

# TEACHING HUMAN BODY STRUCTURES USING VIRTUAL REALITY

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**Abstract** — *Virtual reality can help medicine learning and teaching in biomedical fields. This paper presents three interactive visualization programs for human structures identification: the virtual woman pelvis, the virtual man head and virtual woman heart. The goal is allow an immersive visualization and exploration of the human body anatomy sticking out its main structures. The virtual woman pelvis shows an internal visualization of the female pelvic region with three layers of details: external viewing, skeleton viewing and bone marrow viewing. The virtual man head has as goal to provide a study of some structures found in the human head, as the skin, the facial muscles, the cranial bones and the brain. The system includes the identification of each structure and allows a partial dissection from the skin to the brain. Nowadays, the system offers stereoscopic visualization by anaglyphs and is being updated to offer that visualization by polarized filters/glasses using the VirtWall system [11].*

**Index Terms** — *virtual reality, biomedical education, visualization*

## INTRODUCTION

Virtual Reality (VR) and the systems based on it have a very recent history. The main idea behind VR is to provide 3D environments where user(s) can interact with objects and with the synthetic world and feel immersed on it. For that, VR systems use specific devices to stimulate the user senses, as vision, audition and tactile [12].

Stereoscopic visualization is the more common feature found in VR systems. For this, each scene is generated from two horizontally separated points of view to imitate the eyes separation. When using a visualization device, the left and right scenes generated are observed separately by each eye providing depth perception.

## VR AND MEDICINE

In medicine, VR applications are grouped in three main sets: training, planning and assistance. Training systems use VR environments to prepare users to perform a specific procedure or allow the acquirement of abilities to perform a new technique. Planning systems are build to study a procedure to be done in a specific patient and use magnetic resonance (MR) or tomographic (CT) images of him/her to replicate the real situation. Finally, assistance systems are

used to give support to a procedure by the addition of virtual elements into a real situation.

Medical VR systems date from the 1980s and nowadays there are different medical applications available and VR has been used with significant results in many critical medical procedures [16]. Some of that procedures demands intense decision making from physicians and mistakes are not allowed.

## VR AND MEDICAL EDUCATION

The use of VR for medical or medical related fields education can improve the traditional learning methods by the addition of realistic visualization and/or manipulation of body structures.

Examples of VR based systems for medicine are the surgery and examination simulators. Their goal is provide training to allow users to acquire abilities in tools manipulation and in organs body structures during interventions. These simulators have been developed and used for eye surgery [14], bone marrow harvest [9, 10], tumor detection [3, 4], laparoscopy [13], etc.

Interactive visualization systems for medical education can be based on VR techniques too. In this case, the 3D environments present body structures and allow interactive manipulation for structures identification. The models can be acquired by CT, MR or even be based on a standard shape of the human anatomy [17].

## HUMAN BODY VIRTUAL ATLAS

The idea of a virtual atlas for the human body is not new and is possible to find different projects based on several image or model databases. Many of them provide an interactive way of visualization of the structures and some are available over the Internet, as the system presented by Kriete [7]. It system present interactive models over the Internet but without detailed structures description [5]. A good 3D atlas also available over Internet is [8], which describe all structures visualized. Other works intend to offer a detailed library of 2D images and present explanations of specific body regions [15, 6]. Traditional 2D human atlas, as [1] can either offer video animations explaining the organs functionality.

Our conception of a human body virtual atlas is very similar to others. It includes the presentation of the body structures and textual explanation, but the main difference is in the use of VR techniques to provide 3D visualization with

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stereoscopy and 3D interaction. Additionally, the system runs on low cost platforms.

## PLATFORM

The virtual atlas runs on a platform based on the VirtWall concept. The VirtWall integrates hardware and software for high-end applications and provide low cost computational systems based on conventional PCs and free domain programs [11]. However, the virtual atlas can run also in domestic PC's under Linux operational system with GNU/C compiler.

This way, the virtual atlas runs on a PC and is being developed under Linux operational system, C language and OpenGL graphical routines. The 3D models are composed and saved in ASCII mode and VRML format, which describes the points and polygons of the object.

## DEVELOPMENT

The models used are generic models of the human anatomy and were simplified using the Maya 3D modeler. Each body region is composed by three or four independent models. Once loaded together, one single multi layer 3D model is presented and allows choose of the visible layers.

The user interaction is provided by the use of keyboard and mouse to rotate and close up the body region presented. This spatial observation can be enriched by a stereoscopic view, what position the body region floating in the space, outside the monitor or screen. For this, the user can use colored glasses and a regular monitor or polarized glasses and a silver screen. Both cases allow multiple users view.

## RESULTS

At this moment two body regions were completely implemented and can be observed in 3D: the male head and the female pelvis. Both are semi-transparent representations of the human body and allow the positioning of each layer inside the others for a single model composition.

The head view system is composed by four layers of detail that represent the skin (or external view), facial muscles, cranial bones and brain. Figure 1 shows the head atlas running on our implementation of the VirtWall and Figures 2 and 3 the layers of the head model.



FIGURE 1  
THE HUMAN HEAD VIEW RUNNING IN THE VIRTWALL.

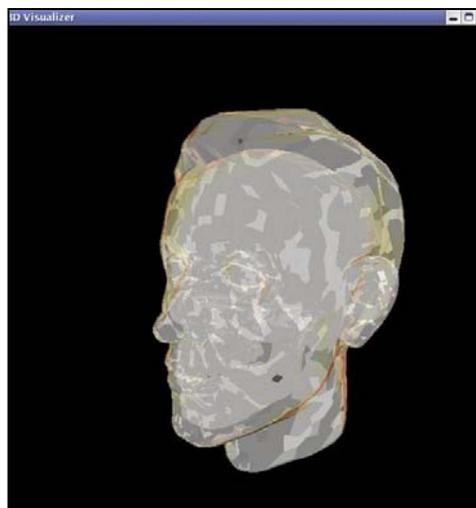


FIGURE 2  
SKIN LAYER OF THE HUMAN HEAD.

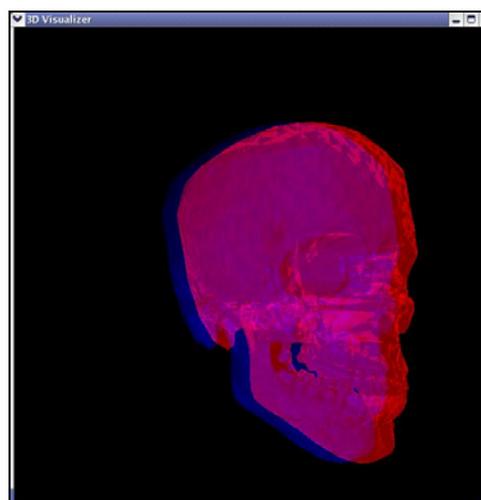


FIGURE 3  
CRANIAL BONES LAYER OF THE HUMAN HEAD IN ANAGLYPH PROJECTION.

The female pelvis is composed by three layers of detail for visualization of a female human pelvis. The user can interact with a semi-transparent representation of three layers: skin, pelvic bones and bone marrow. At this moment we are working to add a new layer for that system to include the muscles representation. Figure 4 shows the pelvis visualization running on a single PC and Figure 5 shows the system running in the VirtWall.

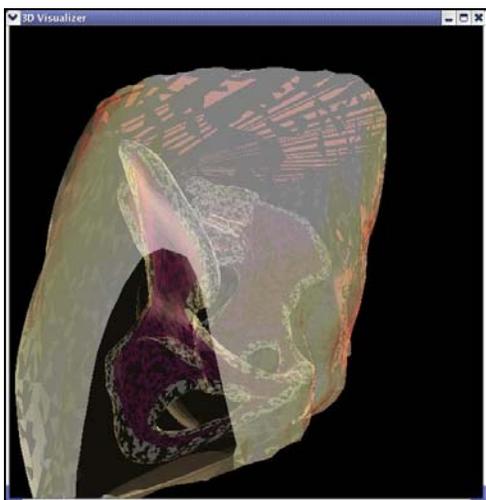


FIGURE 4

SNAPSHOT OF THE FEMALE PELVIS VIEW RUNNING ON A PC PLATFORM.  
DETAIL OF A INTERNAL VIEW OF THE MODEL.

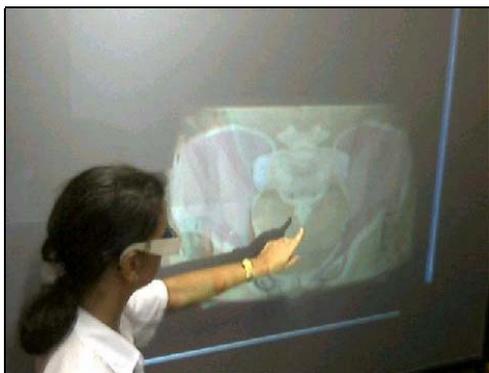


FIGURE 5

SNAPSHOT OF THE FEMALE PELVIS VIEW RUNNING ON THE VIRTWALL.

The third system, still under development, will present the human heart and should be composed by many layers to indicate each heart structure [2].

All the explanation and indication of each structure is being included in the systems. Nowadays we are finishing the implementation of the polarized view in the VirtWall to allow color in the stereoscopic scenes [11]. At the same

time, we are working on other body structures and organs models. The goal is to make available a full body anatomy atlas.

All the interaction is provided by the use of conventional devices, as mouse (rotations) and keyboard (zoom in/out and visible surfaces selection). The immersion is possible due the use of colored or polarized (in a near future) glasses, what projects the objects outside the screen plane.

## CONCLUSIONS

We presented in this paper the first results in the construction of a human body atlas. This atlas is based on VR concepts and allow immerse the user in a 3D environment to better observe the structures present in the human anatomy. Users can interact with the system using a mouse and keyboard to move and select the visible structures of the region.

Our system, if compared with others found in literature and over the Internet, presents stereoscopic visualization of the body part, allows partial dissection by the selection of visible and invisible structures and is available on a low cost (conventional PC) platform without any special device. The multiple user view and immersion is possible by the use of colored and polarized glasses. At this time there are two body regions available for interactive study and we are working on others.

We believe that a complete human body atlas in 3D will allow a better understanding of the body structures for students of medicine, biomedical fields and related fields students. A virtual and interactive atlas eliminates the necessity of plastic models or cadavers to study the human anatomy and enhance it pointing out the description of each structure.

In the future we intend to use the models to compose simulators for training in medical procedures.

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## REFERENCES

- [1] Adam Website. Online: [www.adam.com](http://www.adam.com). 2003.
- [2] Araújo, I.M.L.; Machado, L.S.; Moraes, R.M. "The Virtual Reality for Interactive Visualization of Human Body Structures". In: VI Symposium on Virtual Reality. Proceedings. 2003. pp. 413. (in Portuguese)
- [3] Burdea, G.C.; Patounakis, G.; Pospecu, V.; Weiss, R. "Virtual Reality Training for the Diagnosis of Prostate Cancer". Virtual Reality Annual International Symposium Proceedings, P.190-197. IEEE, 1999.

- [4] Dinsmore, M.; Langrana, N.; Burdea, G.; Ladeji, J. "Virtual Reality Training Simulator for Palpation of Subsurface Tumors". Virtual Reality Annual International Symposium Proceedings, p.54-60. IEEE, 1997.
- [5] Imaging Processing Lab. 2003. Online: [www.med.uni-giessen.de/ipl/vae.html](http://www.med.uni-giessen.de/ipl/vae.html).
- [6] Innerbody Website. 2003. Online: [www.innerbody.com/htm/body.html](http://www.innerbody.com/htm/body.html).
- [7] Kriete, A. et.al. "Ein interaktiv-funktioneller atlas der menschlichen Anatomie: Grundlagen für Modellierung und Simulation". In: Simulation und Visualisierung. Proceedings. SCS Europe/Ghent. 1999. pp. 215-224. (in German)
- [8] Living Cell, Tissue, human-body – Interactive Animated Atlas of Structure and function. 2003. Online: [www.bioanim.com](http://www.bioanim.com).
- [9] Machado, L.S.; Mello, A.N.; Lopes, R.D.; Odone F<sup>o</sup>, V.; Zuffo, M.K. "A Virtual Reality Simulator for Bone Marrow Harvest for Pediatric Transplant". *Studies in Health Technology and Informatics*, v.81, pp. 293-297. The Netherlands: IOS Press, 2001.
- [10] Machado, L.S., "Virtual Reality to Modeling and Simulation of Invasive Procedures in Pediatric Oncology: A Case Study in Bone Marrow Transplant". PhD Thesis. Escola Politécnica da Universidade de São Paulo, Brazil, 2003. (in Portuguese)
- [11] Moraes, R.M.; Machado, L.S.; Souza, A.C.M. "VirtWall: A Concept of Low-Cost Virtual Wall for Immersion in Virtual Reality". In: Symposium on Virtual Reality. Proceedings. 2003. p.
- [12] Netto, A.V.; Machado, L.S.; Oliveira, M.C.F. Virtual Reality, Concepts and Applications (in Portuguese). Visual Books, 2003.
- [13] Oppenheimer, P.; Weghorst, S.; Williams, L.; Ali, A.; Cain, J.; MacFarlane, M.; Sinanan, M.; Laparoscopic Surgical Simulator and Port Placement Study. *Studies in Health Technology and Informatics*, vol. 70, p.233-235. Amsterdam, IOSPress, 2000.
- [14] Peifer, J. Eye Surgery Simulation. Online: [http://www.bic.gatech.edu/bitcprojects/eye\\_sim/eye\\_surg\\_sim.html](http://www.bic.gatech.edu/bitcprojects/eye_sim/eye_surg_sim.html). 1999.
- [15] Pereira, C. "Virtual Man". Isto É Online (magazine). November, 19. Editora Abril.. 2003. Online: <http://www.zaz.com.br/istoe/> (in Portuguese)
- [16] Robb, R.A. "The Virtualization of Medicine: A Decade of Pitfalls and Progress". *Studies in Health Technology and Informatics*, vol. 85, p.1-7. Amsterdam, IOSPress, 2003.
- [17] Schubert R. et. al. "Interactive Volume Visualization Using Intelligent Movies". *Studies in Health Technology and Informatics*, vol. 62, p.321-327. Amsterdam, IOSPress, 1999.