ASSOCIAÇÃO BRASILEIRA DE ENERGIA NUCLEAR – ABEN
2019 International Nuclear Atlantic Conference - INAC 2019
Santos, SP, Brazil, October 21-25, 2019

Agência Brasileira do ISBN
ISBN 978-85-99141-08-3

VIRTUAL VISIT TO NUCLEAR RESEARCH REACTOR IEA-R1

Leandro G. M. Silva and Gaiane Sabundjian

Instituto de Pesquisas Energéticas e Nucleares (IPEN / CNEN - SP)
Av. Professor Lineu Prestes 2242
05508-000 São Paulo, SP
rvestudo@gmail.com
gdjian@ipen.br

ABSTRACT

The aim of this paper is to provide students, educators, and the general public with a virtual tool for learning about the peaceful use of nuclear technology and its importance to humanity. Using new technologies available in the market such as smartphones, software for the development of electronic games, virtual reality glasses, among others, we will virtually reproduce the facilities of the IEA-R1 nuclear research reactor, allowing anyone to perform a virtual and interactive visit to these facilities in a safe and didactic way. The use of virtual reality glasses and applications has been shown to be adequate in relation to the objectives proposed here.

1. INTRODUCTION

Faced with the expectation that there will be some growth of nuclear reactors in the world, there is a need to make this disclosure, so that society can receive assertive information about the benefits of nuclear technology.

Although Brazil has two power reactors and four research centers around the country, visits to these facilities are practically unfeasible, due to distance and safety reasons. The use of visiting applications to nuclear reactors using virtual reality glasses will contribute to the training of high school students on the peaceful use of nuclear technology.

The concept of virtual tour is not just an eventual navigation observing the screen of a computer. For this work will be used a virtual reality tool with a pair of glasses suitable for this, which will increase the immersion of the user in the nuclear reactor.

The objective of this work is to develop a friendly and educational navigation tool, through virtual reality, for students from high school. In this work, specifically, an application will be developed that will allow an interactive virtual visit to the nuclear research reactor IEA-R1, which is used for material tests, experiments, nuclear data collection and radioisotope production. The preliminary results obtained from the virtual reality application for visitation to the IEA-R1 reactor developed in this work were adequate in relation to the proposed objectives.

2. THEORETICAL FOUNDATIONS

2.1. Virtual Reality

The use of virtual reality today is present in the form of entertainment and fun. However, it has been widely used in employee training in high-risk zones to the health, or in environments where the atmospheric situation is impossible to reproduce in a simulation, such as zero gravity or atmospheric pressure at the bottom of the ocean [1].

Several examples of using virtual reality for training and educational purposes can be cited. An example of a successful virtual tour was deployed by the Russian Federal Space Agency, Roscosmos, in 2005. Prior to a routine maintenance trip at the International Space Station (ISS), the Russian technicians in charge went through a series of Virtual travel with glasses of virtual reality. Astronauts were strapped to a suspended chair and used a Joystick to control the thrusters in virtual reality, simulating as if they were performing the task of moving between the Soyuz (Soviet spacecraft) and the ISS to repair. The virtual tour taught the coaches about the caution they should have in a medium without gravity and air resistance. The mission was a success [2].

In Brazil, in 2016, the UFRJ Nuclear Engineering Institute student, Angelo Cnop, developed a navigation system inside the Argonauta Reactor and made a visitation simulation to this facility [3]. Despite providing a visit to the Argonaut on the computer screen, the system did not provide the user with full immersion or interaction.

2.2. Virtual Reality Technical Concepts

Conceptually, Virtual Reality (VR) is the reality that is accepted as true, although it does not exist physically [4]. Pimentel defined VR as the use of high technology to convince the user that he is in another reality - a new way of "being" and "touching" information [5]. According to Latta, VR is an advanced human-machine interface that simulates a realistic environment and allows participants to interact with it [6].

Virtual Reality can be considered non-immersive (eg watching a movie on a monitor screen) or immersive (eg flight simulator in an airplane cabin) [7]. The level of immersion depends on three basic principles: immersion, interaction and involvement [8].

2.2.1. Immersion

Immersion depends on the amount of senses involved in the process. The greater the number of stimulated senses (sight, hearing, smell, touch and taste), the greater the immersion of the user [9].

2.2.2. Interaction

The possibility of interacting with objects and actors in the virtual world in real time, without delays greater than 100 milliseconds, also increase immersion [10]. This interaction occurs through the actions performed by the user in the virtual world, the realism of the textures of the objects, the ambient sound coming from the various actors inserted in the scene in relation to their distance from the user among others.

2.2.3. Involvement

Involvement can be passive or active, and it depends on the stimulus the user is receiving to feel motivated to engage in activities that take place in the virtual world. This involvement can take place on three distinct levels: passive, exploratory and interactive [11].

2.2.3.1.Passive

The user is inserted in the environment only as a spectator, with no possibility of interfering with the actions that are taking place (eg a 3-dimensional watched movie).

2.2.3.2.Exploratory

The user decides which places in the environment to explore and when this happens, but the environment is not able to interact with him / her (eg a visit to an electronic mockup).

2.2.3.3. Interactive

The user decides which places in the environment to explore and can interact with the objects and actors inserted in the environment, and it is possible for the actors to produce actions based on some kind of artificial intelligence (eg video games).

3. METODOLOGY

3.1. IEA-R1 Reactor

IEA-R1 nuclear reactor was installed at Instituto de Pesquisas Energéticas e Nucleares (IPEN) and is located on the campus of the University of São Paulo, in the city of São Paulo – Brazil. The reactor was designed by Babcok & Wilcox Company is of the pool type with power 5 MW, however, nowadays operate at 4.5 MW of power. Its first criticality occurred on September 16, 1957 [12]. Among other applications It is used for material tests, experiments, nuclear data collection and radioisotope production.

Currently, students, teachers and researchers who wish to increase their knowledge of nuclear energy make several visits to the IEA-R1 reactor, accompanied by a nuclear energy technician. For the beginning of the work we followed and filmed some of these technical visits, to collect information of the scenery in general, objects, textures and actors that are commonly involved in the visit. This accompaniment and filming will also serve to build the script, didactic information content and to clarify the most common questions that arose and that will can be accessed during the virtual visit.

During the visit to the reactor are presented various historical information, techniques, operation and applications of nuclear technology in various areas such as industry, medicine, agronomy, research and others.

Figure 1: IEA-R1 Research Reactor.

3.2. Development Tools

The development in the area of VR has grown a lot in the last years. With the support of large groups such as Google, Microsoft, Samsung, among others, new tools, 3D modeling software and game programming game engines have been emerging all the time, making VR content development easier.

3.2.1. 3ds Max®

In order to virtually reproduce the facilities of the IEA-R1 nuclear reactor, it is necessary to use three-dimensional modeling techniques to design the entire architectural plant of the reactor facilities, furniture, objects, structures and equipment. Also being necessary, to apply texture maps and animations of mechanisms and characters.

For this, 3ds Max was chosen, a software widely used in the market to produce electronic models, creation of electronic games, animations used in the cinema, TV commercials and television animations, as well as used for visualization of 3D projects.

Some of the reasons for choosing this tool in order of importance are: the possibility of using it completely free of charge in the educational version [13]; the abundant documentation, tutorials and information that make the use and learning of this tool accessible; and the broad compatibility of output file formats to others software's.

3.2.2. Unity 3D®

After creating all the models, texture maps, and animations, you will need to bring all these scenarios and actors together in one game engine, so that you can build all the programming logic that will allow you to navigate this virtual world.

For this, the Unity 3D game engine was chosen, that to allow the creation of multi-platform interactive games and applications compatible with various operating systems, consoles, browsers, mobile devices and VR platforms.

Unity 3D has a complete Application Program Interface (API) for C # programming focused on creating virtual environments, object movement physics, characters, artificial intelligence for Non-Player Character (NPC), native graphics API, rendering in physics-based real-time and diverse tools that make it faster to develop a realistic and flexible virtual environment for multiple platforms [14].

These are some of the reasons for choosing this tool, including the fact that Unity 3D can be downloaded and used for free, and access to it is free and full for revenue of up to $ 100,000 annually. Plus, there's a lot of free and paid developer documentation, templates, textures, code, and training.

3.2.3. Other tools

Other software for image processing, sound, 3d model libraries and assets may be used as needed. Given the abundant availability and gratuity of these items and tools on the market, they will be used as needed and facility purchased.

3.3. Display Interface

In order for the application user to have full accessibility and ease in acquiring and running the developed content, the entire virtual tour will be developed for the most common smartphone platforms in the market (as long as they support the technology). For full immersion, the smartphone must be attached to a pair of Head-Mounted Display glasses such as Google Cardboard or similar. For increased user immersion a headphone can be used for sound reproduction.

The Google Cardboard is a VR platform developed by Google to be used in conjunction with a smartphone, fitted to the front of a rigid cardboard device, as shown in Fig. 2. It essentially works similar to a pair of VR glasses. Google's device is made up of a piece of rigid cardboard and two convex lenses that simulate the human eye's panoramic view [15] and can be built by the user following the design instructions provided by Google [16] at an affordable cost.

The Cardboard Software Development Kit (SDK) for Unity 3D [17] allows you to develop applications for Android and iOS operating systems. Unity 3D enables developers to incorporate VR content into mobile applications that can be used on such equipment providing a satisfying virtual and immersive experience to user with the great advantage of its low cost and relatively easy access to this technology.

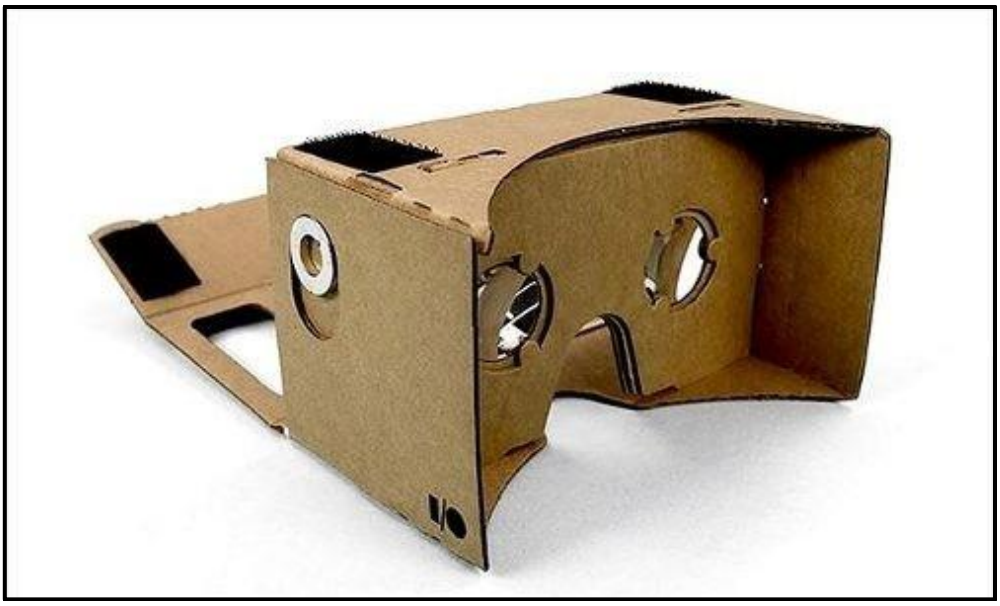

Figure 2: Google Cardboard - Google Image, 2019.

4. RESULTS

To date, various audio and video information has been collected and will serve as the basis for the elaboration of a script that will be used in the construction of the virtual tour.

Other important information such as drawings and floor plans of the reactor facilities were acquired from the competent agencies and are serving as the basis for the construction of three-dimensional models of the reactor building and pool structures, enabling the construction of a scenario closer to reality.

With the aid of 3Ds Max, it is being possible to reproduce, with good precision, the installations of the IEA-R1 nuclear reactor. Using extrusion commands, revolution, boolean operations and more, lightweight polygonal meshes capable of virtually representing walls, doors, railings, ramps, lattices, hydraulic structures, machines the several components that make up the environment are being created. These polygonal meshes can still receive textures, animations, lightings, particle systems (eg light emission, smoke, water, explosions).

Following are two images comparing the IEA-R1 reactor installations and the virtual environment that has been built so far:

IEA-R1 Reactor   Vitual Model - IEA-R1 Reactor

Figure 3: Nuclear Reactor of Type Swimming Pool IEA-R1

4. CONCLUSIONS

Technological development and the ease of acquiring smartphones with higher processing capabilities and motion sensors have made VR a powerful tool to aid learning, disseminate long distance knowledge and didactically present other technologies that were inaccessible to students of the high school and to non-academic public. The evolution of 3D modeling software and game engines has been facilitating the development of VR content and has been shown to be adequate to achieve the objectives proposed in this paper, which is to demonstrate the peaceful use of nuclear technology and its importance for humanity.

ACKNOWLEDGMENTS

The outhors thank the financial support from CPG from IPEN/CNEN-SP.

REFERENCES

1. Rheingold, H., *Virtual Reality*, Simon & Schuster, 1991.
2. Gudilin V.; Slabkiy L., Ракетно-космические системы (История. Развитие. Перспективы) : https://www.revolvy.com/main/index.php?s=Sputnik%201. (2017).
3. Cnop, A. C., "Simulação Virtual de Visita Técnica no Reator Argonauta para Fins de Divulgação Científica", (2016).
4. Vince, John, *Essential Virtual Reality Fast*, Ed. Springer, Berlin, Alemanha, pp.174, (1998).
5. Pimentel, K. & Teixeira, K., *Virtual Reality – through the new looking glass*, 2 Ed. New York, McGraw-Hill, (1995).
6. Latta, J. N. & Oberg, D. J., *A conceptual virtual reality model*, IEEE Computer Graphics & Applications, pp. 23-29, (1994).
7. Leston, J., *Virtual reality: the IT perspective*, Computer Bulletin, pp. 12-13, June (1996).
8. Morie, J. F., *Inspiring the future: merging mass communication, art, entertainment and virtual environment*, Computer Graphics, 28(2):135-138, (1994)
9. Begault, D. R., *3-D Sound for virtual reality and multimedia*, Academic Press, Cambridge, MA, 1994).
10. Watson, B. et al., *Evaluation of the Effects of Frame Time Variation on VR Task Performance*. VRAIS 97, IEEE Virtual Reality Annual Symposium, pp. 38-44, (1997).

11. Adams, L., *Visualização e realidade virtual*, Makron Books, pp. 255-259, São Paulo, (1994).
12. IPEN – Instituto de Pesquisas Energéticas e Nucleares, *Relatório de Analise de Segurança do Reator IEA-R1 – RAS*, São Paulo, Brasil, (2005).
13. Autodesk Inc., *Software Gratuito*, https://www.autodesk.com.br/education/free-educational-software, (2019).
14. Unity 5, Um editor tudo-em-um extensível para se adequar ao seu fluxo de trabalho, https: //unity3d.com/pt/unity, (2019).
15. Google Inc., *Google Cardboard*, https://vr.google.com/cardboard, (2019).
16. Google Inc., *It's your turn to make it* , https://vr.google.com/cardboard/manufacturers/, (2019).
17. Google VR., *Downloads and samples*, https://developers.google.com/vr/develop/unity/download, (2019).