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Proceedings of the International Conference on
Computing in Civil and Building Engineering
W Tizani (Editor)

BIM-based virtual training environment for fire-fighters

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Keywords: serious gaming, BIM, emergency management, fire safety, virtual reality

Nearly every day fire disasters are reported in the news and show the importance of well-prepared action forces like fire-fighters. They have to train their operations regularly to be ready for emergency situations. The best way to do this is to re-enact an emergency-scene in reality. The training face to face with the flames is an important part of the education of fire fighters. This is one of the significantly involved prerequisites to ensure that fire-fighters can complete their missions successfully. They must learn to get a feeling for the conditions in a burning building - roaring flames, temperatures of more than 700°C and toxic smoke can have serious consequences even if the smallest mistake occurs under the high stress for body and mind during an operation. To learn something about the effect of smoke, heat and fire extinguishing, evaporating water the fire-fighters can train in fire houses (e.g. LFW-BW, 2010) or mobile training units (e.g. FIRE HOUSE, 2010).

To train tactic and strategic skills computer games are a common way. With these games emergency response teams can prepare themselves for incidents in a virtual environment. Many incidents can be virtually simulated in dynamic training sessions. Examples for virtual training systems are RescueSim (VStep, 2010) or Tactical Command Trainer (Vectorcommand Ltd., 2010).

With the training methods described above the fire brigade is able to simulate a lot of incidents. But there are some limitations. The scenarios in fire houses or mobile training units are very static and the same variety of fire scenarios than in a training game cannot be simulated. Beyond that, the structural damage of the building is unaccounted. The training game at the other hand cannot simulate real hot conditions like roaring flames or smoke.

However, the assumption is that it is possible to train fire-fighters in virtual reality training methods like it is known from the military sector (Morrison et al 2005). Virtual reality offers high training potential and complex situations can be modeled in an effective manner. Situations which are dangerous for humans can be realistically simulated in a virtual world without any risks.

The aim of the presented research is to improve disaster preparedness by providing a new kind of training environment for fire-fighters based on Building Information Modeling (BIM). Therefore, the development of a new virtual training system is of central interest.

A suitable hardware for the training system is a Virtual Reality Lab like the Darmstadt Civil, Environmental and Safety Engineering Lab (CES -Lab) which was established at the Institute of Numerical Methods and Informatics in Civil Engineering at Technische Universität Darmstadt (IIB). The Darmstadt CES-Lab comes with an efficient virtual environment in the sense of an immersive system. It is assumed that the immersion experience provided by this system, improve the presence of the gamer inside the computer game.

Virtual environments vary greatly in detail of the represented conditions of the real world. It is plausible to assume that the more accurate and richly detailed the real-world is mapped in the virtual-world and the more senses can be stimulated; the training effect in a virtual environment will increase.

In order to approximate the visual stimulus conditions, a visualisation technique will be used, which allows the display of stereoscopic 3D-information. In order to minimize unrealistic behaviour in the virtual world, the gamer should have the feeling to be physically in the virtual world. Playing computer-games, gamer often take unrealistic decisions due to lack of physical pain and injury responses from the virtual world. This is known for military training, the "super-soldier syndrome" (Barlow and Morrison, 2005). The use of heating jackets and / or radiators, treadmills and other devices intended to ensure that no gamer feels himself to be a "super-fire-fighter". Beyond that, the realism of a virtual environment is also influenced by the design of the audio component (surround sound) and sound effects (noise from the roaring fire, collapsing structures).

The virtual training engine can be described as a game engine. A game engine is modular in general and consists of several components like graphics-engine, physics engine, sound System etc. (Gregory, 2009). The core part of the virtual training engine is a simulation model which will include fire, smoke, explosions and structural damage based on the "Building Information Model-Fire Protection" (BIM.FIRE) developed at the IIB (Rüppel et. al., 2006, Theiss, 2005).

The paper introduces a virtual training environment for fire-fighters to train their operations in a save, interactive and real-time simulation of the incident using game- and virtual reality technology. The base of the virtual world, generated by the virtual training engine, is a BIM-data model. This feature allows a quick setup of scenarios. The system described in this paper enables new training methods to approximate "hot"-training in a virtual environment.

It is planned to evaluate the system by implementing the fire house of the fire brigade academy of the state of Baden-Württemberg (LFS-BW, 2010) in a prototype of the virtual training environment (Figure 6). With this fire-fighters are able to train the same scenarios both in a real and virtual environment. This helps to figure out how to adjust the virtual environment to stimulate the training effect.

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