Using Collaborative Virtual Geographic Environment for Fire Disaster Simulation and Virtual Fire Training

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Abstract—**A fire disaster has the highest occurrence of frequency among disasters. A fire presents some of the characteristics of a disaster because of the highly destructive action of fire and of the considerable number of victims. Fire rescue is very essential in fire disaster emergency response. Disaster planning and response require ever more scientific elaboration and technological support. The paper establishes applications of fire disaster simulation and virtual fire training by using our Collaborative Virtual Geographic Environment (CVGE) platform-CySim, which is developed based on open source OpenSimulator server and Second Life client. The approach links fire simulation and human behaviour rehearsal to virtual environment, thus provides a flexibility interaction platform and distributed and collaborative learning network for disaster knowledge learning and virtual training. Users (trainers) can play it again and again, until they get it right. It therefore can be a replacement of live simulation training of fire disaster.**

Keywords-Collaborative Virtual Geographic Environment (CVGE); fire simulation; virtual training; human behavior; CySim.

I. INTRODUCTION

As the development of information sciences and technologies go further, computer-based disaster process simulation, virtual response rehearsal, emergency management, and disaster recovery become possible [1-5]. Governments, industries and researchers pay more and more attention to seek solutions for public safety and emergency problems. The emergence of affordable virtual environment is providing the fundamental infrastructure to build virtual facilities, such as virtual city, virtual highrise building, indoor pipe network, outdoor emergency evacuation site and so on, which can provide an interactive simulation and experimental environment for planning, management, even virtual rescue and evacuation training.

A fire disaster has the highest occurrence of frequency among disasters. A fire presents some of the characteristics of a disaster because of the highly destructive action of fire and of the considerable number of victims [6]. Fire rescuing is very essential in fire disaster emergency response. Disaster planning and response require ever more scientific elaboration and technological support.

Effective training develops the knowledge to make appropriate strategic and tactical decisions as well as proficiency in the skills necessary to mitigate or reduce hazards and provide a safer operating environment. However,

the question of what makes fire training effective is often unasked and even more often unanswered [7].

A Virtual Geographic Environment (VGE) is an advanced information system that combines GIS (Geographic Information System) with Virtual Reality (VR) technology [8]. A VGE is a virtual representation of the natural world that enables a person to explore and interact with vast amounts of natural and cultural information on the physical and cultural environment, in cyberspace. Thus, a VGE is a new generation of information platform that can be used for geographic phenomena representation, simulation, and visualization, as well as interaction between users or between user and the virtual environment by integrating geographic information and process models into virtual environment[9-11]. VGE applications use in fire disaster simulation and virtual fire training can provide people with special insight into the fire disaster process, made it intelligible to firefighters and fire officers, and offer an immersive virtual way for fire training, also can be a valuable tool during recovery and rebuilding efforts. This is of great human, economic, environmental, and educational importance.

This paper presents the applications of fire disaster simulation and virtual fire training established by using our collaborative virtual geographic environment platform-CySim, which is developed based on open source OpenSimulator server [12] and Second Life client [13]. The approach links fire simulation and human behaviour rehearsal to virtual environment, thus provides a flexibility interaction platform and distributed and collaborative learning network for disaster knowledge learning and virtual training. Users (trainers) can play it again and again, until they get it right. It therefore can be a replacement of some live simulation training.

The following of the paper is organized as follows. In section 2 characteristics of fire disaster and fire modeling are described. In section 3 we present our CySim CVGE platform based on OpenSimulator virtual world server, and illustrates fire disaster simulation and virtual fire rescuing training. Section 4 contains some discussions and conclusions.

II. CHARACTERISTICS OF FIRE DISASTER

Although a fire disaster need not necessarily reach catastrophic proportions, a fire of vast proportions can moreover cause damage to the surrounding environment by the massive production of heat and the emanation of burn

gases and fumes. Smoke and gas, because of their suffocating action and their direct action on the airways, represent other specific danger elements. Another factor that makes all fire disasters dramatic is panic. This is due to the realization that the fire can kill within a few moments, cause injuries and permanent disfigurement, and inexorably destroy everything in the vicinity [6]. Figure 1 shows the scenarios of fire disaster. Obviously, heat, smoke and gas are the angerous elements of a fire disaster.

Figure 1. Scenarioes of fire disaster in reality. A fire disaster has the highest occurrence of frequency among disasters.

Masellis M. et al. summarized some specific aspects of a fire disaster [6], which include:

1, the number of persons involved is usually high;

2, the burns tend to be extensive, and the general condition of the victims precarious;

3, the inhalation of combustion gases, fumes, and hot air causes damage to the airways and this alone can jeopardize survival;

4, the place where the disaster occurs is not always easily accessible, and speedy care and assistance may be inadequate.

It is useful to bear these aspects of a fire in everyone's mind for safety. When the fire disaster occurs, a person involved should know how the fire and the smoke spread to judge maximal safe evacuation time. The spread of smoke is ussually described by Zone Model [4].

According to Zone Model, the space a fire involved is divided into two volumes: upper hot gas layer and lower cold air layer. When a fire happens, high temperature combustion becomes the smoke plume above the source of the fire. The axis of plume was surrounded by horizontal cold air. Then the plume of cold air and hot gas mix. Thus the total mass of the plume is increasing, while the average plume temperature and combustion continuously reduce. Plume reaches the roof so that plume spreads around, and becomes the upper hot smoke layer. As a result, hot gas layer in the upper and cold air in the lower layer have a clear interface between them.

We design and simulate fire disasters on the basis of Zone Model by using particle system technology. The visualization effects can be seen from the figure of next section. Training in a realistic context not only provides an opportunity to develop a practical understanding of fire dynamics and proficiency in firefighting skills, but is also a means for learners to recognize cues and conditions that are critical to effective decision-making.

III. FIRE DISASTER SIMULATION AND FIRE TRAINING BASED ON CYSIM

A. CySim: Our CVGE Platform

Virtual world technologies become increasingly important and be applied to develop varies services and applications. More and More people, especially for planners, architects, educators, and trainees. They are experiencing and practicing realistic life through those 3D virtual world platforms, including education, training, collaboration, scientific simulation, geographic information integration, and other specific practices [14-15]. In CySim, a CVGE platform, we use open source virtual world technology, OpenSimulator [12], to implement independent CySim virtual geographic environment servers for the use of our own virtual applications by integrating virtual environment and GIS. The functionalities can achieve to practice, simulate, visualize and conceptualise issues which relate to a medium-large scale area of realistic geographic environments. The architecture and work flow of this project may also benefit other applications, e.g., virtual industry, virtual university, and virtual government, etc. Figure 2 shows the virtual environment of fire disaster simulation and virtual training project.

Figure 2. Fire disaster simulation and virtual fire training project developed based on CySim CVGE platform.

B. Fire disaster simulation and virtual fire training

Based on CySim, we develop fire disaster simulation and virtual fire training by designing and modeling many elements, including virtual buildings with diferent structure, warning facilities, evacuation facilities, and training facilities, visualization of spreading fire and smoke, firefighter action and behaviour.

Buildings include high-rise buildings, low-rise buildings, and underground construction. Internal structure of a building is designed in two types of narrow routeway and broad routeway. We model different kinds of building to simulate different situation.

Warning facilities is designed to alarm all people in the fire scene at a certain time. It may have more forms than in reality. Evacuation facilities are easy to identify and understand and have vision in the smoke so that everybody can evacuate following it.