Session XXXX

Training in Virtual Environments for First Responders

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Abstract

A virtual reality system is being developed to help train first responders in dealing with terrorist attacks involving use of weapons of mass destruction (WMD). The main goal of the project is to determine how effective virtual environments can be used for training first responders, and the project emphasis is on WMD survey training. The virtual environments will be capable of being programmed to allow first responders to train in numerous scenarios. The project is conducted by the University of Missouri-Rolla in collaboration with Battelle Memorial Institute and Army's Maneuver Support Center (MANSCEN) and is funded by Army's Tank-automotive and Armaments Command (TACOM).

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Introduction

Since the devastating terrorist attack at the United States on September 11, 2001, Homeland Security (HLS) has become an issue of utmost importance in the nation. There is great need for developing measures for counter-terrorism and for training of military and civilian first responders engaged in HLS.

Virtual Reality technology uses digital computers and other special hardware and software, including those capable of immersive 3-D visualization and advanced human-machine interface, to generate a simulation of an alternate world that is believable as real by the user. Growing interest in virtual reality has led to numerous applications of this technology in automobile, aircraft, entertainment, medicine, sports and other industries as well as for education and training[1-10].

The application of virtual reality is also a powerful approach to planning HLS strategies and training personnel for HLS operations. Building physical facilities for strategic planning and personnel training in HLS would be time-consuming and costly, and the result would be of only limited utility in planning/training activities. Also, using realistic physical facilities to develop decision-making and operation skills of personnel in counter-terrorism and other HLS missions might be dangerous. The same skills can be gained through training of the personnel with synthetic reality environments that represent highly realistic simulations of physical environments, which provide great advantages in increased safety, reduced cost and time, and unlimited scenarios that can be generated with computers.

The project described in the present paper is aimed at developing a prototype First Responder Simulation and Training Environment (FiRSTE) that can be used in simulation-based analysis to generate specifications of operational requirements for training of first responders in handling terrorist attack incidents involving the use of Weapons of Mass Destruction (WMD). One objective is to determine how trainees can be fully immersed in a virtual environment that realistically simulates an actual situation. Another objective is to provide an effective and inexpensive method of training first responders to meet the difficult challenges of responding to a WMD event. The project will demonstrate why training in a synthetic environment is much safer than training in a live environment, where not all elements of the physical environment can be controlled.

Survey of First Responder Simulation Technologies

We have conducted a survey of hardware and software technologies relevant to the development of a virtual reality simulation environment for training of first responders. The survey of hardware devices was made considering the following system hardware requirements:

- Computer system
- Graphics card

- Immersive 3-D visualization device – head mounted display
- Scene navigation device for trainee including walking/running and turning
- Sensor for tracking of location (position and orientation)
- WMD sensor simulant – input device
- Feedback devices/modalities
- Personal protective equipment & associated accessory
- Other input/output devices

The surveyed software tools was made considering the following system software requirements:

- Hosting computer environment
- Graphics/gaming engine
- Simulation platform
- SAF/Avatar
- WMD sensor simulator
- WMD agent modeling and simulation
- Trainee server
- Trainer server
- Interface software for hardware subsystems

The survey of hardware devices and software tools included information on commercially available products, vendors, performance capabilities, and costs. This information has been used as the basis in making decisions on what to purchase and what to develop in-house for the development of the FiRSTE system.

System Architecture

System architecture is critical to the development of a simulation application such as the FiRSTE system. The concept of system architecture encompasses a set of decisions made on key aspects including organization of a software system, selection of the structural elements and their interfaces by which the system is composed, structural element behavior as specified in the collaborations among those elements, composition of these structural and behavioral elements into progressively larger subsystems, and architectural style that guides this organization. Based on this concept, we consdier system architecture in five fundamental views: Use Case View, Design View, Process View, Implementation View, and Deployment View (see Figure 1). The Case View focuses on the value of the system, i.e. what value the system will provide and how it will be used to deliver this fundamental utility. The Design View focuses on the structure of the code and how it will communicate within itself and with the outside world. Understanding what will happen when the software runs is the focus of the Process View. The Implementation View focuses on the complexity the system will face when it moves from the development phase into the production environment. The Deployment View considers how to package and install the system for purpose of deployment.

Our development of the system architecture is treated as a Rational Unified Process, which is a formal methodology appropriate for the development of a large software system such as the FiRSTE. A fundamental characteristic of the Rational Unified Process is that it is Use Case Driven, i.e., it first determines what value the system will provide a user and whether this justifies the expense of development. The activities involved in the Rational Unified Process include several phases: Business Modeling, Requirements Identification, Analysis and Design, Implementation, Testing, and Deployment. Although distinct among themselves, these phases may overlap during the development process.

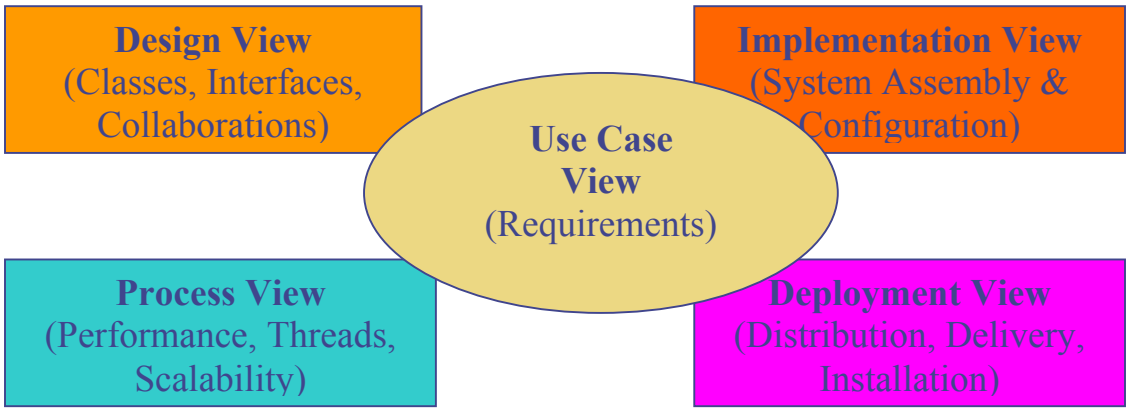

Figure 1 Modeling a system's architecture

A Prototype Virtual Chemical Agents Survey System

We have been performing parallel efforts for the development of a prototype FiRSTE system to investigate the requirements for training first responders in survey of nerve agents during a terrorist attack. The development of this virtual survey system consists of the following efforts:

1) Software is developed to simulate the function of a PID (Photo Ionization Detector), which provides the reading of chemical concentration according to a database expressed in the form of a table look-up.
2) Software is developed using a diffusion model to simulate the dispersion of a chemical agent inside a building.
3) Software gaming engines including Torque II, Half-Life and 3D Game Studio are evaluated for their capabilities and features for manipulation of computer models of objects.
4) Head mounted displays (HMDs), scene navigation devices, and location tracking sensors have been identified and acquired/developed for integrating into the FiRSTE system.
5) Efforts are made on developing interfaces to integrate the various software and hardware components of the system.

We have made good progress on developing/acquiring the various software and hardware components and integrating them toward a complete FiRSTE system. We have developed a computer model of the PID, which realistically simulates the geometry and functions of an actual PID. The software for providing the reading of chemical concentration as a function of time for a given location inside a building is being developed. Also being developed are software interfaces to integrate the PID module and the chemical dispersion module, as well as integrating the combined modules with computer objects generated using gaming engines including the Half-Life and the 3D Game Studio. We are also developing software interfaces to integrate the HMD device and the instrumented treadmill into the virtual reality environment. We have developed interfaces including mounting an infrared sensor based counter on the wheel of the treadmill to measure its rotation for virtual scene navigation and installing an NI-6604 card on the simulation computer to read the data from this counter.

To address the difficulty of integrating application modules developed using different commercial software packages, we have been looking for a simulation platform that will allow more easily integrating the developed application modules and displaying them on different visualization devices including the PC, HMD and the multi-walled CAVE™ without getting bogged down on software integration. We have decided to use EON Reality's products (EON Studio, EON SDK, EON Immersion, EON Raptor, etc.) as the platform for our application development because of the following reasons: 1) EON software created applications and content can be easily displayed on the PC, HMD and CAVE and used on the Internet; 2) EON has a graphical, ease-to-use interface which reduces development time; 3) EON software is compatible to many commercial CAD systems and other 3D formats; and 4) EON software has build-in support for HMD and other immersive visualization devices, motions trackers, and other virtual reality hardware.

Figure 2 Simulation of a warehouse vignette.

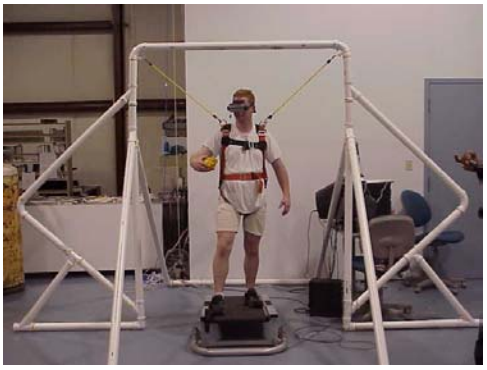

Figure 3 Physical setup of the FiRSTE system.

The initial development of a prototype virtual nerve agent survey system is illustrated in Figure 2. It is a warehouse vignette featuring a nerve agent (inside the warehouse). A simulated PID (shown in the bottom of Figure 2) can display the reading of the nerve agent concentration at the sensor location. Figure 3 shows the physical setup of the virtual training environment. The trainee will wear an HMD to get immersed in the virtual environment

(with the warehouse vignette displayed on the HMD), and will report the reading of the simulated PID to the command and control center for purpose of making decisions on what actions to take. Walking/running on the treadmill will allow navigating the virtual scene, just as an actual scene will change when a first responder walks or runs in a physical training environment.

The University-Industry-Government Partnership

A major strength of this project is the university-industry-government partnership. The partners of this project and their roles are:

- UMR - Assume the responsibilities of developing the FiRSTE system and work with its partners to evaluate this system in first responder training exercises
- Battelle - Identify first responder training tasks, prepare training vignettes, develop concept exploration plans, and conduct training exercises
- MANSCEN - Provide technical assistance, participate in defining project specifics, and oversee the project progress
- TACOM - Provide the contract funds, guide the project, and monitor the project progress

This collaborative project benefits significantly from an excellent synergy between the participating institutions. UMR has strong capabilities and state-of-the-art laboratories to develop the FiRSTE system. However, it lacks knowledge on how first responders are trained in practice. On the other hand, Battelle is very knowledgeable about the practical needs for training of first responders. Also, Battelle has gained valuable experience from its previous participation in developing the Synthetic Emergency Response Training Simulation (VERTS), a system having many similarities to the FiRSTE system. Further, Battelle has established contacts with many first responders who could be invited to participate in the training exercises once the FiRSTE system being developed is ready for testing. MAMSCEN specializes in training of chemical engineers and military police and can share its knowledge about essential elements in conducting realistic training exercises. Besides providing funds for conducting the project, TACOM could share with the project team its experience in using virtual reality technology to develop tanks and other armaments. Besides benefiting from working with the industrial and government partners, the UMR faculty and students involved in the project are able to gain significant cross-fertilization effects, when they interact with each other as a team to develop the FiRSTE system that requires expertise in several academic disciplines.

Conclusion

A virtual reality simulation environment for training of first responders is being developed by the University of Missouri-Rolla in collaboration with Battelle, MANSCEN, and TACOM. A major project goal is to examine the feasibility of developing an advanced virtual

environment where first responders can be trained in response to terrorist attacks, specifically when weapons of mass destruction are involved. The FiRSTE system will be capable of being programmed with simulation environments to allow training first responders under numerous scenarios, which replicate actual situations and can be changed quickly to meet the needs of the trainees. The simulation environment is expected to provide a safer and less expensive method of training first responders to meet the challenges dealing with actual terrorism events involving weapons of mass destruction. The project benefits greatly from the strong university-industry-government partnership.

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