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Collaborative Virtual Environment for Training Teams in Emergency Situations

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This paper describes a Collaborative Virtual Environment (CVE) for training and assessment of collaboration among agents who deal with radiological and nuclear emergency situations at big events. For modelling the virtual environment we used Unity software for the land creation, and Autodesk 3ds Max for the scenery and objects. We include in the Unity core radiation detectors and avatars. For the development of scenarios on the approach to individuals suspected of carrying radioactive materials, we analysed practices, procedures and the organization of radiological protection agents during events in the 2014 FIFA World Cup. Results indicated that the Collaborative Virtual Environment are suitable for training simulations in emergencies, because it was able to represent scenarios quite close to potential emergency situations.

1. Introduction

To The recent scale and frequency of terrorist acts illustrate the increasing complexity faced by professionals and rescuers. With the proximity of the Olympic Games in 2016, Brazil is prone to terrorist attacks. The government and the organizations have created emergency managements to ensure normality of those events. The objective of this research is to create a Collaborative Virtual Environment CVE for training and assessment of collaboration in emergency prevention and response situations in major events.

The management of emergency situations at an event is a complex problem that involves dynamic situations, which may not be easily anticipated. This emphasizes the potential complexity of the contexts in which organizations operate and, consequently, people involved in the execution of multiple tasks, from activities that require intense cognitive effort, often are challenged to adapt dynamically to maintain the productivity of the organization in satisfactory levels of performance, which often prevents them from reflecting on the result of their actions and learn from them. Emergency situations require decision-making occurring under substantial uncertainty, because the information comes from inferences or indirect sources. As a result, it is impossible to describe and completely how to control the system (Woods and Hollnagel, 2005). Under this environment, organizations such as the military, nuclear emergency first responders, firefighters, among others, have increasingly used simulation exercises to training their professionals (Voshell, 2009). This is reflected in the search for new technologies to simulate, explore and test new forms of operations aimed at solving difficult situations or to prevent future emergencies (Hintze, 2008). Therefore, it is important to create tools that address the methods and techniques to assist in the prior training of security agents, for example, the detection and approach people carrying radioactive elements.

Simulation exercises serve as imaginary future situations to explore possible responses to events (Voshell, 2009). Therefore, exercises should be planned to address the cognitive skills that must be developed to respond an emergency situation. The purpose and scope of these exercises may include the training of responders, providing practice opportunities in mew situations, evaluation of new technological systems, building trust on trainees, identifying critical decisions, improving coordination, and testing the plans in the light of new threats.

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One of the possible ways to accomplish this training is through the use of virtual reality (Nazir and Manca, 2015). Therefore, this work proposes the development of a simulator in a collaborative virtual environment (CVE) presenting an alternative method of training to improve the performance of security agents in emergencies. The proposed model uses modern virtual reality technologies in the immersion area, providing a greater involvement of players without having to submit them to the risk of radiation contamination, for example. In addition, CVE developed in this work is capable of reproducing real anomalous events providing the team work at the same time providing subsidies so that team members are able to work collaboratively following the concepts of the 3C model proposed collaboration by Ellis and collaborators (1991). For this it was necessary to define and characterize aspects of complexity that must be treated in an emergency environment as well as to identify collaboration needed among the security agents, who are involved in diverse tasks.

2. Virtual Reality

Virtual Reality VR has been defined in many ways by the scientific community. Kirner and Siscoutto (2007) define VR as an advanced user interface to access computer applications that provide interaction, visualization and movement in real time, in three-dimensional environments. Pimentel (1995) defines VR as the use of high technology to convince that you was in another reality, a new way to access and follow the environment information, a place where humans and computers make contact (exchange of information).
Virtual reality has applicability in various scientific domains (Grimes, 1991). VR is especially suitable for applications in physical security, because it is the easiest and perhaps best way to improve security operational training (Burdea, 2003). VR operational training enable that the possible early mistakes of people or teams are performed in the virtual models. Moreover, this technique makes it possible to train rare and unusual situations, such as an incident of suspected radioactive contamination in a football stadium.

3. Collaborative Systems

Collaborative systems are systems that allow interaction between individuals and groups, to perform tasks and are used to designate the terms "groupware" and "CSCW" (Computer Supported Cooperative Work). Groupware is defined by Ellis et al. (1991) as computational systems whose interface is able to offer a shared environment to support groups of people to engage in a task, thus encouraging the Communication, Collaboration and Coordination between them. The big challenge of these applications occurs when the collaborative activity starts to occur in real time, and especially in collaborative virtual environments shared by users remotely located.
The collaboration provides not only the coordination of knowledge and individual efforts but also the interaction among people with complementary understandings, points of view and skills (Pimentel, 2011). The 3C model analyzes the collaboration based on three parameters: communication, coordination and cooperation. Figure 1 presents a diagram of it (Fucks et al, 2005), an adaptation of the original one proposed by Ellis, Gibbs and Rein (1991).

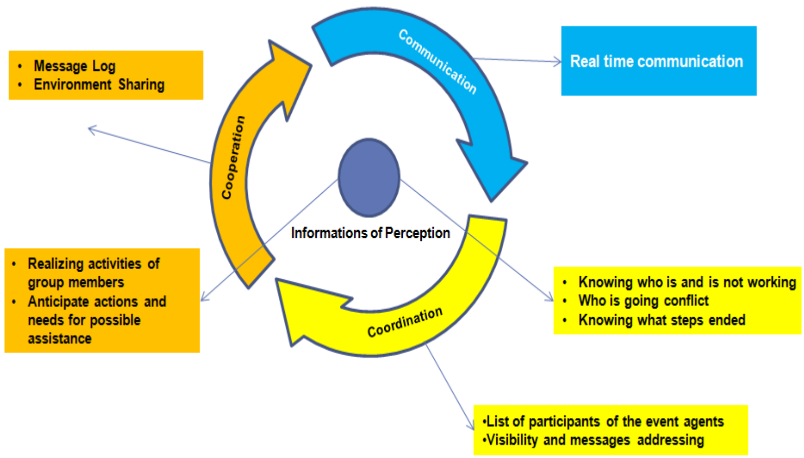

Figure 1: 3C model (adapted from Ellis, Gibbs and Rein (1991))

The information exchanges occurring while communication takes place generates compromises that are managed by coordination, which provides the protocols and rules needed to organize the activities, then avoiding that communication and cooperative efforts be wasted by the individuals. The need to renegotiate and take decisions about unexpected situations during the cooperative processes requires more communication; this in turn demands coordination to reorganize the tasks. This shows the collaboration's cyclic aspect besides of the interdependence among communication, coordination and cooperation.

4. Collaborative Virtual Environments

The ability of communicating and collaborating to perform information exchange plays a very important role on human development. Considering the popularization of the computers and the rise of the internet, digital inclusion has become a reality even in poorest countries. Supported by the quick development of the Virtual Reality (VR) the Collaborative Virtual Environment (CVE) is the evolution of the regular virtual environments intended to aid multiple users participating of a same interaction. Santos et. al (2002) have defined a CVE as a convergence point between VR research areas and collaborative systems (CSCW). CVEs are detaching as an attractive mean to support computer assisted activities in the most diverse domains as observed in medicine (Riva, 2003), education (Blas and Poggi, 2007), and entertainment (Linden Lab, 2009) etc.

Concerning to that, CVEs bring a new perspective to collaborative group work learning, as it provides the users interactions by means of simulations of the real world and manipulation of virtual objects as it is in the real world (Hagsand, 1996). The use of a CVE stimulates the participation of the individuals by dynamically providing teaching activities, training, recreation and many others. In security applications, a CVE can connect remotely different research facilities and local command centers in order to perform trainings on procedures like detection of hazardous materials and suspect approaching, for instance.

Using CVEs, users are free to navigate inside the virtual space (spatial sharing) and can interact with other users (presence sharing). Additionally, a user must be capable to observe the other users behavior at real time (time sharing) enhancing mutual situation awareness. In such environment the verbal and nonverbal communications inevitably occur, as well as coordination and cooperation characteristics. The verbal communication is generally performed by means of chatting tools, audio or video conference whereas the non-verbal one comprehends gestures, facial expressions and avatar's posture. Communication in a CVE is commonly synchronous although it can be also asynchronous.

5. Methodology for the CVE development for security agents training in big events

The CVE modeling comprehends characteristics as shape and appearance of objects, ambient lighting, input and output devices mapping and restrictions imposed when inside the simulation. The development of a CVE requires the use of different types of components including scenario, objects, avatars, animations, texts, videos and sounds. To give realism to it, the objects are designed in 3D according to its real counterparts.

The method aims the developing a CVE and implementing its functionalities to reproduce a real situation where security agents can be trained to deal with security issues in big events. To exemplify the method we develop a CVE around the Maracanã soccer Stadium that will be used during Rio 2016 Olympic Games. The purpose of CVE is to train security agents when dealing with suspects carrying radioactive or nuclear materials in to the stadium. The method comprises the following steps:

1. Modelling the environment where situation occur;
2. Avatars modelling;
3. Implementation of the environment and definition of available functionalities

5.1 Environment (Maracanã and its neighborhoods) modeling

The modeling of Maracanã stadium and its neighborhoods was done by means of Autodesk 3Ds Max software. The process is started by adding a topographic image, which will be the reference for the modeled area.

Poly Modelling is the technique used to modelling it, which consists on adding a primitive box to the virtual space. Next, the shape of the object was refined with textures and colours to provide more fidelity to the original stadium. Figures 2 and 3 show examples of these steps.

To perform the modelling of Maracanã's terrain, was used the Unity 3D. After having done the modelling, the texture and modifications concerned to the area's land relief were applied. Then the objects and edifications were inserted into the virtual environment. Such objects were imported from 3Ds Max to the terrain modelled at Unity 3D as shown in figure 4. Figure 5 shows the stadium entrance where is located Bellini's statue, which is also present at the real stadium. This is to give to the users a major feeling of immersion once everyone who has already visited Maracanã will recognize it.

Figure.2 Autodesk 3Ds Max interface/ Initial step

Figure.3 Object's refinement step

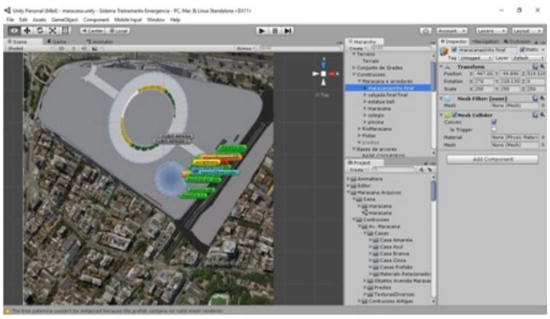

Figure 4 Unity 3D interface.

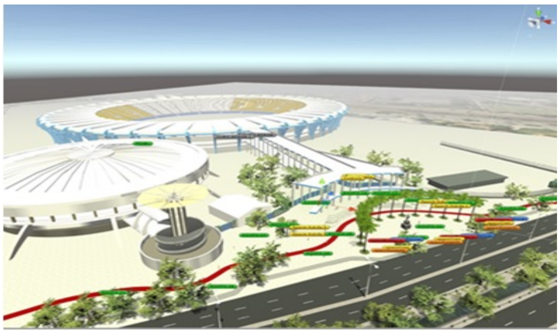

Figure 5. Stadium model

5.2 Avatars Modeling

Avatars are used to provide interaction between the user and the developed environment. In this work besides of the generic avatars representing the audience, there are also specific avatars representing the security agents and suspects. Depending on the ongoing implementation, these avatars can act in different ways such as firefighters, police officers or agents from the local command and control center, according to the user's will. In Brazil, CNEN is the Federal organization responsible for deal with problems related to nuclear issues. As we intend to perform simulations related to nuclear emergencies, we focus on CNEN agents training using the proposed CVE, despite of firefighters and police officers avatars actions are already implemented and available for the other type of scenarios and users.

5.3 Implementation and functionalities

The available avatars can use first or third person view. There are two classes of avatars: controlled and autonomous. The former is used to represent the agents or a suspect during the exercise, while the latter represents the audience. Autonomous avatars movement is predefined; each of them is generated in a random position of the scenery, being deleted after having reached the end of the stadium access ramp. The agent avatars have a special feature which is a virtual dosimeter used to find the suspects. Such device was developed in agreement with its real match having all the functionalities available at the real device.
The basic procedure of the agents was obtained by means of interview with specialists who have worked in 2014 FIFA World Cup Brazil™. They described the characteristics, actions and competencies that must be trained or developed for an agent dealing with this kind of event.
It comprehends two barriers or control points monitored by agents: in the first one there are 2 agents and in the second 1 more agent. They should identify correctly any person suspected of carry a radioactive material using a regular dosimeter. If it wasn't possible the final identification at the first barrier (which was composed by two agents), the last agent, located at the second barrier, would receive the basic information related to the visual characteristics of the suspect via radio in order to capture him/her.
However, such procedure requires a high level of interaction among the agents to identify the suspects. It is true especially in cases in which the agent's approach has result in false positive due people who inject radioactive materials for medical treatments. For this reason, the specialists have suggested that some specific abilities should be detached during the training using the CVE, discussed in the scenario described in the session 6.

During the simulation it is possible to create avatars representing hostiles (then called "suspects") carrying the radioactive material just pressing F2. Each time this command is performed, a new suspect will be created. It is known as single user mode, very useful for individual training. There are also controlled avatars for representing suspects, which can provide a more realistic experience for the user of this application. For the proposed training, the CVE offers six types different of avatars, they are: CNEN is the security agent; HR suspect and LR suspect are the hostiles carrying high and low radioactive materials, respectively; fireman and policeman alternative applications of security agents and watcher is a character who have information about all the participants of the simulation being responsible for coordinate the team actions (it has been not used in this work).

6. CVE Test and Evaluation

In order to simulate the approach to suspects in a big event as Rio 2016 besides of overcome the false positives observed at the real procedures performed during 2014 FIFA World Cup Brazil™, different sceneries were implemented for the CVE. Each of them proposes particular situations that require different strategies and collaborative aspects/competencies to capture the hostiles. There are two barriers composed by the security agents positioned along the ramp of the stadium with two agents in the first barrier and one agent in the second one. One of analysed situations is described in the following table:

Table 1 – Scenery description

Scenery 1
Characteristics: suspect - controlled avatar; number of suspects - 1; radioactive activity – low; Collaborative aspect - Communication
Description of the analyzed situation: The "suspect" avatar tries to reach the stadium interior walking side by side with other avatars that represent the audience (autonomous). As the user that controls the "suspect" avatar can hide himself among the other avatars by imitating its gestures or way of walking, the difficulty on its identification becomes higher. **Objective:** The objective of this scenery is simulate a situation that can contribute to improve the communication among the security agents. Considering they must communicate to each other to increase the chance of having success, it is very important that such communication be as more efficient as possible. It includes gestures or oral signals.

7. Results

The same procedure used during 2014 FIFA World Cup Brazil™ were used to perform the simulations proposed in this work. The tests comprehend an amount of 6 simulations with 3 simulations at the first session and 3 simulations at the last one (all of the scenario described in table 1). The results of sessions 1 and 2 are presented in tables 2 and 3 respectively. The users team is composed by two agents of CNEN that have worked at the security crew during 2014 FIFA World Cup Brazil™ besides three volunteers responsible for controlling the avatars. Each of these CNEN agents has more than 15 years of experience on dealing radioactive safety.

Table 2: Results for the first session of tests

Simulation	Result	Barrier of Identification	Control of Avatars	User View
1	Fail	-	Keyboard and Mouse	Third Person View
2	Fail	-	Keyboard and Mouse	Third Person View
3	Success	Second Barrier	Keyboard and Mouse	Third Person View

Table 3: Results for the second session of tests

Simulation	Result	Barrier of Identification	Control of Avatars	User View
1	Success	First Barrier	Joystick	First Person View
2	Success	Second Barrier	Joystick	First Person View
3	Success	First Barrier	Joystick	Third Person View

7.1 Discussion

As observed in table 2, the simulations 1 and 2 have result in fail as the suspect managed to run way from the security agents. At the simulation 3, the agents were able to identify the suspect correctly. The fail in observed in simulations 1 and 2 was due to the absence of collaboration among the agents. As observed in simulation 3, the communications among the agents have helped on the correct identification of the suspect.
The changes suggested by the agents as well as the results obtained at the end of session 2 are shown in table 3. There were three simulations (namely, 1, 2 and 3) and all the simulations have resulted in success. However, the agents have felt uncomfortable using the joystick and the first person view (which were suggested by them at the end of the session 1).

8. Conclusions

The CVE has managed to add to the training system a greater degree of interactivity and immersion, transferring the participant to a three-dimensional virtual environment, which reproduces the training action scenario. The user (the agents represented by avatars) must make decisions and develop coordinated and collaborative actions, adding an additional value to training, because it is the close to the real environment. The collaborative virtual environment proved to be suitable for training simulations in emergencies, because it was able to represent a scenario quite close to actual and potential emergency situations as it was experienced by CNEN agents during the FIFA 2014 World Cup. Each of the simulations described at the previous section has shown that without collaboration it becomes harder to identify the suspect. Moreover, as confirmed by the experienced professionals which have used the simulator, the proposed method is capable to accomplish its objective namely to provide a collaborative virtual environment where abnormal events can be reliably simulated. In agreement with the obtained results, it is possible to observe that the proposed method can effectively contribute to enhance competencies like team organization and leadership, improve agents' skills besides of allow to evaluate the collaborative level of the team by means of the coordination, communication and cooperation analysis among the members of the team.

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