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Usefulness of VRML building models in a direction finding context ☆

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Abstract

This paper describes an experiment which aims to examine the effectiveness and efficiency of a Virtual Reality Modelling Language (VRML) building model compared with equivalent architectural plans, for direction finding purposes. The effectiveness and efficiency issues being primarily investigated were number of tasks completed overall and task completion times. The experiment involved a series of tasks where participants had to find a number of locations/objects in a building unknown to them at the outset of the experiment. Statistically significant results are presented for the benefit of the research community, law enforcement officers and fire fighters where it is clear that in this context, the VRML model led to better task completions than the equivalent architectural plans. Regarding the task completion times, no statistical significance was found. Given the current climate of security issues and terrorist threats, it is important that law enforcement officers have at their disposal the best information possible regarding the layout of a building, whilst keeping costs down. This also applies to fire fighters when rescuing victims. This experiment has shown that a VRML model leads to better task completions in direction finding.

Keywords: VRML; Direction finding; User interfaces

1. Introduction

In the current modern world emergency services play a constant and important role in safeguarding security and dealing with general emergencies. Fire fighters have to deal with various situations involving fires in buildings of all kinds and navigating their way around these buildings (Leco, 2006). Law enforcement officers are constantly being challenged by new threats and new extreme terrorist acts, such as a building being under siege (e.g. Beslan School Hostage Crisis, 2006). While such personnel are highly trained and make use of various technologies it would benefit them to always use the latest equipment or techniques available to aid their job.

One of the technologies available is the use of Virtual Reality (VR) to model buildings, such as public buildings or buildings of strategic importance. Having an accurate VR model of a building could help fire fighters 'learn' the layout of a building and positioning of key items in a building in a short period of time. Alternatively law enforcement personnel could 'learn' the layout of a building along with the positioning of key items for the unfortunate situation of a building being under siege. Sometimes terrorists have spent considerable time and effort in learning all they can about the layout of a building (U.S. Cavalry, 2006). This can possibly disadvantage law enforcement personnel who do not know the layout of a building.

1.1. Related applications research and work

This section will consider some of the literature relevant to the context of the experiment reported in this paper. This deals with the areas of emergency services, direction finding and spatial understanding of 3D models.

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A context where the use of VRML is showing itself to be useful is in the law enforcement area. Particularly, concerning the use of 'crime maps' (Lodha et al., 1999) law enforcement departments have traditionally used a large map on a wall with coloured pins representing crime issues and thus showing the areas of a city most affected by certain crimes. These have been made electronic in nature (usually linked to a Geographical Information System (GIS)) thus allowing the crime distributions in a city to be viewed on a monitor. However these have usually been 2D in nature and therefore limiting in the help they can give (Lodha et al., 1999). The authors believe that VRML crime maps are more useful as they allow a better understanding of data. 3D VRML models allow users to explore the data by means of animations and various manipulation tools, e.g. tilting and rotating (Lodha et al., 1999).

An additional system discussed in (Abernathy and Shaw, 1998) merges topographical, satellite/aerial images and Global Position System (GPS) data into a VRML model. Their context was modelling a 'relay racecourse' (Abernathy and Shaw, 1998) in the state of California, USA. The idea was to give runners more information when they studied the course prior to running it. One of the ideas was to give runners, unfamiliar with the course, extra information by means of a VRML model, such as being able to see hills and other 3D aspects of the course. While the authors are satisfied with their results, they would like to see VRML improved to facilitate more real world applications development (Abernathy and Shaw, 1998).

One study where direction finding in an evacuation context is being conducted is in (Hisanaga et al., 2005). Their aim has been to transmit 3D evacuation images of some environment to a hand-held device, whilst trying to deal with the obvious issues of large file sizes on a hand-held device. They have had some success in reducing file sizes, however, their work has not been fully evaluated, with only basic experimental participant questionnaire results being reported. The evaluation was informal without firm formal tasks. Whilst the work appears to be still in progress, the 'system' developed should be evaluated more rigorously in terms of effectiveness and user approval.

Considering the context of 'rescue' situations, various simple techniques are being used by emergency services. Some examples include police forces retaining and consulting floor plans of buildings such as schools and having 'resource officers' visiting certain schools on a daily basis so as to be familiar with the building and any changes that may occur to the internal layout (Scallan, 2004). Further the more sophisticated method of using VR in helping to train personnel in the kinds of situations mentioned above (and other contexts, e.g. Li et al., 2000) is being investigated/used by other organisations, e.g. the Sandia National Laboratories are using VR to 'familiarise law enforcement teams with scenarios' involving hostage rescues (Sandia National Laboratories, 2005). Also in (Querrec et al., 2003) virtual environments are being used for training fire fighters. Further work in such training contexts can be seen in (PoliceOne.com, 2005) and (Virtra Systems, 2005). Most of this kind of work centres around scenarios, etc.

In Constantine (2006) and Davis (2006) it is clearly indicated that fire services in certain situations tend to try and find out about the layout of a building as part of a building inspections routine (i.e. before any emergency has arisen).

In an informal interview with Constantine (the author of Constantine, 2006), it was indicated that fire crews are trained in a variety of ways. Some of these include using computer-based scenarios in classrooms. Other techniques include using purpose built buildings. Further, within some real environment, fire crews practice their direction finding by being blindfolded and asked to 'follow' a certain route by 'feel-and-touch'. Informally, 'feel-and-touch' involves a crew member using a hand to 'feel' their way along a set of walls leading to various turnings in a building. Some of these aspects are not unique to the UK fire services, as is indicated in Trozzo (2006). This article reports on how fire services were able to use an abandoned building for real fire training. They went as far as filling the building with smoke and asking fire crews to complete certain scenario 'rescue' missions within the building.

The key aspect with these 'rescue' issues is the fact that fire services (and potentially law enforcement officers) are operating in a real 3D environment of which they may be unaware of the actual internal layout/configuration. These issues link with an experiment conducted by Schnabel and Kvan (2003), in an architectural setting. The experiment tested three conditions for 'cube building', where the aim was to study a cube that was constructed of a series of possible shapes of various colours. Then the participants had to reconstruct what they saw by using actual wooden blocks. Three small groups of participants were randomly allocated to either a 2D paper based plan of a cube configuration, a 3D model of the same cube configuration appearing on a PC screen (like a VRML model) or a 3D model of the same cube configuration in an immersive environment. The authors found that the 2D paper based plans group incurred the most accurate reconstructions with the wooden blocks. Also the participants in this condition studied the plans on a level-by-level basis but manifested a lack of understanding of the spatial volume. However the 3D models gave the participants more knowledge about the spatial volume and the overall 3D configuration of the shape. These findings suggested to us that a 3D model could help in direction finding for 'rescue' type situations, such as those faced by fire services. If the findings of the experiment by Schnabel and Kvan (2003) were applicable to other more realistic and larger contexts, then one would expect that direction finding tasks would be more effective and more efficient given a 3D model and compared with a 2D paper based architectural plan. This is because Schnabel and Kvan (2003) found that the participants in the 3D model groups had a better awareness of spatial volume and 3D configuration knowledge.