Research of Virtual Reality Technology in Home Design

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Abstract. This paper mainly discusses the application of virtual reality technology in home design. Through virtual reality technology, we can have more realistic experience and switch freely in each space, so that customers can feel the future home personally. Built by importing household design, real 3D model, combined with the virtual reality modelling language (VRML) generated with interactive link the prototype of the object, to quickly build furniture design based on the technology of web 3D virtual reality display system. System combined with rich interactive methods, adjust and contrast design, advance awareness the real effect of household is decorated, improve customer satisfaction; Combination scheme design, the system can also be used for virtual simulation practice. Engineering practice proved that the system development is simple, high efficiency and can greatly accelerate the household decoration engineering design schedule and save time cost, and has high value in engineering practice. This article provides a new Angle of view to parse the virtual reality technology in the application of home design.

1. Introduction
In the late 1990s, smart home began to enter our country. Everyone’s living environment is also changing with its development. Intelligent technology has gradually penetrated into people’s lives. Make everyone realize the convenience brought by science and technology [12]. With the prosperity and development of China's real estate market, people's living standards continue to improve, and there is a higher demand for home design. The interior design combined with virtual reality (VR) technology can make the owners have a more real space experience. For example, by building a virtual simulation system, users can easily roam and feel the design effect of the space through interaction. There are also applications of virtual reality technology in home design and interior design to improve design quality and design effect. In 2018, the ministry of education of China put forward the teaching reform strategy of new engineering. Virtual simulation teaching combined with virtual reality technology has become a hot topic in the reform of higher education. With the rapid development of computer technology, the establishment of virtual reality technology is the need of today's social development. virtual reality technology has also become a new design method and means for designers. Obviously, it has become an important research topic to show the final decoration effect of home design to users quickly and truly by combining virtual reality technology.

With the rapid development of network technology, based on the Web3D network of virtual reality technology is also widely used in various industries, including a representative of the VRML (virtual reality modelling language) is an object-oriented 3D modelling language, data format for describing interactive 3D objects, and become the standard of the Web3D technology. The prototype PROTO statement provided by VRML allows users to define their own model objects. It has the characteristics of classes, can encapsulate data and methods, and has good extensibility. VRML redirects data input
and output through routing, and can build a usual virtual scene by combining with script programming, which not only facilitates user operation but also improves work efficiency. VRML can define all kinds of common prototype objects through the prototype, encapsulating the main functions of simulation interaction, such as click, translation, rotation, selection, etc. VRML has rich interactive methods, node scalability, simple and easy to learn and other characteristics, making it possible to rapidly develop VRML based virtual display system for home design. At present, most Virtual reality based home design is mainly oriented to virtual tour of space. In this paper, VRML language is selected and combined with engineering practice to propose a home design framework based on Web3D technology.

2. The Proposed Virtual Reality System

2.1. Concept of Virtual Reality Technology

Virtual Reality (VR) is a comprehensive integrated technology, involving artificial intelligence, human-computer interaction, sensing, computer graphics and other technical fields. Virtual reality technology is an artificial simulation environment under the support of computer technology [13], [14]; it uses computers to generate real three-dimensional audio-visual feelings, enabling customers to carry out realistic interactive experience after wearing various devices. As the customer puts on the device and moves, the computer quickly performs complex operations, transmitting accurate 3D images to the device and creating a sense of presence. Virtual reality technology integrates the latest research results of computer graphics (CG) technology, computer simulation technology, artificial intelligence, sensing technology, display technology, network parallel processing and other technologies, and is a high-tech simulation system generated by computer technology. Therefore, customers can use a variety of devices to virtual themselves into the environment and control the scene in the environment for a specific purpose, that is, to control the scene in the whole environment. Virtual reality system contains a lot of perceptual information. Therefore, the successful implementation of the function mainly depends on the system integration technology. The necessary conditions include information synchronization technology, system measurement technology, numerical conversion technology, discrimination and synthesis technology, etc. virtual reality technology is the most effective way to build a photorealistic system in computer. The system can interact with people, get extremely real feedback, and generate induction.

2.2. Advantages of Virtual Reality Technology

2.2.1. Intuitive. The traditional drawing expression method is easily restricted by the expression method and misleads the customer. However, in the application of Virtual reality technology, customers can put forward modification opinions and feelings on the design scheme through personal experience, so as to make the most suitable use scheme for themselves. Customers can more accurately determine the furniture size, placement position, soft decoration and color matching, lighting selection and other requirements according to virtual reality technology.

2.2.2. Effective. Virtual reality technology provides a real-time interactive communication platform, allowing customers to feel the scene in the environment and support the adjustment of height, overall layout and multiple schemes. At the same time, Virtual reality technology can provide data information such as dimension measurement and area measurement, speeding up the process of design scheme and winning precious time for the start of construction process.

2.2.3. Convenient. Virtual reality technology is not only a display medium, but also a design tool. It expresses the designer's ideas in a visual form. For example, before the scheme design, the whole interior structure should be considered in detail. In order to make the whole scheme design reasonable and creative, the designer needs to design a lot of drawings. However, this kind of drawings has a lot of data and complex content, which can only be understood by insiders. Then, Virtual reality technology can turn these ideas into visible virtual objects and environments, and transform the
traditional design mode into the most intuitive and convenient display state, greatly improving the
quality and efficiency of design and construction.

2.2.4. Advanced. In the past design sales, the common method is to make sand table model and
rendering. The sand table is limited by the proportion, so the client can only see the reduced picture.
The effect picture is limited by the camera perspective, and can only see the effect of one Angle. There
is no human perspective to feel the space, nor can you feel the real sense of space. So, Virtual reality
technology solves these limitations, allowing customers to experience the scale, Angle, proportion of
furniture, color texture of curtain fabric and other real experiences in the home.

2.3. Current Situation of Home Design
Most of today's owner when decorating a new house, completely not concept about the space of the
house, demand for layout and function is fuzzy. The communication between the owners and
designers as follows, In the early stage of design, the designer provides the floor plan, and provides
similar renderings and other real scene photos to the owner for reference. There are also a few parts of
the project that will be displayed in combination with 3D animation. But these cannot let owner
perception lives in the final result that designs actually, often because final decorate the result to be not
what owner wants. In the sales of new buildings, real estate developers usually decorate model houses
for the reference of the owners. Due to the need to invest a lot of manpower and material resources,
the type and quantity of model houses provided are very limited. Therefore, how to show the final
decoration effect to customers in the design process through virtual reality technology has become an
important research topic.

2.4. Virtual Reality System of Home Design Based on VRML
Combined with engineering practice and virtual simulation practice, the main functional requirements
of 3D home design virtual display system are analysed.

(1) The primary function is that users can roam freely in the system, enabling owners to interact
freely in the areas they are interested in before decoration, such as visiting rooms and
functional areas, experiencing design style and spatial scale.

(2) Users can query the information of furniture and change the design of furniture in the roaming
process according to their individual needs, such as selecting the colour of furniture, changing
the style of furniture, adjusting the direction of furniture position and so on.

(3) Through the observation and experience of the whole space, users can quickly understand the
functional partition, spatial scale and traffic line after decoration, perceive the overall effect
after decoration in advance, put forward modification Suggestions and establish effective
communication with designers.

Combined with the above requirements and VRML, this paper proposes a feasible technical route, as
shown in figure 1, to meet the needs of the above designers and owners.

![Flow chart of virtual reality system for home design](image)

**Figure 1.** Flow chart of virtual reality system for home design
Firstly, according to the designer's layout map, import the original CAD frame diagram into 3DMAX software for modeling. The main models include walls, doors, Windows, furniture, etc. After the model is completed, the corresponding real material mapping and baking should be carried out. Secondly, WRL object files are generated through plug-ins, especially window and door furniture models involving interactive links, which must be made with separate modeling files. After generating a separate WRL object file with interactive functions, add interactive code through scripting, and then generate the main scenario file. Assemble scattered WRL object files into a 3D virtual main scene by using the Inline node command, and then add viewpoints, lights, roaming system module and related interactive links to facilitate users to roam and browse in the virtual scene. Finally, Virtual reality products are released. The user interface of the system is customized through HTML web design, and Web3D technology is released on the web. Users can experience Virtual reality based home design and carry out corresponding virtual simulation practices through the network.

3. Experiment and Results

3.1. Modeling the Content

3D home design system based on Virtual reality technology requires detailed models of each furniture all of which should be modelled according to the actual size of drawings, including the internal structure of furniture, it is an important display content in 3D virtual home design to express the appearance of furniture and show the internal structure of furniture by adding interactive operations. The modelling requirements of Virtual reality system are different from that of traditional home effect diagram modelling. Traditional modelling does not require making all models, while Virtual reality system requires scene modelling including walls, floor boards, all doors and Windows and all internal and external structures of furniture.

As the interactive design part of the construction scene is mainly aimed at doors, Windows, wardrobes, cabinets, shoe cabinets and other furniture, these furniture are required to be made into a MAX file separately, and generate their own WRL object file, which is convenient for interactive design and modular management in the virtual scene.

3.2. Model Optimization

In order to ensure the display effect of Virtual reality, Virtual reality systems all require real-time rendering with no less than 12 frames per second, so they have high requirements for models. First can't be too careful, also cannot too rough, how to carry out the model optimization is indispensable link in the process of modelling, with the method of polygon modelling, as far as possible to avoid redundant. Secondly, according to user's need, the effect of reducing unnecessary finely crafted, achieve the goal of optimization. Then try to through the details of the bump map to show the effect of furniture effect, reduce the number of model surface. In addition, VRML LOD (multi-detail level) node can be used for multi-level detailed modelling to achieve dynamic model scheduling management.

3.3. Main scene Generation and Interactive Design

Integration scenarios. The scene of 3D home design virtual system includes model, viewpoint and lighting design, and the integration of model is the key to construct the whole virtual scene. When the 3D model is completed, corresponding furniture and doors and Windows are required to generate separate WRL object files for the subsequent interactive design, which are not directly integrated into the overall scene. How to integrate the independent furniture and doors and Windows files into the main scene according to the location in the design drawings?

First of all, according to the graphic design, each furniture as a whole, can be a reference point, combining with VRML world coordinate system to define the principle, every furniture datum of VRML world coordinates, and then through the Transform of VRML nodes and combine each furniture in the Inline node according to the corresponding position, the corresponding object WRL
file was encapsulates the related interactive operation such as open close the door or push-pull drawer induction events.

As shown in figure 2, the reference point of the desk model in the case (3 900, -5 700, 0) is converted. The reference point in VRML space is (3 900, 0, 5 700), Thus, the Transform {translation 3 900 0 5 700 children [Inline {url "bookcabinet. WRL "}]} can be added to the WRL object file of the desk.

Figure 2. Layout of interior furniture nodes

Finally, a general main scene file is established. In addition to using Transform/Inline node to integrate all model files in the same document, navigation nodes, viewpoints, lighting nodes, navigation maps and other related nodes must be defined.

View design. In the main scene, the viewing position and of the main viewpoints are pre-set, so that users can view the corresponding scenes in the virtual world like a camera. VRML provides Viewpoint nodes to define camera viewpoints; The Position field defines the Position of the viewpoint in the scene, while the Orientation field defines the observation direction of the camera viewpoint. Multiple viewpoints can be defined in VRML, but only one viewpoint can be selected as the current viewpoint at any time, and the viewpoints can be switched between viewpoints. In this case, a total of 9 viewpoints are defined in the scene, including household entry, living room, dining room, bedroom, etc., as shown in figure 3, the viewpoint code is as follows. DEF view0 Viewpoint {position 3 200 1 600-2 200 # Viewpoint; Orientation 0 103.14159 # orientation;}... (Other 8 viewpoints)...
3.3.1. Interactive design of furniture. When a user roaming in the Virtual reality interior space, can feel the real dimension of the space, at the same time hope to according to your own lost sexual feelings, real-time understanding of the relevant information of furniture, to adjust the direction or to the position of the furniture style, to achieve the desired effect of the interior design, space for the best comfort. This requires a system with rich interactivity, such as, information query, furniture position direction adjustment, change the furniture of different style, etc. In VRML in the system, the information query of furniture can be extended node Transform2D to display information contains furniture, and through the touch sensors to activate information display furniture queries. As shown in figure 4 in children room query armchair information: name, positive width, the width of the side furniture, chair surface width, total height, chair, chair frame material, surface material floor mat material, reference price and related parameters.

| Furniture information                        |                |
|---------------------------------------------|----------------|
| Name                                        | The armchairs  |
| below width                                 | 50cm           |
| side width                                  | 64cm           |
| chair top width                             | 46cm           |
| total height                                | 80cm           |
| chair top material                          | PU leather     |
| chair frame material                        | Stainless steel|
| footpad                                     | rubber non-slip pad |
| reference price                             | 300mb          |

Figure 4. Information query diagram of furniture (armchair)

In VRML, adjusting the position and direction of furniture can be achieved by using geometric translation and rotation nodes of extension nodes, while replacing furniture USES Switch nodes. Users' operation data are obtained through routing, and their translation, rotation and replacement parameters are recorded in the database as an adjustment scheme of furniture design.

**Interactive furniture animation.** Furniture of interactive display need to use VRML animation and interactivity, which are the most attractive features of VRML. The realization of VRML animation depending on the specific time sensors and a variety of interpolation device to control the scene to generate animation. Animation is the basic principle of sensors through time defines a clock generator, generate the start and end time, interval, such as controlling parameters, through all kinds of interpolation nodes to produce all kinds of key points and the key value of the animation, the system generated by the method of linear interpolation user defined animation. For example, shoe ark, by adding push-pull drawer and open cupboard door effect to show furniture actually receive effect, the system can be according to the user's operation to determine the degree of push-pull drawer and door open effect to realize the system interaction. Receive a space to show furniture is one of the concerns of the users, can be late for the customer choice of furniture is very intuitive and valuable reference.

In 3DMAX modelling, each drawer door, internal space, and external handle were all formed into a group. The push and pull function of the drawer used a PLANESSENSOR to achieve the push and pull effect of the drawer, which achieved an interactive effect of maximum 200 push and pull on the X-axis direction. The code is as follows:

```plaintext
DEF CTPush PlaneSensor {
    offset 15 400 0
    minPosition 15 400
    maxPosition 215 400
}
```
In this case, the rotation axis of the cabinet door is Y-axis, and the maximum rotation range is 90 degrees clockwise, so the corresponding implementation code is as follows:

```python
DEF door-opentime Timesensor {cycleInterval 5}
DEF door-openori Orientationinterpolator { key [0 1] keyValue [0 1 0 0, 0 1 0 -1.571]}
```

3.3.2. Navigation map implementation. When a user roaming indoors, users want to know his location at any time, at the same time hope out next observation in real time, so I can freely roam and understanding interior decorating, and in practical application, users tend to interior space position are not ripe, when indoor roaming is often difficult to distinguish between spatial orientation. In order to solve this problem, can join the navigation map allows users to learn the user's current location anytime and anywhere and indoor suite of spatial relations. Users in the indoor roaming, often jump to observation suites, for example, when observed in the sitting room, can hope to be able to immediately transferred to the master bedroom to get to know the balcony or the situation of the study, can be transferred to other space to observe at any time, this needs to be implemented by clicking on the navigation map, navigation map clearly visible range is wide, can quickly click and drag on the navigation map or mobile want to see the location of the, straightforward, to meet user demand for indoor household freely roam. The realization of the function of navigation map, the first to realize 3D virtual scene and two-dimensional map in the same rendering space, according to the VRML language mainly through the provision of a two-dimensional map shows the prototype of the (map2D. WRL). Next to solve 2D maps and 3D scene information interaction, user three-dimensional roaming status information is passed to the two-dimensional map for status display, at the same time the location of the user click on the 2D map is passed to the three-dimensional roaming space roaming view switch. Through the analysis of the sensor of VRML, first set a proximity sensor, through its two events Position_changed, Orientation_changed convey user roaming status to map the prototype, the navigation map navigation cone to display the roaming status. Secondly through prototype in 2D map set in a touch sensor, combining Scene position output event, the user selects the actual map coordinates to 3D scene; In a 3D scene, Set view point by Value is used to set the position and Angle parameters that need to be switched from the current viewpoint, quickly switching to the place where the user wants to go.

4. Conclusion and Future Works
The development of 3D home design virtual reality system adopts VRML with concise code, low development cost and short cycle. It combines the development of prototype objects, navigation maps and other modular functions to achieve good immersive experience. Also can be released directly on the Internet, is conducive to business promotion. According to the design scheme, the system also can be directly used as the virtual simulation teaching project, applied to the interior space design teaching, effective. Combined with Virtual reality technology, system breakthrough in the indoor decoration engineering practice forms, the original home outfit by rich interactive methods, change the direction of the position of the furniture, the replacement of different sizes and different styles of furniture, let the user immersion, the effect after the early perception of household decorates. System can compare different decoration effect, at the same time choose satisfactory decorate plan, Improve user satisfaction. Engineering practice proves that VRML is simple and easy to learn with high code efficiency, and the implementation method can greatly accelerate the design progress of home decoration projects and save time and cost, which has high engineering practice value.

In the category of home design, the application of Virtual reality technology has its important practical value and practical significance. For home design, innovation, customization and changeful are the core problems of design. The use of Virtual reality technology solves these inherent difficult problems, accelerates the development of design and injects distinctive vitality into the design industry. In the development of home design industry, Virtual reality technology will effectively solve the problem of understanding and communication between designers and customers. In addition, the advantages of Virtual reality technology can also improve the technical content of the home design industry, providing new impetus for the development of the whole industry.
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