The Design and Development of Virtual Simulation Teaching System for Alpine Skiing Based on VR Technology

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Abstract. Aiming at the problems existing in the current alpine skiing teaching, such as limited teaching environment, single teaching method, weak safety awareness of students and strong fear of beginners, a virtual simulation teaching system of alpine skiing is developed based on VR technology. This system uses 3DS MAX software to model the three-dimensional model, unity3D to build and render the scene, and C# language to develop functional scripts. The momentum theorem is used to calculate the impact force of snowboards. This system designs the skiing scene according to the actual snow field, and enables the user to start, slide and brake the virtual skiing character model by manipulating the external handle. The experiment shows that this system has strong operability and high authenticity of virtual experience, which provides a good example for digitalization and informatization of alpine skiing teaching.

Keywords: VR technology · Virtual classroom · Alpine skiing · Software design

1 Introduction

With the successful holding and coming to an end of the Beijing Winter Olympics in February 2022, it has provided sufficient impetus for the development of ice and snow sports. People all over the country have turned their attention to ice and snow sports, and ice and snow sports are becoming more and more familiar to everyone. The project of "Ice-snow Sports Entering Campus" is a reserve talent that can promote the development of ice-snow sports. Alpine skiing, also known as mountain skiing, is welcomed and loved by the vast number of ice and snow sports enthusiasts all over the world, and it is also a very popular sport in China.

As a new teaching project, most teachers still lack the teaching experience of alpine skiing, and their professional level is uneven. Due to the special teaching environment of alpine skiing, it is necessary to teach in the severe cold on the mountain, so the teaching environment is very demanding. Therefore, most courses are carried out in indoor classrooms, and oral lectures and demonstrations are used in the teaching classroom. This kind of teaching method is single, and there are few opportunities for practical learning. Students often lose their interest in learning alpine skiing courses because they can't

feel the charm of alpine skiing in person. Moreover, most students who study alpine skiing are zero-based students, with weak safety awareness and lack of knowledge of ski resorts. Many students are afraid of building walls in alpine skiing. In practical courses, it is impossible for professional teachers to stare at students all the time, which is more likely to cause accidents. [1].

So, in order to change these situations, we need to optimize and reform the teaching methods of alpine skiing to find a favorable way. In the 21st century, information technology has been developing vigorously, and new high-tech technologies have emerged one after another. The virtual reality technology, that is, the image technology of VR technology, has started to rise, and it has been popularized in various industries such as games, movies, and architecture. The virtual reality technology is a new technology which combines the network application development software technology with wearable hardware devices, artificial intelligence and sensor technology. The alpine skiing teaching may wish to use VR, a new modern technology, to realize the sustainable development of alpine skiing heritage. [2].

According to the above analysis, the author believes that a virtual simulation teaching system of alpine skiing based on VR technology should be developed. In this system, 3DS MAX software is used to build the framework of the system, and unity3D is used to build and render the environment and realize various interactive functions. The virtual reality technology is used to truly restore the alpine skiing environment by building a simulated scene.

2   VR Technology

VR technology of virtual reality is a comprehensive technology combining many technologies. The three technologies involved in this system are mainly introduced in this paper, including three-dimensional modeling technology, three-dimensional object display technology and interactive technology.

2.1   3D Software Modeling

Three-dimensional model modeling means that developers build models of objects in a virtual three-dimensional space through three-dimensional software such as 3Ds Max, Maya and Blender. This technology is to first design a two-dimensional plan and then render a three-dimensional shape, or directly build it by 3D printing equipment. The three-dimensional digital modeling technology is widely used in all walks of life, such as movies, games and architectural design. In the market, three-dimensional modeling software focusing on one industry design has been emerging, such as AutoCAD in the construction industry and plant factory in the plant research field.

2.2   Stereoscopic Display Technology

The stereoscopic display technology refers to the research and design according to the stereoscopic mechanism and law of human vision. If the virtual world wants to achieve
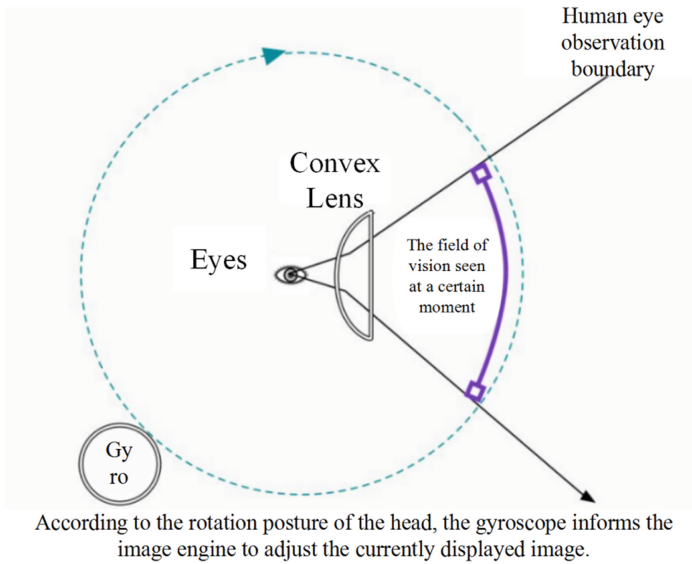
According to the rotation posture of the head, the gyroscope informs the
image engine to adjust the currently displayed image.

Fig. 1. VR stereoscopic display equipment schematic diagram

a realistic look and feel, then it needs to be combined with stereoscopic display technol-
ogy, and the stereoscopic scene of human eyes can be seen by studying hardware dis-
play devices. At present, there are three main types of mainstream stereoscopic display
technologies, namely HMD head-mounted display technology, holographic projection
technology and light field imaging technology. Among them, HMD head-mounted dis-
play technology refers to the use of technology to project virtual images on the retina of
both eyes of human beings. This technology is realized by using the basic principle of
prism reflecting images, so that users can see the display effect of large screen in a short
distance field of vision, and the clarity can be ensured in the process. It is realized by two
small displays built into the headband display, which make the two displays display dif-
ferent images according to the human brain perception mechanism, and the brain fuses
the image contents according to the mechanism, thus completing the three-dimensional
display of the virtual scene, and adjusting the image through the built-in gyroscope of
the device. The schematic diagram of the three-dimensional display is shown in Fig. 1.
At present, the commonly used VR stereoscopic display devices on the market include
HTC Vive, Sony Playstation VR, Oculus Rift and so on. In the holographic technology,
light is used to present images on the holographic film screen, or light is transmitted
through glass or even air to present images. In essence, light field imaging technology
and holographic projection technology are somewhat similar. However, there is some-
thing special about the medium of light field imaging technology, which is realized by
the way that spiral vibrating light is ejected into human retina. [3].

2.3 Natural Interaction Technology

Apart from being able to present three-dimensional objects in virtual scenes, VR technology is more important to interact with human beings. The system is required to interact with human senses and actions such as vision, hearing and touch. Among the natural interaction technologies, the most widely used technologies are motion capture, eye tracking, voice interaction and so on.

The technology of motion capture refers to capturing the basic movements of human body such as gestures, postures and even expressions. The motion capture technology is divided into optical motion capture and non-optical capture. The purpose of eye tracking is to make the image change according to the change of human sight. The principle of eye tracking is to use algorithms to recognize faces and eyes, and then use cameras to capture images, so as to estimate the eyes of users. The eye tracking mainly includes spectral imaging technology to capture the contour between iris and sclera and infrared spectral imaging technology to track the contour of pupil. [4].

The voice interaction includes two parts: voice recognition and voice understanding. The voice interaction technology integrates features extraction, pattern matching and other technologies.

3 Development Process

As shown in Fig. 2, the overall design and development process of the system is preliminarily conceived by the author after collecting the data of the actual skiing scene, and the parameter source is Wanlong Outdoor Ski Resort in Chongli. The 3d digital object is modeled in 3DS max software according to the parameters, then the FBX format file is exported and imported into unity 3D for rendering and building a complete virtual space scene, as well as the development of various functions. After that, unity 3D tests it through the steam VR platform of the built-in OPEN vr. During the test process, the head-mounted display and handle device of HTC VIVE should be combined, and after the test, it is released to steam VR.

3.1 Virtual Scene Building

The virtual scene construction is mainly divided into two parts, one is the three-dimensional model of each object in the skiing scene and the other is the character model.

3.1.1 Construction of Snow Field

The preliminary scene construction refers to the Wanlong Outdoor Ski Resort in Chongli, which has rich and complex landforms. Therefore, this system uses 3DS MAX to choose the mapping method for the long-term construction of the scene, which can simplify the workload of modeling and improve the running speed and rendering speed of the system. Then the ground environment and terrain construction, light source and sky box are designed and selected in Unity3D.
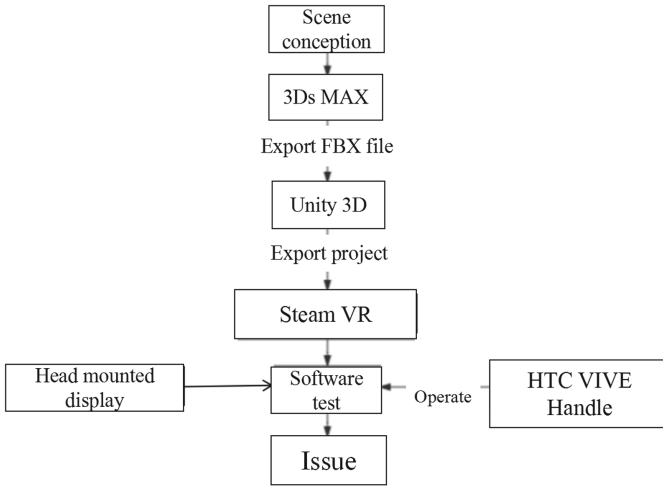
Fig. 2. Design diagram of development process

On the construction of static scene model, it can be divided into three categories: terrain module, vegetation module and sky box module. In order to ensure the authenticity of the virtual scene feeling of the system, the terrain module is constructed in a standardized and equal proportion according to the requirements of the Winter Olympics for alpine ski resorts. And the slope skiers' rolling line parameters should be consistent, and the angle of the ski slopes in disguise should be set at 135, 150 and 160 according to the division of primary, intermediate and advanced ski slopes, with widths of 20 m, 25 m and 30 m respectively. And the joint of key snow trails in alpine ski trails should be more than 2.5 m, such as transition snow trails, approach roads and connecting roads. The Terrain Length parameter of the terrain is set to 3000 m. The maximum height of terrain drop can be divided into terrain width parameters of 400, 650 and 1000 according to the primary, intermediate and advanced track. In order to build the mountain undulation in terrain, the terrain brush in unity3d is used. The raise or terrain is used to set the elevation height of each mountain, and smooth height brush tool is used to smooth and correct the built mountain. The renderings of Unity3D's skiing scene construction are shown in Fig. 3. [5].

Except the terrain, it is necessary to design the vegetation reference of the snow field. The tree model built in 3DS MAX is imported into unity3D, and the trees in the snow field are processed in batches by using the tree editor function. Using brush size brush to set the coverage area of trees, keep the scale Factor parameter of Scale Factor to 0.2. By means of tree height brush, the real height effect of uneven levels of trees can be realized. [6].

3.1.2 Character Model Building

In order to bring users the real experience of skiing assistant teaching, a virtual figure model of skiers with standard movements is created. Firstly, 3DS MAX is used to model the specific and complicated details of the characters, and then the model is imported

Fig. 3. Ski scene construction effect

into unity 3D in FBX format for optimal rendering. In the system, 3DS MAX skeletal human modeling method is adopted. Firstly, according to the human body's hip joint as the most important parent node, the rest of the child skeletal joints are framed, and then the joints' positions are carefully adjusted according to human body parameters. Then the skin is built, and the parameters of the skin need to bind the parameters of the bone joints to complete the construction of the human body model. When unity 3D is imported, it is necessary to build the scene of human coordinate system, which is convenient for users to operate with the character model as a reference. [7].

3.2   Interactive Function Script Design

The UI system is the key connection point between users' use of hardware and system functions. This system focuses on the canvas core component of UGUI system built in unity 3D to realize interaction. With the scene set up, the interactive functions of unity3D system will be developed by using scripts and c# language combined with visual studio software. This part mainly uses two tools. The Console window tool can debug the built project, and can accurately locate the error position of the program. When the developer debugs each function of the project, the location and time of the error code can be directly reminded by using the console window. The developer can directly click the error point, and then directly call visual studio to modify and maintain the code. Development of functions requires operation control of various objects in the system, and this function requires the use of inspector window tools. The Inspecter can check the attributes, coordinates, parameters, scripts and even additional components of an object.

3.3 System Testing

When the system was released, the developers chose other platform terminals to open the alpine skiing virtual simulation teaching system through steam for testing. It was found that the processing time of CPU can reach 23.2MS and that of GPU is only 10.32ms in the non-professional VR system, which shows that the system can still run smoothly in a low-overhead running environment. It only takes 6.65ms for the control script of the character to run once, and other functional scripts run normally. Therefore, the virtual simulation teaching system of alpine skiing designed in this paper can run reasonably and test successfully.

3.4 Development Environment

The hardware environment required for the development of virtual simulation teaching system of alpine skiing based on VR technology is a Dell ALI ENWARE17 computer with NVIDIA GeForce GTX1070OC graphics card and Intel Core i78750H CPU, and the operating system is Windows 10. C# is the main programming language of the system. 3DSMAX 2020 software is used for VR modeling. Make use of Unity3D 2020.3.32 to design the scene and develop its functions. After the development is completed, the software is tested on the steamVR platform with HTC VIVE handle and headband display. After testing, release the system. With the introduction of the above key technical theories, the overall environment of system development, the running process of related software and tools are determined, and the technical feasibility of the whole project of alpine skiing virtual simulation teaching system is also clarified.

4 Function Realization

Firstly, students need to open steam VR to test the use of HTC VIVE's hardware equipment. After confirming that it can be used, they can open the alpine skiing virtual simulation teaching system for learning. With the system turned on, the user can choose whether to use the first perspective for alpine skiing virtual experience or the third perspective for experience. The first perspective can help users experience alpine skiing more realistically and help them to train to overcome their fear of alpine skiing. The establishment of the third perspective is to help users learn in depth by observing the standard skiing movements displayed by the character model of the system. The switching function between the first perspective and the third perspective is realized by calling the sence view component of unity 3D, and the third perspective effect diagram is shown in Fig. 4. The system can focus on the camera component according to the depth and breadth of the user's field of vision, and display it on the head-mounted display screen of the external hardware device.

After selecting the user's perspective, the user needs to equip the helmet, snowboard and snowshoes needed for alpine skiing. In this process, the user needs to complete the interactive operation through the handle, and the operating system will display voice explanation and prompt in each step to strengthen the user's safety knowledge of wearing snow gear. The interaction is completed by canvas component, and the user uses the

Fig. 4. The third view shows the picture.

```
void CastRayUI()
    {
        RaycastHit hitinfo;
        _ray.origin = transform.position;
        _ray.direction = _dot.position - transform.position;
        if (Physics.Raycast(_ray, out hitinfo))
        {
            Debug.DrawLine(_ray.origin, hitinfo.point);
            GameObject gameobj = hitinfo.collider.gameObject;
            if (gameobj.tag == "Mode")
            {    _globalData.HandleUIMode();    }
            else if (gameobj.tag == "Time")
            {    _globalData.HandleUITime();    }
            else if (gameobj.tag == "Del")
            {    _globalData.HandleUIDel();    }
            else if (gameobj.tag == "Shape")
            {    _globalData.HandleUIShape();    }
            else if (gameobj.tag == "Color")
            {    _globalData.HandleUIColor();    }
        }
    }
```

Fig. 5. Function code for interacting with the object model

handle to emit physical rays to collide with the snow gear model object and then trigger the operation. In this system, the TAG value is set for each model object, and the triggered ski model object is determined by triggering the tag value. The implementation code of this function is shown in Fig. 5. [8].

With the snow gear, the system will automatically jump to the safety knowledge class, and users will gradually learn about some sections with frequent accidents in alpine skiing and how to deal with them through the interactive operation and guidance of the system. The body-feeling function of speech explanation is mainly completed by

audisource component. When the head-up viewing angle is set to collide with a specific model object, it will trigger the interface of sound source playback to play.

With the course of safety knowledge, users can officially start skiing simulation. At first, users choose the track according to their personal abilities. The track is divided into primary ski trails, intermediate ski trails and advanced ski trails. The selected user controls the character model to move by operating the handle. In the system, the virtual character controls the starting, diving, turning (obstacle avoidance), deceleration and braking of the character according to the inclination angle of the handle and the pressing force. When the user controls the handle to control the inclination angle of the snowboard, the character will fall when the inclination angle of the snowboard exceeds the prescribed standard. [9].

Actually, the medium snow board will affect the impact resistance and speed according to the inclination angle. Therefore, considering this point in the development process of the system, the introduction of momentum theorem is designed, where M is the mass of snow and V is the relative ground speed learned at point I:

$$I = F \cdot t = m (v_2 - v_1) \tag{1}$$

This function especially uses the open gravity function of rigbpdy component in unity 3D to enhance the interactive real experience of the handle. The design is based on the function principle, which lays a theoretical foundation for the authenticity of human-computer interaction. The movement of the model is realized by animation designed by

```
private float FX1 = 0;
private float FY1 = 0;
private float FZ1 = 0;
Initialization  FY2、FZ2
private float rotateSpeed = 0;
private float moveSpeed = 0;
void Start()
MessageDispatcher. GetSingleton. AddListener ((int) MoveType. F _X1,
evt => FX1 = float. Parse (evt. MsgParams [0]. ToString0));
MessageDispatcher. GetSingleton. AddListener ((int)MoveType. F _Y1,
evt => FY1 = float. Parse (evt. MsgParams [0]. ToString0));
MessageDispatcher. GetSingleton. AddListener ((int)MoveType.F _Z1,
evt => FZ1 = float. Parse (evt. MsgParams [0]. ToString 0));
Call     EX2、FY2, BZ22
back
}
// Update is called once per frame
void Update0
 If the current moving speed in the axis direction is 0
    If the resultant force is less than 0, reset the moving speed to 0.
        When the resultant force is greater than 0.
    Calculate the current acceleration value
MoveSpeed = MoveSpeed + a_ x * Time. deltaTime:
this. transform. Translate(Vector3. forward * Time. deltaTime $ MovcSpeed;
    Calculate the Y-axis speed
    Calculate the Z-axis speed
```

Fig. 6. Character model control movement script code

frames. The role movement is periodic, and the development of life cycle script is used. Activate the start method to make the athletes' virtual characters start alpine skiing. The start method is the execution symbol of this part of the functional script, and the awake and onenable methods are required to start the first action. In this period, the update function will be activated, and the athletes' movements will be repeatedly displayed in a fixed refresh frequency. The script code of character model control movement is shown in Fig. 6. [10].

5   Conclusions

The virtual simulation teaching system of alpine skiing designed in this paper can not only help alpine skiers to eliminate their fear of alpine skiing, but also further learn the key knowledge of alpine skiing through role demonstration, and can also carry out a certain intensity of safety awareness training. The visual interaction function of this system between human and computer is basically perfect, but there are still many places for improvement due to the limited ability of the author. Firstly, the interactive function is a little single, lacking a large number of refined interactive functions, so users can't really experience the changes of body movements caused by the slope and friction of the terrain, and they also need to join the development of hardware equipment connected with ski simulators. Secondly, there are still many defects in the scenery of the ski resort. The scene is single, and the transformation effect of special weather scenes, such as rain, snow, wind and other weather systems, is not considered. Therefore it is necessary to optimize the framework of the interactive system in the future to further improve the overall performance of the alpine skiing virtual simulation teaching system.

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