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VIRTUAL REALITY INTERACTIVE SIMULATOR FOR TRAINING HEALTHCARE PROFESSIONALS IN THE USE OF IONISING RADIATIONS

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ABSTRACT

The application of ionizing radiation in medicine requires a rigorous attention to procedures in order to minimize the risks to the healthcare professional and to the patient. Risk minimization involves the training of the professional and the adequacy of the facilities.

Virtual Reality (VR) is an already consolidated tool for training procedures, including those of the health sciences. In this context, an interactive VR simulator representing a radiotherapy room (bunker) for training healthcare professionals and the inspectors of such facilities was developed.

This VR model allows the user to perform the normal activities on the operation and the inspection procedures of the facility. The model was based on the blueprints of a real radiotherapy clinic.

The virtual model of the radiotherapy bunker, developed at the Institute of Nuclear Engineering, was presented to experts of the General Coordination of Medical and Industrial Facilities of CNEN and is in the process of receiving small modifications to the specific needs for its adequateness, as a training tool, in a training course, sponsored by the International Atomic Energy Agency (IAEA), for inspectors of radiotherapy installations.

This work shows the possibility of using Virtual Reality in the development of training tools for professionals working in radioactive installations.

1. INTRODUCTION

In Brazil, the National Nuclear Energy Commission (CNEN) is the Governmental Agency responsible for planning, guiding, supervising and establishing standards and regulations in radioprotection and on the production and use of nuclear energy. Among its attributions, as an example relevant to the scope of this work, is the elaboration of the CNEN-NN-3.01 and CNEN-NN-3.05 Regulations, which establish the basic safety and radioprotection requirements for Nuclear Medicine services, ensuring the safe use of ionizing radiations in medical procedures. Thus, this particular use of ionizing radiations requires adequate information, guidance and training for each involved individual in order to minimize risks[1].

The use of ionizing radiations should comply with CNEN's recommendations and standards and should have at its disposal specific equipment and personal protective equipment (PPE) for protection of organs and tissues, depending on the procedure in question and the type of radiation involved. In this way, the importance of this proposal in planning and training strategies within the context of a safety culture is evident. With this, the professionals involved will be able to improve their qualifications, reducing the chance of failures and putting in perspective that subjects related to protection and safety should receive the priority compatible with their importance, keeping in mind the health of the worker and the general public as well as environmental concerns.

Virtual Reality (VR) is an already consolidated tool for training procedures, including those of the health sciences[2]. In this context, an interactive VR simulator representing a radiotherapy room (bunker) for training healthcare professionals and the inspectors of such facilities was developed. This VR model allows the user to perform the normal activities on the operation and the inspection procedures of the facility. The model was based on the blueprints of a real radiotherapy clinic.

In this context, the use of new training technologies favors learning. These new technologies also act as a motivating and challenging element, to make the teaching-learning process an innovative, dynamic and interactive activity. In particular, the use of virtual reality techniques allows the development of environments where the trainees feel more integrated due to the immersion sensation created by interactivity and stereoscopic visualization.

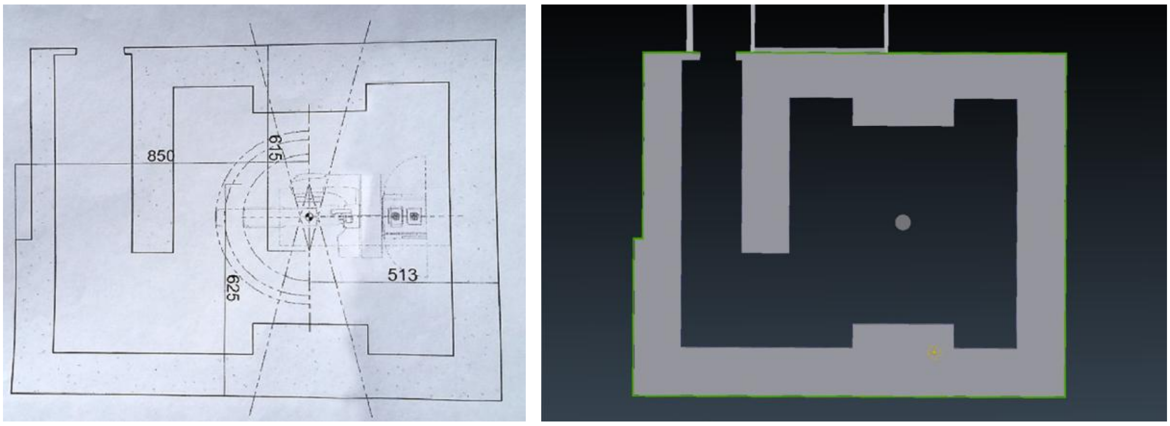
Among the functionalities incorporated in the virtual model is the representation of the structural aspects of the bunker shielding. The function to disassembly and rotate the bunker allows the user to view the radiotherapy room construction details, providing a perception of the structure to shield the radiation emitted by the radiotherapy apparatus (the "machine"). The actions and functions are triggered by the use of a game controller and the 3D environment is presented on a stereoscopic viewer.

The virtual environment was created using Unity 3D, a robust game engine, complemented with several functions necessary for the development of virtual models, such as libraries for the insertion of physical characteristics, lighting, closed circuit television (CCTV) and interactive audio. Blender 3D, an open source program for modeling, animating, texturing, compositing, rendering, video editing and creating of interactive 3D applications such as games, was also used to create the virtual environment.

2. METHODOLOGY

2.1. Requirements Survey

Initially, a survey of the physical characteristics was carried out by means of the blue print of an actual installation (Figure 1 (a) and (b)), which was then used as the basis for the model construction. The modeling of the virtual environment follows the engineering and architectural design of the facility. Scale is an important factor, as it will bring more realism to the virtual environment.



(a) **(b)**

Figure 1: (a) Bunker blue print; (b) Bunker blue print on Blender 3D.

Field research was also carried out in a Nuclear Medicine Clinic, where the structures and equipments were analised and photographed (Figure 2).

Figure 2: Partial aspect of a Nuclear Medicine Clinic.

2.2. Detailed Features and Components Specifications

A detailed specification of the functionalities and components to be inserted in the virtual environment was made, in order to make the functionalities of the virtual model compatible with those of the actual installation. These details were implemented using the appropriate software: Blender for the architectural design of the facility and Unity for the functional aspects and environmental and character interaction.

2.3. Unity 3D

Unity 3D consists of a robust three-dimensional game engine, complemented by a variety of functions needed to develop virtual games or scenarios, such as libraries for the insertion of physics into environments, lighting and interactive audio (Figure 8). Aiming portability, this game engine works in a plurality of platforms. Thus, the programmer does not have to worry about the peculiarities of each operating system or hardware, since Unity makes all the necessary adjustments to this compatibility.

This game engine presents itself as a multi language programming tool, supporting scripts in JavaScript (interpreted programming language) and C# (object-oriented programming language, developed by Microsoft, native to the .NET platform). This feature provides flexibility to developer, leaving the choice of language to the programmer.[3]

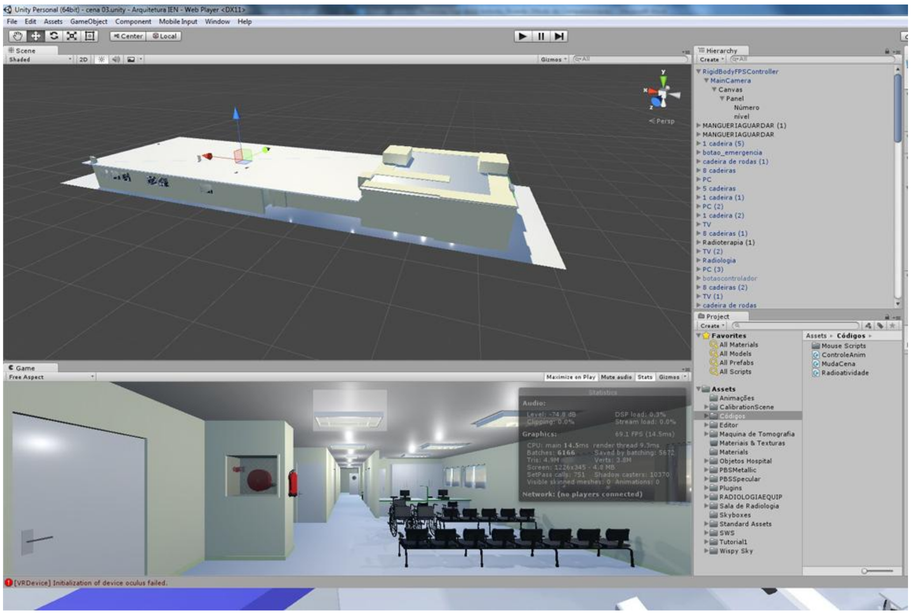


Figure 8: Facility aspect in the Unity 3D engine.

2.4. Blender 3D

Blender 3D consists of a modeling tool solution not for modeling, rendering, creating animation and simulations in three dimensions. It allows computer graphics professionals to develop various applications, such as games, virtual mockups, cinema, animations, etc. Blender 3D (Figure 9) constructions are easy to import to Unity-created environments.[4]

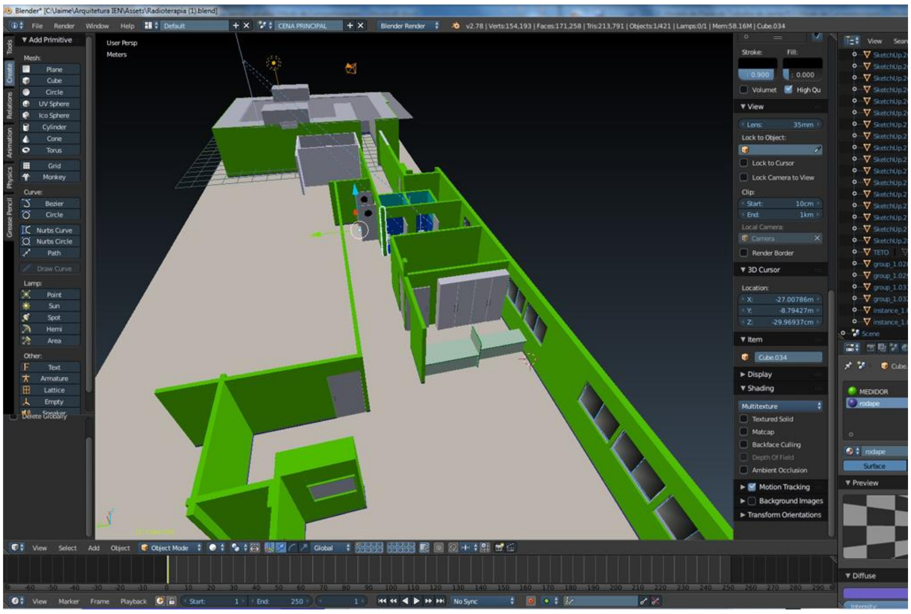


Figure 9: Facility aspect in the Blender 3D software.

3. RESULTS

3.1. Door Interlock

One of the inserted features that is in the CNEN standard and which is part of the Bunker safety features is the interlocking of the shielded door (Figure 3), which causes the machine to shut down if the door is opened when in operation.

Figure 3: Shielded door.

3.2. Emergency Buttons

Emergency buttons (Figure 4 (a) and (b)) were also installed in the radiotherapy room, as another safety feature that allows the machine to be immediately shut down in an emergency.

(a) **(b)**

Figure 4: Emergency buttons; (a) in the bunker access; (b) in the bunker interior.

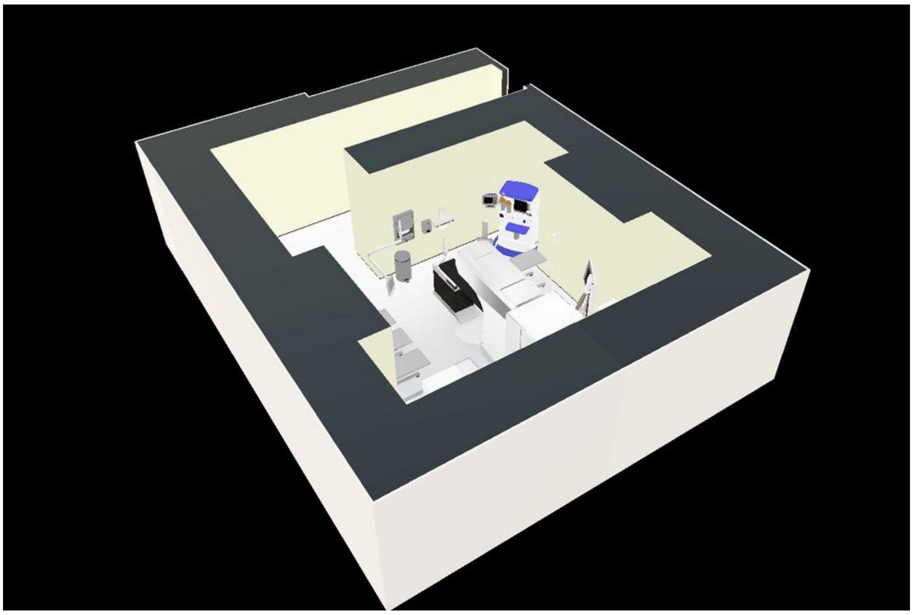


Figure 5: Shielding structure of the bunker.

3.3. Shielding

In controlled environments, it is normal for patients to fear the radiation for lack of information. In order to instruct the general population, one of the VR model features is a functionality where the user can see the protection offered due to the thickness of the concrete walls, that act as shielding to the ionizing radiation and shape of the room structure, that is also designed to block the radiation (Figure 5).

3.4. Virtual Cameras

The control room has four monitors where the images generated by the virtual cameras can be seen (Figure 6). These cameras are located at strategic points, for example, in the corridors, at the bunker door and in the radiotherapy room, allowing greater safety when starting a treatment. These virtual cameras allow that, in multiplayer mode, users in the control room to see the other characters present in the virtual environment.

Figure 6: CCTV monitors in the control room.

3.5. Multiplayer Mode

The multiplayer mode (Figure 7) allows conducting simulation in which different users participate, providing a realistic environment where the characters interact, cooperate and, in some kinds of simulation, hinder or disturb each other or even create dangerous situations.

3.6. Special Features

Among the functionalities incorporated in the virtual model, is the presentation of the structural aspects of the bunker shield. The function to disassemble (Figure 10) the bunker walls was developed so that the user can observe the thickness of the radiotherapy room walls. It also allows to rotation and zoom the image, providing a detailed analysis of the entire structure developed to block the radiation emitted by the radiotherapy apparatus. These functions are triggered by the use of a game controller and are viewed on stereoscopic goggles.

Figure 7: Characters in the multiplayer mode.

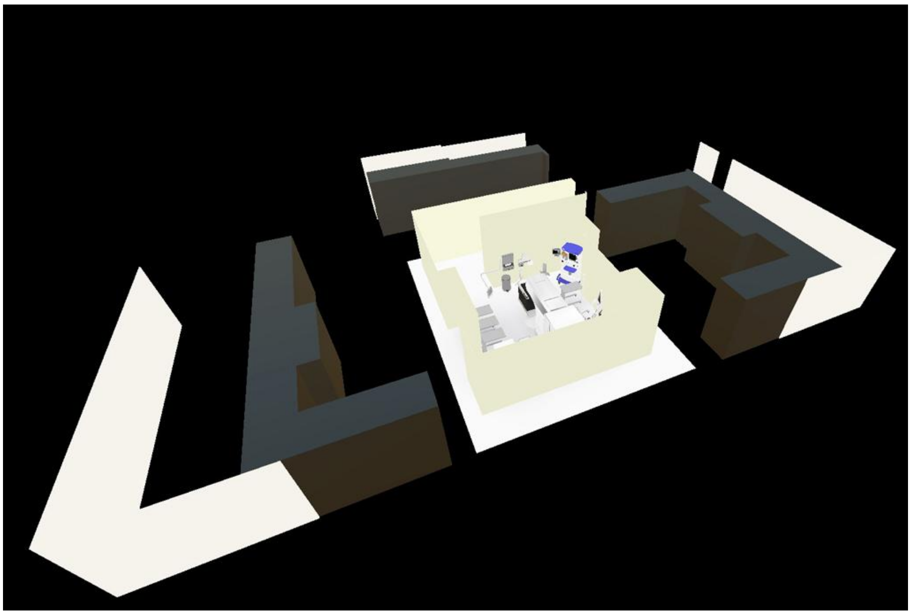


Figure 10: Bunker disassembly function.

4. CONCLUSIONS

The virtual model of the radiotherapy bunker, developed at the Institute of Nuclear Engineering, was presented to the experts of the General Coordination of Medical and Industrial Facilities of CNEN and is in the process of receiving minor modifications for its use as a training tool in an International Atomic Energy Agency course for inspectors of radiotherapy facilities. These modifications encompass the bunker’s shielding factors for realistic readings in virtual radiation detectors, given the machine angle and emission potency.

This work shows the possibility of using Virtual Reality in the development of a tool for training professionals working in radioactive installations, showing the effectiveness of an architectural design for the blocking of radiation emitted in a radiotherapy room and guiding employees and patients on the security procedures of the premises.

This simulator, when used to train new professionals, in order to standardize the use and inspection of radiotherapy facilities, reducing human failures, will reinforce the importance of VR in training techniques.

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