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Interior Design of Smart Home Based on Intelligent 3D Virtual Technology

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Abstract

With the development of society and the continuous advancement of technology, people's research on smart home products is gradually deepening. Compared with the past, smart homes are no longer out of reach, but actually penetrate into our lives. However, while continuously exploring the technology of smart home products, designers have not conducted in-depth research on the interactive mode of the control interface of smart home products. Based on this, the purpose of this article is to study the smart home interior design based on intelligent three-dimensional virtual technology. This article first analyzes the development and current situation of smart homes, and on this basis, combines three-dimensional virtual reality technology to research and analyze smart home systems (S H S). This article systematically elaborates the design of functional modules of the S H S based on intelligent 3D virtual reality technology and the method of converting 2D plane to 3D space coordinate. And use comparative analysis method, interview method and other research methods to carry out experimental research on the theme of this article. The research shows that compared with the traditional S H S, the S H S based on 3D virtual technology studied in this paper has higher feasibility

Keywords: 3D Virtual, Smart Home, Interior Design, Applied Research

1. Introduction

Virtual 3D technology is the use of displays to simulate visual virtual scenes, the use of sensing devices to simulate the perception of objects in the virtual scene (touch, movement, flip, weight, etc.), and the simulation of other perceptual factors such as sound and light, thereby creating A kind of immersive real feeling in the objective physical world [1, 2]. Such a scene simulation control method is not restricted by time, space and other factors, and has low requirements for factors such as venues, equipment, and funds, which provides more possibilities for the realization of control methods and higher efficiency [3, 4].

Smart homes have been widely used since the 1980s. Taking the relatively early development of the United States and Japan as examples, the advantages of American smart homes are luxury, comfort and enjoyment. They use digital homes and digital technology transformation as an opportunity to give People bring good enjoyment, but the shortcomings are also obvious, that is, energy consumption is large, and it is not low-carbon and environmentally friendly [5, 6]. In comparison, Japanese smart homes pay more attention to future development, they are people-oriented, focus on functions, and take into account the future [7, 8]. The domestic smart home industry started late, and the concept of market consumption has not yet been formed in the true sense. However, as an emerging industry, smart home has huge potential and bright prospects in China [9, 10].

The purpose of this paper is to develop a S H S based on intelligent three-dimensional virtual technology. The user interaction method of the traditional S H S is to use terminal two-dimensional software or text commands to control the home in real life. This interaction method has drawbacks and shortcomings, and it is often unable to truly, accurately and intuitively control the state of the home. Information is fed back to users, causing users to misunderstand and operate incorrectly. Introducing technology into the S H S can effectively avoid these problems

2. Research on the Application of Smart Home Interior Design Based on Intelligent Three Dimensional Virtual Technology

2.1. Three-dimensional Virtual S H S Design

2.1.1. Analysis of functional requirements of virtual S H S

1) Virtual smart home display

   Provide a virtual home model so that people can easily preview;

2) Roaming function

   Two roaming methods are provided, one is first-person free viewing angle roaming, so that people can use the mouse and keyboard to roam the virtual scene as they like. One is the function display of fixed-view electrical appliances. According to the controllable electrical appliances selected by the user, the camera is switched to the corresponding virtual model, which is convenient for the user to control [11, 12];

3) Node controllable

   Open some nodes for user control;

4) Information query

   Users can inquire about power consumption, environmental parameters and other information through the virtual scene;

5) Virtual monitoring

   Provide a virtual surveillance camera, and can freely switch the angle, distance, etc

2.1.2. System structure design

The virtual S H S can be divided into three main components. They are a virtual reality client, virtual reality server and mobile phone control terminal.

1) Virtual reality client

   This part is the main and core part of the virtual S H S. The virtual reality client includes the virtual environment that the user feels intuitively, and the user is immersive in the virtual environment presented to the user by the client. The main core technologies of this part include modeling technology, three-dimensional interactive technology and so on

2) Virtual reality server

   The virtual reality server uses Apache server and MySQL database. The Apache server is the most used web server software in the world. Its advantages are cross-platform and security. And it can be fast, reliable and can be extended by simple API to compile many scripting language interpreters into the server. MySQL is a relational database management system and one of the most popular WMAP database application software. Nowadays, the most mainstream web development architecture uses MySQL database with Apache and PHP server scripting language.

3) IOS mobile phone control terminal

   IOS is a mobile operating system developed by Apple. IOS applications can be used on Apple's iPhone, iPod, and iPad. Due to the increasing popularity of Apple devices, this system takes the IOS mobile phone control terminal as an example, and uses the interface provided by the server to develop the control terminal. Of course, the development of the android control terminal is also allowed, because the system itself provides a development interface.

2.1.3. Three-dimensional virtual S H S control module design

1) Virtual scene preset module

In the smart home, people can set the home scene in advance, and different scene environments can create different atmospheres. When using, you can cut off the connection between the control device and the scene. Through the display of virtual reality in the setting, you can experience and adjust the scene atmosphere in the device in advance, and then turn on the switch after setting it, and you can adjust it again for inappropriate places. Such a control method cannot limit the user's position during adjustment, and achieve the effect of saving time and effort. For example, in the free time waiting for someone, you can adjust the scene of celebration at home in advance, and at a certain moment when you enter the door, you can make a specific light and music sound and so on. In addition, the placement of home products can also be pre-arranged. For example, in a virtual reality control scene, users can enter the home furnishings they need to move into a specific scene, pre-design them, and adjust the most ideal layout plan. Re-execution, this can increase work efficiency to a large extent.

2) Intelligent display module

Due to its simple operation, smart home furnishing modules are basically not involved. However, there are also some problems when using home furnishing products. Intelligent control of some movable accessories in home furnishings can improve the barrier-free level of smart homes. For example, through the intelligent control of the wardrobe, the elderly, children and other people with weak mobility can move the clothing they need to a convenient place through a handheld terminal, without the need to step on the height to adapt to the product. In this way, they can increase their self care ability and reduce the burden on the escorts.

3) Instant lighting module

The vision concept of the daylighting module is based on the increasingly mature smart curtain products. The disadvantages of the existing smart curtains are that the operation process is complicated and the reflection delay and the user has a long waiting time. The use of virtual reality control methods can simplify the user's operating actions. The curtains in the scene correspond to the positions of the curtains in reality. The user slides a certain distance on the handheld terminal, and the curtains in reality also slide the corresponding distance to achieve that. The opening and stopping of the curtain, the speed, and the opening position can all be realized by controlling the "curtain" in the virtual scene.

4) The overall control module of home appliances

The part of the virtual scene lies in the research of manual control, which mainly refers to the indoor temperature, humidity, air quality and sound environment. When the number of electrical appliances that need to be controlled in a smart home scene increases, it is inevitable to face many remote controls. The virtual scene can unify multiple remote controls on the same platform, and call virtual simulations by switching between different devices. In the virtual scene, the adjustment of temperature, humidity, air quality and sound environment through virtual reality can also be reflected in the comprehensive adjustment of electrical products. When the user needs to adjust the sound environment, various devices related to the sound environment can be enlarged and displayed in the control scene, and the status of these devices can be displayed at the same time, so that the user can make unified adjustments.

2.2. Research on Interactive Design Method of Virtual Smart Home Control Scene

2.2.1 Visual information interaction

1) Display symbol category

The virtual control interface needs some display symbols to convey information. Display symbols are an important part of conveying the semantics of interactive interfaces, including graphic symbols, text symbols and digital symbols. Many factors in symbol design will affect the user's recognition efficiency of information, such as the shape, color, and contrast of the symbol.

2) Application of color tone

Ergonomics has certain requirements for interface color display. In the man-machine interface of the same product, the design of various operation options, commands, data display and other functions should keep the color and style consistent. The human-computer interface with consistent style will give people a simple and harmonious beauty, which can reduce the visual fatigue of users. The content direction represented by the color tone style has formed some roughly conceptual classifications through human cognition and the subtle influence of web pages, software, mobile phone themes and other interfaces over the years.

2.2.2. Auditory information interaction

Auditory information is an important factor in the design of human-computer interaction, and it is an important sensory recognition method for people. People's detection of auditory signals is better than other signals. Therefore, auditory information in human computer interface interaction can quickly attract users' attention. Auditory information is not only beneficial to people's memory of the operation process, but also enriches the interactive content and improves the commonality of software. The simultaneous presentation of auditory information and visual information to the user can bring a stronger real feeling to the user, and at the same time can create a sense of atmosphere and increase interest for the software. Auditory information can generally be divided into voice, prompt sound and music.

1) Voice

   Voice is the most significant auditory information, it can accurately convey the meaning of the information. Voice interaction can free people from visual information, but the interaction process is slow. For example, with the current intelligent voice, people can give commands through dialogue with the machine. However, due to technical limitations, voice interaction needs to be improved.

2) Music

   Music sound can last a long time in the interface scene, so it can play the role of continuous reminder, such as phone ring reminder, alarm reminder and so on. It can also be used as the background music of the software.

2.2.3. Tactile information interaction

Tactile information can provide more assistance for the user's interactive operations. Generally speaking, people's tactile perception of the outside world includes temperature, humidity, pressure, pain, vibration, etc., and it is an important positioning method for people. In the research on the interface, the communication of tactile information is based on the human perception of the effect produced by the display screen. Due to the limitations of the controller, it can only produce changes in temperature and vibration. The temperature for the controller requires a higher energy consumption, and the user's perception of temperature and vibration is slower, so the identification of the tactile information of the virtual reality control interface lies in the identification of vibration. Among them, the information conveyed by different vibration frequencies, time lengths, and vibration rhythms are different. Generally speaking, the functions transmitted by the tactile information of vibration are: confirmation function and warning function.

2.3. Conversion of Three-dimensional Coordinate System and Two-dimensional Coordinate System

The camera in the virtual scene provides the user with the vision to observe the three-dimensional scene. The conversion from the camera coordinate system to the projection coordinate system is a dimensionality reduction conversion, and two methods of orthogonal projection and perspective projection can be used. Taking orthogonal projection as an example, suppose the camera is at the origin of coordinates, the distance from the near plane to the origin plane is n, and the distance from the far plane to the origin plane is f. The point to be observed is p, and the projection of this point is p'. There is a relationship after projection:

$$p = \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix} \rightarrow p' = \begin{bmatrix} x \\ y \\ -n \\ 1 \end{bmatrix} \tag{1}$$

Because of the orthogonal projection, different projection lines have different projection points, so the x and y after projection will not change, and z will always become -n. We use this useless information to save z, Written as:

$$p' = \begin{bmatrix} x \\ y \\ az + b \\ 1 \end{bmatrix} \tag{2}$$

Thus, the CVV is constructed in the z direction, so that when z is in the near plane, az+b=-1, and when in the far plane, az+b=1, calculate a and b:

$$\begin{cases} az + b = -1, z = -n \\ az + b = 1, z = -f \end{cases} \rightarrow \begin{cases} a = \dfrac{2}{n - f} \\ b = \dfrac{n + f}{n - f} \end{cases} \tag{3}$$

Reverse the orthogonal projection matrix from the current result:

$$p' = \begin{bmatrix} x \\ y \\ az + b \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & \dfrac{2}{n - f} & \dfrac{n + f}{n - f} \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix} \tag{4}$$

Therefore, the conversion matrix is:

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & \dfrac{2}{n - f} & \dfrac{n + f}{n - F} \\ 0 & 0 & 0 & 1 \end{bmatrix} \tag{5}$$

Therefore, the conversion matrix is:

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & \dfrac{2}{n - f} & \dfrac{n + f}{n - F} \\ 0 & 0 & 0 & 1 \end{bmatrix} \tag{6}$$

3. Experimental Research on Smart Home Interior Design Based on Intelligent Three Dimensional Virtual Technology

3.1. Experimental Protocol

In order to make this experiment more scientific and effective, this experiment compares the traditional S H S with the S H S based on the intelligent three-dimensional virtual technology studied in this article, so as to analyze the feasibility of the research topic in this article. This experiment uses the same data set to run the two systems on simulation software and compare them. On this basis, this experiment invites professors of software engineering and Internet of Things engineering majors to conduct online interviews through online interviews. This time, the performance of the S H S based on intelligent three-dimensional virtual technology studied in this article is interviewed and analyzed, and the results obtained are calculated and analyzed using mathematical statistics.

3.2. Research Methods

3.2.1. Comparative analysis method

This experiment compares and analyzes the S H S based on the intelligent three-dimensional virtual technology studied in this article with the traditional S H S to judge the feasibility of the research content of this article.

3.2.2. Interview method

This study invited professors of software engineering and Internet of Things engineering majors to conduct online interviews in the form of online interviews. This time, the performance of the S H S based on 3D virtual technology studied in this paper is analyzed. The data obtained are not only selected for this article. The questions provide theoretical support and data support for the final research results of this article.

3.2.3. Mathematical statistics

Use relevant software to make statistics and analysis on the research results of this article.

4. Experimental Analysis of Smart Home Interior Design Based on Intelligent 3D Virtual Technology

4.1. Comparative Analysis of Smart Home Systems

In order to make this experiment more scientific and effective, this experiment compares the price of the three-dimensional virtual S H S studied in this paper with the traditional S H S. The results are shown in Table 1.

Table 1. Comparative analysis of smart home systems

	Hearing	Tactile	Sense of smell	others
3D virtual	68.9%	77.2%	73.4%	69.8%
Traditional	54.6%	55.1%	57.0%	55.7%

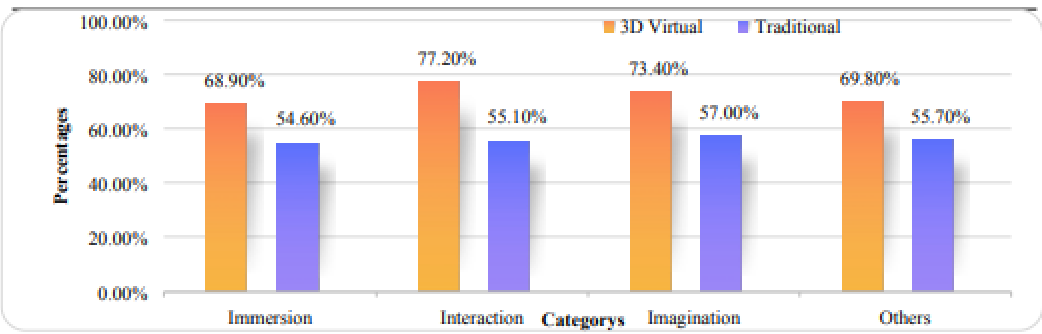

Figure 1. Comparative analysis of smart home systems

It can be seen from Figure 1 that compared with the traditional S H S, the S H S based on 3D virtual technology studied in this paper is more excellent in many aspects, especially in the tactile sense of smart home, which is more than 20%, which fully reflects this article studies the feasibility of the theme

4.2. Performance Analysis of Smart Home Based on 3D Virtual Technology

In order to further study the subject of this article, this experiment invited relevant experts to conduct investigations through the form of online interviews. This time, a total of 15 professors were interviewed. The data obtained are shown in Table 2.

Table 2. Performance analysis of smart home based on 3D virtual technology

	Immersion	Interaction	Imagination	Others
Professor 1.	7.13	7.86	6.88	6.42
Professor 2.	7.76	7.88	6.94	6.39
Professor 3.	7.14	7.70	6.72	6.77
Professor 4.	7.25	8.09	6.38	6.28
Professor 5.	7.22	8.40	6.97	6.40
Professor 6.	7.06	7.98	6.82	6.53
Professor 7.	7.38	7.63	6.76	6.60
Professor 8.	7.10	7.72	6.90	6.45
..				
Professor 15.	6.92	7.84	7.03	6.53

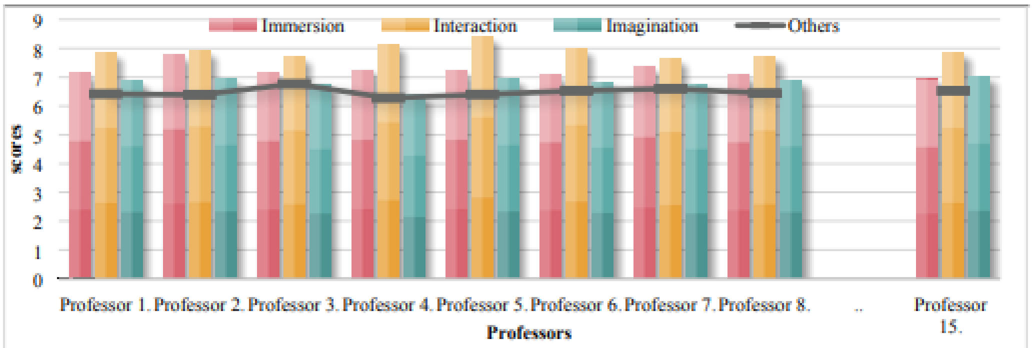

Figure 2. Performance analysis of smart home based on 3D virtual technology

It can be seen from Figure 2 that the scores of the S H S based on the three-dimensional virtual technology studied in this article are all above 5, which shows the feasibility of the research theme of this article. Among them, the interactive type of smart home has the highest score, which fully reflects the excellent performance of the S H S based on 3D virtual technology.

5. Conclusion

As the final way of displaying smart products to users, interaction design needs to be paid special attention by designers. Aiming at the shortcomings of the existing smart home interaction methods, this paper studies the functional requirements, behaviors, and usage methods of users' home life, and summarizes various functional modules, and innovatively proposes functional modules that can be achieved by applying virtual reality methods. So that the interactive interface can fit the user's habits, so as to completely present in front of the user.

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