering technology at the beginning of this century, to the more intuitive three-dimensional roaming and construction animation in recent years, more and more large and medium-sized garden designs have been applied. With the leap of computer graphics processing capability and the improvement of peripheral hardware conditions, virtual reality technology with interactive participation has gradually entered people's field of vision. It is one of the emerging technologies in the garden landscape industry after 3D roaming animation. Virtual reality technology not only achieves a more realistic immersive experience, but also breaks through the one-way transmission mode of traditional roaming animation information, allowing people to participate in and interact with the virtual environment [1]. For example, virtual garden tours in tourism promotion, virtual interactive roaming in real estate sales, virtual construction displays in complex construction projects, etc. Combining virtual reality technology with the specific needs of various fields of the garden industry such as landscape design, engineering construction, project display, and practical teaching can significantly improve the overall level of the industry and further accelerate the industry's informatization development process.

Most of the current landscape engineering planning processes use AutoCAD for floor planning. The development time of relevant special software in China is relatively short, and it is basically evolved from construction and planning software, which has the function of greening. For example, Hangzhou's HCAD software and Hongye software belong to planning software. At present, most engineering applications are designed on third-party platforms such as AutoCAD. Except for the maintenance of software copyrights, most of them are based on their platforms [2]. Based on the basic ability of 3D modeling and data statistics, there are certain limitations. Since the system can only be classified into professional planning or construction software without any professional functions, it is difficult to be recognized by the industry. In this case, the Software Research Institute of China Academy of Construction Science and Technology adopts the Chinese three-dimensional plane garden design simulation system, which closely combines the plane design with the three-dimensional expression. The domestic application of plant database production, garden terrain design, garden auxiliary facility parameter design, garden design, garden auxiliary facility design, etc., makes up for the deficiencies of domestic garden design.

2. Landscape simulation system based on virtual 3D vision technology

2.1 The overall structure of the system

Design a landscape design system based on 3D graphics processing technology, use computer as hardware, and use 3D image processing technology to realize the effect display of landscape initial design and later landscape design [3]. The overall structure of the landscape design system based on 3D graphics processing technology is shown in Figure 1.

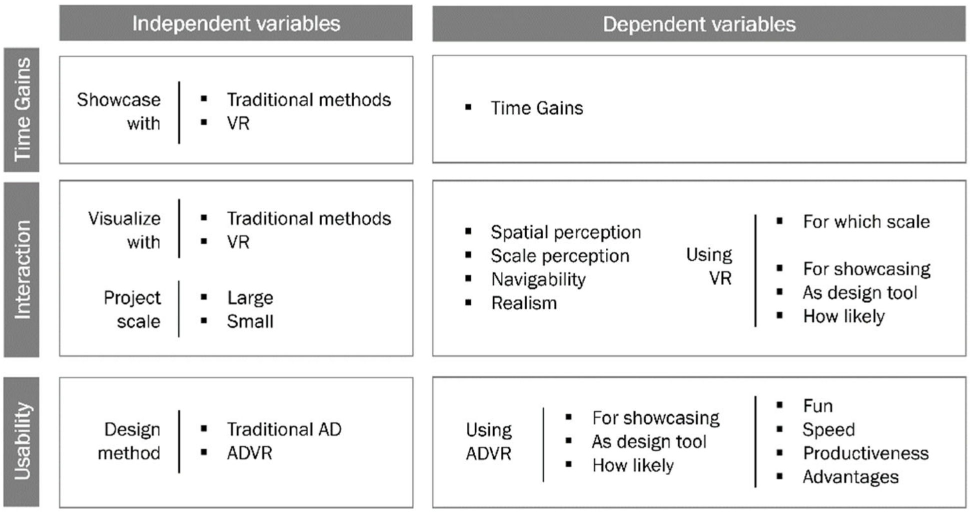

Figure 1. Overall structure of the system

The designed system mainly includes two parts: model scene design module and resource library. The model scene design module includes two parts: editing and model building. The editing part is used to realize different operation editing of the system. The model building part includes four parts: terrain modeling, tree modeling, water modeling and rock scene modeling [4]. The rendering and animation part realizes the integration of the established models, and the integrated model is the final design result of the garden landscape; resource support is provided for the system through the resource library, which includes the garden library, the plant picture library, the garden plane symbol library, and the background picture library four In part, when the relevant resources need to be retrieved in the process of landscape design, the file reading and writing module is used to convert the resources to the required format for easy access by the system.

2.2 System Innovation Points

The three-dimensional garden design simulation system has communicated with professional design agencies several times in the design, so that it can better understand the characteristics of various aspects of the current CAD, and make corresponding designs as needed/make the system comparable to similar foreign software. Compared with the following innovations: professional planting design; professional construction drawing design; the most used plant database in China; parametric design of garden auxiliary equipment; in GIS environment, the planning of landforms It is integrated into the design of the garden; the two-dimensional display and the three-dimensional display are closely integrated, and the simulation results are better reflected by the use of virtual technology.

2.3 Construction of 3D Landscape Model

Based on virtual reality technology, the modeling of people, natural phenomena, water bodies, vegetation, buildings and terrain is carried out through OpenGL, and the construction of three-dimensional landscape models and the roaming of models are realized. Firstly, construct the 3D terrain model, and read the information such as the number of columns, grid spacing, number of rows, and starting coordinates of the DEM data in the data header [5]. Then read the elevation data in the data body, including the elevation value Z, column number, and row number. Obtain the Z, Y, and X coordinate values of each elevation point based on the column number, row number, and grid spacing coordinate values of the southwest corner of the grid. Then build a structure array to store the elevation value Z, Y coordinate value and X coordinate value of the elevation point. Build a wireframe terrain model after connecting the elevation points. The wireframe terrain model is filled with the gl-Polygon Mode function, and the planar terrain model is constructed. Finally, the terrain is simplified by wavelet transform. Specifically, as shown in Figure 2.

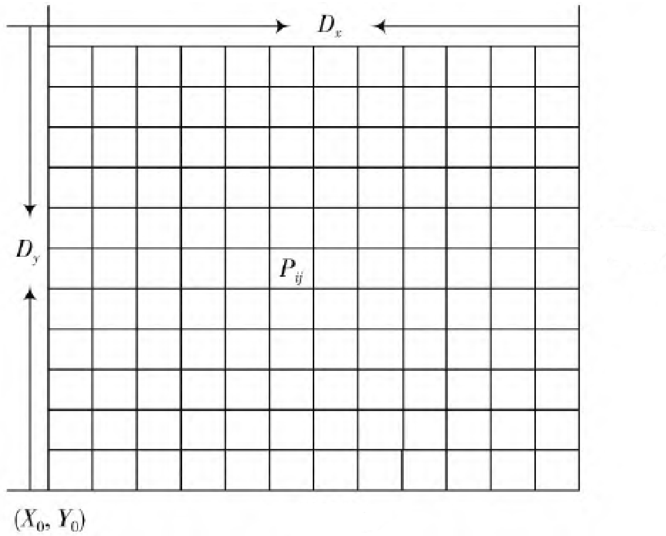

Figure 2. Terrain mesh simplification

P_{ij} is the plane coordinate of any point by deriving the row and column numbers of the grid matrix in I, J F and the basic information stored in the DEM file. The basic information in the DEM file: x, y represents the horizontal and vertical coordinates, (X_0, Y_0) represents the starting point coordinates of the DEM matrix; DEM represents the distance in the x, y direction; M, N represents the number of rows and columns of DEM. The calculation formula for obtaining the coordinate (X, Y) of P_{ij} is:

$$\begin{cases} X = X_0 + J \cdot D_x \\ Y = Y_0 + I \cdot D_y \end{cases} \tag{1}$$

The steps of building a building model are as follows: (1) Use the camera to photograph the side of the building from the front, and obtain the modeling texture image of the side of the building and process it. (2) Crop the top building texture data in the orthophoto with higher resolution. (3) The building model is constructed by using the CAD plane topographic map as the basic data. (4) Add details such as roofs, balconies and building interiors on the basis of the model. (5) Use the material editor to implement texture mapping.

The steps of building a vegetation model are as follows: (1) Obtain real tree images. (2) Map the texture image on the intersecting two polygons. (3) Set the lighting effect.

The construction of the water body model includes two parts, one is the water body, the dynamic water surface effect is obtained by offsetting the position of the texture image, and the water surface is represented by drawing the water surface grid. The other part is a fountain, which simulates a random water body through a particle system. The steps of constructing a natural phenomenon model are as follows: (1) Use the illumination model to simulate the illumination. (2) Three steps to simulate the fog, define the characteristics of the fog, and start the fog. (3) Express snowflakes through particle system.

Build models of people in the form of billboard textures. By integrating vegetation, buildings, water and other objects on the terrain model, a three-dimensional landscape model is constructed, and scene roaming is realized through virtual reality technology.

2.4 System function design

1) Building model design

The acquisition of basic data is mainly building height data and plane data. Among them, the height data acquisition method is to directly extract the height of the building and other related information from the image, and the plane data usually obtains two-dimensional vector data [6]. The establishment of building model is realized through three levels of finer modeling, fine modeling and hybrid modeling. Among them, most buildings use finer modeling, and a few representative buildings can use fine modeling. Hybrid modeling is suitable for the method of combining finer modeling and fine modeling when reconstructing large-scale 3D landscapes. Realize the reconstruction of the landscape. Choosing a reasonable modeling method can improve the modeling efficiency. The collection of building textures is to obtain building texture data through field photography, and directly use it for 3D scene design.

2) Planting tree model design

Using the tree-like node structure method of the three-dimensional landscape organizational structure, the organizational structure of each element of the landscape is constructed. On the one hand, this structure is conducive to the texture rendering of the three-dimensional landscape, and on the other hand, it displays the landscape information in detail, and flexibly adjusts the organizational structure of the landscape. In the vegetation landscape design, the Tree Engine Tree Engine integrated into the system environment is used to load and render the planting tree model to construct a three-dimensional landscape display. The rendering process of the planting tree model loaded into the scene is shown in Figure 3.

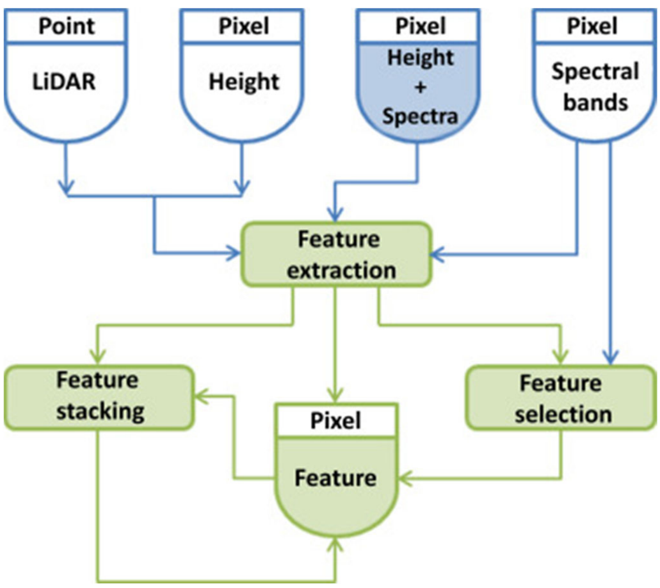

Figure 3. The rendering process of the planting tree model loading scene

3) Landscape Optimization for 3D Texture Rendering

The 3D terrain scene is reconstructed based on the terrain scene map of the designed garden landscape collected by the binocular stereo vision camera. When using a binocular stereo camera to collect terrain and building information, the camera state in the world coordinate system is represented by x_c , and l^T, e^T, v^T, ω^T respectively represents the rotation quaternion, coordinate position, linear velocity and angular velocity of the camera. The formula of the camera state is as follows:

$$x_c = (e^T, l^T, v^T, \omega^T) \tag{2}$$

The three-dimensional world coordinate of the feature state vector of the camera map composed of the feature points is $g_i(x_i, y_i, z_i)^T$. The state vector of the reconstructed 3D terrain scene is composed of the state vector and feature points of the binocular stereo vision camera system. The formula is as follows:

$$x = (x_c^T, g_1^T, g_2^T, \cdots, g_i^T, \cdots, g_n^T)^T \tag{3}$$

In the process of 3D terrain scene reconstruction, a uniform model is selected, and the state prediction formula of the binocular stereo vision camera is obtained as follows:

$$x_{c,t+1} = \begin{bmatrix} e_{t+1} \\ l_{t+1} \\ v_{t+1} \\ \omega_{t+1} \end{bmatrix} = \begin{bmatrix} e_t + (v_t + m_v)\Delta t \\ l_t \times l(\omega_t + m_\omega)\Delta t \\ v_t + m_v \\ \omega_t + m_\omega \end{bmatrix} \tag{4}$$

In the formula, $[m_v, m_\omega]^T$ represents the process noise in the process of reconstructing the 3D terrain scene. The coordinate formula of the projected position of random point Q in the reconstructed 3D terrain scene in the image is as follows:

$$\begin{cases} x = \dfrac{gX_c}{Z_c} \\ y = \dfrac{gY_c}{Z_c} \end{cases} \tag{5}$$

In the formula, (x, y) and (X_c, Y_c, Z_c) respectively represent the coordinates of point Q in the imaging plane and the coordinates in the camera coordinates. Using the feature points matching the map feature points to represent the coordinates of the observations in the collected images, the formula is as follows:

$$D = (D_1\ D_2 \cdots D_n)^T \tag{6}$$

In the formula, m and $D_i = (u_i v_i)$ respectively represent the number of matched feature points and the coordinates of the collected image when the feature point is i.

3. System software and hardware design

3.1 Hardware system

One of the characteristics of virtual reality technology is interactivity. In order to realize the information interaction between the experiencer and the computer, special input and output tools are required, and the experiencer's own physical operation is also required to provide various input instructions. The computer's operation is generated, and the corresponding feedback information is provided, so as to achieve a relatively real simulation effect. Input devices mainly include infrared locators that perceive spatial information and traditional information input devices, including infrared locators, handles, mice and keyboards, etc., which input somatosensory information and touch information into the computer. This platform uses the HTCVive virtual reality device, which uses the

Lighthouse indoor positioning technology, which can use algorithms and sensors to perceive the movement of the experiencer to determine the relative position of the user in the space (Figure 4). Output devices mainly include virtual reality head-mounted displays, computer monitors, ring screen projections and digital sand tables [7]. The virtual reality head-mounted display used in this platform is HTCVive, which can be connected to a computer by using a data cable. The lens in the display corrects the picture seen by the eyes through focusing and secondary imaging, and changes the angle of the two-dimensional image to simulate a three-dimensional image. Convert the abstract information input into a concrete and intuitive picture, which is convenient for the experiencer to observe and interact.

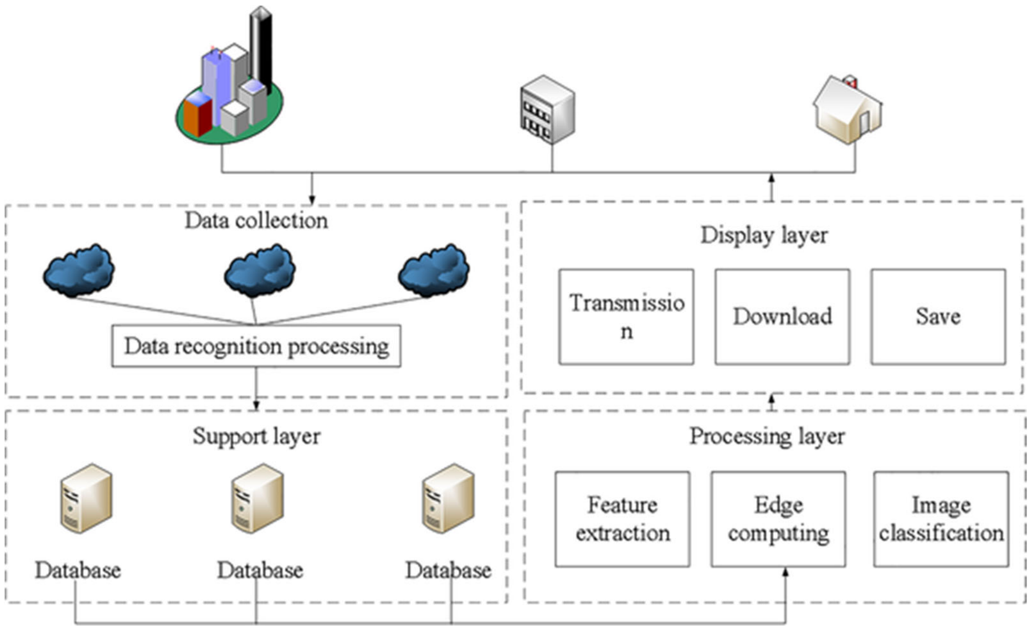

Figure 4. System Hardware Design

3.2 Software functions

The platform software system processes data through the UE4 engine to convert 2D model data, Internet data, and sensor data into 3D VR models, including data acquisition layer, data transmission layer, data storage layer, VR display layer, and VR interaction layer (Figure 5). The data acquisition layer is responsible for providing basic data for platform construction, including model data, Internet data and sensor data [8]. To collect model data, you need to use the SketchUp Ruby program for secondary development of the garden scene model to be displayed. Internet data needs to be accessed through the Internet to collect site-related geographic data; the data transmission layer is to copy the basic information collected by the data layer, network transmission or it is transmitted to the computer by the base station transmission method; the data storage layer is responsible for classifying the basic data and storing it in the package of the UE4 engine. The dynamic data is uniformly stored in the server and called according to the needs of the functions in the venue; data processing The layer is to use the UE4 engine to reconstruct the model data, and to optimize the scene, adding interactive elements and light and shadow changes, so as to realize the conversion of the site model from flat to virtual reality and real scene rendering, using physics-based rendering system (PBR) to achieve the real restoration of the model scene; the virtual reality display layer is to observe the more realistic site effect through the head-mounted display and perform the effect simulation and index monitoring of the data; the virtual reality interaction layer is brought by the experiencer. After the VR headset, the circular process of somatosensory operation, computer transmission analysis and signal feedback are realized.

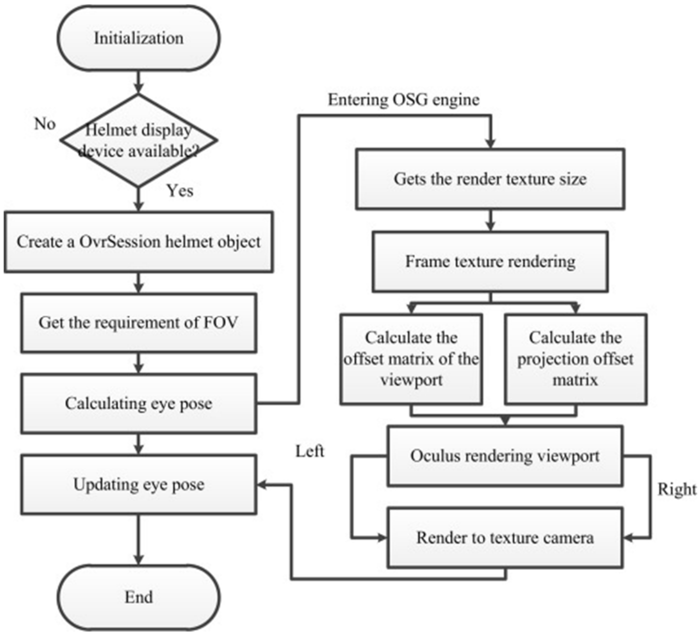

Figure 5. System software flow

4. System Check

This system integrates various simulation technologies such as 3D modeling, 3D terrain design, 3D planning and design, 3D planting design, real-time 3D scene simulation, professional garden construction drawing and drawing, simulation animation, etc. The job, the performance of the system and the performance of the operation all meet the design requirements. Significant progress has been made in the dynamic display of three-dimensional images, the rendering of three-dimensional animation, the application of OpenGL expansion technology, etc., so that the simulation design technology of the entire three-dimensional environment can meet the relevant actual needs, and has been widely recognized in the industry. The only 3D three-dimensional garden simulation design software.

5. Conclusion

Through the analysis of the background, innovation and key technology of 3D garden design, this paper analyzes the key technology and key technology in 3D garden design, and analyzes the main simulation technology and technology in detail, and realizes 3D modeling., 3D terrain design, 3D planning and design, 3D planting design, professional garden construction drawing, 3D scene real-time modeling, post-drawing and simulation animation and other functional modules integration.

References

[1] Li Zhixuan, Wang Dong. The application of virtual reality technology in the protection of traditional garden buildings. Architecture and Culture, vol.7, pp.141-142, April 2021.

[2] Feng Nan. The application of virtual reality technology in landscape design. Modern Horticulture, vol. 43, pp.29-35, April 2020.

[3] Miguel Vida Pura. Present Crisis and Future Challenges of Contemporary Landscape Design: A Design Approach from Trait. Landscape Architecture, vol. 27, pp.140-147, June 2020.

[4] Cao Zhe, Liu Yuping, Liu Lei. Analysis on the advantages and application prospects of VR landscape architecture projects. Inner Mongolia Coal Economy, vol. 7, pp.12-18, April 2021.

[5] Luo Yuxing. Application and Development of Virtual Reality Technology in Landscape Design of Landscape Architecture in China. Intelligent Building and Smart City, vol. 4, pp.22-34, May 2021.

[6] Wang Zijia, Gao Yongxin, Chen Feng, et al. Development and application of a subway fire evacuation simulation platform based on virtual reality technology. Urban Express Rail Transit, vol.7, pp.57-64, January 2020.

[7] Liu Suizhou. Application of virtual reality technology to realize the design of three-dimensional landscape architecture. Information Technology, vol.46, pp.169-174, January 2022.

[8] Hui Jizhuang, Fan Bohan, Ding Kai, et al. Virtual reality-based steel structure bridge assembly construction simulation system. Chinese Journal of Building Science and Engineering, vol. 39, pp.98-104, April 2022.