USE OF VIRTUAL REALITY TO ESTIMATE RADIATION DOSE RATES IN NUCLEAR PLANTS

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ABSTRACT

Operators in nuclear plants receive radiation doses during several different operation procedures. A training program capable of simulating these operation scenarios will be useful in several ways, helping the planning of operational procedures so as to reduce the doses received by workers, and to minimize operations’ times. It can provide safe virtual operation training, visualization of radiation dose rates, and estimation of doses received by workers. Thus, a virtual reality application, a free game engine, has been adapted to achieve the goals of this project. Simulation results for Argonauta research reactor of Instituto de Engenharia Nuclear are shown in this paper. A database of dose rate measurements, previously performed by the radiological protection service, has been used to display the dose rate distribution in the region of interest. The application enables the user to walk in the virtual scenario, displaying at all times the dose accumulated by the avatar.

1. INTRODUCTION

During procedures of operation in nuclear plants, operators receive radiation doses from the environment. These doses, however, must be minimized, based in ALARA principle [1]. In a nuclear plant, the dose rate distribution varies since low values to higher ones, therefore it is important to know this distribution, in order to allow a better planning of the activities to be executed.

In a traditional training, the operators receive instructions and information about the plant’s geometry, the localization and types of radiation sources in the environment, and the tasks to be executed. Measurement records of dose rate distribution performed by the radiological protection service are used in activities’ planning. Operators are also trained in the real plant, with the presence of radiation in the environment.

In this context, virtual reality technology can be a useful tool for operators’ training, since the dose rate distribution can be visualized, while they navigate in the virtual environment [2]. Thus, the operators can be trained initially in the virtual environment, without exposition to
radiation, as in the real environment. The dose accumulated by the operators can also be computed and visualized at all time. Then, the tasks to be executed can be better planned in order to minimize the dose accumulated by the operators, and also to reduce the operation’s time.

To reach the goals of this project, a virtual reality application has been developed by the technical staff of Laboratório de Realidade Virtual – LABRV [3], of Instituto de Engenharia Nuclear – IEN/CNEN, based in a free game engine. Since its code source is available, new objects have been created to represent the regions with dose rates, as well as timers, to compute the dose accumulated by the avatars.

In this work, Argonauta research reactor, of Instituto de Engenharia Nuclear – IEN/CNEN, has been modeled. The dose rate distribution was based on records previously performed by the radiological protection service.

2. ARGONAUTA RESEARCH REACTOR

Argonauta research reactor of IEN/CNEN is a thermal reactor of the type swimming pool, with operation power of 300 W, and maximum power of 5 kW. Since 1965, Argonauta has been used in research involving neutrons radiation, for a diversity of applications [4]. Among the main research topics is thermal non-destructive testing with neutrons, with application to the biology, industry, environment and national security.

It is also used for radioisotope production (Mn-56, La-140, Se-75 and Br-82), to be used as radiotracers for environmental and industrial applications. University subjects are taught in its dependencies, to complement students’ formation, from the undergraduate to the doctorate’s levels.

3. VIRTUAL REALITY

Virtual Reality started when, after the Second World War, the United States Air Force started development of flight simulators. Currently, virtual reality is applied to many diverse areas, and at each day new applications are covered with this technology. Among the advantages of virtual reality, one can cite ergonomic studies, maintenance and digital training.

Virtual reality is a term used to describe technologies that allow the sensitive integration between the user and the computer, aiming to give the participant the sensation of presence in the virtual world. In general, an immersive and interactive experience in three-dimensional computer generated images in real-time is achieved.

Virtual reality can also be characterized by the coexistence of three basic ideas: interactivity, immersion and involvement [5]. Immersion is related to the sensation of being within the environment, interaction is the environment’s response capability to user’s actions in real time, and the involvement idea is related to the degree of user’s motivation with the activity. Then, systems can be classified as immersive or non-immersive.
In general, immersive virtual reality makes use of head-mounted displays, or projection rooms. In these types of systems, very powerful hardware is necessary to produce images for real-time virtual environments, in order to guarantee the immersion sensation.

On the other hand, non-immersive virtual reality does not need specific hardware; therefore the users can use conventional computers and simple interfaces, as monitors, keyboards and mouses, to interact with the virtual environment.

4. RESULTS

Argonauta research reactor has been modeled, also with its room, from architectural databases, as shown in Fig. 1.

This simulation has been based on real measurements, performed by the radiological protection service of IEN/CNEN, during operations procedures of Argonauta research reactor. However, these measurements had not been collected with the intention to be used in virtual simulations, but only for monitoring purposes of some critical points within the environment, from the point of view of radiological protection. Therefore, these measurements are scarce, with few monitored points.

Rectangular or square objects, around the measured points’ coordinates, simulate the monitored areas, in order to compose a mesh of dose rate measurements. Within each object, the dose rate level is considered to be constant. Figure 2 shows the environment, with the dose accumulated by the avatar during simulation, both for Gamma and for Neutron.
The avatar can walk freely through these objects. The program identifies when the avatar enters the collision area of an object, although there is no collision in fact, but a timer initiates the time counting, with which the dose accumulated by the avatar is computed and displayed in the screen. When the avatar is placed in the border between two or more objects, the calculation is performed by the average of the dose rate values of all the objects in which it is inserted.

The avatar can remain in each place, and can also walk through the plant, as pre-defined in a particular operation’s procedure. The application shows in the screen the dose accumulated by avatar.

5. CONCLUSIONS

This example demonstrates that it is possible to use this developed tool to simulate this or ant other nuclear plant. In the present case, a coarse mesh has been generated, since the measurement database is scarce, but as long as a more detailed database is available, the more realistic can be the simulation. For Argonauta research reactor, a more detailed virtual environment can be simulated, as long as a further measurement procedure is performed by the radiological protection service, with this purpose in mind. Precision in the measurement database have to be balanced with real measurement possibilities, considering possibly interpolation among measurements, to generate a more detailed database [2].

Alternatively, the dose rate distribution can be computed, instead of measured from the real environment, or even both approaches can be combined in a simulation, according to the availability of measurements, or to radiation sources’ location and environment’s geometry.
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REFERENCES