Emergency Response Training for Safety Accidents Based on Computer Simulation and Virtual Reality Technology

Ping Zhang*
Liaoning Jianzhu Vocational College, China, 111000

*Corresponding author e-mail: j1050526100@126.com

Abstract. Given the realistic contradiction between the frequent safety accidents in densely populated places and the difficulty in implementing emergency response training and the low level of response, we propose the emergency response training for safety accidents based on computer simulation and virtual reality technology in this paper, which has solved the problems such as huge consumption of human and material resources, disruption of the normal order and difficulty to organize in the practical training. Computer simulation and virtual reality technology is highly situational and immersive, which has provided a new way of emergency treatment training for safety accidents.

Keywords: Computer Simulation, Virtual Reality, Safety Accident, Emergency Response Training

1. Introduction
Attributing to the improvement in the relevant theories of emergency mechanisms, the relevant concepts of work safety accidents and emergency mechanisms can be defined more clearly [1-2], which has enriched the theories of emergency mechanism in China and provided certain guiding ideology for the final construction of work safety emergency mechanism. In fact, it has provided ideas and methods for the establishment of an emergency mechanism suitable for the primary stage of socialism as well as some emergency rescue knowledge for production managers, with a significant effect in preventing and curbing various safety production accidents and reducing casualties and property losses caused by accidents in the production process in the future [3-4]. In general, the features of safety production show that safety production accidents cannot be prevented. The establishment of an emergency mechanism is the sum of the prediction, prevention, rescue, and subsequent compensation and reconstruction of the accident, which makes the prediction ability of the crisis and the rescue efficiency reach the highest [5]. There are many safety risk factors in the densely populated places, and the safety accidents are very dangerous, so safety prevention is difficult, and the safety situation is especially difficult. The
timeliness and effectiveness of the emergency rescue work is an effective means to reduce the loss, which requires the emergency rescue personnel to be familiar with the scene of the accident, with accurate judgment and decision-making power. In the face of an unknown working environment, sophisticated site facilities, and massive accident information, without long-term training under the practical background, it is difficult to organize commanders and field operators to deal with them in time and correctly in an emergency. In reality, the drill of emergency plan for safety accidents is difficult to organize, affects the normal order, is only a form, and is difficult to play a good training effect. Therefore, it is necessary to introduce a more intuitive and scientific way to guide the training for emergency response of safety accidents when the researchers are intensive in the field of emergency response training\(^6\).

With the continuous development of computer simulation and virtual reality technology, virtual simulation provides a new way for emergency response training. The application of virtual reality technology, accident scene based on virtual simulation, process model and virtual simulation architecture based on the emergency protocol are established to implement the command simulation training for command and management personnel, the collaborative operation and use model of emergency treatment equipment based on operation regulations, and the emergency treatment simulation training for on-site treatment personnel. Through the integrated training, the command and management personnel and on-site treatment personnel will effectively promote the emergency treatment ability of safety accidents in densely populated places, and reduce the loss of personnel and property.

2. System Establishment

The emergency response training system mainly includes four parts: 3D data collection and modeling of safety accident scene and emergency response equipment, model integrated management platform, simulation training subsystem of safety accident emergency organization and command, and simulation training subsystem of safety accident scene treatment. The relationship between the parts is shown in Figure 1.

To obtain realistic 3D simulation effect, it is necessary to build 3D models of site facilities, facilities and equipment, and emergency treatment equipment to provide realistic 3D simulation training scenes and objects for safety accident emergency training. Model integrated management platform is the core of simulation training system. Based on the Web3D engine, all kinds of resource data of the system are integrated to form a comprehensive two-dimensional situation and 3D scene. Through web services, the data of the simulation training subsystem of emergency organization and command and the simulation training subsystem of accident scene treatment can be shared, integrated and interacted; through script library, the scene driving, immersive swimming, plan deduction and real-time simulation of human in the simulation training subsystem of emergency organization and command can be implemented; Through wearable virtual interactive equipment and multi-channel stereo projection or stereo helmet, the multi-person collaborative interactive training for emergency response on the scene of accident can be implemented.
Figure 1. Relationship between components of emergency response training system

Based on the simulation integrated management platform, the simulation training subsystem of accident emergency organization and command implements the simulation training for accident emergency organization and command through the functions of emergency scenario management, emergency plan management, emergency organization and plan deduction. Through the research and development of demonstration and verification system, this project implements the prototype system of accident emergency organization and command simulation training. The simulation training subsystem of accident scene treatment applies virtual reality technology and 3D interactive technology to the simulation training for emergency treatment. Under the virtual environment, the on-site treatment personnel interact with the virtual environment based on the virtual equipment, improve the proficiency of the environment and equipment facilities, and coordinate with other rescue personnel. In the interactive virtual field treatment environment, users can use all kinds of interactive devices to operate the emergency treatment devices as in the real environment. In the operation process, the system provides real-time functions such as personnel interaction, emergency handling, realistic constraints and equipment use. In this way, users can analyze the operability of products, verify and plan the operation sequence of emergency treatment equipment, train on-site treatment personnel, etc. On-site treatment shows that the system can record all information of treatment process, and generate review report, video recording, etc. for subsequent analysis.

3. System Modeling and Technical Implementation

The 3D scanning technology based on laser surveying and mapping is used to establish accurate 3D models of site facilities and emergency treatment equipment. Laser scanner is used to acquire 3D data. The general steps are survey area, site layout, equipment installation, 3D scanning and point cloud processing. The 3D data collection of all rooms, channels, installed equipment and facilities in the whole technical position is shown in Figure 2. After 3D data collection, the initial point cloud data is formed. Through 3D modeling software, such as 3DMAX and Maya, the point cloud data is processed subsequently, and finally the accurate 3D data is formed. Moreover, independent modeling is carried out for important equipment to provide accurate data support for subsequent technical preparation and other processes.
Figure 2. Accurate 3D modeling process of densely populated places

The model integration management platform mainly consists of two-dimensional / 3D core engine, two-dimensional situation integration, 3D scene integration, web service interface and related databases. Through the web service interface based on SOA architecture, the numerical models such as hazardous substances in densely populated places are integrated to implement the integration of two-dimensional situation and 3D scene. Meanwhile, it can also provide support for the emergency organization drawing and scene treatment simulation training subsystem.

Based on the 3D virtual emergency treatment equipment model, the practical training scene is reconstructed in the virtual environment through the 3D rendering engine. Trainees can interact with equipment in the virtual environment through digital helmets, body sensing equipment, etc., or implement on-site emergency treatment operation according to the business process in multi-person collaborative environment.

Given the sample data set, \( D = \{x_1, x_2, \ldots, x_n\} \), \( x_i \in \mathbb{R}^d \), \( i = 1, \ldots, n \). Assuming that the first sample is labeled, mark it as \( \mathcal{E} = (x_1, x_2, \ldots, x_i) \), corresponding label \( \mathcal{Y} = \{y_1, y_2, \ldots, y_i\} \).

The importance of each feature dimension in the classification problem is different. To some extent, the training data of emergency treatment of safety accidents can overcome the shortcoming that the training data of emergency treatment of safety accidents treat each feature dimension equally, with the definition as follows: for samples \( x_i \) and \( x_j \), the emergency response training data of safety accidents between is defined as

\[
d_d(x_i, x_j) = \sqrt{(x_i - x_j)^T A (x_i - x_j)},
\]

\( x_i \in \mathbb{R}^d, A \in \mathbb{R}^{d \times d} \) indicates symmetric semi positive definite matrix

Based on the properties of positive semidefinite matrix, \( A \) decomposable into \( A = L^T L \), the above equation is:

\[
d_d(x_i, x_j) = \sqrt{(x_i - x_j)^T A (x_i - x_j)} = \sqrt{(x_i - x_j)^T L^T L (x_i - x_j)} = \sqrt{(Lx_i - Lx_j)^T (Lx_i - Lx_j)}.
\]

It is equivalent to a matrix \( L \). As a mapping, the data of the original space is mapped to the new space, and the training data of the original space is transformed into the training data of the new space, the trainees can have real training experience even when they are not in contact with the equipment. Through virtual interactive means, the trainees can truly complete the interactive training process, and
can correct and guide their wrong operation, which will greatly improve the efficiency of traditional teaching. The system can implement the training for emergency plan processing without accessing the practical equipment, which is safe, reliable, and repeatable at any time.

The last link to emergency management of work safety accidents is post recovery and reconstruction. It's about people's livelihood. The contents of restoration and reconstruction include maintenance and reconstruction of damaged public facilities, debris cleaning, provision of temporary shelter, psychological consultation, etc. Furthermore, how to enhance the defense ability of similar accidents in the follow-up work. We should focus on improving the post-reconstruction mechanism. Emergency social mobilization of safety accidents is a problem that needs further discussion. How to achieve effective and controlled social convening, all levels of government agencies and relevant departments should play a guiding and controlling role. In contrast, non-governmental organizations, such as the masses or some charities, play a role under the correct guidance of government agencies. Social mobilization should be within the scope of relevant laws and regulations as well as the political economy, and its purpose is to gather effective social resources and comprehensively promote the handling of work safety accidents.

4. Conclusions
The technical approach proposed in this paper focuses on resource integration, where advanced general technologies, including laser scanning, 3D engine and virtual reality technologies, are introduced and comprehensively used. In terms of system design, the typical functions of the system are extracted in the platform to implement the integration of various models and provide the standard interface to integrate specific scenes and special subsystems via the general integration platform, thereby improving the system scalability and flexibility. In terms of functional implementation, some accident emergency simulation training is implemented preliminarily. In the future, the customized system function of the system can be implemented based on the practical scene and safety prevention focus of various scenes to enhance the fit with the practical situation, striving to enhance the emergency response capacity for accidents in densely populated places and minimize the loss due to safety accidents.

References
[1] M.-K. Tsai, & N.-J. Yau. (2014). Enhancing spatial information for relief work during nuclear accidents. Lecture Notes in Electrical Engineering, 280, 237-243.
[2] Manuel Fogue, Piedad Garrido, Francisco J. Martinez, Juan-Carlos Cano, & Pietro Manzoni. (2013). A system for automatic notification and severity estimation of automotive accidents. IEEE Transactions on Mobile Computing, 13(5), 948-963.
[3] Terry L. Hardy. (2014). Case studies in process safety: lessons learned from software - related accidents. Process Safety Progress, 33(2), 124-130.
[4] Khaled Amailef, & Jie Lu. (2013). Ontology-supported case-based reasoning approach for intelligent m-government emergency response services. Decision Support Systems, 55(1), 79 – 97.
[5] C. Chang, Z. Jia, X. Ma, F. Kong, & Y. Liu. (2012). Emergency case supporting system for engineering accidents by cbr. Lecture Notes in Electrical Engineering, 124, 503-510.
[6] Hengchang Liu, Zhiheng Xie, Jingyuan Li, Shan Lin, David J. Siu, & Pan Hui. (2014). An automatic, robust, and efficient multi-user breadcrumb system for emergency response applications. IEEE Transactions on Mobile Computing, 13(4), 723-736.