Research and Development of Coal Mine Disaster Prevention and Rescue Drill Platform Based on VR Virtual Reality Technology

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Abstract. In order to improve the disaster rescue ability of coal mine rescue teams and enhance the effectiveness of daily training, based on the Unity3D virtual reality development platform, combined with rescue drill content, a framework for implementing a coal mine rescue virtual simulation drill system is designed. Use high-quality modelling technology to establish rescue models and scenarios. Based on database data management, research a multi-person collaborative coal mine rescue drill system based on the real environment of the mine and the evolution scenario of disaster accidents. Through training in realistic disaster accident scenarios, it can be enhanced Trainee's sense of presence improves the response speed, emergency handling and commanding capabilities of on-site operations, rescue, coal mine emergency commanders.

1. Introduction
The coal mine ambulance team is a professional team that handles mine disaster accidents. It handles emergencies in a timely and effective manner. Rescuing threatened personnel and state property is the responsibility of the ambulance team. The success of rescue operations during rescue depends on the professional quality of rescuers. Performing emergency deductions on a regular basis is a traditional and effective prevention method that allows ambulance personnel to be trained in a real simulated environment, but its disadvantages are also obvious. The investment cost is high, the security risks are large, and a large amount of investment makes it impossible. It is frequently performed, and at the same time it is limited by the relatively complicated natural environmental factors of the mine. It is not realistic to simulate any environment. With the development of virtual simulation technology, it becomes possible to develop a simulation system for training and training of coal mine rescue teams with high fidelity, high immersion and convenient interaction. The dissertation designs and develops a set of coal mine rescue virtual simulation drill system based on virtual reality technology. The dynamic disaster scenarios constructed by the drill modules in the system include fire, flood, coal and gas outburst, coal dust explosion and roof disaster, which can provide various realistic The drill environment is used for daily training and drills of rescuers, which is of great significance to promote...
2. Virtual reality technology

Virtual reality is a high-tech that has appeared in recent years, also known as spiritual realm technology or artificial environment. Virtual reality is the use of computer simulation to generate a three-dimensional virtual world. It provides users with simulations of senses such as sight, hearing, and touch. It allows users to observe things in the three-dimensional space in a timely and unrestricted manner [1]. Virtual reality is a combination of multiple technologies, including real-time 3D computer graphics technology, wide-angle (wide field of view) stereo display technology, tracking technology for the viewer's head, eyes, and hands, and tactile / force feedback, stereo, network transmission, voice Input and output technology.

1) 3D modelling technology. Mainly through accurate measurement of real scenes and equipment in coal mine underground roadways, equipment-related pictures and video collection. Then through Maya, 3DMax and other modelling tools, according to the obtained material information, a virtual model that is the same as the real scene and equipment is built [2]. 2) Surround sound technology. This technique enables one to determine the direction of the sound source very well. In the horizontal direction, we rely on the phase difference and intensity difference of the sound to determine the direction of the sound, because the time or distance of the sound reaching the two ears is different. The common stereo effect is achieved by hearing different sounds recorded at different positions in the left and right ears, so there will be a sense of direction. Not only does it provide a better horizontal surround sound experience, but it also allows viewers to feel the gradation of sound in vertical height.

3) 3D film technology. Currently, 3D projection technology commercialized in global cinemas mainly includes active stereo and passive stereo. 3D imaging is produced by the visual aberration of two eyes of a person. A person's 2 eyes (pupils) are usually about 8 cm apart. For people to see 3D images, it is necessary to let the left and right eyes see different images, so that there is a certain gap between the two pictures, which is to simulate the actual situation of human eyes. This is how the 3D stereo feel comes from.

3. Overall design of coal mine disaster prevention and rescue system

![Overall system framework](image-url)

**Figure 1.** Overall system framework
The coal mine rescue drill system can realize the online training of trainees. Trainees log in to the system as commanders, operate the peripheral equipment to autonomously roam in the created virtual disaster scenario, and complete the entire rescue process according to the task prompts. The system is developed and designed based on the Unity3D platform. According to the system development level and performance points, its architecture can be divided into 3 levels [3]: data access layer, business logic layer and application layer. The logical framework is shown in Figure 1.

3.1. Data access layer
The data access layer is used to store system data and system programs, and is the core of the entire system. According to the data type and role, the content of the data access layer is divided into three parts: database, method library and knowledge base.

1) The database contains the scene database, model database, equipment database and basic database. The scene database is used to store the mine industrial square, underground systems, and mine disaster scenarios; the model database is used to store rescue teams and underground models, including ambulance vehicles, character models, and mine fixed equipment; the equipment database is used to store the interactive behaviour equipment information content, including respirators, gas detection devices, ambulance equipment, etc., serves interactive operations; the basic database mainly stores system information, logs and other basic content. 2) The method library mainly provides algorithms for system function implementation, and can retrieve objects (such as fans) from the database. Retrieve the corresponding method from the method library (such as the start-up control program of the fan), and realize the corresponding function through connection. The method library defines and stores data, uses various mathematical models to form method programs, and stores them in the method library. At the same time, the method library provides interface programs to achieve connection with other contents of the data layer. 3) The knowledge base is based on the knowledge inference of the input information. First, the structure and knowledge of the research object (such as mine dynamic disasters) are summarized. The characteristics and behaviours of the research object (such as the harmful gas expansion law) are described by data abstraction, and the corresponding Mathematical models, physical models, and corresponding logical relationships are used as knowledge in the inference process.

3.2. Business logic layer
The user's operation interface, the main business components include scene management, message management, process management, sound management, window management, task system, time management and dynamic reasoning [4].

1) Scene management is used to control the creation, addition, switching and visibility of mine roaming scenes. 2) Message management Controls message prompts, manages the registration, deregistration, and distribution processes of messages, such as equipment error operation prompts and equipment information display. 3) Process management is used to record and manage the data generated during the exercise, and serves to evaluate and optimize the rescue exercise process. 4) The task system is used to manage the task process and task logic, simulate the actual drill task, form a task line, and guide the drill. 5) Dynamic reasoning serves the dynamic simulation of disasters, and simulates the reasoning results generated by the knowledge base. 6) Time management Manage time-based content, such as exercise time control, respirator use time control, disaster area rescue time control, etc. 7) Sound effect management controls various sound effects (such as sound of fire burning and gas explosion) and background sound effects during the exercise. 8) Window management is used for unified management of system windows such as "About", "Help", "Settings", "Exit", and "Popup Menus".

3.3. Application layer
The application layer mainly implements system functions. Set different disaster simulation interfaces for floods, fires, outbursts, explosions, and roof disasters. According to the rescue drill process, they
can be divided into six functional modules: preparations for downhole, reconnaissance in the disaster area, gas detection, mine annotation, on-site first aid and disaster treatment [5].

1) The downhole preparation module trains the equipment selection ability and safety awareness of the rescue team members. It can simulate the content of the preparation work of the rescue team members before going down the well. It can select different disaster relief equipment for different types of accidents and conduct various trainings for pre-war equipment inspection. 2) The disaster area reconnaissance module mainly trains the process and precautions of reconnaissance in the disaster area during the mine rescue process, including the establishment of underground bases, environmental testing, and emergency response to special disaster situations. 3) The gas detection module is used to train the use of monitoring instruments, methods of gas detection, and maintenance of related instruments. 4) The mine icon annotation module trains the mine map identification, mark symbol identification and labelling content to ensure correct labelling for the ground command to formulate a reasonable disaster relief plan. 5) The on-site first-aid module trains the correct use of first-aid and medical equipment for common disaster injuries by setting up corresponding wounded models. 6) The catastrophe processing module is to train team members to deal with disaster emergency response in a dynamic catastrophe environment, helping team members to use rescue equipment correctly and take corresponding rescue measures [6].

4. System main functions

4.1. Exercise comprehensive monitoring / full monitoring
The performance of the participants in the three-dimensional scene, including the walking route of the personnel, the process of reporting the accident, the process of issuing emergency instructions, the implementation of the rescue process, etc. You can monitor the entire exercise process from a global perspective, or you can switch to the perspective of each participating role to track the corresponding character exercise process.

4.2. Exercise implementation
During the exercise, the trainees arrived at the task execution area, used the assigned carrying equipment correctly, and allowed the body to breathe artificially, resuscitate the heart, and prone forward, etc. according to the task requirements. The exerciser automatically completed the action corresponding to the skeleton animation.

4.3. Emergency Handling
During the training process, the system provides artificial additions and changes to the environmental functions of the exercise, including weather (external environment) condition adjustment, disaster condition adjustment, rescue force adjustment, new task release, and other emergencies. It trains trainees on emergencies. Emergency response capabilities.

4.4. Exercise Assessment
During the exercise, the participants responded to the questions online or performed tasks in a timely manner according to the requirements. Only the correct points were obtained for the correct answers or operations, and their theoretical and practical skills were evaluated.

4.5. Walkthrough
The system has a complete and detailed record of each part of the exercise in time slices, including the participants' walking routes, scene changes, operating equipment, performing rescue actions, and mutual text and voice communication. The exercised content can be replayed in a three-dimensional scene, and the playback speed can be controlled.
4.6. Exercise Scheme Configuration
According to the requirements of different drill missions, you can quickly configure the required drill schemes. For different drill schemes, you need to plan the mission area that needs to be evaluated, and configure relevant parameters in the mission area, including participating roles, role equipment configuration, and specific task content in the region.

4.7. Resource Library Management
Package the relatively fixed scene content of the mine into a complete file for unified management to form scene resources; simulate production operations on conventional equipment operations (such as exploration sticks, gas measuring instruments, oxygen measuring instruments, etc.) and personnel skills (such as wound dressing, etc.) animation effects are formed Equipment, action resource library.

5. VR-based scene simulation and related parameter settings

5.1. VR scene simulation
The creation of virtual scenes includes model building and scene management. The model is built using 3DMAX. The basic modelling, composite object modelling, modifier graphics modelling, polygon modelling, patch modelling, and NURBS modelling methods provided by it can ensure the accurate creation of various complex models. The establishment of a simple model is based on the built-in model provided by the 3DMAX system. For example, a simple standard geometry and an extended collection are combined to build a three-dimensional model. The basic body is simply modified and edited to implement the model. Some models and 3DMAX provide the effect of the basic body is different, but the structure is relatively simple. You can create three-dimensional images by using three-dimensional graphics (such as loft modelling, NURBS modelling), or by using two-dimensional graphics through turning, extrusion, and other operations. Scenes in Unity3D are also organized in a hierarchy, using a feature called parenting, which is used by the editor and is a key part of using game objects. To establish a parent-child relationship, just drag the created object to another object to become its child object. The function of patronization is to change the state of a child object completely depending on its parent object. In simple terms, it means that one object changes with the change of another object's attributes. This organization method has a clear and structured structure, which can accurately depict the organization and information structure of the entire three-dimensional scene, realize the systematic management of virtual scene data, improve the operation efficiency of scene object reduction, collision detection, and so on. Achieving efficient rendering has played an important technical support role. Figure 2 shows the VR simulation of mine rescue.

![Figure 2. VR simulation of mine rescue](image-url)
5.2. Parameter setting
Fire-related special effects are all implemented here using the particle system provided by Unity3D, where sparks are sparks generated by friction between the tape and the stuck roller. First open the Unity3D development tool, and then select Create other submenu under the game object menu. The next submenu will pop up. Select the particle system item here, and a Particle System item will appear in the Hierarchy panel. Click to change the name. After selecting the particle system, you just added, the particle system-related settings will appear in the Inspector panel. The final effect of the particle system depends on these settings to comprehensively set.

| parameter       | value   |
|-----------------|---------|
| duration        | 0.1     |
| cycle           | select  |
| Start life cycle| 0.1     |
| Start speed     | 0.1     |
| Starting size   | 0.01    |
| Start colour    | dark red|
| Largest particle| 10000   |

6. System visualization
The realization of the system functions needs to be presented in a visual form on the screen, used to implement the functions of the business logic layer, and to achieve the corresponding correspondence between business logic and interface visualization. Through the user interface, the functions of the system can be fully displayed, scene visualization (drilling scene area), character status visualization (character status bar), character position visualization (mine map indication), operation program visualization (operation record box), equipment information visualization (Equipment storage bar) and control (setting) of the system and sound effects. The complete exercise system interface is shown in Figure 3. Use the mouse and keyboard to control the character's walking and using equipment in the interface, and implement six simulation drill functions: preparation for going down, reconnaissance in the disaster area, gas detection, mine annotation, on-site first aid, and disaster treatment.

7. Conclusion
The coal mine tape fire simulation system based on virtual reality technology can fully simulate the effect of a real underground fire, and can realistically and intuitively display the fire occurrence and development process, which has a certain promotion effect on disaster simulation training for coal mine enterprises. Through the interactive control between the trainees and the system, the trainees are fully aware of the occurrence, development process and serious consequences of the disaster, as if in a disaster, so that the underground staff can take precautions and respond in real time in future work. Fully prepared for various disasters to ensure the life safety of underground staff.
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