USE OF VIRTUAL SIMULATOR FOR AGENT TRAINING IN RADIATION PROTECTION ACTIONS IN MAJOR EVENTS

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ABSTRACT

With the proximity of the events of the Olympic Games, Brazil can become a great place of visibility for running dirty bombs or any other radiation mode proliferation by terrorists. Aware of these problems, the government and the organizations created managements of emergencies to ensure that these events elapse in an orderly and safe manner. The management of emergency situations at an event is a complex problem, which involves dynamic, unforeseen and unintended situations, emphasizing the potential complexity of the contexts in which organizations operate and, as a consequence, the people involved in the execution of multiple tasks from activities that require intense cognitive effort, are often challenged to adapt dynamically to maintain the productivity of the organization at satisfactory levels of performance usually impedes these people reflect on the results of their actions and learn from them. Therefore, it is extremely important to create tools that address the methods and techniques of Cognitive Task Analysis (CTA) to assist in the previous training of the security agents, for example, detection and approaches of people who carry radioactive elements. One of the possible ways to accomplish this training is through the use of virtual reality. Virtual environments bring some advantages like reducing costs and risks. The aim of this paper is to present a virtual simulator to evaluate the use in training agents in major events. As a case study, the Maracanã and the agents of the National Nuclear Energy Commission (CNEN) was chosen.

1. INTRODUCTION

Although Brazil is not the typical target of terrorist actions, this danger must not be ignored or minimized because the realization of large scale events such as the Olympic Games, arouses the attention of terrorist organizations to practice terrorist acts with the aim of conferring visibility to their cause and projection internationally. Knowing this, the
government, the organizers and the competent bodies created managements of emergencies to ensure that these events elapse in an orderly and safe manner.

The management of emergency situations at an event is a complex problem that involves, besides a lot of technology, social and organizational aspects. Therefore, it is extremely important to create tools that can assist in prior training of the security agents, for example, detection and approaches of people who carry radioactive elements.

Emergencies require making decisions that occur in substantial uncertainty as the information comes from inferences or indirect sources. As a result, it is impossible to describe and completely control a complex system [1, 2, 3, 4].

According Perrow [3], in complex systems there is a high degree of interconnectivity and interdependence of the components, for example, which also happens in an emergency situation.

Considering the importance of managing emergencies, are of great use, methods and techniques to make training for adverse events, even before its appearance, so that it can even foresee them. Another important aspect is to communicate clearly to the general public its mode of operation and the safety criteria involved. It is also equally important to create tools that can assist in preplanning of activities to be carried out in areas subject to radiation, estimating possible doses to operators, so that the dose insurance limits are respected.

One possible way of obtaining these operating modes and involved safety criteria is the use of CTA methods that is seen as effective to support the diagnosis and description of processes, work activities, decision-making process and events in which are implicit cognitive or reasoning factors, being a suitable tool for revealing risks and opportunities [5].

However for the training sessions for adverse events with lower costs and risks, one possible way is to create tools through the use of virtual reality. Virtual environments bring some advantages, including: (i) are attractive to the public because it allows the same feel immersed in the respective environment without being exposed to any risk; (ii) allows simulations and evaluations of facilities not yet built in the real world, or it may be difficult to access; (iii) allows to estimate the radiation doses absorbed by the workers; (iv) does not expose workers to any radiation level for carrying out simulations and training, presenting no health risk thereof; (iv) contribute to a better planning of activities in these areas, measuring the received doses and thereby evaluating the risks to health.

The main objective of this work is to develop a virtual environment in response to agent training simulation detection of radioactive elements in major events, integrating virtual reality techniques (RV), of collaborative systems and of resilience engineering concepts to operational procedures CNEN agents. For this, the virtual environment will be based on an information architecture that provides mechanisms available procedures and CNEN's operating rules and a gaming core for development of a Virtual Interactive Model to assist in the training of agents.

As a case study, we chose to develop a virtual environment that simulates the entry of spectators at an event held in the Maracanã stadium. To improve human performance in the cognitive process that the task requires, the virtual environment used the CTA methods for obtaining the knowledge, analysis and representation of knowledge.
2. METHODOLOGY

To develop the virtual simulator and training approaches to individuals carrying radioactive elements, this work began from more in-depth literature searches in various areas such as training, virtual reality, collaborative virtual environments and cognitive tasks analysis. The following topics present a brief description of these areas.

2.1 Virtual Reality

The Virtual Reality term is defined in many ways by the scientific community, coexisting varied definitions according to the experience of each researcher. Most settings are similar but containing subtle differences. Kirner and Siscoutto [6] define RV as an advanced user interface to access computer applications that provide interaction, visualization and movement in real time, in three-dimensional environments. Already Fitzgerald and Riva [7] define it as a world, space or environment that does not exist, or is virtual, but that one can perceive and interact through the senses, as is done in the real world. Pimentel [8] defines it as the use of high technology to convince the user that he was in another reality, a new way to use information, in the case of a place of humans and computers make contact (exchange of information).

Virtual reality has applicability in various scientific fields and especially in the context of physical safety where it offers new forms of training, such as in police training that has been conducted in Brazil and in other countries like China [9], Germany [10] and Cyprus [11].

In the present work, the RV will allow exercise, for example, communication techniques allowing for coordination, collaboration and cooperation between the agents, use of techniques of personal search, progression techniques in the field with the use of covers, control and areas of domain with the use mobile railing, approach people and vehicles and various other technical variables.

2.2 Collaborative Virtual Environments

Applications with collaborative environments are potentially useful for the development of activities for user groups in any area of knowledge. The application of these ideas in the field of virtual reality has given rise to Collaborative Virtual Environments (CVE), which is computer simulated environment with a form of visualization, manipulation and real-time interaction. The CVE’s can also assist in information sharing tasks and communication, since they provide a context for communication and information sharing can happen. According Churchill [12], "A CVE is a virtual area or set of spaces based on computer and distributed. In such a space, people can meet and interact with other people or with virtual objects." Another definition is given by Hagsand [13] where CVE is defined as a real-time simulation of a real or imaginary world, where users are simultaneously present and can navigate and interact with objects and other users.

The CVE’s has made the RV passed have greater recognition by the scientific community, leveraging several research groups to investigate new techniques and approaches in addition to the use of this technology in various areas [14].

For the development of virtual environment proposed in the work to simulate training strategies approaches to radiological protection at major events, the detailed survey of the
characteristics that involve the environment was necessary, such as the stadium itself and the objects that compose it, as well as the components for the collaborative construction of a virtual world, such as scenes, objects, avatars, animation, text, video and sounds.

The scene is a 3D themed environment with space for interaction between users, this work was modeled scene representing the surroundings of the Maracanã stadium, more precisely where is located the statue of Bellini and the ramp as shown in Figure 1.

![Figure 1: Maracanã Stadium Modeling in Unity 3D.](image)

The objects are three-dimensional models of occurrences found in the real world. In this work various objects present in the Maracanã stadium facilities that represent aspects of security (access control, security posts, surveillance cameras, metal detectors, radiation detectors, smoke detectors, guardrails & c) were modeled, as well as objects that present a danger people present (radioactive sources, weapons, explosives, stones, sharp artifacts & c).

The avatar is a representation of the character (user) in the virtual world. In the present work addition of automatons avatars that represent the population, there are also some specific and controlled representing security officers, as fireman, policeman and nuclear agents. Figure 2 illustrates the policeman avatar.

![Figure 2: Avatar representing the policeman in front of the statue of Bellini at the Maracanã stadium.](image)
Animations reproduce real world movements. For the AVC of this work were used traditional animation to walk, run and jump, and also the functionality present during the training of agents such as:

- Pick up and drop grids, executed by police only functionality, this feature allows the policeman cordon off the area of the population.
- Measure radiation, this functionality is performed by the nuclear security officer who uses a measuring device that informs the level of radiation present in the exposed object.
- Pick up and drop object, functionality performed by a citizen, this feature allows the citizens leave the suspicious object anywhere.

### 2.3 Simulation and Training

Simulation refers to the idea of a training, a stage prior to a particular activity and the possibility of manipulation of parameters, where are given similar conditions to the environment in which the action for which training, will occur. According Lévy [15], the possibility of manipulation of these parameters and the simulation of all possible circumstances give the program user a kind of intuition about the relationship of cause and effect present in the model. He acquires knowledge by simulation of the modeled system, which does not resemble neither theoretical knowledge nor practical experience, or the accumulation of an oral tradition.

The main objective of the simulation study is to improve the quality of administrative decisions [16], and a desirable feature of the Simulation is graphic animation (where is the use of virtual reality), especially for modeling manufacturing processes [17] and in military applications when are properly designed, they offer the user an exact simulation of real events in a safe and controlled environment, as some training procedures may have element of danger when using real situations. Although the initial development of simulators software is expensive in the long run, it's cheaper than putting soldiers into real vehicles or simulated situations physically.

Simulation systems create virtual environments that seek to recreate real-life experiences with the ability to change the event setting, allowing the exercise or scene is repeated as often as necessary for the development of motor response (motor program), thereby decreasing the response time of the agents when faced with similar scene in their daily activity.

Currently, surveys are well advanced, with several companies in the world in different areas are investing in the development of prototypes and new forms of virtual reality applications, among these companies, we can mention Brazil, the Nuclear Engineering Institute (IEN) that has as one of its lines of research, creation of tools of virtual reality to study, review and training in physics and nuclear security strategies to nuclear installations applications, and too applicable in industries of security, airports, major events & c. where is situated the job.

Given this context, several authors [18, 19, 20] reported the use of virtual reality for teaching and training, and Kozak and Wittenberg [21, 22] demonstrate studies in which the results obtained in training with virtual reality use are clearly superior to those obtained with real systems.

Concluding, training reduces the possibility of error and enhances the ability to who will perform the procedure. Virtual systems reduce training costs and are available anytime,
anywhere (depending on the infrastructure) to simulate the desired task, also not submitting the learner to risk situations.

However, a significant amount of training conducted in organizations is not about training to be surprised, but to show the individual's competence and that the current training is effective. These socio-technical organizations large scale could be more resilient if they could use opportunities these exercise to capture of more effective way of learning to facilitate a deeper understanding behind the cognitive work in the field.

2.4 Cognitive Task Analysis CTA)

The CTA is a general term that encompasses a set of methods and techniques used to understand and describe the cognitive aspects of daily work activities, including how professionals see the work they do, and how they give meaning to events and constraints that find during the performance of its activities [5]. These methods rely on direct access to professionals or experts or experienced workers in specific areas of which is sought to extract information.

The product of a CTA project is the decision-making process, where we obtain the perception about the nature of the decision and point of view of the problems of experts in the work context.

CTA researchers studying experts to describe good decision-making processes and define the quality of decision making [23]. A good decision making, acts as the expert, to notice the signs and patterns, thus facilitating the adaptations and anticipations, something that beginners can’t do.

The results of studies on CTA have been applied quite successfully in the areas of education and training, an area in which this job applies.

The second step was based on field studies for the development of training to detect radioactive elements. The chosen experts were CNEN agents involved in the detection strategy at the World Cup stadiums in 2014, for it was adopted the methods of Cognitive Task Analysis (CTA), which includes data collection through bibliographic research, documentary, observations and interviews with participating agents. Figure 3 illustrates the strategy employed.

![Figure 3: A strategy for detection of radioactive elements made in the 2014 World Cup stadiums](image-url)
The strategy used during the world cup games, the viewer to enter the stadium, validate your ticket at roulette and then passed through a metal detector, and if lead some luggage, that would pass by a ray x mat. After the detection step, the viewer followed towards his seat, during this trajectory, he passed by two radiation barriers imposed by the nuclear security officers. This step was not perceived by most viewers, because agents positioned in strategic places, did not offer some sort of barrier to walk of these.

This strategy proved to be effective for capturing radioactive elements in people with no intention of committing terrorism, for example, people who underwent exams that use some type of radiopharmaceutical up to twenty four hours before the event, then the pager signaled and the agent going to meet to address it. However one or more bad intentioned people could use, for example, a person who underwent the examination mentioned above as bait and go unnoticed by the agents, because the machine identifies the energy but not the distinque in cases of people nearby.

Parallel to this step, we investigated some training exercises that have reached a variety of challenges in planning and scales that accompany any exercise. These exercises were the Ft Huachuca, Kings Mall - Urban Firefighting Exercise and the Strong Angel III [24].

In the third and final stage, from the details of the problems, a general architecture has been set for the development of a computational tool to assist in the training of CNEN agents with the aim of learn to detect the highest possible number of people carrying radioactive elements.

The development methodology of this tool in which the work is based uses Virtual Reality techniques, 3D modeling tools and game engine is already being used by researchers involved in this proposal [25, 26, 27, 28, 29, 30, 31].

Modeling tools intended for the manufacture of virtual objects in three dimensions. It is understood by the three-dimensional modeling, the process of developing surface computational graphical representation or three-dimensional objects. These objects can be animated or static, equipped with various features like shapes, textures and structures.

For the production of electronic games, games engines include several functions, libraries, and tools necessary for the development. Also known as core games and game engines provide programmers the centralization of the main requirements involved in creating games quickly and integrated.

3. RESULTS AND DISCUSSION

As preliminary results, the developed virtual environment proved to be suitable for training simulations in radiological emergencies in large events in stadiums, as managed to reproduce quite closely the training approaches of CNEN agents in a safe and controlled environment, without exposure risks and at low cost. The scenario was built based on the Maracanã stadium and around the statue of Bellini entrance is endowed virtual dosimeters, radioactive sources and automata and manipulated avatars. Automata avatars represent the general public and the manipulated avatars represent the suspect citizens and also the security agents, i.e., policemen, firemen and agents of the CNEN. In the simulation, the radioactive source can be transported both by avatar automaton (citizen) as the manipulated avatar (suspect). The
number of avatars automata is configurable and can range from 10 to 1000 according to the need of training and the number of avatars manipulated will be according to the number of trainees available for training.

To initiate the training in the virtual environment will require that each training participant (which may be located elsewhere) use a computer connected to the same network of other trainees and choose the type of user who may be a police officer, a firefighter, one CNEN agent and a radioactive citizen (identified as a suspect in the virtual environment) as shown in Figure 4. The environment allows more than one user of the same type.

Chosen the type of user, the trainee is put into the environment where it will be able to perform the pertinent tasks duties. The virtual environment can also be collaborative, as it enables the trainee, in addition to visual communication (as it is possible eye contact inside the simulator between the trainees), the exchange of information through the use of a head set, thus enabling collaboration between trainees.

For the execution of the radioactive elements detection training, you must configure the environment to have at least one avatar radioactive automaton or a radioactive manipulated avatar, to enable avatars (CNEN agents), provided with a portable dosimeter, can locate these sources through methods approaches and determine their intensity, making it possible the full realization of training.

As expected of a virtual environment, the built in this work is designed to achieve higher levels of emotional energy, interactivity and effectiveness for learning compared to conventional resources such as books, lectures, videos and other artifacts produced.

The virtual environment of this work is able to remotely involve a larger number of officers in each agency in the direct experience of the causal mechanisms and system structures, and through experimentation and discovery, helping them to acquire more knowledge and skills. It is also expected that agents trained on the simulator to learn from the strategic, instrumental, social and intellectual challenges to test the limits of a simulation and are free to

**Figure 4 : Menu of the emergency training simulator options at big events**
make unexpected movements to just see what will happen and that the flaws have no consequences tragic, on the contrary, with the failure is possible help build resilience.

4. CONCLUSION

This work highlighted the importance of simulation exercises in training and learning, because in the current crisis management environments, these exercises are no longer being carried out and assessed for training purposes only, instead they are running as complex simulations designed to meet an infinity of learning objectives through of the cognitive work spectrum of exercises based on the exploitation of the skills to make complex decision-making under uncertainty.

The virtual reality techniques to build the virtual environment, the methods of the CTA for abstraction of tacit knowledge of experts CNEN agents to prepare the training approach to individuals carrying radioactive element and more literary review of some emergency training exercise (who reached a variety of challenges of planning and scales that accompany any exercise) showed quite effective for elaboration the work.

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