Virtual reality application applied to biomedical models reconstructed from CT scanning

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ABSTRACT

Virtual reality-simulated environments have been used for training for more than 40 years. In recent years, an active development of 3D technologies dealing with medical training, planning and guidance has become an increasingly important area of interest in both research and health-care. Moreover, surgery planning and diagnosis using virtual reality (VR) technology has received much attention. User studies show that the method is both effective and easy to use.

The purpose of this paper is to present a VR application based on three-dimensional (3-D) surface reconstruction CT imaging for surgical planning and simulation. We propose an interactive tool to improve observation before surgery and increase diagnosis efficiency through virtual reality. This tool allows to obtain a more accurate representation comparing with current technology, such as CT or MRI vision. This cost-effective solution can be easily adopted in any hospital for daily use.

Keywords
Virtual reality (VR) · CT scanning · Biomedical models.

1. OBJECTIVES

The aim of the study is to describe the method that can build a three-dimensional (3D) high-resolution model using DICOM images from CT/MRI and export them to create a virtual environment that improves medical knowledge. Also establishing an interactive environment between the user and images based on virtual reality. Another objective is to build an easy and effective tool suitable to be disseminated.

2. METHODOLOGY

Functional requirements required in the app are:

1. The application must allow users to move and rotate the reconstructed model facilitating zoom in and out simply pressing buttons.
2. The application should play model rotation animations for easy viewing from different points of view.
3. Layers will have to show different human tissues separately.
4. Some application settings may be controlled by the user, such as speed of movement, brightness and screen contrast.

In order to generate a 3D virtual reality model and animations, two types of software are required; firstly, 3D reconstruction software that translate the

DICOM (digital imaging and communications in medicine) files from CT/MRI scans into a 3D CAD files (. STL or .OBJ), and secondly Unity 3D or similar to create a virtual reality environment compatible for Oculus Rift glasses.
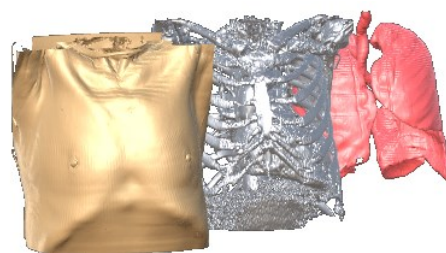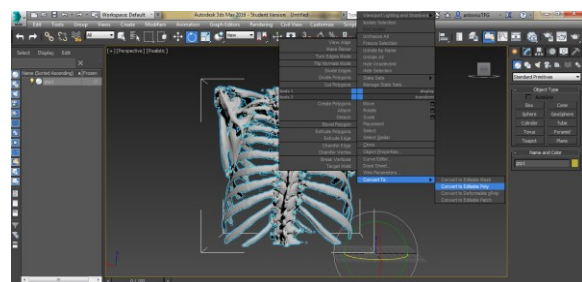

Figure 1. Modelling software 3D Studio Max.

There are many 3D reconstruction software options, free open-source, such as 3D Slicer or InVesalius and 3D professional software like Mimics, 3D Doctor or ScanIP. In all instances the working process is similar. A region of interest (ROI) must be selected and then use threshold and segmentation function to define the tissue to reconstruct. STL (Standard tessellation language) export 3D file is one of the most used. InVesalius was selected as development tool after analyzing other alternatives. It is a free software (GNU GPL 2) than generates easily and quickly 3D medical imaging reconstruction based on a sequence of 2D DICOM files acquired with CT or MRI equipment. The 3D reconstruction models can be save as STL format to its export to other 3D CAD software like Unity 3D or 3D Studio Max (Table 1).

When the desired models meet the required characteristics, they are brought to a development platform (Unity3D), allowing visualization of the object in a more interactive environment where analysis functions allow to provide more information, such as increase areas of interest, rotate the model, select different layers, etc., giving a more realistic and simple vision.

Software	Company	Free	OS platform
3D Slicer	Surgical Planning Laboratory	Yes	W,M
Osirix	Pixmeo	Yes	M
MITK	German Cancer Research Centre	Yes	W,M
MIPAV	NIH CIT	Yes	W,M
InVesalius	CTI	Yes	W,M
MeVisLab	MeVis Medical Solutions AG	Yes	W,M
3D Doctor	Able Software	No	W
Amira/Avizo	FEI Visualization Science Group	No	W,M
Mimics	Materialise NV	No	W,M
ScanIP	Simpleware	No	W
VoXim	IVS Technology	No	W
Dolphin Imaging 3D	Dolphin Imaging and Management	No	W
Threshold/segmentation and Export STL included in all software STL, Standard tessellation language; OS, operating system; W, Windows OS; M, Mac OS.			

Table 1. Software comparison

Surgical preparation with virtual reality may represent a more cost-effective and efficient alternative. Virtual reality training improves operating performance. The use of VR surgical simulation to train skills and reduce error risk in the OR has been applied over the last years. User studies show that the system is both effective and easy to use.

In Figure1, we can see the main menu, with different options to select layers, split layers, and sectioning. There are also available buttons to zoom in / out and rotate, both vertically and horizontally.
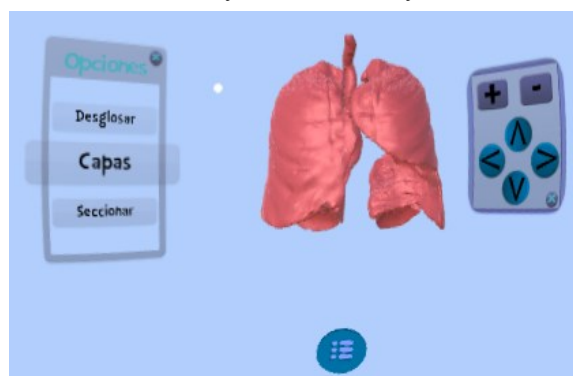

Figure 2. Modelling software 3D Studio Max.

Models can be animated and displayed in three different layers.

Three buttons were created to break down (divide the object into parts), create layers (define different tissues) or section (cut model) (Figure 2).

Options rotate and zoom are controlled. Speed and Brightness adjustments have also been taken into account in the application.

The user is able to select options moving the pointer with his own head. Thus, there is no need to use input devices.

3. RESULTS

Surgical preparation or diagnosis with virtual reality may represent a more cost-effective and efficient alternative. Virtual reality training improves operating performance. The use of VR to train skills and reduce error risk in the OR has been applied over the last years. User studies show that the system is both effective and easy to use.

At this point, the app should be tested in the hospitals that are collaborating with our university. Specifically, it will be tested in minimally invasive surgery procedures such as vertebro- and kypho-plasty in a University Hospital. This app is important to reveal the different microstructural features of different vertebra (sacral, lumbar, etc.) in order to provide specific and individual solutions in

accordance to the actual state of the osteoporotic vertebra that is going to be infiltrated by bone cement. This approach will serve to optimize both the instrumental and the surgical procedure.

4. CONCLUSIONS

This process can be applied and should assist future authors to improve similar experiences. This application will be available for different platforms such as Android, iOS and Windows, so it's possible to use it on different devices. The cost-effective solution proposed here can be easily adopted in hospitals.

5. REFERENCES

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