Development and Application of 3D Home Design and Its Display System Based on VR Technology

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Abstract. With the improvement of people's living standards and cultural literacy, the demand for home design has gradually changed from simple and practical in the past to personalized customization and intelligent interaction, so that traditional home design and display methods can not complete the presentation of design effects. In this regard, based on many shortcomings in the current home design process, this paper will put forward a set of three-dimensional home design and display system construction scheme, give full play to the application advantages of digital design technology, and realize the update of design language, creative techniques and display forms. The whole system is B/S architecture, the front end is user interactive interface, and the back end is application control server. The functional application of the system covers the whole process of furniture design, and with the help of 3ds Max, CAD and other software, the two-dimensional furniture design is transformed into a three-dimensional model in the virtual scene, and the parameters of the model are adjusted by Web3D technology to realize online design and display. Practice has proved that the three-dimensional home design and its display system based on VR technology increase the immersive interactive experience in the design process, enrich the display mode of furniture design, and help solve the problem of low design efficiency.

Keywords: VR technology; home design; Web3D; Visualization interaction; Computer software applications

1 Introduction

With the rapid development of China's social economy, the change of people's consumption concept and the improvement of cultural literacy have prompted the consumption pattern of household products to present new characteristics. The huge home product system, diversified design concepts and the wide application of intelligent equipment have effectively met people's needs in home beautification, comfortable environment, personalized customization and intelligent interaction, and improved people's quality of life. [1] But at the same time, it also brings some impacts and challenges to the traditional home design mode. Traditional home design mostly uses two-dimensional graphic design software of Auto CAD, which is difficult to operate and takes a long time. It can't show the highlights of home design in an all-round and three-dimensional way, and there are some problems such as insufficient design flexibility and inconsistent design intention with actual presentation. [2] In view of this, this paper thinks that it is the only way to solve the current home design problems by introducing network communication technology, VR technology and 3D technology into the home design

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exhibition process and forming a brand-new digital design model. [3] Three-dimensional home design and its display system adopts B/S architecture as a whole, with user interactive interface at the front end and application server and database at the back end. WebGL technology is integrated into the front-end interface, which can draw and render 2D and 3D models online, and rely on the Three.js 3D engine to complete the definition and execution of interactive operations. It is convenient for users to complete home design and display with Web applications, break through the time and space restrictions under the traditional home design mode, immerse users in the virtual reality scene, and achieve timely feedback of what you see is what you get.

2 System composition

First of all, the authenticity and quality level of three-dimensional home design and display are determined by the fineness of modeling in home design. The design process is the modeling process, which mainly involves three-dimensional data collection, CAD drawing, model construction, texture mapping and baking. [4] The object of 3D data collection is real household products, mainly including hard clothes, soft clothes, furniture, household appliances and other categories. Input data into CAD software to form two-dimensional three views, and on this basis, directly draw out the solid model in 3ds Max software, and bake and render the material, color and luster of the model, making the model more realistic and vivid. Figure 1 shows the process of building a three-dimensional home model.

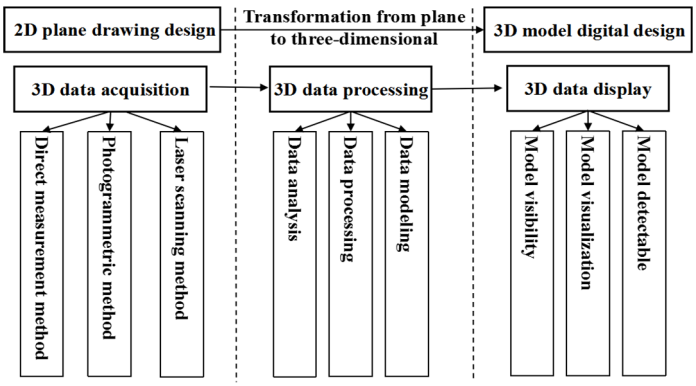

Fig. 1. Construction process of the 3D home model

Secondly, after the design and construction of various models are completed, WebGL is transformed by Verge3D software and exported as a gltf file. Deploying such files directly on the Web server can support the Three.js 3D engine to reference the 3D model in the front-end interactive interface. [5] The core application of Three. JS 3D engine lies in the realization of key interactive functions. In the development process, it needs to rely on a lot of script editing work, such as the change of perspective, the movement of position and the triggering of events. The interactive functions can give users a more realistic sense of substitution and immersion.

Finally, the client page is built with JSP technology as the core, while the server-side development follows the MVC design pattern, and the SpringMVC 4.1 development

framework is selected with Apache Tomcat 9.0 to complete the server-side configuration. [6] In addition, the bottom operating system of the platform is Windows Sever Standard, JDK version is 1.8.0_251, the integrated development tool is Eclipse Neon 4.6.2, and the database server is MySQL 5.7.

3 Functional implementation

3.1 Online design

After logging in to the system, users can select the corresponding home type in the homepage interface for design. The whole process of online design consists of several steps, such as house type construction, 3D design, effect rendering, display and export. [7] Among them, house type construction supports users to draw house type by themselves in the form of manual design, and can also automatically generate corresponding house type by importing CAD drawings. The 3D design is completely realized by relying on the material library of the home product model of Haoshui, and users can directly add, delete and modify it under the editor page. Some operation codes are shown below.

```
function createDragControls(objects) {
  var dragControls = new DragControls(objects, camera, renderer.domElement);
  dragControls.addEventListener('dragstart', function (event) {
    console.log("createDragControls dragstart");
  dragControls.addEventListener('dragend', function (event) {
    console.log("createDragControls dragend");
    orbitControls.enabled = true });   }
```

In addition, the system will also support users to quickly obtain the household product model needed in the design process by searching in the editing interface, and the system interface is shown in Figure 2. When users are designing their homes, they can directly use the category function to enter the product classification list, and they can also use keywords for precise search.

Fig. 2. 3D home product model search tool

Compared with classified list display, keyword search needs to rely on search engines and search algorithms. The keyword search service architecture of the system is shown in Figure 3. Among them, Query parsing service can clean the keywords input by users, divide words and expand synonyms. Then, the query sentence under the search engine OpenSearch is called through the search service, and the sorting clause is constructed according to the preset sorting expression setting, so as to complete the search of the index database of household product models and obtain the corresponding search results. Finally, the Web server controls and returns to the front-end interface to realize the display of search results. [8]

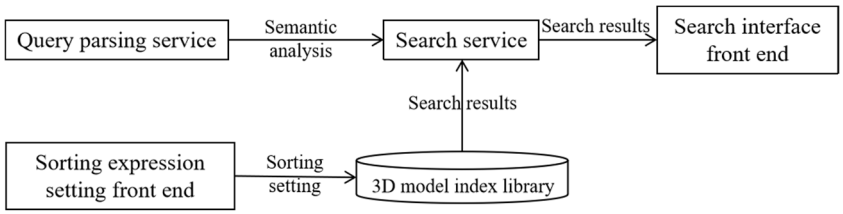

Fig. 3. 3D home product model search architecture

The essence of the search process is to measure the correlation between the query keyword sentences and the index texts in the index database, and to get the score by using the weighted calculation method to complete the sorting. The scoring formula used in this system is shown in Formula 1. Where Q is the keyword sentence input by the user, q_i is the result of word segmentation, n is the number of words generated after word segmentation, d is the text content in the index library, and W_i is the weight value of words, usually the inverse document frequency (IDF value). [9] Table 1 shows a summary of the actual practical effects of users, thus completing the utility comparison between category function and keyword search function. The results show that keyword retrieval is more efficient and accurate.

$$S(Q,d)=\sum_{i}^{n}W_i\cdot R(q_i,d)\quad W_i=\log\left(\frac{N-n(q_i)+0.5}{n(q_i)+0.5}\right) \tag{1}$$

Table 1. Summary of simulation practical effects

No.	Classification	Simulation times	Single time	Quasi-precision
01	List of categories	100	75s	37.51%
02	Keyword search	100	18s	58.33%

When the household product model enters the interior of the house type space, it is necessary to determine the location information of the model. The system will build a two-dimensional plane coordinate system in the house type space, and get the displacement of the home product model in the three-dimensional space through the reference object. [10] When the horizontal displacement of the household product model in the two-dimensional coordinate system is x_1 and the vertical displacement is y_1, the formula for calculating the position of the reference object in the two-dimensional coordinate system is shown in Formula 2. Where w is the overall X-axis displacement, h is the overall Y-axis displacement, and (x_0, y_0) is the center position of the reference object.

$$x_0 = \frac{w}{2} + x_1,\ y_0 = \frac{h}{2} + y_1 \tag{2}$$

Then, the three-dimensional coordinates of the reference point are obtained by using the GetPosition function. As shown in Formula 3, p represents the actual three-dimensional spatial position of the household item model, p_0 is the coordinate of the reference object, and p_z and pl are the relative positions in the plane coordinate system.

$$p(x,y,z) = \frac{p_0(x_0,y_0,z_0) - p_z(x,y,z)}{p_l(x,y,z) - p_z(x,y,z)} \tag{3}$$

When the hard, soft, furniture, home appliances and other categories in home design are all designed, the effect rendering can be completed online. In the process of rendering, users can adjust rendering pixels, set lighting elements, and modify camera and viewing angle height. After setting, the system will automatically complete panoramic rendering.

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3.2 Panoramic roaming

Under this function module, the system supports users to automatically roam the rendered home panorama through "naked eye 3D". The realization of this function, on the one hand, needs to use sky box map to realize panoramic display. On the other hand, users need to set a path according to different spaces or camera positions in the house type to complete automatic scene switching. [11] In Three.js, the scene is compared to a cube, and six different faces correspond to our visual picture, and then it is transformed into texture and added to the cube, which can realize the panoramic display of our scene. In addition, when the texture is given, it is necessary to complete the optimization of all models and materials in the scene, so as to further reduce the load of server rendering during panoramic display. Generally, it is realized by deleting redundant or invisible scenes, changing high mode to low mode, and calculating material bitmap nodes, as shown in Table 2, which shows the system operation before and after the optimization.

Table 2. The system operation during the panoramic display

No.	Model, material	Memory occupation	Runtime
1	Before optimization	549MB	1.69s
	After optimization	407MB	1.06s
2	Before optimization	439MB	1.37
	After optimization	368MB	0.88s
3	Before optimization	859MB	1.99s
	After optimization	736MB	1.64s

3.3 Virtual interaction

Under this function module, users can carry out more complicated home design operations through the mouse or keyboard. For example, users can fill and deploy the household product model in the scene with patterns and colors, and the formed samples will also be stored in the

system synchronously, and the rendering and display will be completed in time. The realization of this function needs to design the size of the model with geometry Box, and realize different operations on the model with function clicked () and if statements. [12]

4 Conclusions

In order to realize digital home design, this paper takes virtual reality technology as the core and combines Web3D technology to build a three-dimensional home design and its display system. The system will focus on home online design, panoramic roaming, virtual interactive experience and other aspects, which can create a brand-new home design form with simple, convenient and efficient operation, greatly improving design flexibility and work efficiency. In the follow-up research, the system will further improve the overall quality and classification accuracy of the household product model, strengthen the fluency and immersion of virtual interactive operation, and make a positive attempt for the transformation and upgrading of the household industry.

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