Design and Implementation of Smart Home Virtual Scene Based on Unity3D Technology

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Abstract. With the development of society and the progress of science and technology, people's application of smart home is gradually deepening. However, in the process of smart home design and display, limited by the traditional two-dimensional graphic design mode, it is difficult for the design scheme to provide customers with the opportunity of panoramic on-site display and interactive simulation operation, which directly affects the user's experience of smart home. In this regard, this paper puts forward a set of construction scheme of smart home virtual scene, which combines virtual reality technology with smart home design to promote the digital transformation and upgrading of design mode. The construction of the virtual scene will take 3ds Max as the modeling tool and Unity3D as the development platform, aiming at the three-dimensional and scene-based transformation of the traditional smart home design renderings, and satisfying users' design requirements and product experience for smart homes through a large number of visual interactive operations. Practice has proved that the virtual scene of smart home can combine design with experience, support users to complete operations such as adding, deleting, adjusting and controlling smart home, facilitate users to understand the design and deployment scheme of smart home in a WYSIWYG way, and then meet users' personalized customization needs.

Keywords: virtual reality technology; smart home; Unity3D; visual interaction; computer software applications

1 Introduction

With the rapid development of the new generation of digital information technologies such as 5G communication, Internet of Things and artificial intelligence, smart home has attracted more and more attention because of its outstanding comfort, convenience, safety and energy saving, and has become an important part of modern home life. [1] However, the measure of the overall utility of smart home depends not only on the abundance of intelligent furniture products, the breadth of functional applications and the fluency of interactive control, but also on the rationality and feasibility of the planning and design of smart home. As far as the current smart home design mode is concerned, the renderings designed by two-dimensional plane can't present the practical application effect of smart home at the design stage at all, which limits the choice of consumers and easily leads to problems such as the design demand is inconsistent with the actual effect. [2] In view of this, according to the research progress of virtual design of smart home at home and abroad, combined with the research results of Ile Sanmi Banjo Olufemi [3] and others in the design and implementation of smart home

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automation system; The prototype design method of smart home put forward by Pedro Racha-Pacheco[4] and the research and development system of virtual reality smart home designed by Zhou Chengmin [5], this paper puts forward a set of construction scheme of virtual scene of smart home, which effectively applies digital and virtual design tools and interactive techniques to the design and display stage of smart home, forms a comprehensive smart home design scheme with three-dimensional virtual scene as the carrier and visual interaction as the starting point, and promotes the design and display of smart home. [6] In the virtual scene of smart home, consumers can directly participate in the design process, and can experience the real effect of smart home through simple operation, so as to achieve the purpose of what you see is what you get, thus improving the design effect and design efficiency.

2 Virtual scene construction

The overall construction idea of smart home virtual scene is shown in Figure 1. Among them, the object of data collection is real smart home products, mainly including intelligent lighting, home security, smart home appliances, home environment control and other categories. Input the data into 3ds Max software to complete the three-dimensional modeling one by one, and bake the map to make the model more realistic and vivid. The production of the map material depends on Photoshop software. After the design and construction of various models are completed, 3ds Max software exports all 3D models as. FBX files, and introduces such files into Unity 3D. In Unity 3D software, the integration and assembly of models and scenes, the addition and optimization of dynamic effects, the setting and processing of objects in the environment, and the development of key interactive functions will be completed. [7]

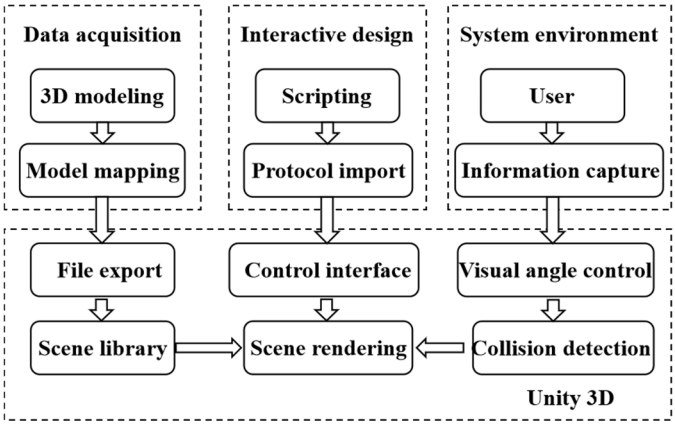

Fig. 1. Construction idea of the virtual scene

Among them, the development of interactive function is the core content of the construction of smart home virtual scene. The whole process not only depends on a large number of script codes, but also needs many components as support. Taking the autonomous switching of perspectives as an example, the user can trigger the UserController event by operating in the control interface, and support the user to control the Cam control to switch the first and third person perspectives through input devices such as keyboard or mouse. [8]

In addition, the overall scene construction and simulation test environment configuration are shown in Table 1. In the process of developing the control interface, we mainly rely on the methods of SendMessage () and Application.ExternalCall () in Libuv class library to realize the data communication between virtual and reality, and realize real-time control through Socket, so that users can directly control various smart home products in the virtual scene and obtain the values of various smart sensors in time. [9] After the modules and applications are built, they will be packaged and distributed to the IIS server. After the corresponding ports are configured, users can complete the use of the background control interface from the client browser.

Table 1. Configuration of smart home virtual scene construction environment

Hardware	Configuration information	Software	Configuration information
CPU	Intel Core i7-12700F@ 2.10GHz 4.90GHz	Web Server	IIS 10.0
RAM	DDR4 3600 16G	ASP.NET	.net framework 4.7
SSD	Kingston KC3000 1TB PCI-E4.0	Data Base	SQL Server2019
OS	Winsows 10.0-64 bit	IDE	Visual Studio 2019

3 Functional implementation

3.1 Virtual design

In the virtual scene of smart home, users can add, move, rotate and delete smart home products by controlling the mouse and keyboard to achieve the purpose of virtual design. [10] The scene library contains a large number of added product models, which users can choose independently according to their own personalized needs. Figure 2 shows the virtual scene effect.

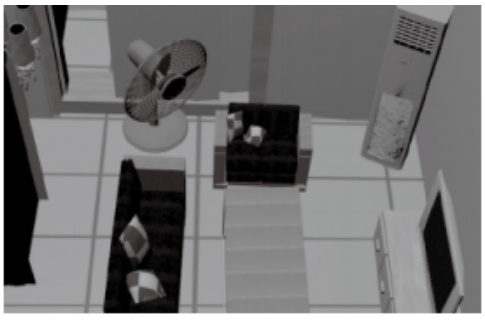

Fig. 2. Smart home virtual scene

3.2 Virtual interaction control

When users finish adding smart home products, they can perform virtual interactive control on smart home products in the control interface. Taking the TV in Figure 2 as an example, the user can set the video source of the TV, or set the specific playing time and automatic closing time. The video source will be given to the TV model again as a kind of map of the TV, so as to realize the video playing function. Some codes are shown below. [11]

```
void Start () {
   renderer.material.mainTexture=mMovie ;
   mMovie.loop=true ;  }
void Update () {public void OPenTV()
   { renderer.material.color=Color.white ;
     mMovie.Play() ;  }
```

3.3 Virtual scene roaming

When many smart home products are all designed, users can roam autonomously from the first perspective in the virtual scene, support users' own movement, and control their own observation angles to enhance the experience of smart home. [12] Scene roaming can integrate the scene, model, interactive control and other aspects, and it is easy to increase the running load of the virtual scene visualization rendering engine, so that there is a jam and delay. In the development of virtual scene roaming function, LOD technology needs to be integrated to improve the rendering ability of virtual scene engine.

LOD divides the virtual scene based on quadtree principle. The division principle is shown in Figure 3. The coordinates of each node are (x,y,z), (x,z) stands for position, and (y) stands for height. The position d from the o point to the observation point can be found by (x,z), and the division factor is set to C_1. The calculation formula of scene division standard is shown in Formula 1. If the value is greater than C_1, it indicates that the division result is the best; if the value is less than C_1, it indicates that the node needs to be further divided. The larger the C_1 setting, the higher the rendering accuracy of the virtual scene. [13]

$$\frac{\mathrm{d}}{\mathrm{l}} > C_1, \frac{\mathrm{d}}{\mathrm{l}} < C_1 \tag{1}$$

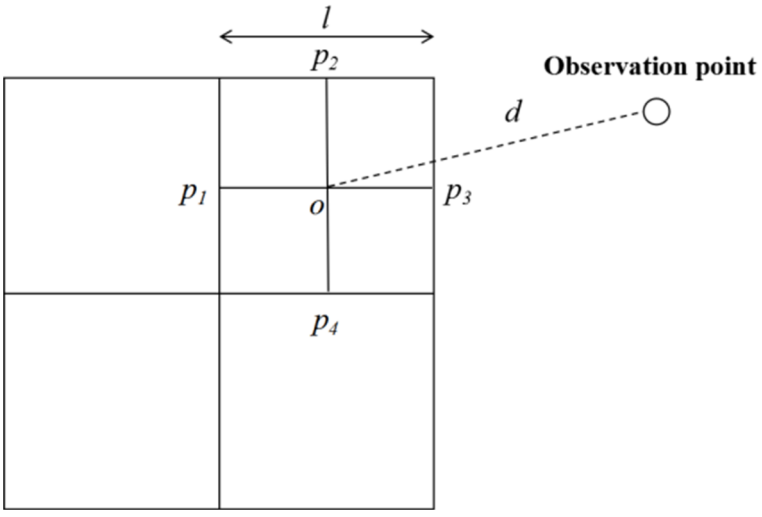

Fig. 3. Quadtree partition principle of virtual scene

In the virtual scene of smart home, the ground is taken as the root node for segmentation judgment. If the segmentation condition is met, the root node is recursively divided into four equal sub-node regions until it cannot be divided. However, the nodes that do not meet the segmentation conditions are directly saved as leaf nodes, and finally unified drawing and rendering form a simplified result. The segmentation process is shown in Figure 4.

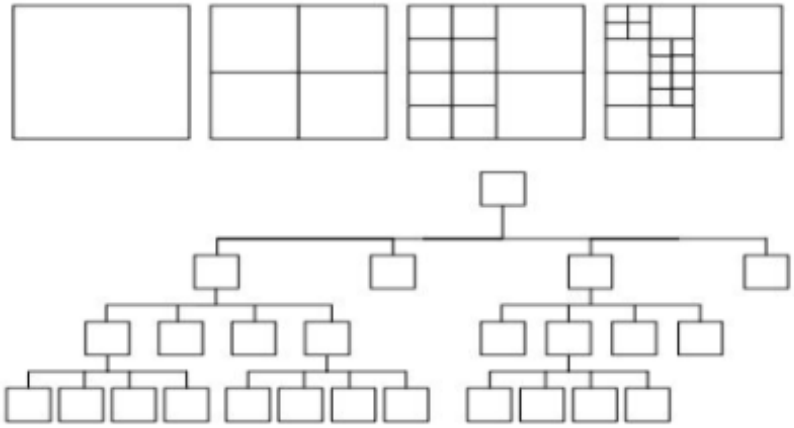

Fig. 4. LOD quadtree segmentation process

The application effect of LOD technology in the simulation test is shown in Table 2. The results show that LOD technology can obviously improve the rendering efficiency before and after use, and can effectively reduce the running load of the server when the scene roams.

Table 2. System operation under the LOD technology

Virtual scene	Pre-use rendering frame rate	After-use rendering frame rate	Proportion of promotion
2389 faces and 11 nodes	151/Hz	197/Hz	30.46%
14759 faces and 61 nodes	58/Hz	88/Hz	51.72%
225671 faces and105 nodes	24/Hz	47/Hz	95.83%

4 Conclusions

In order to improve the design and experience mode of smart home, this paper aims at many shortcomings of the traditional two-dimensional graphic design mode, uses 3ds Max as a modeling tool and Unity3D as a development platform to build a virtual scene of smart home. In the virtual scene, users can complete the virtual design of smart home, interactive control, scene roaming and other operations, effectively improving the flexibility of design and the authenticity of experience. In the follow-up research, the application scope of smart home virtual scene needs to be further expanded, and more smart home product models should be absorbed into the scene library to strengthen the fluency of virtual interactive control and make contributions to the promotion and development of smart home.

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