Application of Virtual Reality Technology in Coal Mine Tunnel Drill Training

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Abstract. Combining virtual reality technology into the design process of drilling rig, the virtual reality system of drilling rig design is realized by using industrial model data import, physical engine technology, 3D engine principle, light processing technology, non-programming production design, and resource cloud management, and the virtual assembly, virtual maintenance, and virtual mechanical operation training courseware production are realized. Give workers and customers a more authentic, immersive experience during assembly or operation.

Keywords: virtual reality; physical engine; rig operation; training course material.

1 Introduction

Virtual reality technology is the use of computer systems and sensor technology to generate three-dimensional environment, create a new way of human-computer interaction, by mobilizing the user's various senses (vision, hearing, touch, smell, etc.) to feel a more real, immersive experience [1].There are also more and more technological developments in the field of construction machinery involving virtual reality technology. However, in the development process of coal mining machinery industry, the intervention of virtual reality technology is relatively small. Especially in the complex underground environment of coal mine, the necessity of safe production puts forward an urgent demand for virtual reality technology. From coal mine machinery design, assembly processing, production to coal mine underground industrial experiments and other processes, virtual reality technology can play an important role in them, with low cost, high immersion, high efficiency human-computer interaction and other advantages.

2 Drilling Rig Design Status

As the underground drilling equipment of coal mine, with the application and development of computer technology in manufacturing industry, product development, design

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and manufacturing process has begun to develop in the direction of digitization and integration [2]. At present, the design of drilling rig in Xi 'an Institute mainly uses NX software to complete 3D design, and designers need continuous guidance in the processing and training stages of products, and the development cycle of new products is long, which is not conducive to the release and sales of new products. In the process of drilling rig research and development, the digital assembly system based on virtual reality technology is mainly used for the parametric import, accurate measurement, collision analysis, assembly process training verification, ergonomics analysis, etc., to generate assembly operating system and operation training system, and generate courseware respectively.

Virtual reality technology is used to simulate the rig assembly process, and technical training is carried out to make workers familiar with the assembly process [3]. In the physical assembly, it can shorten the assembly time, reduce the processing cycle of the prototype, reduce the time of technical personnel guiding the equipment debugging and training during the processing of the scientific research prototype, and improve the design efficiency. At the same time, using virtual reality J technology to present the product to customers in advance, customers can operate the rig to experience the product in advance, and they can also train workers in advance. Aiming at the industrial field, it studies the operation and mechanical operation characteristics of underground coal mine drilling rig, extracts their common characteristics, establishes mathematical models, designs mechanical component templates, and develops corresponding 3D engine software system combined with physical simulation technology. Users can make virtual reality courseware of underground coal mine drilling rig through this system without programming.

3 Virtual Reality Technology Application Necessity

(1)Simulation of product shape design is conducive to improving the design level of drilling rig appearance. The shape design modeled by virtual reality can be modified and evaluated at any time, and the modeling data after the scheme is determined can be directly used for design, simulation, processing, training or advertising[4].

(2)Simulation of product structure design, to achieve the optimal design of drilling rig products. In the structural design of complex products, virtual reality technology can be intuitively designed to avoid potential interference and other problems[5].

(3)It is helpful to guide workers to carry out assembly operations. The virtual assembly process of the rig based on virtual reality technology is more intuitive to see that workers can complete the assembly operation by themselves without the on-site guidance of the designer[6].

(4)It is conducive to the promotion of new rig products. The drilling machine virtual system based on virtual reality technology can simulate the real drilling process of the drilling machine, and has a stronger sense of reality in the training process, and can shorten the training time. At the same time, the new products can be better displayed to users.

(5)Compared with the traditional physical training, assessment and teaching system, the access to virtual reality technology can save the training cycle, get rid of the space constraints of the physical venue, and reduce the manual maintenance cost of physical teaching aids, thus reducing the overall cost of training, assessment and teaching.At the same time, it also reduces safety hazards caused by physical teaching aids.

4 Design Principle of Virtual Assembly System of Drilling Rig

The design of virtual assembly system of drilling rig mainly includes industrial model data import, physical engine technology, 3D engine principle, light processing technology, non-programming production design, and resource cloud management.

(1)Industrial model data import: 3D models are the basis for building immersive virtual reality scenes. The product model data completed by NX software is directly imported into the system, so as to realize the virtual reality application in industrial field; The system accesses the NX software through the NX opening library to realize the analytic model structured catalog nodes including vertex, UV and normal data, and realizes the balanced regulation of details and performance through further grid optimization algorithm, so as to achieve the model grid optimization[7].

(2)Physical simulation is an important technology in virtual reality simulation. The system uses the numerical integration method Runge-Kutta algorithm to calculate the motion equation and the Gilbert-Johnson-Keerthi (GJK) algorithm to calculate the collision detection. Physical and mechanical simulation (mass, gravity and collision), hose simulation, fluid, rope and other physical simulation.

(3)The 3D engine is mainly responsible for handling the rendering of virtual scenes and model actions in virtual reality technology, and the architecture includes design patterns, multi-threaded programming, algorithms, GPU programming, etc. 3D engines designed with modularity in mind are easy to expand and can effectively reduce the integration between modules[8].

(4)Lighting processing is an important intuitive element of visual experience. Clustered Forward Rendering and Clustered Deferred Rendering lighting algorithms are used to realize adaptive switching according to hardware video memory performance, so as to achieve balanced control of vision and performance.

(5)Non-programming production design through highly encapsulated behavioral logic coding, the upper layer only exposed simple interactive editing to the user, to achieve the whole process of virtual reality editing without programming.

(6)The cloud management of resources in the system communicates data with the cloud server through the HTTP network protocol, the double-ended data fragments follow the JSON format protocol, and the data is encrypted by MD5 before data transmission to ensure the security of data transmission, so as to realize the access and management of cloud resources[9].

5 System Overall Design Framework

The system application architecture mainly includes two parts: virtual reality resource management and virtual reality courseware making. Virtual reality management mainly includes virtual reality courseware catalog maintenance, virtual reality basic information maintenance, virtual reality technical parameters maintenance; Virtual reality courseware making mainly includes courseware making and publishing.

(1)Display layer: Through Unity and other basic UI components, to provide spatial UI interface, unified system interface style. Using MVC mode, the data model output by the server is bound to the UI component through the interface rendering engine such as C# to realize the isolation of interface and business logic. As shown in figure 1.

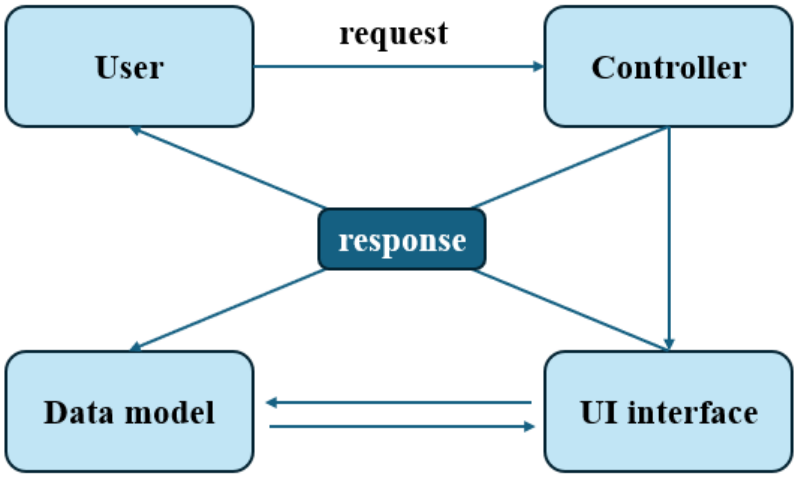

Fig. 1. Presentation layer

(2)Logic layer: Using common basic application components provided by the rapid business development platform on the Unity and C# architecture, the system framework is quickly built, and the basic data used to support the business is provided through the rich and flexible configuration of the platform. The basic application component is 3D model service management, which can save 3D model files and call courseware. As shown in figure 2.

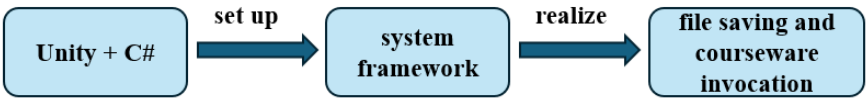

Fig. 2. Logical layer

(3)Storage layer: mainly includes structured data and 3D data file storage. "Relational database" is mainly used to store structured data, using SQL statements to mine structured data, analysis and processing, is based on the relational model of the database, with the help of set algebra and other mathematical concepts and methods to deal

with the data in the database. The relational model consists of three parts: relational data structure, relational operation set and relational integrity constraint[10].

6 Functional Module Analysis

The function module of template building analyzes the operation and running characteristics of most mechanical operations in the industrial field, extracts their common characteristics to establish mathematical models, and establishes the template of mechanical components by program coding. The module was prepared to access NX Opend library to extract industrial model data, design related grid construction and optimization algorithms to create model body, and design related kinematics algorithms to conduct physical and mechanical simulation calculations with PhysX physics engine. Design related ray path simulation algorithm combined with DirectX bottom graphical interface to simulate the ray effect, realize resource cloud management through network cloud technology, and design data encryption algorithm to ensure the security of data transmission process. NET platform as the main body of the program coding, following the MVC pattern design concept, the rendering layer, engine layer, business logic layer, data layer independent modularization, to ensure the robustness and scalability of the system framework.

The functional module of the rendering layer in the system is mainly to operate the solid model, lighting, environmental hdr, material texture and courseware UI elements in the virtual scene. The functional module of the business layer mainly includes logic control and algorithm scheduling in the system, and a large number of logic control and algorithm interfaces are encapsulated in this functional module. The function module of the engine layer is mainly the engine calculation of the system background, including the collision calculation between the model files, the light calculation of the rendering material texture call, etc. The function module of the data layer is mainly to set and manage the parameters and data structure of the model, light, material, environment and other components in the scene, which can be used to call and set in the later courseware production.

7 Application Example

Drag the model of ZDY12000LD rig to the system. The position of the rig is the most convenient to drag with the mouse, and the properties can be adjusted slightly. The best position is to select the orientation and distance that the rig can simulate drilling, as shown in figure 3.

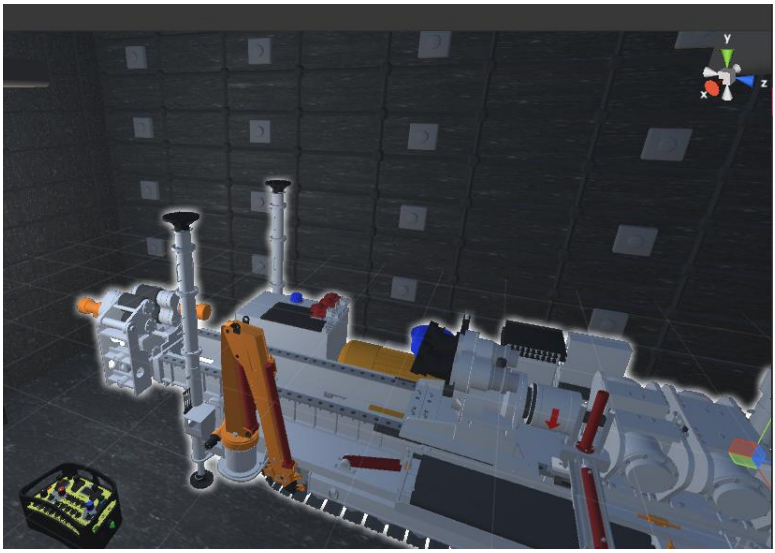

Fig. 3. Model simulation of drilling rig in coal mine

(1)Define animation

ZDY12000LD drilling rig in the system designed a total of 6 animation combinations, mainly including UI prompts, automatic rod, power head back, brick drill animation, shackle clamp, Angle adjustment and clamp. Among them, the animation properties of "automatic rod adding" are position and rotation, which involves a lot of components, including "adding rod three-stage cylinder rod base", "adding rod gripper", "drill rod", "adding rod three-stage step base", "adding rod two-stage cylinder rod base". The system can move or modify the value by clicking the orientation icon with the mouse. Using the recording function in the system, edit the content of the UI prompts at each stage, set the first frame and the second frame respectively, and complete the animation effect.

(2)Define script

According to the operation process of the rig, the design adds "start", "delay wait", "animation", "joystick" and other triggers, and defines the properties of each trigger, including time, animation name, start position, end position, hand position of the operating rod, monitoring events, target value and allowable deviation value. Interconnect the arrows of each trigger in order to form a complete process, and can be executed coherently according to the process. Watch the entire animation flow in the scene window. With virtual reality equipment, you can carry out virtual operation of the equipment and watch the operation or operation of the equipment. The animation preview of ZDY12000LD rig model is shown in Figure 4.

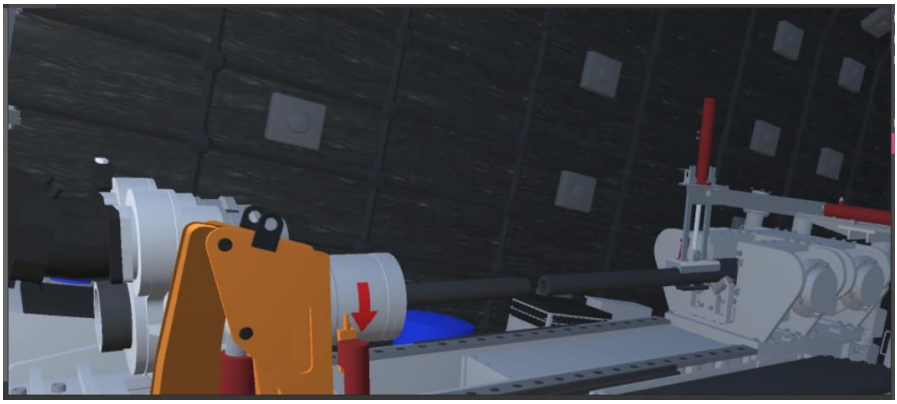

Fig. 4. ZDY12000LD rig model animation preview

8 Conclusion

The system has function modules such as model import, physics engine support, rendering support, animation engine support, etc. Users without any programming foundation can also make virtual reality operation simulation software and training courseware of industrial machinery equipment such as coal mine drilling rig through this system, which helps the virtual reality of coal construction machinery industry and reduces the research and development cost of coal mine machinery.

Through in-depth analysis of industrial machinery operation and mechanical running characteristics, the system extracts its common characteristics and establishes mathematical models and mechanical component templates, realizes virtual assembly of drilling rig, virtual maintenance, virtual mechanical operation training, etc., and generates training courseware.

At the same time, virtual reality technology has certain challenges in real-life simulation of industrial machinery. For example, large-scale machinery scenes are relatively complex and need to be equipped with wearable devices with better performance for simulation; in terms of program optimization, GPUs need to be called for core calculations to improve the overall texture.

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