Design and Development of "VR + Arduino" Immersion Interactive Experiment Case

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Abstract. In order to guide students to master Arduino development board, sensors, unity3d and other software and hardware application methods, familiar with the development process of virtual reality and intelligent hardware control platform. Learning from the WeChat "jump and jump" finger game, based on virtual reality technology and Arduino intelligent hardware control platform, the virtual intelligent fitness device with good immersion, strong interactivity, and combining entertainment, exercise and virtual experience is developed and designed. The "virtual reality + Arduino" immersion interactive experimental platform provides immersive and interactive immersive helmet and desktop screen display modes, uses a variety of intelligent control methods such as in-situ jumping action or grip to replace the finger pressing action in WeChat to control the jump of the game model, and can choose the sky, ocean, land and other fitness Scene, to achieve physical exercise and intellectual purposes. In the process of case design and production, virtual reality immersion equipment, grip and running pad are combined with fitness to cultivate students' comprehensive practical innovation ability.

1. Introduction

Virtual reality (VR) is a computer simulation system that can create and experience the virtual world and generate a system simulation of multi-source information fusion, immersive interactive 3d dynamic view and entity behavior [1,2]. By using virtual reality technology to build virtual Spaces with rich content, participants can have better experiences and interests. Arduino development board is a convenient, flexible, and easy-to-use open source electronic platform. It has many advantages, such as short development cycle, strong scalability, low power consumption, fast processing speed, etc., and it can build a bridge between software and hardware platform to "upload and release" data flow. Through the virtual reality technology and intelligent Arduino hardware control platform, combining with the real WeChat small experiment teaching content, the form of game to make the students easy to understand and grasp the learning content, and guide students to strengthen professional in making
games and machines cognitive ability, training professional design ability, and improve the comprehensive innovation ability [3, 4].

In recent years, represented by national virtual simulation experiment of the university experimental teaching resources is accelerating the pace of the construction and the open sharing of [5], dan-ting li et al. studied the construction of the virtual simulation teaching system [6], Zhu Xingyu device sensor is used to collect the body data construction, natural human-computer interaction virtual experiment platform [7], Liu Wei and others to carry out the smart grid panoramic virtual platform design based on the pattern of MOOC [8], Yan Fupeng and others to carry out the virtual simulation laboratory based on modular construction research [9], but in the virtual simulation experiment resources relative lack of semi-physical simulation experiment platform.

The immersive interactive experiment platform of "Virtual Reality +Arduino" takes the "Jump" intelligent fitness device as an example to guide students to design and develop a virtual intelligent fitness device that can carry out actual man-machine interactive operation. Traditional indoor exercise methods such as treadmill and supine board are not interesting. Many people will not set aside time for exercise due to limited time and venue. By developing a comprehensive recreation, exercise, virtual experience and various models of good immersive, interactive, "jump and jump" intelligent machines that use virtual reality technology to realize the choice of different exercise scene, and use the Arduino intelligent hardware control platform to jump to the participants to make real-time response, and to judge of jumping distance and direction, can realize the function of physical exercise and mental. This experiment is a complete set of experimental platforms based on virtual reality technology and Arduino intelligent hardware control platform. It requires several stages of learning, such as theoretical learning, design and development, and integration testing. The experiment is divided into 16 class hours in total. The class schedule of the specific case experiment is shown in Table 1.

| Case study stage       | Content of the plan                      | The experimental goal                                                                 | Scheduling |
|------------------------|------------------------------------------|----------------------------------------------------------------------------------------|------------|
| The theory of learning | Case basic content learning              | Master the basic content of case making and design the overall framework of the system | 2          |
|                        | Jumping platform construction            | Master the method of using AI design drawing, and use it to make "jump" virtual intelligent fitness equipment jumping platform | 2          |
| Design and development | Programming debugging for Arduino platform | Master the use and development methods of the Arduino development board, the installation and configuration of the Arduino integrated environment IDE, and the integration with the sensor module and Bluetooth module. Students are required to be proficient in C/C++ language, and be able to check and modify the mistakes in the programming | 4          |
|                        | 3D modeling and virtual scene construction | Master the basic functions of 3dsMax software, familiar with common modeling and scene construction methods, understand the basic methods of mapping | 2          |
|                        | Immersive interaction                   | Understand the basic functions of Unity3d software, master the C# programming language required in the development environment of Unity3d, and be able to realize the interconnection with the Arduino development board, as well as the control of roles and modification of attribute values | 4          |
| Integration testing    | Case functional test                    | Integrate and test the entire case                                                    | 2          |

Table. 1 Case experiment class schedule
2. System functional structure

The functional structure of the smart fitness device is shown in Figure 1, mainly including the overall system architecture design, jumping platform construction, data acquisition, transmission and interaction, immersive interactive scene construction, system integration test and other components. The overall architecture design of the system mainly includes the design and development of the system's functional structure. By using acrylic plate as the platform material, the platform thickness, platform area, height, shock absorption and other aspects were analyzed, and the value of the pressure was designed. The data acquisition, transmission and interaction module write a data processing program in the Arduino IDE through C++ language. After repeated optimization tests, the program is burned to the Arduino, and then connected to the sensor module and Bluetooth module, etc., so as to achieve data collection, processing and sending. Through modeling, mapping, rendering and other processes, 3DMaxs is used to build models of characters and squares, build virtual reality sports scenes, and export them to FBX format file [10]. By importing the model and scene into Unity3d, adding script, numerical reading, setting camera position, collision and other properties to the jump model in the scene, and displaying virtual information in the virtual immersive device [11], system publishing and integration finally realized the production of "jump and jump" virtual intelligent fitness equipment experiment platform.

Figure 1. Function structure of "Jump" intelligent fitness device

3. "Jump" virtual intelligent fitness equipment experiment platform design

3.1. Overall system architecture design

"Jump and jump" virtual intelligent fitness equipment includes jumping platform construction, data acquisition, transmission and interaction, immersive interactive scene construction and system release and integration, etc. In terms of the construction of the jumping platform, the jumping platform was made by using acrylic plates with excellent compression performance and easy customization, and the jumping platform was placed on the pressure sensor with a total load of 160 KG. In terms of data acquisition, transmission and interaction, the data sent from the jumping platform is converted from analog signal to digital signal by USING HX711AD [12], and then the signal is transmitted to the Arduino development board through NRF24L01 wireless module or cable, and the data is optimized and processed, and then sent to the computer side for second editing [13]. In terms of immersing interactive scene construction and system integration test, 3DSMAX was used to build models such as jump characters, jump platforms and jump scenes. Then, Unity3D was imported for the development of virtual reality content, and the data was connected with Arduino to realize the interaction between figure models and scenes in the data control scenes of Arduino. In terms of system release and integration, the FBX model was imported into Unity3d, scene parameters were set and corresponding scripts were written, so that the scene and character model could correspond to the value of Arduino.
output, and the contents of the desktop screen were displayed in the virtual immersive device, so as to achieve dynamic interaction effect [14]. The overall architecture of the case is shown in Figure 2.

![Figure 2. Overall architecture of the experimental platform](image2)

3.2. Jumping platform construction
"Jump and jump" virtual intelligent fitness equipment is mainly used for fitness, so the stability of the product, reliability, safety, fun, portability requirements are higher. Through the detailed analysis of the thickness, area, height and shock absorption of the jumping platform plate, the final jumping platform is made of acrylic plate with high strength and good toughness. The plate thickness is 10 mm, which has been accurately measured and perforated. Accuracy is controlled within 2 mm; Four 40 Kg pressure sensors with a maximum load bearing of up to 160 Kg are used to ensure the stability and safety of the jumping platform. Finally, a more comfortable mat is laid on the platform. The AI drawing design of the skip platform is shown in Figure 3, and the assembly of the skip platform is shown in Figure 4 and Figure 5.

![Figure 3. Design of jumping platform AI Drawing](image3)

![Figure 4. Installation of jumping platform](image4)
3.3. Data acquisition, transmission, and interaction

3.3.1. Data acquisition of pressure sensor. In order to accurately obtain the height of each jump, four groups of bridge pressure sensors with a total load of 40 KG and 160 KG were adopted to take pressure data respectively, and then the technical solution was averaged in the Arduino. However, the placement of pressure sensors will affect the experience and value accuracy. After many tests and analysis, the pressure was placed in the center of the acrylic plate connecting the four sides of the square to ensure the accuracy of data sampling. Installation and debugging of the pressure sensor are shown in Figure 6.

3.3.2. Arduino data interaction. Arduino development board has many advantages, such as short development cycle, strong scalability, low power consumption, fast processing speed, etc., so Arduino is chosen as the control board. Arduino development board is not only the data processing center of the whole system, but also the connecting point of hardware platform and software, playing the role of "uploading and transmitting" data flow. In the Arduino IDE, I wrote a data processing program using C++. After many optimization tests, I burned the program to the Arduino, and then connected the sensor module and bluetooth module, etc., so as to realize data collection, processing and sending. The analog signal acquired by the pressure sensor USES HX711 module for digital-to-analog conversion and shielding processing. The converted digital signal is transmitted to the Arduino UNO core development board, and the average value of the four groups of jumping values is taken as the final value and transmitted to Unity3d. As shown in Figure 7, the effect diagram of the Arduino development board integrated with HX711 module and put into the jumping platform. The integration test and application of the Arduino development board, the result is shown in Figure 8.
3.3.3. Data transmission of Bluetooth module Fitness equipment using HC-05 Bluetooth module to achieve wireless transmission function, so that the fitness equipment platform from the cable constraints, mobile interaction. Firstly, the Bluetooth debugging assistant is used to set the input port and output port of the Bluetooth receiver and transmitter, then the Code of calling Bluetooth I/O is added in the Arduino program to send signals to the PC, and finally the COM port is set on the PC to realize the communication between the Arduino and the PC, and finally the value is transferred to Unity3D. The HC-05 Bluetooth module is shown in Figure 9.
3.4. **Immersing interactive scene construction**

3DSMax modeling is characterized by short development cycle, convenient development, and lifelike model. By using 3DSMax modeling tool, jump characters, platform models and part of jump scenes are built. After mapping and rendering, the files are exported as .FBX format, and then imported into Unity for integrated development. The jump character, platform and scene model are shown in Figure 10.

![Figure 10. Jump characters, jump platforms and jump scene models](image)

3.5. **System integration**

3.5.1. **Unity3D integrated development** After the completion of hardware platform and 3D scene production, integrated development was carried out in Unity3D. Import the pre-made 3d scene in the format of FBX into Unity3d, then add script to the characters in the scene, read the value passed in by Arduino, and set the response action to achieve the dynamic effect of characters. Then set up the scene camera, collision and other elements, edit the interaction function and related attributes, and finally package and publish the system as a .Exe executable file. The integration development of Unity3D is shown in Figure 11.

![Figure 11. Unity3D integration development](image)

(a) Unity3D Integration Development I  
(b) Unity3D integration development II

3.5.2. **Immersive helmet display** Virtual immersive display devices are used to closely combine fitness and entertainment activities with virtual reality experience to show users a completely virtual world. However, in order to ensure the stability of the virtual 3D perspective during the jumping process, a good helmet and a portable all-in-one machine helmet are required. The HTC helmet content display is shown in Figure 12.
4. System function test
Through the above steps to complete the "jump and jump" virtual experiment platform of intelligent machines, desktop screen can display the traditional game modes, with a jumping efforts to control the computer desktop display of virtual characters, and USES the precise setting jump spacing and incentive mechanism to control the position of the characters in the scene, at the same time through the Arduino real-time access to environmental information and injection of virtual scene, the control system for the virtual environment changes in a scene, make immersion jump helmet display myself is the protagonist of the game, jumping are themselves in the virtual scene first further, and to exercise in various interesting scene. Let 30 users participate in the system experience and test, the desktop screen display test is shown in Figure 13, and the immersive helmet display test is shown in Figure 14. Through testing, it can be seen that more than 80% of users respond that the system is highly comprehensive, highly interactive, and involves a wide range of technologies. It is novel, occupies little space, and costs less. The participants of each jump can judge the position and control strength by themselves, making it easier for people to stick to it than the traditional fitness system. However, about 10% of users give feedback when wearing the helmet, and under the premise of limited area of the jumping pedal, AR helmet or safety barrier can be used to ensure the safety of the system in order to ensure the safety of jumping after wearing the helmet during the game.

5. Conclusions
With the rise of high and new technologies such as virtual reality and artificial intelligence, traditional exercise methods are not interesting. Many fitness equipment is limited by time and venue. By referring to WeChat "jump and jump" finger game, the "jump and jump" virtual smart fitness equipment is developed and designed based on virtual reality technology and Arduino intelligent hardware control platform. By guiding students to master the application methods of Arduino
development board, sensor, Unity3d and other hardware and software, they are familiar with the development process of virtual reality and intelligent hardware control platform, and combine virtual reality immersive equipment, grip force device and running pad with fitness in subsequent experiments, so as to cultivate students’ comprehensive practical innovation ability.

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