Use of Augmented Reality for demonstration of PET/CT and X rays room to teaching Medical Physics in Nuclear Medicine

Utilização da Realidade Aumentada para a demonstração de PET/CT e sala de raios X visando o ensino de Física Médica em Medicina Nuclear

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Abstract

One of the great challenges for professionals in Medical Physics (MP) is to manage the fundamentals of radiation protection, aiming at the protection itself, the patient's, the general public and the environment. Thus, the use of techniques that adopt radiological protection is extremely relevant for application and training in the area. In this sense, this paper aims to propose the application of Augmented Reality (AR) technology as a teaching tool in MP and Nuclear Medicine (NM) training, using as an example the PET/CT equipment modeling and an X rays room. The methodology involved the analysis of the equipment and the environment cited in real size for the modeling in virtual elements, and later creation of devices in the form of QR-codes, where it is possible to visualize the modeling animations. It is understood that the use of the AR technology can aid in equipment and procedures training, with emphasis on those that potentially pose a risk of occupational exposure to ionizing radiation in NM services. In addition, it can assist in the teaching of terms and concepts, by making learning more dynamic and interactive through the visualization of equipment, meeting the fundamentals advocated by radiation protection, by avoiding, for example, visiting an hospital environment.
Keywords: augmented reality; QR-code; radiation protection; PET/CT; X rays room; medical physics teaching.

Resumo

Um dos grandes desafios para os profissionais da Física Médica (FM) é o de dominar os fundamentos de proteção radiológica, visando à própria proteção, do paciente, do público em geral e do meio ambiente. Assim, a utilização de técnicas que adotem a proteção radiológica é de extrema relevância para aplicação e treinamento na área. Neste sentido, este trabalho tem como objetivo propor a aplicação da tecnologia Realidade Aumentada (RA) como ferramenta de ensino na FM em Medicina Nuclear (MN), usando como exemplo a modelagem do equipamento PET/CT e de uma sala de raios X. A metodologia envolveu a análise do equipamento e do ambiente em tamanho real para a modelagem em elementos virtuais, e posterior criação de dispositivos na forma QR-code, onde é possível visualizar as animações das modelagens. Entende-se assim que a utilização da tecnologia da RA pode auxiliar no treinamento sobre equipamentos e procedimentos, com ênfase naqueles que potencialmente envolvem riscos associados à exposição ocupacional à radiação ionizante em serviços de MN. Além disso, pode auxiliar no ensino de termos e conceitos, pelo fato de tornar o aprendizado mais dinâmico e interativo por meio da visualização dos equipamentos, indo ao encontro dos fundamentos preconizados pela proteção radiológica, ao evitar, por exemplo, a visita a um ambiente hospitalar.
Palavras-chave: realidade aumentada; QR-code; proteção radiológica; PET/CT; sala de raios X; ensino de física médica

1. Introduction

1.1. Presentation

The application of ionizing radiation in Nuclear Medicine (NM) is becoming increasingly complex and challenging, requiring professionals to have high quality specific training in different areas of knowledge such as physics, biology and chemistry[1].

In addition, one of the major challenges for Medical Physics (MP) professionals who works with NM today is to master the fundamentals of radiological protection, as well as to know the national standards and related international recommendations, aiming at their own protection, that of the patient, the general public and the environment (1).

So, it is understood that safety is extremely important in the construction of knowledge in NM, due to the use of radioactive sources in its practice (1).

In this sense, the Institute of Radiation Protection and Dosimetry (IRD), that is a research, development and teaching institution in the area of Radiation Protection and Dosimetry, acts in favor of the health and safety of the population and workers exposed to radiation, promoting the preservation of the environment (2).

Connected to the Directorate of Research and Development (DPD) of the Brazilian Nuclear Energy Commission (CNEN), it works in collaboration with universities, government agencies and industries, generating and disseminating knowledge and technology to promote the safe use of ionizing radiation and nuclear technology, aiming at improving the quality of life in the country (2).

In addition, IRD offers courses at level of postgraduate, master and Ph.D. to disseminate the knowledge about Radiation Protection and Dosimetry, with the basic purpose of training specialized human resources in its areas of activity, including NM (2).

Thus, the use of techniques that adopt radiological protection as a foundation is extremely relevant for application and training in MP (3).

For this, it is essential, first, to empower people before exposing them to a dangerous situation and, if possible, to reduce the time of exposure to radiation (3).

Besides that, the constant and rapid technological and scientific development that occurs in the areas of radiotherapy, radiodiagnosis and NM requires that new knowledge be developed, and that professionals in the field are in constant formation (1-3).

Therefore, the adoption of safer methodologies is fundamental in the teaching-learning process. One possibility is the use of new technological tools, such as Augmented Reality (AR), that simulate reality without endangering users' health or the environment.

Thus, AR are increasingly being used to present virtual elements such as equipment, spaces, concepts and practices in real environment, avoiding contact with radioactive sources.

1.2. Theorical Framework- AR Definition

The evolution of technology has given rise to the use of new computational interfaces that help and influence the users' senses (4).

The improvement of computer graphics, through new software and hardware, and telecommunications, gave rise to the so-called AR, which had its first steps in the 90's, but which only took on greater proportions in the years 2000, with the creation of new devices and systems (4).

Then, AR is a technological tool that allows the overlapping of objects and virtual environments with the physical environment, through some technological device (5).

AR enables easier and more natural tangible interactions without the use of special equipment (such as glasses and computers - although it can also be used), and can be used in any environment (open or closed), facilitating tangible actions and multimodal operations, involving voice, gestures, touch etc (6).

Therefore, AR only needs a mechanism to combine the real and the virtual, and not a mechanism to integrate the user into the virtual world, as with another technological tool, Virtual Reality (VR) (7).

Thus, AR can be used in the most varied areas, from entertainment (games) to scientific experiments (simulating research laboratories) (7).

So, AR could enrich the real environment with virtual objects, using some technological device, working in real time, mixing the real and virtual worlds at some point of reality/virtuality continuous, seeming to coexist in the same space, to enrich the real scene with virtual objects (4-7).

Finally, AR could be used in by classroom lectures with textbooks, computers, handheld devices, and other electronic devices (4-7).

1.3.AR in Medical Physics and Nuclear Medicine

Currently, AR has been applied in several areas of education and training. Medicine is one of the areas that most demanded the use of RA in training, diagnosis, treatment and simulation of surgeries, due to its characteristic of 3D visualization and real-time interaction, allowing the realization of innovative medical applications (4).

The medical community has been looking for alternative forms of training, especially those related to the nuclear field, as simulation-based training has also become an important alternative for safe learning, especially in practices subject to exposure to ionizing radiation (8).

NM, a medical specialty that uses radioactive compounds for therapy and diagnosis of various diseases, requires continuous training and qualification of workers (8).

Approximately 35 million tests are performed worldwide each year, and Brazil has more than 432 nuclear medicine services (8).

According to the Basic Safety Standards (BSS) published by the International Atomic Energy Agency (IAEA) and the National Nuclear Energy Commission (CNEN) Standards, some actions must be ensured for the qualification and qualification of these professionals (8).

In addition, Medical may also use AR in MP for (9-11):
1) Visualization and training aid for surgery;
2) Real-time 3D patient data collection using non-invasive sensors such as Magnetic Resonance Imaging (MRI), Computed Tomography (CT), or Ultrasound for real patient rendering and vision would give an "X rays vision" effect "of a patient";
3) General medical visualization of tasks in the operating room;
4) Elaboration of a surgical environment, taking advantage of the equipment available for Image Guided Surgery (IGS), using a prototype that receives all the necessary information from a device for intraoperative navigation;
5) Creation of three-dimensional objects used to represent patients, equipment, environments (offices, operating rooms) and human organs;
6) Collision detection in medical applications, accuracy, response time, impact location knowledge and interpenetration verification, all of which are fundamental for realistically simulating procedures; and
7) Stereoscopy to provide the sensation of immersion and depth; retinal degeneration analysis, allowing the user to view altered real images to address this visual impairment.

Thus, it is understood the range of applications in which RA can be used can also assist in teaching and training for NM and MP.

1.4. RDC Nº 50

The Collegiate Board Resolution (RDC) nº 50 of the National Health Surveillance Agency (ANVISA), of February 21, 2002, provides for the Technical Regulation for planning, programming, elaboration and evaluation of physical projects of health care establishments in Brazil (12).

Within these establishments are the X rays rooms (including here the CT scan). This resolution sets the minimum sizing for these rooms(12).

These dimensions were determined in view of image quality, radiological protection of the patient and also of the operator, thus ensuring their safety (12,13).

For the energies that are used in X rays rooms, such as CT, radiation exits the tube, interacts with the patient, interacts with the walls, and returns to the patient (12,13).

Then, the shorter the distance between wall and tube, the greater the radiation back to the patient and detector, thereby reducing image quality. This effect is called backscattering (12,13).

Because of this effect, it is essential that during the design of an X rays room, its design based on RDC nº 50 is foreseen, so that the environment is optimized and can be used with the highest quality and safety possible for patients and workers (12,13).

For example, in an X rays room, the tube can never reach less than 1.5 m from any wall; the table cannot reach, considering its displacement, less than 1m; and its bases cannot reach less than 0.6m (12,13).

2. Materials and Methods

In this sense, this work consists in demonstrating the possibility of using AR as a pedagogical tool for teaching MP, with the simulation of a Positron Emission Computed Tomography (PET/CT) equipment and an X rays room; i.e., to enable the use of the virtual environment for training occupationally exposed individuals (OEI) in the real world with virtual objects.

In addition, this practice was developed to be used in teaching NM in IRD courses. IRD offers NM training in continuing education courses and in its postgraduate courses - such as the Postgraduate Course (PGEC) in Radiological Protection and Safety of Radioactive Sources (offered in partnership with the IAEA for students from countries that speak Portuguese) and the Master's and Doctorate Program in Radiation Protection and Dosimetry.

Therereby, the simulation of the AR equipment took place in four steps, as follows:

1) Drawing, 3D Modeling and Rendering - photos were initially taken to make modeling as real as possible of the original equipment. It was then done the drawing, 3D modeling and rendering of the two equipments using the software "Sketchup". Measurements with measuring tape for the most faithful proportion of the components were measured in both equipment;

2) AR generation - so that the 3D image of the equipment could be presented in a virtual way, the software "Augment" (mobile App that visualizes 3D models in AR, integrated in real time in their true size and environment) and "Augmentaty" (mobile and computer App, responsible for bringing real-time and real-scale AR) were used;

3) Conversion of AR to QR-code (Markers) - Marker is an element for image registration and for

referencing the virtual object in the real world. The most common type of marker is the QR-code (quick response code). The information contained therein may be a uniform resource locator (URL), text or general information such as business cards, videos, among others[4]. The AR marker is slightly different from QR-code, as can be seen in Figure 1.
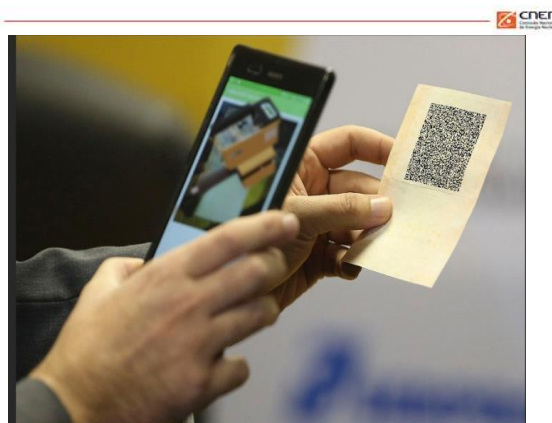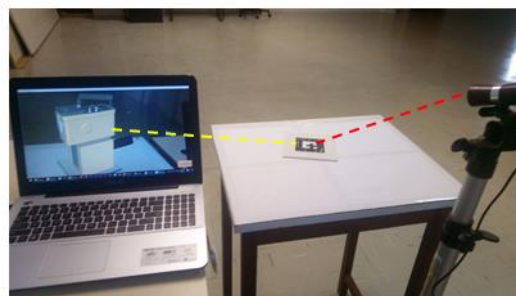

Figure 1. Image generation from QR code on mobile and fixed devices. Source: The Author.

4) Image generation from QR-code - the processing and recognition of this type of marker is done through computer vision. QR-codes are a two-dimensional barcode that can be easily scanned using most camera-equipped peripherals (phones, tablets, PCs). This code can be converted, for example, into text (interactive), a 3D model, a URL address, a phone number, a georeferenced location, an email, a contact, or an SMS. For this work was used with a mobile device (mobile) and a fixed (a camcorder attached to a computer), as exemplified in Figure 1. In order to view the equipment is necessary to download the free App "Augment" or "Increaseaty" for the devices and scan their QR codes. The finishing done for the printed QR codes was in "PVC", where the user can see on one side the image that same QR codes represent (Figure 1).

3. Results

3.1. AR of PET/CT

The choice for PET/CT is because it is one of the most modern equipment used in state-of-the-art medical imaging, responsible for the diagnosis and follow-up of diseases with high precision, mainly

applied in the areas of Oncology, Neurology and Cardiology (14).

Besides that, PET/CT is able to perform a metabolic mapping of the whole body, or follow-up of various cancers, evaluation of neuropsychiatric and cardiovascular diseases (14).

After modeling and rendering of a standard PET/CT model, a QR-code was generated by the software "Aumentaty" (Figure 2a) and "Augmented" (Figure 2b), which after reading by fixed or mobile device generated the AR image (Figure 3).
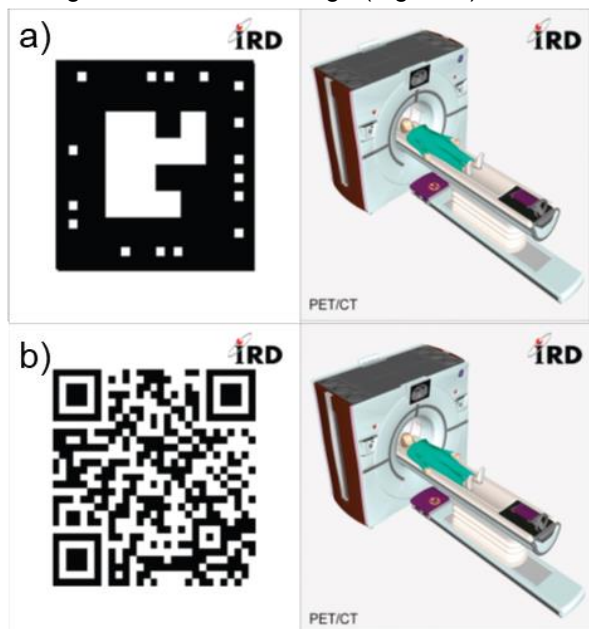

Figure 2 (a) Generation of QR-codes using the software "Aumentaty" for PET/CT. (b) Generation of QR-codes using the software "Augmented" for PET/CT. Source: The Author.
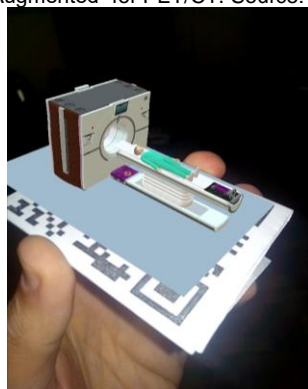

Figure 3. AR generation from QR-code for PET/CT. Source: The Author.

3.2. AR of X rays room

The X rays room was modeling based at the Ministerial Ordinance 453/98 of the Ministry of Health of Brazil (which was replaced by RDC No. 330, published on 12/20/2019), where the main rules regarding radiological protection during an X rays examination is established (15). Regarding the environment, we can highlight:

. Every individual working with X rays should use a monthly indirect reading individual dosimeter;

. The presence of caregivers during radiological procedures is only allowed when their participation is essential to help the patient;

. During exposures, the use of personal protective clothing that is compatible with the type of radiological procedure and which has at least 0.25mm of lead is mandatory for the accompanying persons;

X rays rooms must have:

a) Walls, floor, ceiling and doors with shielding that provides radiological protection to the adjacent areas, and should also be observed: the shielding must be continuous and without failures; the wall armor must be at least 2.10 m, except in specific cases;

b) Cockpit with dimensions and shielding that provide sufficient attenuation to ensure operator protection, and the following requirements shall be observed: when the control is inside the X rays room, the cockpit is allowed to be opened or a screen permanently attached to the floor with a minimum height of 210 cm is used, provided that the control area is not directly reached by the beam spread by the patient; The booth must be positioned so that, during exhibitions, no individual can enter the room without being noticed by the operator;

c) Signage visible on the outside of the access doors, bearing the international symbol of ionizing radiation and the inscription: "X rays, restricted entry"; and

d) Personal protective clothing for patients, staff and caregivers. There should be appropriate supports to support the lead aprons in order to preserve their integrity. It is not allowed to install more than one X rays equipment per room; a medical exposure control system should be in place to prevent inadvertent exposure of pregnant patients.

After modeling and rendering of a standard PET/CT model, a QR code was generated, which after reading by fixed or mobile device generated the AR image.

Thus, based on these recommendations, the modeling and rendering of an X rays room was performed, a QR-code was generated by the software "Aumentaty" (Figure 4a) and "Augmented" (Figure 4b), which after reading by the fixed or mobile device generated the AR image (Figure 5).
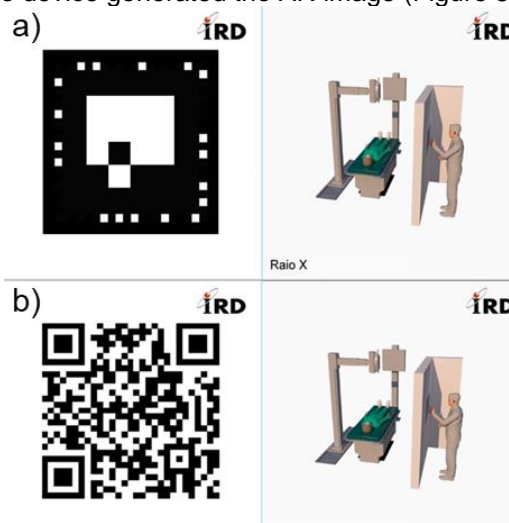

Figure 4. (a) Generation of QR-codes using the software "Aumentaty" for X rays room. (b) Generation of QR-codes using the software "Augmented" for X rays room. Source: The Author.
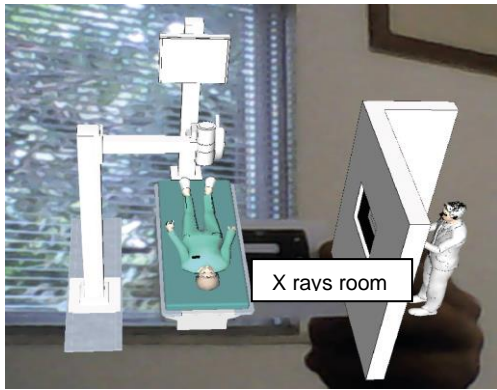
Figure 5. AR generation from QR-code for X rays room.
Source: The Author.

3. Discussion

Regarding 3D modeling, the use of free software was important for the study and deepening of this work.

In the case of AR, the software chosen for the project development works on both computer and mobile devices, as well as being free.

For QR-code, both software can synchronize the 3D model with a real environment.

By synchronizing the model with the program, the QR-code for the specific model is instantly generated.

Both students and teachers can work with RA. For this, there are two options of free applications (software) that were tested and used during the research, in the case of Aumentaty and Augmented.

Thus, it is possible to generate QR codes for each piece of equipment that you want to demonstrate in the classroom. Each application generates a different QR Code for the same equipment.

With a copy of these QR Codes, the teacher can make the base file available to be opened on the student's cell phone or on the computer, which through the webcam would read the QR Code.

The most important is not where the student sees (cell phone or computer), but the possibility of the same power to rotate and study the equipment or the object up close.

In addition, if the intention is to use AR in the classroom to demonstrate this equipment, both RDC Resolution No. 50 and Ordinance 453/98 may be used as parameters for discussion of measures, procedures and limits to be adopted aiming at radiological protection.

4. Conclusion

The research project aimed to develop the use of AR for visualization and simulation of a PET/CT and an X rays room.

It has been shown that AR is feasible and can be used in training, and that the procedures performed in any virtual training follow the same protocols as in a real environment.

The main challenges encountered were initially the modeling of equipment that is quite complex.

The choice of platform that reproduces the AR has been tested taking into account performance, stability, offline use of the platform and free for academic purposes.

The finishing done for the printed QR-codes was in "PVC", where the user can see on one side the image that same QR-code represents.

Specifically about AR, with the rapidly changing society where there is a wealth of information and knowledge available, the adoption and application of information at the right time and place is necessary for greater efficiency in school and company settings.

In this case, AR is a technology that dramatically displaces location and time of learning and training.

It is therefore understood that the use of the AR can assist in training on equipment and procedures, with an emphasis on those that potentially involve risks associated with occupational exposure to ionizing radiation in MN services.

In addition, it can assist in teaching terms and concepts, by making learning more dynamic and interactive through the visualization of equipment, meeting the fundamentals advocated by radiological protection, by avoiding, for example, visiting an environment hospital.

Accordingly, new technologies and information communications are not only powerful and compact tools for delivering AR experiences through personal computers and mobile devices, but also developed and sophisticated to be able to combine the real world with interactively increased information.

In the future it is intended to apply this technology in the classroom in the Postgraduate Programs of IRD for explanation and detailing of these extremely important equipments for the area of MP in NM.

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