Design of Fire Fighting Simulation Training System Framework for Dangerous Chemical Storehouse

Chiyuan Li¹,*, Changyuan He²*, Weichao Li³, b

¹Department of Fire Command, China People's Police University, Langfang 065000, China
²Department of Postgraduate, China People's Police University, Langfang 065000, China
³Political Department, China People's Police University, Langfang 065000, China

*Corresponding author e-mail: hechangyuanxf@163.com, *750206158@qq.com,
b326635101@qq.com

Abstract. In recent years, fire and explosion accidents occur frequently in dangerous chemical warehouse in China. It has become an important problem for fire department to extinguish the fire in large dangerous chemical warehouse. In order to enhance the training effect of these fires, this paper introduces the simulation training system into the field of fire fighting training for fire rescue team in hazardous chemical warehouse, and develops a prototype of dangerous chemical rescue command simulation training system framework.

1. Introduction

With the continuous improvement of science and technology in China, the chemical industry gradually plays an important role in regional development and construction. Due to the particularity of storage materials, most of the hazardous chemical warehouses are located in remote place where transportation is inconvenient and water is scarce. These factors objectively increase the difficulty of fire fighting operations. In addition, due to the special nature of hazardous chemicals, the frequency of use is getting higher and higher, the number of uses is increasing, and the items in the warehouse are frequently turned around, causing artificial fire risk factors to increase, which is likely to cause fire accidents [1]. In recent years, there have been a number of fire and explosion accidents in chemical dangerous goods warehouses in China, as show in Table 1. It can be seen that how to deal with the fire of dangerous chemical warehouses scientifically and improve the corresponding disposal capacity of the fire rescue team has become an important issue in emergency rescue.

At present, most computer-aided simulation training systems for fire-fighting and rescue simulation training systems still have problems such as limited participation of participants in China, insufficient training authenticity, poor system operation experience, and difficulty in expanding only for a single emergency case. Besides, due to the special characteristics of hazardous chemical storage warehouses, it is not possible to conduct full-scale fire-fighting rescue tests in warehouses with a large number of hazardous chemicals [2]. Therefore, based on the analysis of the requirements of the fire extinguishing simulation training system for hazardous chemical warehouses, this article determines the tactics and
command training elements and subject requirements for fire extinguishing and extinguishing of hazardous chemical fires, and establishes the main functional framework of the system.

**Table 1.** Statistics of fire and explosion accidents in typical dangerous goods warehouses in China in recent years.

| Number | Accident Date | Accident Location       | Accident Reason                              | Casualties   |
|--------|---------------|-------------------------|----------------------------------------------|--------------|
| 1      | June 29, 2010 | Fangshan, Beijing       | Fire of stored material                      | No casualties|
| 2      | April 14, 2011| Zhuzhou, Hunan          | Improper storage of sodium hydrosulphite     | No casualties|
| 3      | December 1, 2014| Wenzhou, Zhejiang      | Explosion during loading                     | 3 injured    |
| 4      | August 12, 2015| Binhai, Tianjin        | Spontaneous combustion of nitrocellulose     | 165 dead and 798 injured |
| 5      | April 22, 2017 | Taizhou, Jiangsu       | Fire in the pipeline                         | 1 dead       |
| 6      | December 30, 2017| Shenzhen, Guangdong  | Operational error                            | No casualties|

2. Demand Analysis of Simulation Training System for Hazardous Chemical Warehouse

2.1. Construction Demand

The fire fighting simulation training system for dangerous chemical warehouses can be divided into 2 parts: system management platform and training seats [3]. The system management platform includes user management, performance management, scenario management, plan management, basic data editing, model assembly, scene editing, seat management, and evaluation indicators. Training seats include director seats, fire command center seats, forward command seats, team seats, and commentary observation seats. The structure of the training system is shown in Fig.1. The distributed deployment of these seats provides guidance control, action handling, training observation and other functions.

2.2. Use Demand

From the perspective of the user, the use of simulation training mainly includes the following aspects:

1) Realism. Compared with real-life training, the venue, event, and command interaction are all implemented by computer simulation [4]. This requires as close to the real scene as possible to meet the immersive requirements of simulation training. The system should be centered on the virtual scene of fire fighting and rescue, and show the real virtual environment of fire or other disaster scene as one of visual, auditory and tactile.

2) Visibility. On the one hand, the system needs a variety of simulation scene presentation methods, such as floor plans, two-dimensional maps, three-dimensional views, etc., and provides convenient zoom, displacement, and perspective transformation operations to meet the need to view the scene at different levels and at different resolutions [5]. And development needs; on the other hand, it also needs diversified data display forms, such as emergency resources status and emergencies plotted on the map, and the number and location of emergency resources in the form of a list on the operation interface to assist training personnel.

Scalability. The computer simulation training system can not only be applied to a single scenario or plan, but can support emergency simulation training for different emergency plans, scenarios and even industries by expanding models, events, and processes. The easy-to-expand system can provide users with relatively low-cost system value-added services, and even the users themselves can realize system business value-added.
2.3. Using Objects Demand

The system is mainly divided into several types of objects, such as administrators, teachers, trainees, according to user types.

The administrator is usually an instructor. The main functions are: user management, basic data editing, model assembly, scene editing, scenario editing, seat management, performance management, scenario management, difficulty setting, plan management, evaluation indicators and other functions. The instructor mainly completes the functional operations of the director's seat. The director's seat issues or pushes various control information to the trainees, and guides the training to proceed as planned. The director's seat is responsible for controlling the entire training process. Trainees are responsible for simulating various on-site disposal roles. When training designers to prepare initial scenes or scene lists, the system provides tools for making scenes, events, images, text, audio, and video [6]. At the same time, as the system is used and gradually accumulated, it can provide more and more rich scene libraries and event simulation libraries. The scene library contains virtual blocks and buildings, and the event library contains various fire-related events.

3. Framework Design of Simulation Training System for Hazardous Chemical Warehouse

3.1. Overall System Design

The fire simulation training system for hazardous chemicals warehouse is composed of different functional modules, which needs the system to gather them together through certain technical means. Based on the system's openness and scalability requirements, this system is designed to build a system using a training platform combined with training packages. Among them, the training platform is a general-purpose and extensible platform architecture provided for simulation training. By loading training packages, and then training designers to perform simulation models, user interface configuration, and simulation scene design based on the resources in the training packages, rapid-oriented Network-based simulation exercise system for specific plans. The training package packs the corresponding training scheme, human-machine interface configuration, three-dimensional scenes and models, training scenarios and simulation models, typical event models, and analysis and evaluation.
models. In the system construction, fire fighting training kits for hazardous chemical warehouses will be developed in a targeted manner [7]. The training platform comprehensively uses virtual reality technology, simulation modeling technology, and data analysis and evaluation technology in a layered architecture, which can better meet the needs of reality, visibility, easy organization and easy expansion of the system.

3.2. Functional Architecture Design
The functional architecture design of the system is based on the time sequence of the fire extinguishing and rescue operations in the hazardous chemicals warehouse [8]. The system corresponds the execution process of the simulation system to the fire extinguishing and rescue command process one by one [9].

First, the system starts to initialize the data design of the simulation system according to the training mode. The scene control management member will be the first component in the training process. Use the characteristics of the component to create a system framework for execution and join the system execution, and then other components of the training script are added to the system execution in order, the object instance enters the simulation cycle, and the fire fighting task is performed [10].

After the mission is over, the system will conduct battle reviews based on the training playback situation and the evaluation system, and analyze the problems one by one. The end of the battle evaluation is the end of the simulation process, and each component exits execution. When the last component unit exits, the system execution is also cancelled.

3.3. Functional Detailed Design
The training process mainly includes 6 major function processes: training package design, training preparation, training process and evaluation. The major function processes are shown in Fig.1.

Basic data editing is mainly used for training package design. This tool is mainly used to manage and assemble the data part of the model. The data preparation personnel no longer need to focus on the business capabilities of the model, and can complete the data entry of the model before the model business development is completed. Model assembly can realize the dynamic assembly of entity, component, task and behavior models according to the model requirements of individual firefighters, equipment, flames, and warehouses.
Training preparation is mainly reflected in adjusting the simulation time, simulation environment, and simulation model parameters. Set the difficulty level of the stage before the simulation runs. After the simulation starts, all configured seats in the seat configuration phase are automatically started.

After each training seat is opened, you can choose "Novice Guidance" or "Training Practice". The novice guide can enter the novice tutorial, the system prompts how to operate the current seat. The training practice enters the training implementation stage.

During the training evaluation stage, the training process can be replayed, and key processing actions can be scored. The scores are combined with automatic assessment and expert assessment. The assessment team and expert team can modify the assessment results. The process record playback refers to the playback of the training situation process generated by the process record. Training evaluation According to the evaluation link and evaluation items, the system or expert records the performance score of each recorded item in the training.

4. Conclusion
The simulation training system can be used for practical training and teaching, thereby effectively improving the tactical ability and command level of participants. This paper starts with the system requirements of simulation training system into the field of fire fighting training for fire rescue team in hazardous chemical warehouse, and constructs a fire fighting simulation training system framework, which has certain guiding significance for the training of fire department.

References
[1] Yu Z F, Guan J L, Fire and Rescue Combat Technical Training System Construction for Dangerous Chemicals, J. Procedia Engineering. 135 (2016) 654-659.
[2] Using Serious Games and Virtual Simulation for Training in the Fire Service: A Review, J. Fire Technology. 51 (2015) 553-584.
[3] Sun Y , Fisher R , Wang F , et al. A Computer Vision Model for Visual-Object-Based Attention and Eye Movements, J. Computer Vision and Image Understanding. 112 (2008) 126-142.
[4] Becker M , Kuznik C , Mueller W . Virtual Platforms for Model-Based Design of Dependable Cyber-Physical System Software, J. (2014).
[5] Chi JH. Metallographic Analysis And Fire Dynamics Simulation For Electrical Fire Scene Reconstruction, J. Forensic Sci. 57 (2012).
[6] Xue-Sheng J , Di-Ping Y . Fire Fighting And Rescuing Scene Simulation Based On Vega, J. Fire Safety Science. (2007) 111-114.
[7] Finney M A , Grenfell I C , Mchugh C W , et al. A Method for Ensemble Wildland Fire Simulation, J. Environmental Modeling & Assessment. 16 (2011) 153-167.
[8] Hansen L , Bradish J K . Chemical Hazards, Exposure Concerns At Oklahoma City Oil Warehouse Fire, J. Firehouse Magazine. (2006) 663-664.
[9] Wang L , Xie J , Shi Z , et al. The Personal Protection of Emergency Rescuers in Dangerous Chemical Accidents, J. Procedia Engineering. 45 (2012) 755-762.
[10] Miles S D , Cox G . Prediction of Fire Hazards Associated with Chemical warehouses, J. Fire Safety Journal. 27 (1996) 265-287.