Design of Remote Control System for Smart Home Based on Unity and the Internet of Thing

Yujie Zhang1,∗ and Xiaona Yin1

1Shaanxi University of Science & Technology, xi’an, Shaanxi, China, 710000

∗Corresponding author e-mail: zhangyujie@sust.edu.cn

Abstract. In view of the problems of unintuitive operation and poor user experience in the human-computer interaction of smart homes, the article proposes the application of virtual reality technology on the basis of relevant theoretical analysis, based on unity development platform and smart home control center, a smart home control system based on virtual reality technology is designed and developed. The system is composed of client, cloud and device. The client realizes virtual roaming, real-time display of device status and remote control. The cloud realizes the functions of control command forwarding and data storage. The gateway is used to communicate with each home device and cloud to realize the functions of sending control commands and reporting device status data. The test shows that the system is novel and practical. Using virtual reality technology as a human-computer interaction interface for smart home control can give users an intuitive smart home control experience and improve the user's experience.

Keywords: Smart Home, Virtual Reality Technology, Unity, 3ds Max; Human-Computer Interaction, Remote Control, Web, The Internet Of Thing

1. Introduction

With the advent of the 5G era, the development of smart homes has become more and more rapid, and a new round of Virtual Reality(VR) fever is also coming. VR technology, as a new human-computer interaction technology, is widely applied in the real world.

At present, the development of smart home technology is relatively mature, but there is still relatively little research and development in the human-computer interaction of smart homes. Currently, there are two main ways of human-computer interaction in smart homes. One is based on mobile phone APP, one is voice interaction based on smart speakers, in which APP occupies the dominant role. The current APP interactive operation is not intuitive and cumbersome, and it is inconvenient for some special groups to operate. Moreover, it cannot be used across platforms, and it has not really reached intelligence and humanization. How to make the smart homes better perform human-computer interaction, improve user experience and lower user thresholds is the key to the development of smart homes[1-4].

Based on this, this article proposes the application of virtual reality technology, a new human-computer interaction, to the control of smart home. Use virtual reality technology to build the
corresponding virtual family model by collecting the user's actual family data, and add interactive functions to the model through user-defined scripts. The virtual family model is exported and deployed on the web server, so that users can directly see and control the home equipment through the web login. The control method is novel and can further improve the user's sense of human-computer interaction in the smart home control, and can also be suitable for different ages users\cite{5-9}.

2. System structure design and function design

2.1. System structure design
This paper proposes a smart home control system based on virtual reality technology. The system is composed of three parts: user, device, and cloud. The overall structure design of the system is shown in Figure 1. The device side is composed of gateways and sub-devices. As the management and control center of various home equipment, the gateway connects with various home equipment downwards to realize the management and control of home equipment, including parameter configuration, control, status query and other functions; connects to the server upward to realize the status information reporting of different home equipment, and receive control commands issued by the server and other functions\cite{10-11}.

Clients include mobile phone, PC clients and other devices that contain browser functions. The user can interact with the device in real time through the 3D interface of the virtual control of the smart home to realize the functions of virtual home scene roaming, device status information display and remote control. The user terminal is used to provide an interactive and visualized 3D user interface.

The device side and the user side transmit data through the server and wireless router. One end of the wireless router is connected to the gateway, and the other end is connected to the server through the HTTP protocol. The LAMP (Linux, Apache, MySQL, PHP) environment is deployed on the server to realize device information storage and control command forwarding, and other functions\cite{12-18}.

Figure 1. System structure design.

2.2. System function design
In this system, gateway is used to control different home devices in a unified way to realize real-time collection of status, parameters and other information of home devices. The Unity engine is used to develop cross-platform applications to achieve remote virtual control of smart homes. Cloud server is used to achieve device information storage and command forwarding. By roaming in the 3D virtual home scene and interacting with the virtual home device model in the scene, the functions of remote control of home equipment and real-time reading of equipment status information can be realized. The system function is shown as in Figure 2. System functions include:

1) Scene roaming: View the entire virtual home model and roam in the virtual home scene through the first-person and third-person roaming methods, so as to realize the functions of zooming in,
shrinking, moving back and forth, left and right of the virtual home scene.

2) Device status reading and display: When the user clicks on a home device in the 3D virtual home interface, the device status can be displayed on the interface in real time.

3) Home control: Click on the home device model through the mouse and touch screen device to trigger device status display event and device control event to realize the information display of the current status of the device and control device.

**Figure 2.** System function design.

### 3. Key technology of system development

Use the browser or the software with embedded browser function as the entrance of the smart home remote control, which saves user from the trouble of downloading APP, allowing the user to enter the URL of the virtual home model web page (Uniform Resource Locator, referred to as the URL) in the address bar of the browser, or link to this webpage via a hyperlink, which will present a designed 3D virtual home interface. Unity allows the developed application to be published on the WebGL platform in the form of JavaScript language, using HTML5 technology and WebGL rendering interface to run Unity content in a web browser.

WebGL (Web Graphics Library) technology is a 3D drawing protocol, which combines JavaScript with OpenGL (Open Graphics Library), and is implemented through a unified, standard, and cross-platform OpenGL interface, which enables developers to display 3D scenes and models in browser more smoothly with the aid of system graphics card. At the same time, it can be used to create website pages with complex 3D structure and even be used to design 3D web games. WebGL is based on the OpenGL interface, which provides technical support for displaying 3D scenes and 3D models on the web. It can realize interactive 3D animation of web through HTML script without any browser plug-in support; it can also use the bottom graphics hardware accelerate function and OpenGL interface to realize graphics rendering.

### 4. System implementation

#### 4.1. Development of virtual home scene based on the Unity platform

Unity is the mainstream software in the field of 3D roaming, with features such as the characteristics of accessibility, extensive script support and plug-in availability, high development efficiency, and good user interface. The platform can realize the interaction between the virtual home scene and the smart home control center, and realize the remote control of the smart home. Unity communicates with the server through its own interface UnityWebRequest to realize the sending of control commands and the real-time acquisition and display of device status information. The virtual scene interacts with the real scene in real time, which has a strong and realistic visual impact, giving people an immersive experience feeling.

3ds MAX is used for scene modeling, model rendering and processing. Unity is used for smart home roaming, device status information display, remote control and communication. The
human-computer interaction interface design and development process of the smart home virtual reality control system is shown in Figure 3. Adding interactive functions to the model is the key to realize the remote control of the smart home based on virtual reality technology.

![Diagram](diagram.png)

**Figure 3.** Development process of human-computer interface.

Using C# language to write the script file for device control, mount the script on the corresponding device model, and trigger the script file through collision detection technology to realize the interactive function of the model. Collision detection technology is mainly to detect whether there is a collision between models in the virtual scene or whether there are obstacles on the roaming track. In the development process, ray class is used to detect whether a certain model in the virtual home is clicked with a mouse or other touch screen devices, which triggers a certain script file. For example, an adjustable ball is added to the air conditioning model to control the temperature. The model and the script to trigger the model are shown in Figure 4. The ball is at the optimal temperature of the human body at the beginning of 26°, the temperature of the upward sliding ball increases, and the downward sliding ball decreases the temperature.

![Script](script.png)

**Figure 4.** Air conditioning temperature control model and trigger script file.

4.2. **Interaction with the server**

In order to realize the real-time interaction between the virtual scene and the real scene, the server is used as the bridge between the user side and the device side. In Unity, it uses its own interface UnityWebRequest to communicate with the server to achieve the function of obtaining device status information from the server and sending control commands to the server.

UnityWebRequest provides a modular system for combining HTTP requests and processing HTTP
responses. The system decomposes HTTP transactions into three different operations: providing data to the server, receiving data from the server, and HTTP flow control. The UnityWebRequest modular system composition is shown in Figure 5.

1) Provide data to the server: UploadHandler is responsible for sending data to the server. There are two ways to upload data to the server in Unity, one is to send the form data to the server through UnityWebRequest.POST, and the other is to send the original data to the server through UnityWebRequest.PUT. Use the UnityWebRequest.POST method to send control commands of different devices to the server during system development.

2) Receive data from the server: DownloadHandler is responsible for receiving, caching and processing the data received from the server. The UnityWebRequest.GET call is used in the design, which buffers the data received from the server and provides the data to the script when the request is completed.

3) UnityWebRequest is responsible for managing the other two objects and realizing the control operation of HTTP flow. In this object, you can customize Headers information, URL, and store error and redirect information.

4.3. Export and deploy on the server
Unity supports publishing applications to different platforms, such as Linux, Windows, Mac, Android, iOS, WebGL, etc. In this system, in order to save users the trouble of downloading APP, the created application is published to the WebGL platform and deployed on the web server for users to use.

In order to make the generated WebGL project run on different browsers, the generated WebGL file is deployed on the built Tomcat server, so that the user can enter the web page through the URL of the web page, and the web page will present a three-dimensional visualization. The remote control interface of the smart home allows users to remotely control the smart home.

5. Test
Using the built software and hardware platform, the laboratory air-conditioning equipment has been experimentally verified, and the effect is good. After clicking the air conditioning model in the virtual home model, the current air conditioning equipment status is displayed on the interface, and the corresponding control 3D model is displayed according to the current status of the air conditioning, and the air conditioning equipment in the real home after sliding the small ball in the 3D model that controls the temperature, the temperature rises. The web-side smart home control interface is shown in Figure 6. Figure 6(a) is the smart home control scene of the entire room, Figure 6(b) is the indoor virtual roaming scene, and the air conditioner status is shown in Figure 6(c).
6. Summary
The article mainly applies VR technology, a new human-computer interaction technology to the control of smart home, and designs and develops a 3D visualized smart home remote control interface. At the same time, the control of the home also adopts the three-dimensional model, the design is novel, and the user operation is simple and intuitive. The user can control the home devices in the real home by roaming and simple operations in the virtual home, and the virtual scene interacts with the real scene in real time, which improves the user experience.

A good human-computer interaction experience is the key to the development of smart homes. Combining virtual reality technology with the control of smart homes not only improves the user experience, but also enhances the comfort and convenience of the user.
experience, but also the operation is intuitive and simple. It can be applied to users of different ages, and at the same time with the web combined, only one link is needed to operate the home devices after the user logs in. Smart home human-computer interaction based on virtual reality technology makes the control of smart home more intelligent and humane.

Acknowledgments

Weiyang District Science and technology plan project of Xi'an city”level landscape lighting management and control system development based on cloud platform（No.201816）; Shaanxi Province Science and technology plan project: Research on special screen display and landscape lighting control technology and key equipment development based on Internet of thing(No.2020gy-063).

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