THE USE OF VIRTUAL WORLD PLATFORMS FOR SUPPORTING AN EMERGENCY RESPONSE TRAINING EXERCISE

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ABSTRACT

The development of a computer-based simulation for emergency response exercise training to facilitate trainees' learning activities and learning outcomes is proposed. Some limitations in using these simulations in emergency services include a focus on small-scaled individual task training and highly controlled environments designed to measure trainees' performance. These problems decrease the realism of the simulation which should represent more diverse, open-ended, counter-intuitive and unpredictable environmental conditions. These problems could reduce learning outcomes brought about by allowing open-ended discussions and team working.

Virtual worlds provide a new methodological framework for conducting emergency response exercises. This paper describes a research agenda for the development of a virtual training exercise for emergency response. It has three objectives: firstly, it highlights the issues of validity of exercises for emergency events; secondly, it reviews possible virtual worlds which could be deployed as test bed environments and presents methodologies for their evaluation. Lastly, it suggests a future development of a virtual environment that may be used to support the emergency planning community by considering an existing similar project.

KEYWORDS: Second Life, OLIVE, emergency response training, Serious Games

INTRODUCTION

Computer-based simulations have been widely used in emergency response agencies to facilitate trainees' learning activities and learning outcomes (e.g. Dobson *et al.* 2001; Granlund 2001; Robert *et al.* 1996). However, there are limitations with using these simulations with emergency services. First, most of them focus on small-scaled individual task training, rather than communication and coordination skills that are required during an incident. Mainly, it is because computer systems may not be able to simulate overall scenarios to the degree of fidelity, and consequently, factors involved in the scenario may be over simplified (Stolk *et al.* 2001).

More recently, the use of virtual worlds has become more widespread for supporting training and education (de Freitas 2008). Virtual worlds allow users to be represented in the virtual world through avatars (in-world representations of the trainee). Virtual world applications also support a range of functionality that includes supporting social interactions, modelling real environments, document sharing and recording facilities that allow users to replay activities undertaken in-world. The multimodal dimension of virtual worlds has indicated positive benefits for learning transfer, and a number of leading edge projects using virtual worlds for supporting learning have suggested that virtual worlds can be effective for training purposes, e.g. Youngblood *et al.* 2007. To provide validation for these preliminary findings, the research group at the Serious Games Institute is undertaking a series of studies predicated upon the notion that virtual worlds can be effective for learning and training, and are focusing upon the strengths of virtual worlds for supporting training distributed groups in their use of emergency response management training methodology and application. This paper lays out the purpose of using virtual worlds for supporting emergency response training and provides a framework based on existing methodologies to be employed for evaluating their efficacy. Given the lack of methodologies to select virtual worlds, the OLIVE platform has been selected given its usefulness in previous, similar exercises at Stanford Medical School.

THE FUNCTIONS OF EXERCISES IN EMERGENCY RESPONSE TRAINING

Exercises as a training model have been widely used by the emergency response training community for a long time (Chen and Borodzicz 2006). Exercises in this article refer to the training method that requires high participation and learning objectives; trainees are allocated in a (partial) representation of the real and dynamic reality to achieve a particular goal, process or environment. They are methods used by emergency services to facilitate cross agency communication and coordination, as they provide a platform for participants to examine and evaluate each other's roles and responsibilities.

Perry (2004) summarises several functions and benefits that exercises in emergency services act on. First, it is used to test the 'emergency plans', 'operational procedure' and 'the management of the organisation'. Secondly, it serves as an educational platform to train decision makers to respond to different types of real world scenarios. In particular, the flexible, adaptive, accuracy and effective skills and competences that are required to deal with crisis and emergency events (Ford and Schmidt 2000). Many teamwork articles also stress the importance of establishing teamwork skills in order to survive in uncertain and dynamic environments, such as communication and coordination (Schaafstal *et al.* 2001). Lastly, an exercise is also governmental policy dissemination medium to the public. For example, there were more counter-terrorist exercises conducted after the 11th September event in the United States. Through these exercises, the government demonstrates their priority in the security agenda.

PROBLEMS COUNTERED IN EMERGENCY RESPONSE EXERCISES

In order to validate the effectiveness of an exercise, scholars use internal and external validation to evaluate the success of the exercise (Feinstein and Cannon 2002). Internal validity refers to the degree to which the purposes of the exercise have been achieved. Individual and organisational learning outcome should be linked to the purposes and objectives of the exercise (Vissers *et al.* 1998). Ideally, an exercise designer should identify learners' need and design the exercise for them. However, it becomes more difficult at the strategic level, when the exercise involves more participants, agencies, and becomes more complex and abstract (Chen and Borodzicz 2006). For example, strategic officers are often occupied with other business commitments and/or do not have time to travel to the exercise site, and therefore, they may not participate in the whole process of the exercise, and/or they might assign a colleague to take part in the exercise (Chen *et al.* 2008). The expense of holding real-world exercises can also be prohibitive (Schaafstal *et al.* 2001).

External validity is the level of fidelity that the scenario of an exercise represents to the participants. Some scholars believe that high fidelity scenarios help trainees use the knowledge, attitudes and skills that were learned in the exercise if the same or similar event occurred (Rolf 1992). However, it is not possible to conduct live exercise frequently. First, these exercises are involved with many personnel - exercise designers, participants, administrators, exercise directors, and training technologies, it can be difficult to gather the relevant personnel to take part in the one or two-day exercise. It is time-consuming and expensive, for example, it takes at least one year to complete a whole exercise in the UK, if it is a large size exercise: from design, conduct to debriefing phases, for example, Exercise Triton (Environment Agency 2005).

Hence, scholars have attempted to produce low fidelity exercises to train decision making under disastrous and crisis situations, and they also argue that real world scenarios are not necessary for learning, mainly because they may reduce the skills that could be gained for participants because they might be over stimulated, see Crichton and Flin (2005). However, criticisms regarding low fidelity exercises, for example 'Exercise Rain' (Chen and Borodzicz 2005), include: the difficulty to evaluate their performance and the lack of evidence of linking learning outcomes to the purposes of the exercise as participants verbally debrief and reflect on their learning experience. In addition, there is a lack of training on the technical and procedural perspectives. Other issues such as retention, knowledge transfer also arise (Ford and Schmidt 2000).

THE USE OF SIMULATIONS TO ASSIST EMERGNECY RESPONSE EXERCISES

Researchers have attempted to use different technological tools and applications to avoid the limitations of traditional exercises in emergency response training and to increase the efficacy of learning activities whilst improving learning outcomes (Chen and Borodzicz 2006). These tools can be categorised as non-immersive and immersive in character. Non-immersive tools for example may include text-based web tools, which create a simulated environment for participants to act in a safe and controlled scenario. This provides players with a real-time based environment (Jenvaldet *et al.* 2001), although this may not be immersive as in 3D modelling of an environment, they can nonetheless allow players to exchange their feedback and reflections.

Other tools include computer modelling, which is used to support decision-making. For example, PC-based emergency hurricane evacuation planning module (Tufekci 2001). Dobson *et al.* (2001) attempt to use 'agent simulation' to facilitate participants' communication and reflection skills, while Granlund (2001) uses web-based simulation to facilitate competences such as team building and decision-making. Other techniques include interactive websites and on-line discussion rooms (Robert *et al.* 1996).

However, there are some weaknesses in the use of these non-immersive computer-based simulations for emergency exercises. First, even if the computer-based simulation could represent the complex workplace dynamics and further teach participants how organisations work, it is still difficult to simulate multiple agency exercises due to the complex psychological, social, and political factors, the scenario could only represent a reduced verisimilitude (Stolk *et al.* 2001; Hill and Semler 2001). Consequently, computer-based simulations are often limited to small-scale exercises and/or are used only at the operational level. Secondly, in order to evaluate the players' performance, strictly controlled environments are used, and this limits the degree to which the fidelity can be demonstrated in the simulations (Wybo and Lowalski 1998).

These difficulties suggest that there is a need to explore new technologies and methodological frameworks with which emergency exercises can be more effectively designed and implemented to support specified training outcomes, in particular, strategic exercises.

More recently, new virtual world and games technologies are allowing for greater immersion within 3D environments via avatars which represent the individual in the 3D environment. This is opening up the potential for training exercises and scenarios that can be enacted with distributed learner groups, with scope for more dynamic scenario editing and therefore greater potential for creating dynamic and interactive virtual exercises. The next section discusses the benefits of using immersive virtual environments for emergency response training and presents some of the platforms that may be used to implement virtual emergency response situations. The following section also discusses evaluation methodologies allowing for the identification of an appropriate virtual environment to implement a virtual emergency response exercise.

EVACULATION MODELS FOR VIRTUAL WORLDS

In order to implement an emergency response exercise using a virtual world, it is first necessary to define the virtual world on which it will work and assess its potential and challenges. Some advantages of virtual worlds over traditional methods include the possibility of conducting real-time, distributed, multi-user, immersive, collaboration and interaction. In general, virtual worlds have attributes that make them attractive for the definition of learning and training situations which are relevant to emergency response exercises. These attributes include shared space, graphic user interface, immediacy, interactivity and persistence (de Freitas 2008). However, individual virtual worlds offer different functionalities and design features which need to be evaluated when deciding which one is better for emergency response simulations. The problem when evaluating virtual worlds is the lack of methodologies to do so. This section outlines some of the characteristics that such methodology should posses and presents preliminary work towards defining an evaluation framework.

According to the Serious Virtual Worlds scoping study (de Freitas 2008), the Federation of American Scientists (FAS) has identified aspects of virtual worlds in need of consideration for developing sets of metrics to be used to evaluate different virtual worlds for learning and instruction:

- Learner control. Learner/user control and interactivity through the creation of an avatar

- Collaboration. Emphasis upon collaboration and community building

- Persistence. Persistence of the world has led to the capacity for immediacy and synchronous use of the world has appeal

- Requirement for 3D interactions and experiences. While the user interface is often 3D, this is not always the case. Some social worlds particularly social worlds for children are animated and 2D, and some mash-up applications of mirror worlds are distinctly non-3D but rely upon a layering of data and data sets.

- Inclusion of sharable and user generated digital content. Most of the virtual worlds have included digital interactive content be it games (which are particularly popular) or user generated content used for sharing with others.

- Immersion and interactivity. Immersion and interactivity are the additional characteristics to include in any list of requirements for a serious virtual world, the user must feel immersed in the environment and fully engaged with the activities being undertaken. This is normally achieved through how the user and environment are represented in-world.

Another question that has to be addressed, however, is in relation to how flexible the virtual world is and to what extent it allows the application of learner-centred (Quintana *et al.* 2002) design techniques. It would be desirable that the virtual world supports a process of analysis and evaluation in collaboration with emergency training learners. The four-dimensional framework (de Freitas and Oliver 2005) is a design methodology that takes into account not only the environment but also the learner and the pedagogy that makes it a good candidate:

- Learner: The virtual world caters for the target learners of the serious game and is easily manipulated to allow role play and the exploration of competencies.

- Context: The virtual world can be used in the context of the learning and it has access to further learning resources.

- Representation: The virtual worlds allow for true representations of the activities, actors and objects surrounding the serious game at hand; it also allow levels of immersion depending on the task and supports interactivity between learners and objects.

• Pedagogy: The virtual world is able to support a learning pedagogy such as constructivism.

In the four dimensional framework, these four aspects are determined at the beginning of incrementally more sophisticated developmental stages. Initial stages would consist of basic prototypes to evaluate proof of concept which in later stages will gradually lead to the final prototypes or the final product. The four-dimensional framework supposes the learner's participation and co-design from the outside ensuring the validity of the prototypes throughout the design process.

Although we are not aware of a single, coherent methodology for the design and evaluation of virtual worlds scenarios, the four dimensional framework is a good candidate as it has the potential for increased learning outcomes and improved performance. However, in evaluating the functionalities and design features of different virtual worlds it is also necessary to account for usability factors. User-centred evaluation methodologies would be an important element when evaluating virtual worlds for learning. The methodology developed by (Hix *et al.* 1999) consisting of conducting a series of evaluations between expert and novice users could be incorporated into the four dimensional framework. In the next section, a number of virtual worlds is presented as potential candidates to implement an emergency response training exercise, described in the following section. Towards the end of the section we argue in favour of OLIVE as it has been used in previous, similar exercises at Stanford Medical School.

USING VIRTUAL ENVIRONMENTS TO TRAIN FOR EMERGENCY RESPONSE

The evolution of telecommunication technologies, web-services and software engineering has allowed for new ways of exploring web-based applications. Virtual worlds are synthetic representations of reality that are focused on the experience that the users of these worlds have. Virtual worlds take place in real time, They can be used by distributed groups of large numbers of players, and are immersive and interactive.

These virtual world applications allow collaborative use of three-dimensional spaces which are used for learning and educational purposes in a number of educational domains. The main strengths of virtual worlds could be generalised as being in the areas of communication, visual expression of information, collaboration mechanisms, interactivity and entertainment. As a result, virtual worlds have the potential of offering new capabilities for users to enhance and promote educational and learning in a number of potential scenarios such as emergency response training exercises. Some of the most characteristic examples of virtual worlds include Second Life, Active Worlds and the OLIVE platform.

Second Life is a cross platform application powered by proprietary new technologies, creating a robust and endlessly modifiable platform for entertainment, business, communication and creativity (Linden Research 2008). All content including objects, textures, audio, video and motion is streamed to the users in real-time. The capability of streaming positional voice creates a rich audio landscape that conveys distance and direction. The Second Life Grid uses industry-standard cross-platform technologies, including: OpenGL, UDP networking, Linux servers and Ogg-Vorbis compression for audio. It also supports multiple communication channels (voice, chat, instant message and group notices), international languages, and 3D proximity-based spatial awareness. In addition, residents build in-world in real-time with other residents and meet co-workers to collaborate on projects. Finally, it uses a rigid body physics simulation where all objects in the world can be collideable, dynamic and moving.

Active Worlds (1997) offers an online comprehensive platform for efficiently delivering real-time interactive 3D content over the web. For consumers, Active Worlds hosts a Universe of over 1000 3D virtual reality worlds where users can choose from a vast array of avatars that fit their personality. The browser has web browsing capabilities, voice chat, and basic instant messaging in real-time. In other words, Active Words allows users to connect, explore, and gain a more in depth understanding of 3D. Similar to Second Life, users can use move about, play online games, shop and make friends with people from all over the globe. It is also possible to stake claim to a piece of land and build virtual homes, mansions, estates or castles. Moreover, Active Worlds allows chatting and users have the option of electing in order to become an Active Worlds citizen. A Software Development Kit (SDK) finally allows users to generate their own virtual establishments.

It is worth-mentioning that there are also custom online virtual gaming platforms originating mainly from Universities and research institutes. These are more experimental prototypes and usually use dedicated hardware devices such as advanced visualisation (head-mounted displays, stereoscopic displays), interaction (3D mouse, orientation and position sensors) as well as haptics (gloves). However, usually the costs involved in these types of configurations are still very high, compared to the alternatives presented above.

On-Line Interactive Virtual Environment (OLIVE) is a software platform that allows customers, partners, and developers to create persistent virtual worlds where users can collaborate over networks to communicate, train, rehearse, analyse, experiment, socialise, and entertain (Forterra Systems Inc. 2008). OLIVE employs a client-server architecture where PC clients are connected to a central server via a network. The architecture ranges from single user applications in one physical location to large scale, simulated environments supporting many thousands of concurrent as well as geographically distributed users. OLIVE supports a great number of capabilities and functionality in the baseline platform which are essential to support a wide variety of interactive virtual world operations. This includes fully operational avatars, voice over IP communication, distributed physics, networking and a session record and playback capability. Moreover, a set of general 3D art assets including avatar clothing, gestures, faces, as well as buildings, vehicles, vegetation, and many other objects are provided. It is worth-mentioning that external parties can create and control their own virtual worlds through the OLIVE SDK, through licensing.

A recent application of the Olive platform by Stanford Medical School project (de Freitas 2008) seems to be the best case study available to illustrate the efficacy of using virtual world platforms to support training. The learning scenarios of the project involved practice innovation through supporting training for cardio-pulmonary resusitation (CPR), mass casualty and assessment in acute-care medicine. The OLIVE platform was used to support training sessions of medical staff using a replica of the Stanford emergency driveway, entrance, waiting area, acute five-bed suite, treatment area, hospital beds and equipment. A number of synthetic, physiologically realistic avatars were programmed to exhibit the signs and symptoms of victims including physiological and biochemical parameters of a range of disease states. In addition, the avatars were 'treatable' in that the correct or incorrect interventions produced medically realistic effects. Two scenarios were developed, one for a chemical exposure incident and one for trauma injuries from a radioactive bomb explosion. A pop-up interface was developed to allow for interactions with the virtual patients. The main learning goals centred upon:

- performing different roles (team member and team leader)
- implementation of the emergency response guidelines and codes for a mass casualty incident
- assessment and management of patients (from either scenario)

The number of trainees in the Stanford Medical School project was small but interesting findings emerged. Evidence demonstrates that training increase trainees' confidence. Under safe context, life-threatening situations were reproducible and clinical skills, as well as team work skills were enhanced during the training (Granlund 2001). Although the project aimed at training operational responders during an emergency, it provides exercise designers an insight with how OLIVE platform can be used to train emergency response managers at the strategic level, for example, strategic response to a big scale flood hazard.

For these reasons, it seems that a virtual world platform may be considered as a crucial part of the future of modelling and simulation, and not just for training systems but also for presenting disaster cases. The example outlined above, and OLIVE in particular would also allow for developed and incrementally complex exercises, considering the four dimensional framework (de Freitas 2005) as it would support high and low fidelity scenarios, multi agency and large scale exercises. Given the evidence from the Stanford Medical School example, it seems OLIVE allows for the assessment of user's performance in less controlled situations via personalised interfaces considering different roles in an emergency.

CONCLUSION

This paper has investigated the current status of using virtual worlds for supporting disaster management and has identified the methods for evaluating these exercises. The research will underpin a series of training exercises being undertaken by the research group to test the validation and evaluation strategies outlined here.

The value of virtual world applications for supporting training in medical environment has been demonstrated in previous work, this new research will aim to produce a model for validation and evaluation of these innovative methods of training increasing the efficacy of the training and supporting multimodal learning.

As discussed, virtual world platforms such as Second Life Active Worlds and OLIVE present potential advantages relating to increasing internal and external validity. It is concluded that these could provide participants with a higher level of realism and immersion. In addition, it has the benefits of reducing the costs, securing anonymity, and it is easy to be accessed remotely by distributed groups. The platforms also allow for greater flexibility regarding different training scenario.

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BIOGRAPHY

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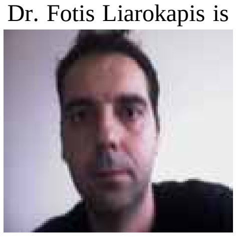

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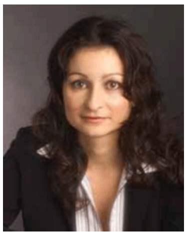

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El Parker is Principal Lecturer in Natural Disasters in the department of Geography, Environment and Disaster Management. Her primary area of interest is people centred early warning systems focusing of the communication of hazard and risk between professionals and the public. She has also been heavily involved in developing training programmes for emergency planning practitioners in order to build their capacity to respond to emergencies, this involvement raised an awareness of the need to provide cost effective operational, tactical and strategic training opportunities at greater frequency than many multi-agency budgets will allow. Virtual world environments can provide potential solution.