Application of Computer Virtual Reality Technology in Design

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Abstract: With the continuous development of technology, the design of the environment can be simulated by computer technology. The virtual reality (VR) technology can be used to take the real world as a three-dimensional space, three-dimensional space can be designed to simulate the actual environment. In this paper, virtual reality technology is applied to design, and design is divided into two fields, namely landscape design and scene lighting rendering. We study characteristics of virtual reality technology and framework of virtual reality technology, at the same time, we define the concept of light and the concept of landscape in design, and analyze the problem of lighting rendering and the problem of landscape design. From the perspective of landscape design, we discuss the difficulties of virtual reality-landscape design, and further analyze the landscape design level and multi environment elements display based on virtual reality technology, and propose a feasible virtual reality-landscape design method; from the perspective of light rendering, the principle of lighting tracking algorithm can be analysed, the realized method is used for lighting rendering, the game engine is used as the rendering engine, MAYA and Photoshop software are used as the main rendering techniques of virtual reality, therefore, the real-time rendering of landscape's surrounding environment is realized.

1. Introduction
Virtual reality (VR)[1] technology is a combination of technology, which integrates the knowledge of computer, sensing, electronics, art and other fields, virtual reality technology can help developer of designing to arrange the engineering environment, which includes the placement of buildings, the greening around the building, and the living space of people in the building. The design of environment[2] involves the landscape around the building[3] and the lighting effect[4] around the building, therefore, this paper transforms problems of design into the problem of landscape design and the problem of lighting rendering.

Virtual reality technology is firstly used in the scene rendering of 3D films. In order to make the overall effect of animation more realistic, Pixar Animation[5] adopted the computer technology for the lighting of simulation scene. The Renderman ray generator[6] they developed can make light rendering in different environments, the intensity of light can be adjusted, at the same time, in order to match the scene, the renderer can adjust different colors of light, the greatest advantage of renderer is that the image rendering has strong characteristic of real-time, that is completing the rendering of image in a very short time, and then it will help improve people's visual experience. According to the related research, the virtual reality environment needs to have a certain refresh rate of image[7], at least, it should be 90fps, so people don't feel dizzy, people will feel the real experience of virtual environment on the 120fps refresh rate.

The traditional landscape design adopts 4 methods, which include manual hand drawing[8],
In these 4 design methods, manual hand drawing can only be used in the conceptual design of architecture, it is a general form of architecture; the model of architectural landscape needs to be reduced based on the proportion of real buildings, it is difficult for people to assess the actual size of the building; the design of landscape rendering can only get partial architectural effect, it is difficult to obtain the full view of architectural landscape; the landscape animation has a strong dynamic display ability, people can clearly see the whole picture of building, but can only be passively guided to different directions of the building, and can not adjust the architectural perspective by own wish. Some researchers thought that, when landscape designers design buildings, they need to carry out the design of modeling and environment design, which require a strong sense of space and rich design experience, at the same time, designers need to consider the demand of users; in the process of planning construction project, designers need to calculate the parameters of building, analysis the gap between the realizing performance and the expected performance, and then, the design scheme should be fixed, it can be improved to improve the feasibility of overall landscape design. Designers need a long time to achieve a reasonable design, they need to draw many scenes day and night, these scenes are part of the landscape, in order to describe the whole landscape, they need to draw a lot, but this kind of drawing will make the landscape lack of aesthetics, function, designers just care about the overall layout, from the perspective of building landscape display, developers want designers to show the beauty of architecture. Designers need to constantly improve design drawings, and excellent ideas are often stifled, because the integrity of landscape display is difficult to be expressed in traditional ways.

Lighting rendering need to be gived a attention to the angle of light projection and the intensity of ray casting, therefore, lighting rendering needs to be gived a attention to ray casting algorithm[12]. The concept of the earliest ray casting was proposed by Arthur Appel, which described the casting of light as the space of ray casting in the nearest point of object, the brightness of space[13] is related to the material, ambient light, and the reflection of surrounding environment. The plane of ray casting is in a plane of strong light, ray casting algorithm can efficiently calculate the effect of light-shadow around a lighting object, the surrounding environment includes trees, people, buildings, public facilities and so on. In the process of ray casting, it produce the refraction light, the reflected light and the shadow surface, light reflects the plane, the reflected light interacts with the nearest object, and the nearest object will refract the light. If light reflection is consistent with the position of the object, light will come up the tracing phenomenon; if the light reflection is not consistent with the position of the object, the light will scatter in the dark place of object. The traditional calculation method of ray casting needs a lot of calculation, it is difficult to meet the requirements of real-time image, with the improvement of hardware performance, GPU gradually replaces the CPU, it can realize the real-time processing of image, combine with the illumination renderer, the real-time rendering of scene can be completed efficiently. According to the related research, mentalray, V-ray and other rendering software are also developing image processing technology of supporting GPU, so we can see the performance of GPU rendering[14]; people put CPU[15] into lighting rendering, it takes a long time to calculate, and the error rate is high, calculation time is too long, which would result in a dead cycle and greatly affect the processing schedule of lighting rendering.

In this paper, we put virtual reality (VR) technology into the design of environment, we divide the environment design into landscape design and lighting rendering of scene, that is, above two aspects should be comprehensively considerrd, and it help realize the design of environment. We analyze the characteristics of virtual reality technology, design the implementation process of virtual reality technology in detail. In view of landscape design and lighting rendering, we analyze their concepts and do in-depth research on the shortcomings of traditional practices by the form of cases. From the perspective of landscape design, we discuss the difficulties of virtual reality-landscape design, and further analyze the landscape design level and multi environment elements display based on virtual reality technology, and propose a feasible virtual reality-landscape design method; from the perspective of light rendering, the principle of lighting tracking algorithm can be analysed, the realized method is used for lighting rendering, the game engine is used as the rendering engine, MAYA and Photoshop software are used as the main rendering techniques of virtual reality, therefore, the
real-time rendering of landscape's surrounding environment is realized.

2. Virtual Reality (VR) Technology

VR is a 3-dimensional modeling technology, which is mainly realized by computer technology and sensor, among them, sensor can capture a lot of signals, which include heat, light, wind and so on; computer technology can express the received signals with different colors and different signs. Computer can generate the building images of equal proportion from the data of sensors, and grass and trees can also be generated around the building. The combination of computer technology and sensors can help people create a virtual environment, people can feel the real experience in this environment.

2.1. Characteristics of VR Technology

VR technology can make people feel a real feeling, people wear VR glasses and gravity sensing helmets, people see virtual scenes, and they also get the feeling of physical contact in the surrounding of virtual environment. These feelings include gravity, pain, heat, cold, smell and so on. We can further explain that the visual sense of VR can also stimulate other feelings of people, therefore, it put people into a real living environment.

In Figure 1, we sum up the technical features of VR as authenticity, interactivity and multi-sensing, and further described as: (1) authenticity, people wear VR glasses, and gravity helmets, people will put themselves in a virtual environment, in which people can feel the sound, smell the flower, and be able to feel the trees and flowers in the virtual environment; (2) interactivity, the interactivity of VR is not only the machine can react, but the things can do the reaction to the user in the virtual environment, for example, in the virtual environment, the user gives the dog food, the dog will lick the face of the user; (3) multi-sensors, the user is able to feel something of the virtual environment, which requires some sensors on their bodys, so these sensors can get the sensation of the body, just like heat, cold, and even smell.

![Figure 1. The technical features of VR](image)

2.2. System Framework Based on VR Technology

The system framework of VR technology includes hardware system, user's complex feeling, and the construction of virtual environment, human and system of VR technology needs to be viewed as a whole. People can experience the real living environment in the virtual environment, at the same time, according to the user's reaction, the virtual environment will change itself. The system framework for VR technology is shown in table 1:
Table 1. The System Composition of VR Technology

| Composition  | hardware system | complex feeling | virtual environment |
|-------------|-----------------|-----------------|---------------------|
| VR glasses  | sense of smell  | building        |
| gravity helmet | tactile sensation | trees          |
| PC         | sense of hearing | sounds          |
| sensor     | visual sense    | people          |

In table 1, we can see that VR technology requires hardware to build the environment, and users’ emotions need to be involved in the virtual environment. In the virtual environment, users can see buildings, can see trees, can hear different voices, and can talk with virtual characters.

Table 2. The Application of VR System

| Function            | Description                                                                 |
|---------------------|-----------------------------------------------------------------------------|
| Visual modeling     | 1. VR technology is used for geometric modeling.                             |
|                     | 2. the VR technology is used to synthesize the incomplete image.             |
|                     | 3. the VR technology is used to the restoration of 3D images.                |
| Acoustic modeling   | 1. put VR technology for special sound.                                      |
|                     | 2. VR technology can be used for adjusting the space range by echo of user.  |
|                     | 3. VR technology can be used for getting the animal's voice.                 |
|                     | 4. VR technology can be used for storing the voice of virtual character.      |
| Tactile modeling    | 1. users' tactile analysis.                                                 |
|                     | 2. the pressure can be evaluated by the help of VR technology.               |
|                     | 3. the temperature can be evaluated by the help of VR technology.            |
|                     | 4. VR technology can be used for simulation of production activities.        |
| Mixed sensing modeling | 1. VR technology is used for image computing.                             |
|                     | 2. VR technology is used for modeling 3D images.                            |
|                     | 3. the discovery of the acoustic propagation path.                           |
|                     | 4. the rate of heat volatilization can be calculated by VR technology.       |

The system of VR technology can be used in many fields, as shown in table 2, which can be used for visual modeling, acoustic modeling, olfactory modeling, and hybrid sensing modeling. The VR technology can analyze the virtual things and generate the corresponding data description. For example, the VR technology can adjust the settings of virtual space by the echo of user, that is, the bigger the space get, the longer the response time of sound get, the smaller the space get, the shorter the response time of sound get; the VR technology can also be used to evaluate the force of object, heat of animal, production of life.

3. Related Concepts of Light Rendering and Landscape in Design

The environment design needs the layout of scene, the rendering of light, and the design of the VR technology, it is necessary to study the concept of light rendering and landscape, therefore, it is helpful to provide the theoretical basis for VR’s design.

3.1. The Basic Concept of Light Rendering

Sunlight helps people see things, because human eyes are not luminous, scattering of light and refraction of light helps people get images of things. In a sense, there is no light, the world does not exist, the world is a entity of light projection, by the mapping of light, people can better understand the world. Human visual cognition is derived from light, light effects on objects, it can clearly reflect the basic features of things, we can see the shape of things and the color of things. In life, we often see different colors, one color can be represented as a building or a street. The boundary of colors show there is a certain boundary between space and space, at the same time, different lights can produce different effects of rendering, as shown in Figure 2.

In Figure 2, we can see different types of light, of which (A) means candlelight, and (B) represents
the blinding sunlight, (C) represents a beautiful sunset, and (D) represents the streets under the night. We can further see that compare with the light of (A)-(B), (C) and (D) are more complex, in the figure (C), red can be taken as the basic color in the sunset, the golden yellow is mixed in red, the outside of red contains light blue, in the figure (D), we can see that the night is dark, the street light is yellow, the more concentrated luminescence is golden yellow. The rendering of light can clearly show the change of color, different colors can map different things, at the same time, the same thing can also show different colors, because the intensity of color is different at different distances.

Figure 2. Different types of light

Lighting can help people illuminate, in scene rendering, light can increase the beauty of scene, can increase the reality of picture, different types of light need different types of light. Light travels in the course of illumination. Under the shining of light, the front brightness of object is higher, the back of object displays a strong shadow, and there will be scattered light around the object. In the design of virtual reality, we need to consider the effect of light, the principle of light propagation should be taken into account, so that the vision of the light is closer to the scene of life, and the reality of scene is further increased, as shown in figure 3:

Figure 3. A building under natural light
In figure 3, we choose a teaching building as an object of study, sunlight illuminates the building, looking up at the building from the staircase, we will see the blinding sunlight; from surrounding environment of the building, we can see that a large number of plants get be illuminated, which is known as casting of the light; we can see a faint brightness from the pillars of the building, the sunlight illuminates the pillars by refraction of light. We need to consider the propagation principle of light when we design the lighting effect of the scene, that is, we need to consider the refraction of light.

### 3.2. The Basic Concept of Landscape Design

Landscape design involves many aspects of content, it can be understood as the activities of creating environment, it is an interdisciplinary, it needs to combine architecture with landscape, that is, the architecture needs to show beauty, the design of architecture is regarded as an art. Landscape design can be used for regional planning, can be used for the layout of architectural space, and can be used for doing external modification of buildings. The landscape design needs to be practical, beautiful and economical, in these features, the practicality indicates that the design of the building should be available and will not waste any building material; the beauty shows that the design of the building needs a sense of modernity, it needs bright colors, and it can highlight the fashion flavor of building; economy means that the consuming of building needs to be maintained within a certain range of cost, at the same time, the power consumption of buildings is within a certain range of cost.

Some scholars believe that landscape design is a spatial description on the ground, and is also a architectural art of 3-dimensional space, it can be further described that the designers adopt artificial way to construct the 3-dimensional space, which includes landscape, plants and buildings. With the improvement of people's living standards, people put forward more and more demands on the building's greening and building's energy consumption, therefore, the building needs to be integrated with the planning of city and nature. Landscape design needs to be in line with the regional planning of city, the population needs to be considered, and the traffic conditions around the building need to be considered. Some scholars said that the design of landscape should be analyzed by regional strategy, that is, the design of landscape should be consistent with the development planning of city, and improve the layout of city. In the process of designing, different buildings should be met some certain conditions, which include demographic factors and traffic flow factors, as shown in table 3:

| Building      | Conditions                                                                 |
|--------------|----------------------------------------------------------------------------|
| University   | 1. convenient transportation, fewer factories, get extensive land.          |
|              | 2. it can accommodate a large population.                                  |
|              | 3. it should be planted a large of trees.                                 |
|              | 4. it should have a humanistic atmosphere.                                |
| Residential  | 1. convenient transportation, fewer factories, get extensive land.          |
| building     | 2. it can accommodate a large population.                                  |
|              | 3. it should be planted a large of trees.                                 |
|              | 4. it can get enough electricity.                                          |
| Hospital     | 1. convenient transportation, fewer factories, get extensive land.          |
|              | 2. it can accommodate a large population.                                  |
|              | 3. it should be planted a large of trees.                                 |
|              | 4. it can get enough power supply and have standby power supply.           |
| Bank         | 1. convenient transportation, many factories, get extensive land.           |
|              | 2. it can accommodate a large population.                                  |
|              | 3. It should be near the residential building, which is in the middle of the residential area. |
|              | 4. it can get enough power supply and have standby power supply.           |

In table 3, we can see that the location of different buildings is different, but they also have some
common characteristics. These buildings need to accommodate a large number of people, at the same
time, the traffic around them must be convenient, that is, it take different ways of transportation to
reach their destinations. Some buildings need to be recharged, we list hospital and bank as examples,
in which hospitals need to receive patients from time to time, and bank need to meet people's needs of
taking money. In the design of landscape, we need to consider the building facilities, that is, the
function of building needs to meet the hardware conditions, therefore, according to the actual
circumstances, we may need to open the road around the building, and may also need to set up power
stations around the building.

4. Environment Design Method Based on Virtual Reality Technology

We turn the problem of design into light rendering and landscape design. From the perspective of
light rendering, we adopt ray tracing algorithm to capture the key points of object, and then color it;
from the perspective of landscape design, we adopt virtual reality technology to reconstruct the
3-dimensional space.

4.1. Principle of Ray Tracing Algorithm and Algorithm's Implementation Based on Vr

Particle filter is a stochastic process of speculative style, it is necessary to establish state prediction
model and system evaluation model for target tracking. Particle filtering needs to consider the
prediction's stage, that is, according to the probability, adopting the current particle data to calculate
the particle data of next moment; then we need to consider the update's stage, that is, according to the
image data obtained from each frame, to update the result and get the current motion state of target,
the general flow is as shown in the figure 4.

According to figure 4, the particle initialization is to adopt uniform distribution for N particles or to
adopt gauss distribution for the target, give the same weight; the conjectural process of state is a
process of real-time updating of a target state walking with time, that is, the particle state of t-1
moment is known, then calculate the particle state of t moment; the evaluated process of system
actually is a process of calculating based on similarity, each particle will get a new state value when
the development state of system changes, in the process of evaluation, the result of state change is
checked by the evaluation value of t moment, the evaluation process of system is given the weight
value of particle based on the similarity of current particle and current motion state of the target, the
greater the degree of similarity, the greater the weight is; the average calculation of state is generally
adopted in the method of weighted mean, that is, after the current particle's weight is normalized, the
final state value of target is obtained by the weighted summation of different weights; finally,
according to the given weight, the particle set is resampled for the next iteration process, and the
iteration process will run repeatedly if it doesn't run to the last frame.
The ray tracing algorithm can set parameters for the emission of light and refraction of light, these parameters are used in the scene design of MAYA and Photoshop software, we can adopt the parameter results to color the scene objects, as shown in the Figure 5:

**Figure 4.** Target tracking executive steps based on particle filter

**Figure 5.** Comparison of regional diversity by RGB features and LBP features

In Figure 5, we adopt RGB features and LBP features to render images, the color of images is obtained by ray tracing algorithm. Under the illumination of light, the car in the picture shows a clear difference of color, that is, the color of the body is different from that of the tire and that of the window, and the ground is similar to the adjacent buildings. In Figure 5, we can see that the ground's color is coffee, the adjacent building's color is also coffee, but the ground's color is gray, the adjacent
building's color is white, because the effect of light, the ground's brightness is similar to that of adjacent building, so the colors of them are the same. Under the effect of ray tracing algorithm, the lower the brightness of objects, the deeper color they give.

In Figure 5, the light is irradiated on the floor of street, we can see that a part of the street shows a high brightness in the image, the MAYA software has yellow spray on this part, and the window shows the lowest brightness next to the vehicle, so the part need to be given a dark-blue spray.

4.2. Realizing Method of Landscape Design Based on Virtual Reality Technology
A basic task of landscape design is the reconstruction of 3-dimensional space, which requires the expression of space based on developers' demands. It takes a long time to draw the 3-dimensional space in traditional way, it is difficult to take all the factors into account. Virtual reality technology can take the outline of a building, surrounding of buildings and weather factors as a whole.

In the face of different times and different seasons, virtual reality technology can simulate the virtual scene of the building; in the face of different angles and different positions, the virtual reality technology can display all the facilities of the building in all directions. The way we operate is to arrange a number of sensors, which include temperature sensors and azimuth sensors, they can obtain traffic information, traffic information and air information around the building, so that we can determine the orientation of building, the area of building and the height of building. The design method of landscape based on virtual reality technology is as follows:

1) taking 3D space, sound and architectural behavior as reference factors, MAYA software and image processing technology are adopted for landscape design;
2) the interior tracking facilities and external environment are tracked by ray tracing algorithm;
3) users can modify the facilities in the building, and the scene will also adjust the internal objects;
4) we need to set the scope of scene modification, that is, allowing users to modify the object, and restrict the freedom of user's behavior;
5) the landscape space needs to retain some not-developing parts, and users can expand the landscape space in this part;
6) some objects in the building should be designed with some alternative reference materials, so it can facilitate users to compare physical objects.

5. Conclusion
In this paper, virtual reality technology is applied to design, and design is divided into two fields, namely landscape design and scene lighting rendering. We study characteristics of virtual reality technology and framework of virtual reality technology, at the same time, we define the concept of light and the concept of landscape in design, and analyze the problem of lighting rendering and the problem of landscape design.

From the perspective of light rendering, we analyze the ray tracing algorithm, and study the implementation steps of algorithm in detail, this algorithm can set the parameters of light emission and the parameters of refraction, which are used in the scene design of MAYA and Photoshop software, we can adopt the results of parameters to color scene objects; from the perspective of landscape design, we adopt a number of sensors, which include temperature sensors and azimuth sensors, they can obtain traffic information, flow information and air information around the building, these collected data are used as parameters, put them into MAYA software and image processing techniques, and MAYA software is designed for architectural design, the corresponding parameters need to be adjusted, and the Photoshop technology is used to further deal with the generated building images.

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