Analysis of the Oculus Rift Device as a Technological Resource in Medical Training through Clinical Practice

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ABSTRACT
We present a virtual environment for three-dimensional visualization of a hospital operating room, through stereoscopic rendering, using the Oculus Rift headset with a wide field of vision. The application developed allows immersion into an artificial situation where the user can perceive the virtual experience created by the system as real. The system enables the training and familiarization with the different operating room devices and monitors, as well as with the equipment installed. Therefore, an effective training is accomplished as practice for the real situation the user will face.

Categories and Subject Descriptors
H.1.2. [**User/Machine Systems**]: Human information processing

General Terms
Measurement, Design, Human Factors

Keywords
Virtual reality, stereoscopic vision, Oculus Rift headset, clinical training, operating room.

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1. INTRODUCTION
There are increasingly immersive applications aimed towards acquiring clinical skills. The advantages that these virtual environments have in the learning process are well known [1-3]. Stereoscopic vision (or three-dimensional vision) is the gathering of three-dimensional visual information and/or the creation of depth illusion in an image. Each eye, from its position, collects in its retina a slightly different image from the reality before them. These small differences are processed in the brain to calculate the distance to the objects through the parallax technique. Calculating the distances places the objects we are seeing in a three-dimensional space, getting a sense of depth or volume.

There are several methods to reach stereoscopic vision, one of them is through the use of glasses with an infrared sensor that synchronizes the screen's alternative images using the LCD lens of the glasses.

3D reconstruction is a process through which real objects are reproduced in a computer preserving their physical characteristics (dimensions, volume and shape). Various reconstruction techniques and methods for three-dimensional modeling aim to connect the set of representative points from the object as surface elements, such as triangles, squares or any geometric shape. The three-dimensional reconstruction is a process that analyses a set of images to find the relative position of the corresponding points and based on a series of parameters from the camera configuration, determine the position of a point in the three-dimensional space through a process called triangulation. The triangulation method determines the two lines that join each correspondence with the camera's focus point and then find the specific point whose distance to these lines is minimum.

In order to reconstruct an object, the different points must be obtained using a scanner with or without physical contact.

The Virtual Reality (VR) techniques are starting to be used more frequently in different medical training applications. VR is a computer system used to create an artificial world in which the user has the sense of actually being in that world, having the ability to move and manipulate objects in it. These techniques are applied in multiple contexts [4-17].

Until recently, the equipment required to develop advanced VR technology was very expensive. However, new technology proposals have recently appeared, like the Oculus Rift headset, which is more affordable.

We present a virtual experience that combines new technologies at an affordable price, and by adapting them, aim to make them more affordable and useful in medical training environments. This technology allows users to enjoy an immersive virtual environment, creating stereoscopic vision with excellent depth, scale and parallax; with unique and parallel images for each eye recreating a natural 3D experience. The personalized monitoring technology of the Oculus Rift headset, offering an ultra-low latency when tracking the head in a 360° environment, key in the improvement of the virtual experience.

With this study we intend to create a VR experience in an operating room supported by a platform that provides an artificial environment where the user can perceive virtual situations as real; using the Oculus Rift and showing its excellent immersive potential. Since an operating room is a very restricted area within a hospital and there is a need to control it because of the sterile and aseptic techniques carried out, using it for trainees is difficult. VR devices with stereoscopic vision headsets enable a training approach close to reality.

2. MATERIAL AND METHODS

The virtual environment created for this experience was built using Autodesk Maya (Figs. 1 to 3). This software has different tools for modeling, animation, rendering, amongst others; it works with any type of NURBS (figures created from curves and surfaces) surface, polygons and surface subdivision. It also has the possibility of conversion into any type of geometry. Through Maya we get a virtual space based on a mathematical model defined by a Cartesian system of three axes: X, Y, Z.

In this virtual space, the different three-dimensional objects can be created, modified and arranged. They will make up our scene, in our case a hospital operating room.

We also used the Unity 3D software, which is a game engine created by Unity Technologies. It is used to design technological procedures in different platforms (Search Engines, Windows, OS X, Linux, Xbox 360, PlayStation, Wii, iPhone, Android, Windows Phone, amongst others). It generates high-end models and can import models and animations from Maya.

The model of the glasses used in our study was Oculus Rift development Kit 2 (Fig. 4). This device has a Software Development Kit (SDK) that combines tools to develop virtual environments in some of the best known platforms (Unreal Development Kit, Unreal Engine or Unity).

The Oculus Rift headset comes with a plugin specifically designed for Unity 3D, used with a special camera.

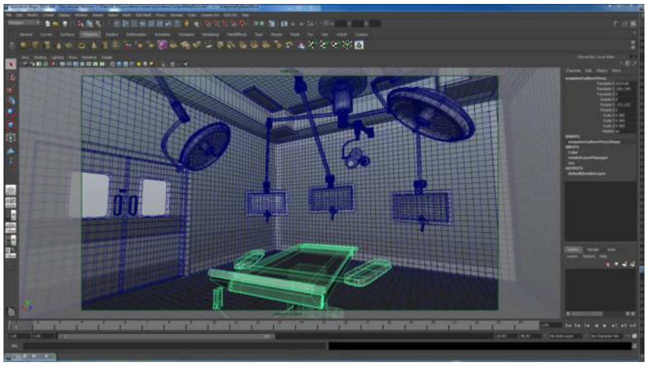

Figure 1. Autodesk Maya Interface. 3D generation of a virtual operating room.

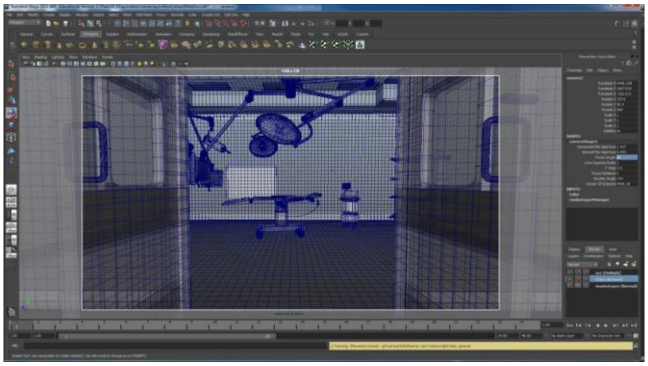

Figure 2. Autodesk Maya Interface. 3D generation of a virtual operating room

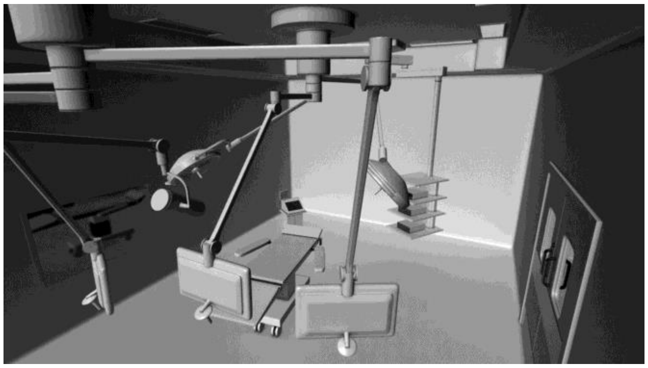

Figure 3. 3D vision of the virtual operating room developed.

Figure 4. Headset used in our project. Oculus Rift Development Kit 2 Model.

The color depth is 24 bits per pixel. The 7 inch screen makes the 3D stereo vision no longer have 100% overlap, the left eye sees the additional space to the left and the right eye sees the additional space to the right. This imitates human normal vision. This version of Oculus Rift K2 covers almost all the user's field of vision to create a stronger sense of immersion. The resolution is 1280 × 800, leading to an effective 640 × 800 per eye.

The weight of this device is approximately 380 grams. The kit also includes interchangeable lenses that allow the simple correction of diopters. The software adjusts the distance between each eye and although it has a wide exit angle, this is not a problem when using the Rift.

The Oculus Rift uses a USB interface to send monitoring data to the server and turn on the device, avoiding the need for an external power supply. Nevertheless, since its energy requirements slightly surpass the USB classification, the Oculus Rift comes with a power adapter that can be used to connect the control box to an outlet for computers that do not have enough USB power.

3. RESULTS

The animation software in 3D Maya provided a complete set of creative functions to make 3D animations, modeling and rendering within a highly scalable production platform. Maya gave us a set of tools and effects of high visual quality and an increase in the modeling productivity, with real textures and creation of shadows. This is how we created a virtual operating room close to reality. The Oculus Rift virtual reality headset leads a new generation of devices with a wide field of vision, stereoscopic 3D rendering and low latency monitoring, having a strong sense of immersion. The field of vision is 90° horizontally and 110° diagonally; thus filling, almost completely, the user's field of vision; getting a strong sense of immersion (Fig. 5). With this technology system, we assess the basic and main elements that health science users must know to perform well inside an operating room.

It should be noted that because of the 1000 Hz sensors, there is a latency reduction between the head movement and the representation on screen. The device also records rotations in the three spatial axes.

With this application the user can value everything that surrounds the operating room, from walls and ceilings and ventilation and lighting systems (Figs. 5 and 6), to the different equipment like oxygen and anesthetic gas; operating table, hemodynamic monitoring parameters and appropriate furniture (stool, benches, tables with the necessary instruments for the intervention, amongst others), assessing their location and arrangement.

Every operating room has specific furniture and appropriate equipment; however, there are some common elements in all operating rooms. In our virtual operating room design we have reconstructed the following elements (Fig. 6): double action doors with peepholes; electric lighting systems (articulated and intensity adjustable mobile lamps, plugs); grounded operating table to avoid electrical discharges through the patient; table for the surgical instruments used in the operation, covered by a sterile green drape; vital signs monitor; display monitor for radiographic images; oxygen cylinders; tabletop surgical aspirator to suction blood during the intervention making the surgical field visible for the surgeon; single arm pendant with different outlets for oxygen, vacuum, anesthesia cart, etc.; anesthesia cart with gauges, valves, flowmeter, vaporizers, etc.; air conditioning system that keeps a clean and dust free atmosphere; walls with light colors that reflect the light and waterproof floors.

Figure 5. Demonstration of the Oculus Rift headset, and user on screen visualization.

The sense of reality is attained by navigating in real time through the 3D geometric models, using immersive techniques with the Oculus Rift headset (Fig. 6); the user interacts implicitly, the system captures the user's natural movements and actions and sends that information to the system. The stereoscopic headset is fully immersive, it nullifies the view of the real environment, replaced by the virtual one. However, it still does not record linear movement, for example if we move the head forward or walk through the space.

Figure 6. Virtual visualization of the environment by the user with the Oculus Rift headset.

4. DISCUSSION

There are different terms that clarify specific situations in virtual reality. One of them is virtual environments, like geometry, parameters and static configurations that model an environment, whether it is simulated or not. Another term used is artificial reality, which is only one of the system possibilities. There are two basic differences between virtual environment and virtual reality; the experience, understood as the interaction in real time; and the virtual subject, or the user's relationship with the virtual environment. The augmented reality is based on superimposing computer generated objects over the physical environment. It is done through a special visualization system, allowing the user to have a direct view of the physical environment where computer generated images are also shown. The visualization system must have an orientation sensor so it can know the right direction, place and time to generate the virtual objects.

The uses of VR have been varied, although the most common is in research and simulation. With the exception of military applications, most VR research and product development is being conducted by small companies focused on training, apart from university and expert groups [18-20].

Several technical aspects still need to be solved to have a complete presence of the virtual environment in our brain, for example eliminating some physical discomfort related to the use of VR glasses. To date, few virtual environments have been created from scratch, most of them come from experiences and adaptations from different existing videogames, so there will still be some mistakes and imperfections in these devices. However, a carefully designed virtual experience can give the user a sense of control over the environment, even though it is fictitious, and significantly facilitate the learning process and training in medicine.

The progress made in virtual reality developments is so fast it is important to study its possible side effects. VR devices can cause subjective discomfort, such as dizziness and fatigue, loss of balance in some users, as well as visual disturbances. It is therefore advisable to use this technology in short sessions, extended over days or weeks to improve adaptation and human-computer interaction.

Despite these considerations, it is clear that the use of these virtual reality systems and devices in medical training, facilitate the practice of clinical skills. We believe that these type of technology tools, used appropriately and with the necessary precautions, can certainly contribute to an improvement in medical training processes.

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