Simulation System of Coal Mine Mechanical and Electrical Equipment Maintenance Based on Virtual Reality Technology

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Abstract. Aiming at the problem of cumbersome disassembly and assembly of large-scale equipment in coal mines and high cost, this article takes coal shearer, hydraulic supports, road headers and hoists as the research objects, and uses virtual reality technology to design and implement a set of virtual assembly subsystems. Virtual assembly and simulation system composed of scene simulation and roaming subsystems. The article uses Maya to model large-scale equipment, through VS programming, interactive control in Unity, and realizes the virtual assembly and maintenance of equipment and the virtual simulation roaming function of coal mining face. The test shows that the training and use of the simulation system effectively improves the actual assembly and maintenance capabilities of the equipment, while reducing the cost, and has a significant practical application effect.

Keywords: Virtual reality technology, coal mine electromechanical equipment, simulation, equipment maintenance.

1. Introduction

The driving force for the generation and development of virtual reality technology comes from the requirements of the US military department. It has been widely used in many fields including military, commerce, design, teaching, medicine, and entertainment. This technology has created a new field for the development of human-computer interaction interface, provided new interface tools for the application of intelligent engineering, and provided a new description method for large-scale data visualization of various projects, and undoubtedly also strengthened the theoretical research of geological sciences. Provides powerful means and methodological support [1]. Through virtual reality technology, a large number of geoscience data can be modelled, and it is possible for geoscience researchers to understand the complex spatial relationships of geology, landform, hydrology, meteorology, soil, vegetation and other data through the virtual realm established and through personal experience. In order to deepen the understanding of their internal relations and internal mechanisms, and achieve the goal of promoting the development of geological theory and the rapid development of geographic science.
In the coal industry, virtual reality technology has huge application prospects. Various spatial objects common in coal production, including the stratum, boreholes, surface industrial square buildings, underground tunnels, chambers, and electromechanical equipment, can all pass-through virtual reality. Technology simulation pass-through. The use of virtual reality technology to build a virtual mine system is of great significance in the construction of digital coal mines. According to the development status of virtual mine system, starting from the production and application of coal mine enterprises, starting from the bottom, develop a virtual coal mine software platform with independent intellectual property rights, using virtual reality technology to realize simulation management and monitoring of electromechanical equipment: 1) It can be intuitive. Accurately express the surface structure and indoor space structure and equipment distribution of underground caves; 2) Without going down, management and technical personnel can obtain the latest status information of underground electromechanical equipment in a timely and intuitive manner to support decision-making support; 3) Safety in mines It can play an effective guiding role in production, mining design and personnel training.

2. System software selection

2.1. System architecture

VR-Plant form, also called VRP, is currently one of the most widely used virtual reality software in the domestic market. It is a three-dimensional virtual reality software platform with complete intellectual property rights independently developed by China Vision Digital Technology [2]. It has good light and shadow Processing power makes the scene effect realistic, and provides optimizations for textures, lighting, etc.; VRP has good compatibility with most hardware platforms, and can take advantage of the computing speed of most graphics cards and CPUs on the market to make the system run smoothly; At the same time VRP also provides a secondary development interface, designers can tailor their own simulation software; in addition, VRP with its own script editor and full support for the universal lua scripting language and Flash scripting language, making interactive editing more flexible; Moreover, VRP provides an efficient real-time collision detection algorithm, which can imitate the gravitational fall of objects and the automatic climbing effect of stairs, etc. It also supports single-sided detection of the collision surface of objects, and provides database interfaces with the help of ADO dynamic data objects, and supports such as SQL SERVER Or ACCESS database connection, so as to realize the storage of relevant information of the model, such as animation, texture or data information. VRP-SDK can be used as an extended function of the existing system, which can be extended without affecting the normal operation of the existing system Virtual reality development. Its development architecture is shown in Figure 1. The virtual reality system can be used as an intermediate processing system that can run independently, or as a separate business system. According to the VRP-SDK response cycle mechanism, it can be implemented. The processing of existing or newly developed system services in virtual scenarios.
2.2. Hardware configuration of 3D technology system
The three-dimensional technology of the coal mine safety virtual reality system consists of workstations or three-dimensional technology; data input devices include: digital cameras, video capture devices, audio capture devices, digital scanners, and three-dimensional technology keyboards; data output devices include: laser printers, plotters, Projector, digital photography, scanner, touch screen and three-dimensional technology display; storage media and equipment include: CD, hard disk, etc. It is shown in picture 2.

2.3. Scene simulation roaming system
The scene simulation roaming system is mainly to simulate the fully mechanized mining face in the underground mine, including the modelling of underground equipment and the simulation of the roadway. This subsystem is a virtual reality scene simulation roaming system established by Unity and Visual Studio 2013 as an integrated development environment [3]. Use the 3D modelling software Maya to realize the equipment part modelling, and also use the Photoshop software to process the textures,
and finally complete the virtual scene integration and interactive design, realizing the virtual roaming function. Virtual roaming: In the built virtual scene, the user can roam the entire virtual scene through automatic roaming or controllable roaming. Through forward, backward, left, right and other operations, you can roam to every corner of the underground scene.

3. The technical route of the platform implementation

3.1. 3D graphics engine
The 3D graphics engine is the bottom layer of the virtual mine platform. To develop a virtual mine platform with independent intellectual property rights, a 3D graphics engine must be developed independently. The primary function of the engine is to organize and encapsulate virtual scene information. The organization structure of the scene is shown in Figure 3. Each relatively independent object in the whole scene is decomposed into entities, organized in a tree structure, and the root node is the scene entrance. The data of entities and light sources contained in the scene are all stored in the scene node, which is a tree structure leaf node [4]. The scene node can be directly attached to the root node, or attached to the child nodes of the root node or deeper child nodes. The camera is hung under the root node in a similar way to the node, which contains the viewport information generated by the camera.

![Figure 3. Scene organization structure](image)

The engine also provides a three-dimensional geometric operation library and a mathematical operation library for the platform. The geometric operation library encapsulates the transformation, projection, and spatial relationship judgment operations of spatial points, lines, polygons and geometric bodies. The mathematical operation library encapsulates various operations of real numbers, vectors, and matrices. Obtaining the coordinates of the model in the scene is the key to achieving accurate assembly of the model [5]. The system designed in this paper has cross-platform features and can be published on mainstream platforms currently in use, such as PC terminals, web platforms and mobile terminals. When running this system on a PC terminal, the coordinates of objects in the scene can be obtained through the position and rays of the mouse on the screen. The XY position of the mouse on the screen is perpendicular to the screen and shoots a "ray" to the 3D scene. When the ray touches a point in the 3D scene, it returns to the 3D coordinates of that point. If the ray touches an object, it returns to the origin of the object coordinates to obtain Object location. When running the system on mobile devices such as smart phones, the coordinates of the object are obtained through the position of the
trigger point on the screen. Combining the gravity sensor and finger touch to obtain the input data, the VR system receives the input instruction and executes the corresponding output. When using human-computer interaction devices, such as data gloves, stereo glasses, force feedback devices, etc., combine the position tracker to calculate the transformation matrix, and then obtain the coordinates of the manipulated model in real time. The specific process is as follows:

The paper converts the data obtained by the position tracker and the sensor in the data glove into the transformation matrix of the virtual hand in the virtual scene [6]. Every time the system is refreshed, the virtual hand data will also be updated in real time. For example, to transform a fixed-point V in a two-dimensional coordinate system into V’ in another coordinate system, it is necessary to sequentially multiply the transformation matrices generated by a series of motions in the coordinate system:

\[
V = V' \left( M_n \backslash M_{n-1} \backslash M_{n-2} \ldots \backslash M_0 \right)^{-1}
\]

The angle posture change is represented by \( a^a \rightarrow b^b \), multiplied by the matrix

\[
d = a^{a^{-1}}
\]

\[
b = \frac{a^* b}{\|a\|}
\]

3.2. Visual interactive platform

The visualization platform is the main interface of LR-VRMINE, which calls the 3D graphics engine library for graphics operations. In the visual interactive platform, it is necessary to provide users with menu commands for basic functions such as file operations, management views, and data management. At the same time, in response to user interactive operations, the scene images generated by the 3D graphics engine rendering are also provided in the visual interactive platform to the user [7]. When an application function is needed, it can be realized by adding a corresponding module to the interactive platform. Since graphics operations can be completely completed by the engine, in the interactive platform, you only need to focus on the realization of professional application algorithms. The visual interactive platform is also developed in C++ language, compiled to generate executable files for users to use.

4. Realization of simulation of mine electromechanical equipment maintenance

In the Windows environment, using Visual Studio C++2005 as the development tool, combined with the coal mine electromechanical equipment monitoring system, the electromechanical equipment monitoring is realized. In the design and development of the system, there are still some areas worthy of improvement. First of all, the support for the scene capacity is limited. The number of objects in the scene, the accuracy of the model and the size of the texture will all have a significant impact on the operating efficiency of the system [8]. Secondly, the human-computer interaction method is more traditional. Although many researches and improvements have been made to enhance the effect of virtual simulation, most of them are concentrated on graphics, and the interaction of application functions still uses the traditional interface method. As is shown in Figure 4.
Figure 4. Coal mine virtual simulation and remote-control system simulation experiment

5. Conclusion
Through in-depth research on virtual reality technology in the maintenance of thermal power plant equipment, successfully completed the research and development of the thermal power equipment maintenance simulation system, which played a demonstrative role for the design and research of the three-dimensional simulation system. The system studied by the subject is not only for the training of equipment maintenance for thermal power plants is of reference significance, and it also provides inspiration for the application of virtual reality technology in the field of actual management of thermal power plants.

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