Application Research of Virtual Reality Technology in Design

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Abstract. With the improvement of people's living standards, virtual reality technology has been applied to different industries, its own interactive feature, real-time feature and scene feature, which make it widely used in the field of architecture. This paper applies virtual reality technology to interior design, users can experience immersive-artistic conception in the virtual scene. We introduce the concept of virtual reality, and analyze the relationship between virtual reality technology and interior design; we study several main technologies of virtual reality, which include VRML modeling for installing interior virtual scene, using X3D technology for scene expansion of virtual interior design, Web technology is used to share virtual scenes. In the process of interior design, we put VRML technology into realizing the initialization of virtual scene, then adopt X3D technology to simulate the virtual scene, and proofread the generated virtual scene based on VRML technology, in order to realize online experience of the virtual scene, we display the effect of virtual interior design in the web environment, so that users can interact with the virtual interior design scene. By a large number of experiments, we prove that X3D technology can be used for displaying the virtual scene space in many dimensions, and the virtual environment has good maintainability; with the help of online-virtual reality technology, users can modify the scene of interior design, move the objects of scene, so that users can optimize the design of space according to their own wishes.

1. Introduction

Virtual reality technology[1] was proposed by American Jaron Lanier, who described that it can take computer technology as the core, the image is embedded in hardware devices for displaying, users can experience the online-virtual scene in the hardware devices. Virtual reality technology helps people experience the building of virtual design, that is, the building based on virtual reality technology and the building of actual design have a strong similarity, this similarity is a kind of similarity of experience, experiencing feeling[2] should include hearing, vision, smell and other feelings. In the virtual scene, people will get auditory feeling, visual feeling, tactile feeling, and it is similar to the experience of real environment.

Virtual reality (VR) technology has three basic characteristics[3], namely, scene, interaction and space. These characteristics promote people to feel very close to the real life in the constituent scene of virtual reality. In the past, people could only be as a operator, watch the processing effect of the picture by computer operation, based on virtual reality technology, people could as participants, have a more intimate experience of virtual scene; in the past, people could only modify the digital image in one dimension by the input device of computer and output design of computer, watch the revised result, but the virtual reality technology can combine the computer with the sensor[4], the sensor can get information of different environmental factors, the computer can sort out the information of many
environmental factors[5], and promote the user to form a multi-dimensional view of the image; in the past, we adopt ordinary computer technology, acquired images and acquired lens[6] are relatively static effect, the processing of lens is lack of interactivity, angle adjustment of lens is limited, the application of virtual reality technology can be redefined for user experience, it will be converted into different settings, and make the processing effect of lens be closer to the actual scene in life.

The level of United States is the highest. Their research[7] on VR mainly focuses on picture perception, user experience, software maintenance, hardware design and so on. NASA applies VR technology[8] to data visualization, data can be expressed more intuitively, by data acquisition, satellite movement, space station operation can be simulated; the United States also applies VR technology to the field of education[9], it involves many science and engineering professions, which include physics, chemistry and so on, based on VR technology, it can truly display the experimental results of these disciplines. Japanese research institutes apply VR technology to the acquisition of knowledge[10], because VR technology can collect all kinds of information from real objects, many of which can not be obtained by conventional technology; many Japanese game manufacturers apply VR technology to the upgrade of game[11], the characters of game will be more realistic, especially facial expressions of virtual characters and gestures of virtual characters are closer to real humans. British R&D institutes put VR technology in distributed processing, aided design and artificial intelligence[12], they set up several R&D centers of VR, part of local governments try to apply VR technology to British film industry and British tourism industry.

The Chinese government attaches great importance to the development of VR technology, and our country has also issued many policies, which provide more funds for universities to set up VR disciplines and promulgate the national VR technology development plan. Universities are the main force for China to develop VR technology. Some colleges and universities adopted VR technology to describe physical characteristics[13] and process physical characteristics; some colleges and universities applied VR technology to the field of computer vision and distributed data parallelism[14], VR technology provides a virtual scene to correct visual effects, and it can simulate the processing effect of distributed data paralleling, taking distributed operation as an example, the effect is very close to the real scene, the error is less than 0.5%; Some colleges adopted VR technology to determine the route of the aircraft, and can also take VR technology as a simulation tool to test the ability of pilots to resist unexpected situations; some colleges adopted VR technology in the interior design of virtual scenes[15], VR technology can be used for acquiring multi-dimensional features of image, which is conducive to realizing feature matching of real scenes; some universities have put VR technology in the compounding field of CG animation, and have prepared a set of real-time browsing system of virtual environment. This system adopts layer-iteration technology and edge-concealment technology to realize the stereo of picture, at the same time, it also provides many interactive tools to enable users to adjust the CG screen.

This paper put virtual reality technology into interior design, firstly, we study the concept of virtual reality, analyze the relationship between virtual reality technology and interior design; secondly, several main technologies of virtual reality are studied, which include VRML modeling for installing interior virtual scene, using X3D technology for scene expansion of virtual interior design, Web technology is used to share virtual scenes; at last, in the process of interior design, we put VRML technology into realizing the initialization of the virtual scene, then adopt X3D technology to simulate the virtual scene, and proofread the generated virtual scene based on VRML technology, in order to realize online experience of the virtual scene, we display the effect of virtual interior design in the web environment, so that users can interact with the virtual interior design scene. In the process of design, we adjust the scene of X3D technology, virtual scene can be updated in real time, it can move the scene according to user's wishes, at the same time, X3D component function can help virtual reality technology and Web technology achieve better integration.

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2. The Concept of Virtual Reality and Relationship Between Virtual Reality and Interior Design

VR technology can increase the user's experience, this experience is very close to the real scene, this paper will apply VR technology to interior design, we need to further analyze the relationship between VR technology and interior design.

VR technology is a comprehensive technology, it involves many fields, such as graphics, human-computer interaction, artificial intelligence and so on. VR technology is took computer technology as the core, adopt hardware equipment, functional software to generate realistic hearing, smell and other senses, people can set up manually to increase the experience of virtual environment. When the user browses the scene, the computer can calculate the moving points, which include the image of XYZ axis, the orientation of the image, will be recalculated, and then return the image of the virtual scene. We do further description, virtual reality technology asks the computer to do multi-dimensional computing for complex environment, so as to achieve an all-round interaction between people and the environment, this all-round interaction, it includes visual interaction, auditory interaction, tactile interaction and so on. Compared with the traditional human-computer interaction, virtual reality technology has made great progress in the category of interaction and the experience angle of interaction. "reality" of virtual reality is anything that exists in the physical or sensory sense, it is touched in real life, at the same time, it is not fully captured by the general technology. The "virtual" means that the scene is generated by computer technology. Virtual scene can be adjusted by various hardware devices, which makes the virtual environment closer to the actual environment, that is, people interact with the virtual environment, and people can also change the virtual environment. According to relevant definition, virtual reality technology can be interpreted as:

Interpretation 1: based on the software-hardware environment of the computer system, the real world is simulated by the output device;

Interpretation 2: adopt computer technology to construct scenes, participants can get a more realistic virtual world;

Interpretation 3: a virtual three-dimensional space, users will feel that they has entered the space, experiences a real feeling, and they can also adjust the three-dimensional space.

Interior design is closely related to virtual reality, we need to analyze it from two aspects: virtual reality and interior design, from the perspective of interior design, it has the following reasons:

Relevant reasons 1: interior design not only meets people's living needs, but also reflects people's behavioral psychology, feelings of space, facing different people is needed to adopt different design methods;

Relevant reasons 2: interior design involves many environmental factors, which include macro environment, micro environment, architectural style, indoor cultural atmosphere and other environmental factors;

Relevant reason 3: interior design should be both artistic feature and practical feature, from the artistic perspective, interior design is needed to be coated with style paint, the wall should have a certain structure, and also have a beautiful style, from the practical perspective, interior design is needed to consider water, electricity and other basic life issues, at the same time, also consider fire hazard problem.

These related reasons of interior design, the physical indoor environment should be needed to be taken into account in, the environment include its own house, facilities, interior air density, interior water pipelines and interior electricity pipelines. Virtual reality technology can accurately present the environment, fire and air concentration can be used as conditions, and the virtual environment will be changed accordingly. VR-PLATFORM material library and VR-PLATFORM material library can be used for changing the material of the virtual scene, different materials will show different texture and color in the virtual scene, virtual reality technology can change the material, and also bring people the feeling of interior environment change. Virtual reality technology can simulate the changes of environment, which includes natural environment and interior environment, therefore, it is feasible for applying virtual reality technology to interior design.
3. Related Technologies of Virtual Reality

We introduce several main virtual reality technologies, which include XMRL modeling, X3D technology and Web-based virtual reality technology. Among them, VRML modeling implements the building of interior virtual scene, X3D technology is used for the scene extension of virtual interior design, and Web-based virtual reality technology can promote the virtual scene to share in multiple Web-ends.

3.1. VRML Technology

VRML is a virtual reality modeling language, it can create 3D graphics on the web page, it is also a language that adopts text description to interact with the environment. The language can publish 3D effect on different platforms, and users can participate in the experience of 3D virtual scene in an interactive way. With the development of VRML technology, the works of virtual reality gradually change from static to dynamic. The VRML language is described by ASCII code, the node is the basic unit, C/S is the access mode, users can view it by browser, the server provides the file with the suffix wrl, their working mode is shown in Figure 1:

![Figure 1. The operating mode of VRML](image)

VRML has the following characteristics:

1. network transmission is more convenient. VRML supports ASCII code for scene description, so it supports different platforms; at the same time, VRML can transmit and receive instructions remotely in heterogeneous network environment, real-time send and receive 3D information, and the requirements of computer performance are not very high for the transceiver of computer.

2. dynamic adaptability. The technology can implement its functions under different hardware configurations, and the upgrade of hardware configuration will not affect the application of the technology.

3. script support. This technology can embed the JavaScript language into the implementation of virtual scene, which will become more realistic.

4. C/S mode. VRML is worked between the client and the server, where the server can provide VRML files and other needed scene resources; the client can download files from the server by the network and access them in the local browser.

5. separate-development mode. Each file with the suffix wrl can be viewed as an element of the scene, and they can be saved as objects. VRML provides a mechanism that allows you to adopt hyperlinks to download these objects for scenario extensions.

6. enhancement of static scenes. VRML can generate a variety of 3D entities, these 3D entities can greatly facilitate the layout of the scene, you can choose the location of the entity as you wish; in the corresponding scene location, you can choose the appropriate object interactively.

3.2. X3D Technology

X3D is an extensible 3D markup language proposed by the Web3D coalition, its predecessor is VRML97, it has made a major change, combines VRML97 with XML, the 3D editing language is
extensible, many 3D objects can be described in a file. According to its definition, in a long distance transmission, multiple 3D objects can be transmitted by one file at one time.

Because of its extensibility, X3D can interact with three dimensional elements on multimedia platform. X3D technology can be applied in many fields, which include scientific visualization, multimedia technology, education, website construction and other fields. At the same time, it does not require high performance of hardware, can be edited and displayed on different hardware devices. X3D has the following features: (1) scene simulation; (2) network transmission; (3) script editing; (4) definition of virtual objects; (5) 3D coordinate positioning of objects; (6) human-computer interaction; (7) creation of audio objects and creation of video objects; (8) production of 3D animation. In syntax, X3D has strong expansibility, without strict syntax constraints, and does not define any concept of dependent objects.

The X3D system consists of four parts, which include extended language set, application program interface, VRML object set and X3D kernel, among them, software component can be as an important unit, and integrate a set of related nodes, the structure of X3D is shown in Figure 2:

![Figure 2. The architecture of X3D](image)

X3D encapsulates many elements of VRML and extends them to the kernel of X3D, by the use of VRML elements, the performance of X3D kernel can be further expanded; the operating system library integrates many extensibility functions, and it also involves many functions of running the kernel; X3D architecture also provides rich application program interfaces, which include SAI interface and DOM interface.

X3D as a markup language, from the perspective of concept, it involves the notion of annotation, file body, file header and file structure. File structure is mainly composed of file header and main program, which contains a large number of node types, and they include perception type, component type, rendering type and object type. X3D can nest multiple nodes in a certain format and describe them in a data structure, we will find that it is a tree structure, the structure is well-preserved hierarchy, many sub nodes can be set at different levels, the file structure of X3D is shown in Figure 3:
In each X3D file, the first line is the declaration of format, which is as follows:

```xml
<?xml version="1.0" encoding="UTF-8"?>
```

In the declaration, we can see two main pieces of information, one is the XML version number of the written document, and the other is the encoding format, the default format is UTF-8. The file body describes the main program appearance of X3D, which include necessary description information, component information and node information. The node information contains the elements needed by the scene, which are described in text. Different nodes can also define the corresponding attributes, they and the elements form a node information module.

### 3.3. Virtual Reality Technology Based on Web

VRML has powerful network transmission function and network display function, and VRML also has the following three main network functions:

1. The combination of objects. VRML has the performance of hyperlinking, VRML files and HTML files can interact with elements, that is, VRML can transfer its elements in the form of files, written pages of HTML can receive elements of VRML files for the display of web page. VRML can collect multiple scene elements in a file, so different scene objects can be combined to achieve the unified management of multiple physical elements.

2. The real-time performance of the network. VRML is used to transfer objects and replace scene elements, the server only need to apply, so it can download a complete text file of VRML to the client, users can analyze and operate the downloaded files by the browser. Most of the work is done by adopting a copy of the document, and the replica can be reused. In the process of the hyperlink operation or refresh operation, the client needs to contact the server to get the updated part of the link content, but in other processes, the client and the server are separated.

3. Scalability of VRML. VRML edited files can be edited and displayed on different grades of machine. It allows browsers to display objects on poorly configured machines or display objects on better-performing machines, they just have different display effects, but they can retain the main features of objects. In the Cosmo Player 2.0 VRML browser, 4 display attributes are set, which include: (1) display texture; (2) switchability of different views; (3) transparency of the background; (4) texture/image quality of the object. In the process of display, we can choose different attributes, or we can only select the "fastest" attributes, so as to obtain the fastest display speed and download speed.
4. Implementation of Interior Design Based on Virtual Reality Technology

We combine the above several main technologies, design the geometric model of the virtual scene by adopting 3Dmax software, the elements of the scene is edited in the form of files by VRML technology; the scene can be modified dynamically by X3D technology and adjust the expression of the elements in the scene; the scene can be uploaded to the customer by Web technology, users can share the scene by the browser so as to realize the interaction between the virtual scene and the browser.

4.1. Realization of Virtual Interior Scene Based on Vrml Technology

We need to set the ground center of the building, set the table, tea table and other objects, then adjust the coordinate system to the center of the desktop, and finally create a table. In the process of creation, we firstly need to define the background, movement variables, virtual character objects, table objects, and multiple visual point objects required by the scene.

Define the background and the ground, as shown in Table 1:

| Attribute       | Value                                      |
|-----------------|--------------------------------------------|
| skyAngle        | (1.057, 1.630)                             |
| skycolor        | [(0.0, 0.0, 1.0), (0.3, 0.3, 0.8), (1.2, 1.2, 1.2)] |
| groundAngle     | (1.374, 1.682)                             |
| groundcolor     | [(0.0, 1.0, 0.0), (0.2, 0.6, 0.6), (1.2, 1.2, 1.2)] |

In Table 1, we can see that the setting of the background part should be included two parts, one is the setting of the sky and the other is the setting of the ground, the setting of each object includes two attributes, angle and color.

The interior floor is represented as a cuboid of lower thickness, we can define its length and width, set the surface texture, and adjust the angle of ground, as shown in Table 2:

| Attribute  | Value                             |
|------------|-----------------------------------|
| Covercolor | RGB_value=0.0, 0.6, 0.8           |
| Size       | Length=70.0, Width=70.0, Height=0.08 |

We need to set the wall, set its thickness, wall height, wall width, at the same time, we need to set the three-dimensional coordinates of the wall, which corresponds to the coordinate system, and set the wall map, as shown in Table 3:

| Attribute      | Value                                      |
|----------------|--------------------------------------------|
| Position of XYZ| X’=0.0, Y’=3.6, Z’=-1.7                   |
| MapUrl         | F:\collectedMaps\walls\014757248.jpg     |
| Size           | (12.7, 6.8, 1.2)                           |

In Table 3, we can see that the center of the wall is (0.0, 3.6, 1.7), when setting it, we assume that the center of the table is the center of the scene, that the wall should be deviated from the center, and that the texture path of the wall is F:\collectedMaps\walls\014757248.jpg, the texture can be overlaid on the wall surface by the way of linking, the size of the wall is set to 12.7 meters in length, 6.8 meters in width and 1.2 meters in height. In the design of the actual scene, the size and position of the wall can be adjusted properly.

We design tables in the center of the coordinate system, the table can be viewed as a combination of the desktop and legs, the desktop and legs can be viewed as different objects, they need to set three
properties, which include their relative center, texture path and their size, the settings of table are shown in Table 4:

| Attribute                     | Value                                      |
|-------------------------------|--------------------------------------------|
| Position of desktop          | X' = 0.0, Y' = 1.8, Z' = 0.2               |
| MapUrl of desktop            | F:\collectedMaps\desktop\014712248.jpg   |
| Size of desktop              | (15.0, 6.6, 0.025)                         |
| Position of table legs       | (X', Y', Z')_{center} < (X'Y'Z' of desktop)_{center} |
| MapUrl of tableLeg           | F:\collectedMaps\tableLeg\014712108.jpg  |
| Size of tableLeg             | Radius = 0.02, Height = 1.4                |

In Table 4, the position of the desktop is set to X' = 0.0, Y' = 1.8, Z' = 0.2, the map path is set to F:\collectedMaps\desktop\014712248.jpg, the size of the desktop is set to (15.0, 6.6, 0.025), and the thickness of the desktop is 0.025 meter, and the position of the legs is set to be less than the center of the desktop, the map path is set to F:\collectedMaps\tableLeg\014712108.jpg, the radius of leg is 0.02 meter and height of leg is 1.4 meter, the table is designed as shown in Figure 4:

![Figure 4. Effect chart of table](image)

In Figure 4, we adopt 3D Max to design the table, the color of background is black, the texture of ground is the texture of wood, the texture of desktop is the texture of marble, the texture of legs are metal, and the number of legs is 8.

4.2. Scene Generation Algorithm Based on X3d Technology

Scene settings can be divided into several sub-scenes and entities, sub-scenes can be divided into several sub-scenes and entities, entities as the most basic unit, can be tables, chairs and so on. But from the perspective of the scene, the dining room can contain tables and chairs; the kitchen can contain cabinets, microwave ovens; and the living room can be decorated with TV sets, tea tables, sofas and other objects. A complete interior scene needs to set up multiple sub-scenes according to the interior layout, and different sub-scenes have parent-child relationship, therefore, it is necessary to further divide the hierarchy.

Based on the idea of whole-partition, we can adopt X3D technology to design basic objects, dynamically create a three-dimensional model of each object, and save it as a file; select multiple entities, render space, generate sub-scene, the entity data of sub-scene and rendering data of sub-scene should be stored in the database; after creating many sub-scenes, we adopt the connection function provided by X3D technology to merge different sub-scenes as a whole, then we adopt the lighting
function of 3D Max to place the corresponding cameras at different angles of the scene, adjust the angle, and further enhance the display effect of the scene.

In the actual programming, we adopt X3D technology to write the scene algorithm, the code is relatively simple, the key is the grade of scene, each grade needs to be set different physical and physical properties, the algorithm flow as shown in Figure 5:

**Figure 5. Scene generation algorithm flow**

In Figure 5, we see that the algorithm's data is retrieved from the database, and the corresponding scene should be corresponded to different grades, each of which contains the scene ID and other attributes of the scene. During the execution of the algorithm, we can see that it is a cyclic process, that is, the level is not equal to 0, it will continue to cycle, output the corresponding grade of the scene, until the level is equal to 0, the algorithm ends.

4.3. Implementation of Online Virtual Scene Based on Web

Virtual reality technology can also be implemented by web technology, the implementation process includes three-dimensional modeling, display and interaction, and network output, their relationship is shown in Figure 6:

**Figure 6. Implementation of VR based on Web**
In Figure 6, we transform the effect of 3D objects into the synthesis of multiple 2D images, the processing of 2D images can be realized by image perspective, image mosaic and image editing, therefore, 3D effect can be created. Compared with the traditional 3D modeling method, this method has a large amount of calculation, and is not limited by the scene, the method requires less hardware and is more operable. Web-based development can be implemented by many programming languages, which include Java and C, they all integrate object-oriented features, and their integration is consistent with the integration of scenes.

5. Conclusion
Virtual reality technology has a wide range of applications in interior design, this paper focuses on the concept of virtual reality and the relationship between virtual reality and interior design; several key technologies in virtual reality technology are studied, which include VRML modeling, X3D technology and Web-based virtual reality technology, we analyse the characteristics of technology and the realization of technology; by VR technology, we propose an interior design method based on VR technology, that is to, adopt VRML technology to realize the initialized virtual scene, then adopt X3D technology to simulate the virtual scene, proofread the virtual scene generated based on VRML technology, by Web technology, it can display the designed virtual scene by the browser, users can get real scene experience.

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