Design and Implementation of an Indoor Radiation Accident Emergency Training System

Fengying Hu [1,2,a], Ming Guo [1,b], Jijun Zhang [2,c*], Guobo Zhong [1,3,d], Xiaofei Feng[1,3,e]

([1]College of Nuclear Science and Technology, Naval University of Engineering, Wuhan 430033,China
[2]The No. 91049th of PLA, Qingdao 266102,China
[3]The No. 91515th of PLA, Sanya 572001, China)

([a]344600384@qq.com, [b]mingguo11@163.com, [c]zjj2011pp@126.com*, [d]zhonggb80@126.com, [e]fxf1618@163.com)

Abstract. Based on UWB positioning technology, an emergency training system for indoor radiation accidents is designed in view of the problems such as low level of actual combat in emergency training. The system can flexibly construct radiation accident scenarios required for emergency training through the combination of hardware and software, and can carry out multi-subject emergency handling training and drill, with a high level of actual combat, which can effectively improve the emergency handling ability of personnel and units.

Keywords: indoor positioning; radiation accident; emergency training; radiation monitoring

1 Introduction

Radiation accident emergency training is the main way to improve the unit's emergency handling ability. In the actual training, because there is no real accident radiation pollution of the environment, resulting in the actual combat level of emergency training is low. For this reason, many researchers have proposed corresponding solutions, which are mainly divided into two categories: First, the radio frequency transmitter is used as a simulated radioactive source to build accident scenes for training [1]; Second, computer software is used to simulate and construct radiation accident scenes for personnel to conduct relevant training [2-6], such as virtual reality technology (VR) [7-9]. The first kind of scheme is not realistic because the layout of simulated radioactive source is very obvious. The disadvantage of the second type of program is that the improvement of personal practical operation skills is limited.

Aiming at the above problems, this paper proposes a new emergency training system scheme, which can improve the fidelity of training and effectively improve the training effect.

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2 System Design

2.1 General System Design

The indoor radiation accident emergency training system is mainly composed of positioning module, scene construction module, analogue monitoring equipment, group training module and so on. The logical interface relationship between the modules is shown in Fig. 1.

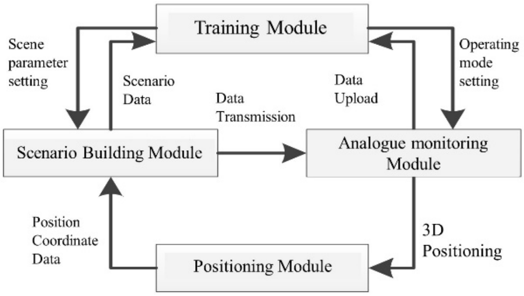

Fig. 1. Module logical interface diagram

2.2 System Realization

Positioning function implementation

Based on UWB positioning technology, Through the proper configuration of the positioning base station and the positioning algorithm, indoor 2D positioning and 3D positioning can be realized [10-11]. If the accident scenario is constructed using two-dimensional positioning, the system will not be able to distinguish the level of radioactive surface contamination activity on the surface of objects with the same location but different heights. Therefore, it is necessary to use three-dimensional positioning to construct accident scenes to meet the needs of actual emergency training.

The positioning system selects a 4-base station stereoscopic configuration scheme, as shown in Fig. 2.

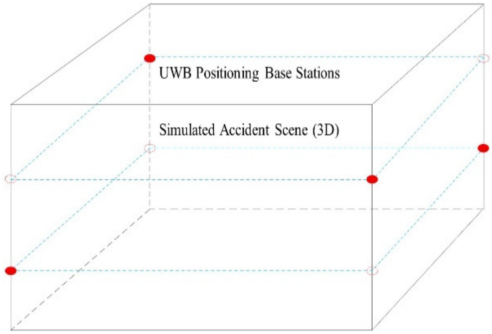

Fig. 2. Indoor positioning base station configuration diagram

Scenario Building Functionality Implementation

Scene construction simulates the radioactive surface contamination and aerosol activity concentration of the accident site on the computer, and realizes the data distribution and reception based on the positioning engine software.

After the accident, the activity concentration of radioactive aerosol showed a trend of first increasing and then decreasing. Its change process can be roughly expressed by the probability density function of equation (1) χ2 distribution, where n is the degree of freedom, and K_1 is used to adjust the level of radioactive activity.

$$f(x) = \begin{cases} K_1 \times \dfrac{x^{\frac{n}{2}-1} \cdot e^{-\frac{x}{2}}}{2^{\frac{n}{2}}\Gamma\left(\frac{n}{2}\right)} & x \geq 0 \\ 0 & x < 0 \end{cases} \tag{1}$$

With the gradual settlement of radioactive aerosol, the surface pollution level gradually increases and approaches a stable value. Therefore, its change trend can be approximated by equation (2). K_2 regulates the range of surface pollution levels.

$$f(x) = K_2 \times \left(1 - \frac{1}{x+1}\right) \tag{2}$$

After the scene data is generated, the positioning engine software detects that the simulated monitoring device has entered the training area and sends the corresponding type of data according to the device ID. When the device leaves the area, it automatically stops sending data.

Analogue monitoring equipment

The analogue monitoring equipment mainly includes radioactive aerosol monitoring equipment and surface contamination monitoring equipment, and its design idea is to be realized by adding a training module on the basis of the actual equipment.

The operation, use and data display of the two devices in the measurement mode and the training mode are exactly the same. The only difference lies in the data source. The data in the training mode comes from the simulated radiation data generated by the scene construction system.

Group training modules

Group training module is the application layer software part of the whole system, including training prefabrication, scene control and assessment and other functions. Training prefabrication is to set training subjects, training objects, training content, training time and training objectives according to the needs of training or exercise. Scene control can realize the selection of training scene, the setting of accident scene parameters, the selection of accident scene view, etc. Assessment provides a comprehensive assessment of training.

3 System Application

The application of the system mainly includes four stages: task planning, training preparation, training implementation and assessment.

3.1 Task Planning

The organizer decides the task according to the subjects, training objectives and requirements, and assessment objectives stipulated in the training program, including training subjects, training equipment, training personnel composition, accident scene parameters, etc.

3.2 Training Preparation

According to the proposed content, organize personnel to be in place, distribute training equipment, generate simulation data in the scenario construction software, and delimit the pollution scope.

3.3 Training Implementation

Taking the whole process emergency drill as an example, the implementation process is as follows:

After the accident occurs, the on-site operators immediately handle the accident, seal the accident parts, and evacuate the site after completion.

Emergency radiation monitoring personnel carry analog monitoring equipment into the accident site for emergency detection according to the instruction. The scenario construction software sends the simulated data of the corresponding location to the device based on the device ID and location.

The command group will study and judge the detection results, and order the decontamination disposal personnel to carry relevant equipment into the entrance for pollution removal operation, and withdraw from the scene after completion.

The command group ordered emergency radiation monitoring personnel to conduct another radiation detection, evaluate the effect of decontamination disposal, and determine whether further decontamination is needed.

Emergency termination, site recovery, relevant personnel and equipment according to the situation to wash, the end of the drill.

3.4 Assessment

The results of the training are given by the comprehensive evaluation of the software and evaluation experts, and the evaluation content mainly includes the operation, completion time, disposal process and method, the fluency and rationality of command and coordination.

4 Conclusion

In this paper, an indoor radiation accident emergency training system is designed and implemented based on UWB positioning technology. The system has the functions of building radiation accident scenes on demand, setting training subjects, training assessment and evaluation. Among them, the positioning module can not only locate the analog monitoring equipment, but also send the corresponding analog data according to the ID of the equipment, so as to realize the closed-loop simulation of the accident radiation environment and emergency monitoring. The system has the advantages of flexible scene construction, real training feedback and close to actual combat, and can provide effective technical support for the actual combat training of radiation accident emergency response.

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