González Izard, S., Juanes Méndez, J. A., García-Peñalvo, F. J., Jiménez López, M., Pastor Vázquez, F., & Ruisoto, P. (2017). 360° vision applications for medical training. In J. M. Dodero, M. S. Ibarra Sáiz, & I. Ruiz Rube (Eds.), *Fifth International Conference on Technological Ecosystems for Enhancing Multiculturality (TEEM'17) (Cádiz, Spain, October 18-20, 2017)* (Article 55). New York, NY, USA: ACM. doi: 10.1145/3144826.3145405

360º vision applications for medical training

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ABSTRACT

In recent years, 360º videos combined with virtual reality (VR) techniques have been developed so that users can experience the content and interact with the environment, rather than just watch them. These technological resources offer an immersive vision in which each person can choose where to look at. Therefore, we began to move away from the classic forms of traditional recording and reproduction to focus on the most innovative production and video viewing in 360 degrees as a more real-world technology experience that allows the visualization of panoramic images in 360º, which facilitates a complete perspective of an object or environment with a surprising luxury of details, through images captured from different angles. We present a teaching experience of 360 degree immersive visualization of an operating room and an anatomical dissection room, with the aim of generating a virtual environment for learning, training and valuing the equipment that exists in these medical rooms.

CCS CONCEPTS

• Computing Methodologies - Symbolic and algebraic manipulation - Artificial Intelligence - 3D Imaging

Social and professional topics - Professional topics - Computing education programs

Software and its engineering - Software organization and properties - Contextual software domains - Virtual worlds software

KEYWORDS

Virtual Reality; Virtual 3D World Immersion; Stereoscopic Vision; Immersive System; Medical Training; Training Virtual Tool.

1 INTRODUCTION

Virtual Reality is a technology clearly on the rise and with great potential in a wide range of sectors [1-8]. It is currently drawing increasing atention in the field of medical education. There are two large groups of Virtual Reality systems: first, those based on spherical recordings and images, and second, those that introduce the user to a completely virtual world. In the first case the user will be immersed in a real world, since it has been recorded with real images, spherical, but taken from reality at the end of the day. In the second case, the immersion takes place in a completely computer-created world, which normally brings a greater 3D feel but a logically inferior level of realism [9-11].

We can say that there is a third kind of classification, that mixes the two previous ones: we introduce virtual elements, created by computer, in within a real environment, in turn created from images or recorded videos. This is very interesting, as *we cannot yet expect a digital patient to be indistinguishable from reality* [12]. The fact is that it is necessary to sacrifice the 3D models quality to be able to render it in real time [13], and to allow the user to interact with the virtual world. That is the reason why it is interesting to mix a virtual environment with 360 degree images and videos, where the user will find realistic visualizations. This will be the type of systems that we will analyze in this article with the aim of studying its potential as a didactic tool in the field of medicine.

The spherical virtual environments and 360 degree recordings constitute a new audiovisual dimension that allows the immersion in the recording and the possibility of observing the recorded as if it were physically in that place [14]. If until now the video was a linear material, whose movement and possibility of observation depended exclusively on the angle of capture of the recording, the management of the 360º cameras has been taken one step further, where the viewer can interact directly with the recording and choose at whim to see as if you were physically present at the recording location [15].

This article will analyze how recording actual surgeries with 360 degrees technology can improve students' ability to understand surgical procedures.

At the moment the medical students come as spectators to the surgeries with the objective to familiarize themselves with the environment, to know the mechanics of work, the medical procedure of action. The problem is that the number of students that can enter the operating room is limited, so that students can have this experience a few times [16-18].

Thanks to the 360º recordings, we have been able to relive the experience of being spectators in a surgery as many times as they wish.

Figure 1 Part of one of the spherical images taken in the dissection room

In addition, on these spherical or 360º recordings, interactive systems can be implemented in which the user can interact with the environment, thus opening up to new possibilities, ranging from being able to perform a simulation of surgery to obtaining information about the elements that surround to user.

A spherical recording of an operating room and anatomical dissection room has been performed, in addition to different surgeries and the implementation of a system in which the user can perform a small interaction with the environment (Fig. 1). These systems are intended to demonstrate the potential that spherical recordings offer to medical training.

The image illustrated in Fig. 1 is no more than a part obtained from a spherical image, which allows the student not only to see this portion visualized here, but the whole environment that surrounds it. In addition, a small 360º video has been made so that the student can check how other students perform anatomical dissection of a human being (Fig. 2).

With 360º video streaming technology, surgeons will also be able to operate remotely using virtual reality technologies [15]. In combination with haptic devices, that allow the surgeons to manipulate medical equipment remotely, this will be the future, not only for possibility of remote surgeries, but also for the precision that devices can get in comparison with human hands. This technology will be soon available, and will also allow other surgeons to be present during the surgery as support.

Figure 2 Part of one of the spherical images taken in the dissection room

2 MATERIALS AND METHOD

We recorded a dissection room in 360 degrees with the aim of allow the user (student), to observe in a virtual way the most relevant elements available in an anatomical dissection room. We also recorded different operating rooms to create virtual environments, with immersive characteristics, to analyze the most representative elements of an operating room.

For the development of our technological procedure we used multiple hardware devices, which allowed us to generate different immersive Virtual Reality environments. A 360 degrees camera was used to record different clinical environments both in an operating room and an anatomical dissection room. To this end, we use the camera Samsung Gear 360 (Fig. 3), which has a spherical design, 6 cm in diameter, and 152 grams in weight. It has two sensors on opposite sides, each comprising 180º of visual field and 180º apertures f/2.0; With a maximum processed video resolution of 4K 30fps. Among other technical features of this device, the following should be highlighted:

- Dual 15 Megapixels sensor
- Dual fisheye lens with f / 2.0 aperture
- Video resolution of 3840 x 1920 pixels at 30 fps
- Image resolution of 7776 x 3888 pixels (equivalent to 30 MP)
- Modes: Video, photo, time-lapse, video looping
- Size: 66.7 x 56.3 x 60.1 mm
- microSD slot

We can find many different 360-degree cameras in the market, however we used Samsung Gear 360 because it offers good quality images and videos if we have in mind that performance is a very important requirement in the development of the system described in this article. Although it is true that there are many other cameras that offer better quality, the problem is that if we use high resolution images and videos our application will have two problems. First of all, its size will be too high, and on the other hand the performance will be lower, and the users will need better devices to run the system and get a quality experience.

However, these devices will greatly improve over the next five years, getting better spherical images and videos that will be perfectly visualized in smartphones, as mobile devices are also improving really fast every year.

Figure 3 Samsung Gear 360 Camera

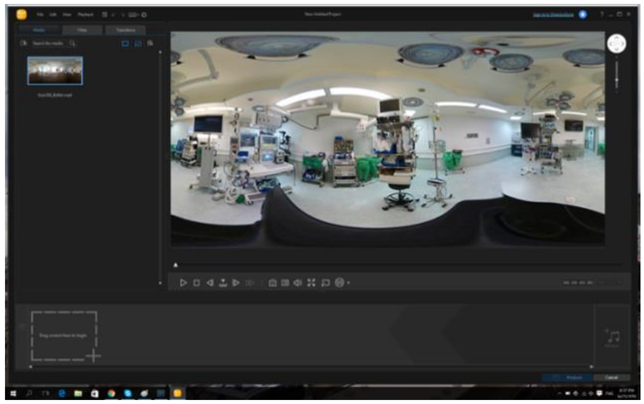

Figure 4 Gear 360 Action Director program

Once the images were recorded, they were assembled using Gear 360 Action Director software (Fig. 4). It is an editing program to create videos in 360 degrees that can be viewed with both traditional devices, such as a computer, and with Reality glasses (stereoscopic glasses). Even videos can be viewed by taking advantage of the 360º recording on smartphones and tablets, where the user can look at any direction of the video by moving the mobile around.

One of the tasks carried out by this program is the stitching of the images, which consists of joining the image captured by a lens with that of the opposite lens, avoiding imperfections of the resulting image.

For optimitizing the visualization of results, the ideal is to have a stereoscopic glasses, since this device offers us a complete immersion in the 360 degrees images and generated videos. The sense of realism is much greater than with other techniques previously mencioned [19].

So far we have recorded a video with 360º technology, assembled and edited, stitching the images to create a spherical video. This video could already be visualized in glasses using distribution platforms such as YouTube.

However, we wanted to take a step further by adding Virtual Reality and user interaction to our system. In this sense, we created a spherical image of the operating room and we added virtual 3D elements that provide information about different devices that the user can find in the operating room.

To this end, we used the Unity3D video game engine. This program allows creating three-dimensional environments and programming interfaces and different behaviors for each of the 3D elements.

First, we created a three-dimensional sphere, and we inserted our spherical image of the operating room into the sphere, stretching it to occupy the entire inner surface. Next, we placed the camera, in other words, the key element that will allow the user to see the virtual world, right in the center of our sphere. This camera carries scripts (portions of source code) that makes the camera move in the specific direction the user moves his head, allowing the user to discover the surrounding environment.

Secondly, we correctly illuminated the scene and added the 3D elements that provide information about each device. These elements are placed carefully to match the position of the devices that appear in the image. They also associated scripts to appear only when the user was looking at the machine with which they are related.

Of course, in addition to all of the above it is necessary to configure other elements for the system to function correctly. For example, empty elements or Game Objects were defined following the terminology of Unity3D, and were totally invisible to the user. These Game Objects were placed in the path from the center of the sphere where the spherical image (or video) was projected to the position where the machine or medical device from which we want to offer information was located. These Game Objects were associated with a script that received a notification when the user directs the view (the pointer) towards them, which allowed us to program a certain action when this happened. In this case, the action to be performed showed the virtual elements that were associated with that Game Object, or in other words, displayed the virtual panel associated with that medical device. In the following image (Fig. 5), we can see a snapshot of the programming environment used.

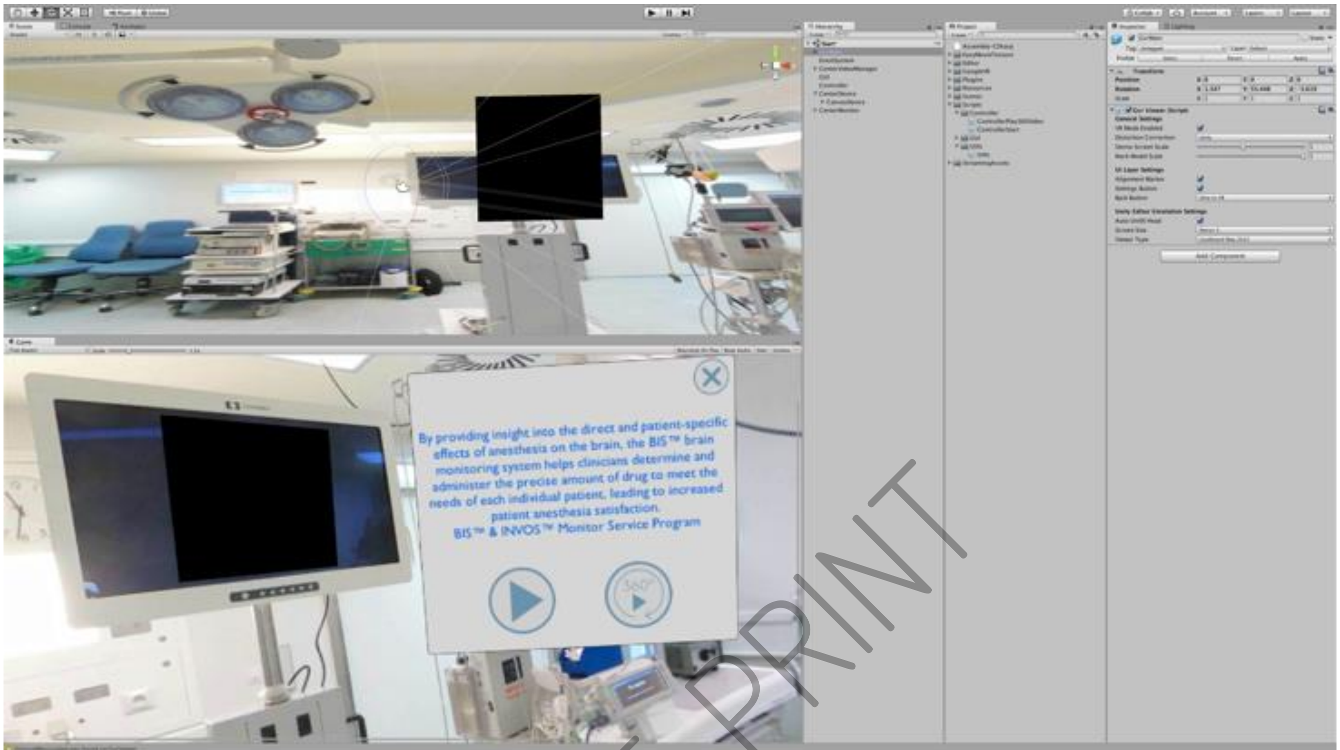

Figure 5 Image of the development environment used for the implementation of the system

3 RESULTS

In this system, we highlight the most typical elements that can be found in every operating room. So when the user looks at a specific device, the system will show him/her information about that device. It will also be able to show a video that allows him/her to see how the device must be used or even a spherical video to immerse the user in a real surgery. It is very important to create a virtual experience as realistic as possible, so we took this into consideration while programming the different functionalities. For example, videos will be visualized in the monitors.

In addition, an anatomical dissection room was recorded. The study of anatomy is one of the most basic and important within medical education and in all degrees of health sciences. Its importance can not be overestimated since its knowledge lays the foundation for both medical research and for the improvement of treatments that may depend on a more solid training of doctors for every specialties. In most of those cases, learning is fundamentally based on the meticulous study of the human corpse.

Therefore, we have generated virtual visualization spaces in 360 degrees, so that the user (student) can evaluate each of the components that make up the operating rooms (Fig. 6), as well as the anatomical dissection rooms, within a virtual immersed environment, but still with real appearance.

In Fig. 6 a stereoscopic image is shown, which was projected on the screen of the device that executes the system. Thanks to the glasses of Virtual Reality, we got each eye to see an image and thus form in our brain a three-dimensional image. In this particular image, we see how the user is looking at a specific device, and just at that moment the system shows a virtual panel with information about that device. Similarly, in Fig. 5, we saw how, when the user looks at a device, in that case a monitor, besides seeing a panel with information we got two buttons. The first one allows to project a video on this monitor, while the second takes the user to a different scene or level, where you can see a video recorded with 360 degrees technology of a real surgical operation carried out in that same operating room. In this way, the student will have the sensation of being inside the operating room while carrying out a real operation, discovering how the different devices are used by observing how the surgeon and the other medical professionals who are in the living room.

Figure 6 **Estereoscopical vision of the operating room including virtual information of electrosurgical platform**

Figure 7 **View of part of the 360º image**

As it is difficult to describe these systems only with images, we created a video for our readers about a virtual immersive system developed by us as an example. Please follow this link to see the video: https://youtu.be/IQCSzc7oACA

Currently, students attend real operations to learn through the experience of visualizing a disection in real life. Thanks to this system, they will be able to experience this same experience as many times as necessary. This is different from what is happening today, where it is not possible for students to go to as many surgeries as they want.

Our technological system supports the idea that Virtual Reality techniques provide excellent advantages over other traditional training tools, such as educational videos, or different computer programs that allow teaching presentations. They allow user to get immersed in the virtual scene, obtaining a much greater sense of realism, added to the 3D effect provided by the stereoscopic glasses, allowing a better understanding of aspects such as depth, fundamental to understand the bone structures that constitute human skull, where there are a lot of nooks and crannies which would not be appreciable through a simple video, or a two-dimensional and static images.

The use of mobile devices in teaching, together with the combination of virtual reality glasses, is already a positive element in the construction of knowledge, since with the use of these technologies increases the possibilities of interact with complex content.

Finally, Fig. 7 is part of the image we can see in Fig. 4. This is what the user can see when looking at this part of the 360º image using estereoscopic glasses, or just using a PC, smartphone or tablet with a web brower.

4 DISCUSSIONS AND CONCLUSIONS

Visual and interactive learning aids provide an incentive for the student in health sciences education, in addition to improve long-term retention. The visualization of real images in virtual environments of learning, constitute a very efficient form of representation of the corporal anatomy, which facilitates a better understanding of its content for its study and analysis. This study provide a tool for developing a more natural interaction with anatomical structures as well as with objects that participate in a surgical intervention room or in other clinical environments. Nowadays, emerging technologies facilitate the generation of computerized medical training procedures of great interest in various fields of Medicine and Surgery. In addition, these technologies allow us to create artificial scenes close to the real ones, which increases the motivation and engagement of the users who use them.

The management of technological devices such as the ones we have used will allow students to manage their knowledge and practical skills, developing new forms of teacher innovation and raising the quality of the academic process. We believe that these technological applications will encourage student learning, promoting a more active approach in the learning process.

We must take into account that, in many cases, the first contact that medical students have with some practices that are carried out in this discipline, are too shocking for some, creating feelings of dizziness or anxiety in some of them. Virtual Reality allows them to have a first contact in a secure setting, in order to reduce the impression they will get when they first face the real task, for example, the anatomical dissection of a human body.

It is clear that the generation and development of these technological resources, such as the one we have developed for this project, will enrich and facilitate the transmission of didactic contents, favoring the training in health related sciences for both undergraduate and graduate students. However, to demonstrate this fact we will perform a study comparing the results of students who have used this resources to others who have used only traditional resources, such as 2D videos or similar.

In the future, we will not only be able to visualize images, videos and virtual environments to form ourselves in different medical environments, but we will also be able to see a live operation directly, and use this technology for remote operations, so that a surgeon can be found on one continent and remotely operate on a patient found in another. The surgeon can guide the devices through haptic devices with the sensation of being in the same operating room thanks to Virtual Reality and high quality spherical recordings.

5 ACKNOWLEDGMENTS

The authors would like to specifically thank the members of the company specialised in virtual and augmented reality systems ARSOFT, located in Parque Científico de la Universidad de Salamanca, for their technical work and collaboration in the implementation of this system.

This research work has been carried out within the University of Salamanca PhD Programme on Education in the Knowledge Society scope (http://knowledgesociety.usal.es) [20,21].

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