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AVOIDING RADIATION EXPOSURE WHILE TRAINING TO LOCATE A RADIOACTIVE SOURCE: A VIRTUAL REALITY EXERCISE

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ABSTRACT

A technician undergoing radioprotection training must learn to use radiation detectors. Practical exercises involve being near to radiation sources. The work here presented reduces the exposure to individuals using a virtual environment to achieve preliminary apprenticeship prior using real radioactive sources.

1. INTRODUCTION

Radioactivity is a natural phenomenon and sources of radiation exist in the environment. Radiation (*i.e.*, ionizing radiation) and radioactive material can be natural and of artificial origin and have many applications, including uses in medicine, industry, agriculture and research as well as for nuclear power generation. The risks to people and the environment due to the use of radiation and radioactive material must be assessed and regulated through the application of standards of safety [1].

When dealing with ionising radiation one must always refer to safety and security norms both within the legal and regulatory frameworks of its own country and the international safety guides supporting them [2].

In this work a virtual reality (VR) tool is proposed to be used in the initial training of the technicians learning how to use radiation detectors.

2. RADIATION SOURCES AND RADIATION PROTECTION

Radioactive sources emit radiation and contain radioactive atoms. These atoms decay releasing particles and photons. Each type of radioactive decay has its own signature, i.e., type of particle emitted and photon energy. The photons emitted in radioactive decay are in the gamma ray spectrum of energy. Both these particles and photons are ionising radiations,

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thus, its interaction with biological tissue must be avoided, as ionized molecules will behave according to its chemical, rather than biological, nature. This behaviour can be enough to impair the function of the exposed tissue or organ or even destroy it [3].
Radiation protection is a series of techniques designed to avoid risk to people and to the environment due to radiation. Radiation exposure is avoided by limiting the time of exposure, increasing the distance from the source and by shielding the radiation source [1].

People working with radiation or radiation sources must follow a series of recommendations issued by the regulatory organs of its country, which normally follow international protocols. These recommendations include an annual limit to radiation exposure and intensive training. One of the abilities these technicians must acquire is the use of radiation detectors. With these instruments, they can measure radiation amounts and intensities, but this implicates in the use of a radiation source to obtain readings in the detectors.

3. METHOD

Recent publications indicate the use of VR tools for many applications involving nuclear or radioactive activities. They include radiation dose estimation in nuclear facilities [4], the training of its operators [5, 6], ergonomic studies [7] and security of nuclear facilities [8].

3.1. Game Engines

The video game industry is responsible for a great part of computer´s graphical and processing advancements in recent years [9]. To allow its users not only to play games, but to design their own, some companies made available, via the internet, programmes called game engines. These engines are interfaces in which the game programmer can create environments, characters and their interaction. The game engines are also being used by professionals with other than games in mind [10]. They are a low cost and effective way to create VR environments for simulation and training.

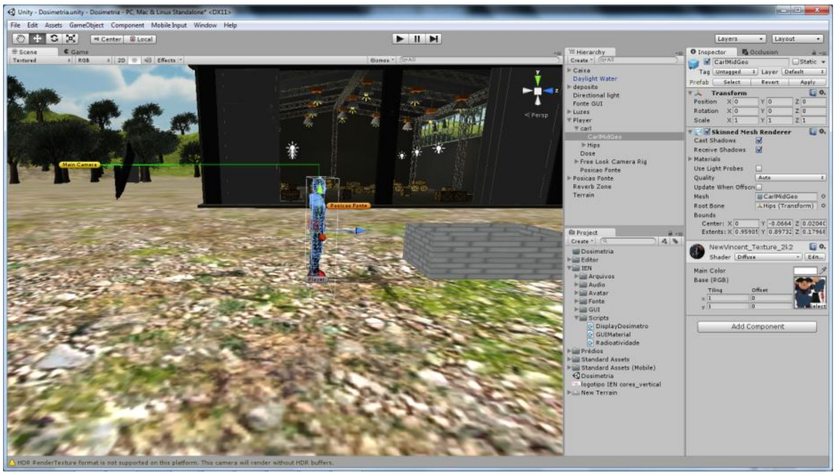

Figure 1: Engine interface

To create the programme to train the radiation protection technicians the UNITY 3D© game engine was used. Figure 1 shows UNITY´s interface with the programme scene.

3.2. Environment

The environment is simply a landscape with a warehouse where the radioactive source will be placed. Figure 2 shows a view of the interior of the warehouse.

Figure 2: Warehouse interior view

3.3. Avatar

The character that represents the technician, called an avatar, has physical characteristics such as size, walking and running velocities and physical interactions with the environment in the likeness of a normal human being. It can be presented in the third person (the user looks at the avatar) or in the first person, when a model of a detector is displayed as if it were in the hands of the avatar, as shown in figure 3.

3.4. Radioactive Source and Detector

The radioactive source is a box that is placed in one of a number of predetermined locations. These locations are randomly chosen at the beginning of each exercise. The source remains invisible until the avatar is within a short distance from it, when it is represented as a cube with the radioactivity symbol. The avatar must fetch the source and place it in a shielding box to start the next exercise. Figure 4 shows the appearance of the source representation.

The detector indicates the value of radiation emitted by the source, taking in account that the reading falls with the distance squared, added to a typical value of background radiation.

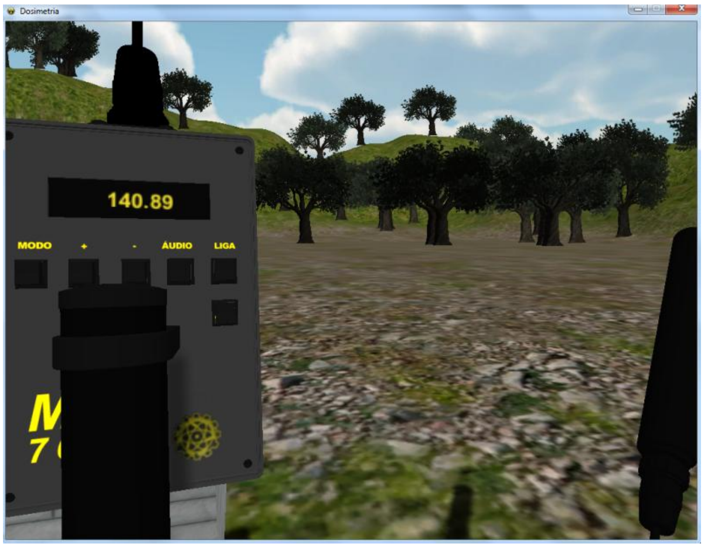

Figure 3: View in first person, holding the detector

Figure 4: The avatar near the source

3.5. Learning Measurement Criteria

To compare the effectiveness of the exercise, a scoring system was devised. The exposure to radiation is proportional to the product of the radiation level to the time of the exposure. Thus, at the end of each exercise a number of points is recorded. The idea is to measure if the execution of a series of exercises would improve the ability to find the source, reducing the score, thus the virtual exposure. A limitation to this system is that a score can only be compared to another if they have the same source location. Another limitation is that the improvement in the ability of the user to locate the source may not be distinguishable from an improvement in its ability to control the avatar.

4. VALIDATION AND LIMITATIONS

The Institute of Nuclear Engineering (IEN – Instituto de Engenharia Nuclear, Rio de Janeiro, Brazil) team of experts in radiation protection evaluated the programme and presented the following observations.

The programme is useful to train a technician to locate a missing radioactive source, but the procedure in its recovery is not in accordance to the real field proceedings. In the real world, once the source is located, the technician must identify its nature (the radioactive elements present), investigate if the radioactive material is a sealed source, if it is contained in a container or if it is spread in the location and only then the source can be dealt with.

5. CONCLUSIONS

Measurements confirm that virtual training can lessen the time to perform tasks [11]. VR simulators are particularly useful when the real situation involves risk or high costs. The reduction of radiation exposure is always desirable and will prevent or delay the technician´s dose limit to be exceeded. Thus, this programme can be used to train technicians in the task of retrieving a radioactive source.

6. ACKNOWLEDGMENTS

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7. REFERENCES

[1] Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards - General Safety Requirements Part 3; International Atomic Energy Agency (IAEA); 2011.

[2] Fundamental Safety Principles; Series SF-1; International Atomic Energy Agency (IAEA); 2006.

[3] TURNER, J. E.; Atoms, Radiation, and Radiation Protection, 3rd Edition; WILEY-VCH; 2007.

[4] MÓL, A. C. A.; JORGE, C. A. F.; COUTO, P. M.; AUGUSTO, S. C., CUNHA, G. G.; LANDAU, L.; Virtual Environments Simulation for Dose Assessment in Nuclear Plants; Progress in Nuclear Energy, Vol. 51, no 2, 2009.

[5] AGHINA, M. A. C.; MÓL, A. C. A.; JORGE, C. A. F.; COUTO, P. M.; CUNHA, G. G.; Landau, L.; PEREIRA, C. M. N. A. Virtual Control Desks for Nuclear Power Plant Simulation: Improving Operator Training; IEEE Computer Graphics and Applications, Vol. 28, 2008.

[6] XI, C.; WU, H.; JOHER, A.; KIRSCH, L.; LUO, C.; 3-D Virtual Reality for Education, Training and Improved Human Performance in Nuclear Applications; ANS NPIC HMIT 2009 Topical Meeting - Nuclear Plant Instrumentation, Controls, and Human Machine Interface Technology; Knoxville, Tennessee, April 5-9, 2009.

[7] MÓL, A. C. A.; LUQUETTI, I. J. A.; GATTO, L. B. S; JORGE, C. A. F.; Legey, A. P.; Virtual simulation of a nuclear power plant's control room as a tool for ergonomic evaluation; Progress in Nuclear Energy; Volume 64; 2013.

[8] SANTO, A. C. E.; Estudo da Viabilidade do Uso de Realidade Virtual na Criação de uma Ferramenta de Apoio ao Planejamento de Segurança Física em Instalações Nucleares; Masters Dissertation (Mestrado em Ciências em Engenharia Nuclear); Comissão Nacional de Energia Nuclear/Instituto de Engenharia Nuclear, Conselho Nacional de Desenvolvimento Científico e Tecnológico. Advisor: Antônio Carlos de Abreu Mól; Brazil; 2013 (in portuguese).

[9] GEER, D.; Taking the graphics processor beyond graphics; IEEE Computer; Vol. 38, no. 9, 2005.

[10] ZYDA, M.; From Visual Simulation to Virtual Reality to Games; IEEE Computer, September 2005.

[11] HAQUE, S.; SRINIVASAN, S.; A meta-analysis of the training effectiveness of virtual reality surgical simulators; IEEE Transactions on Information Technology in Biomedicine; Vol. 10, no 1; 2006.