Wiimote-Controlled Stereoscopic MRI Visualization With Sonic Augmentation

Jonathan Lam[1], Christopher Collins[2], Bill Kapralos[1,3],
Andrew Hogue[1,3] and Miguel A. Garcia-Ruiz[4]
[1]Faculty of Business and Information Technology, [2]Faculty of Science,
[3]Health Education Technology Research Unit.
University of Ontario Institute of Technology. 2000 Simcoe Street North, Oshawa, Canada. L1H 7K4.
[4]College of Telematics University of Colima Ave. Universidad 333, Colima, 28040, Mexico
{jonathan.lam, christopher.collins, bill.kapralos, andrew.hogue}@uoit.ca mgarcia@ucol.mx

ABSTRACT

Medical imaging techniques such as Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) that produce three-dimensional views of the body have become commonplace. In this paper we provide a preliminary overview of an MRI stereoscopic visualization system that we have recently begun developing. Stereoscopic visualization augmented with auditory cues (sonification) and a Nintendo Wii remote controller ("Wiimote") allows the user to easily manipulate the visualization.

Categories and Subject Descriptors

I.4.10 [**Image Processing and Computer Vision**]: Image Representation—*Volumetric.*

Keywords

Magnetic resonance imaging (MRI), visualization, sonification, Wiimote

1. INTRODUCTION

Medical imaging, or the use of imaging-based techniques to generate and process images of the human body (or parts of the human body) is an integral component in clinical decision making. Recently, techniques such as Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) which produce three-dimensional views of the human body (or parts of the body) have become commonplace, aiding in the diagnoses of a number of diseases and in surgical planning as they provides surgeons and medical experts with internal views of the patient's body prior to the surgery. This reduces the likelihood of damaging organs and other parts of the body. Such techniques reconstruct a three-dimensional view ("volume") using a series of "slicing images" and ultimately require visualization and analysis of three-dimensional (3D) objects in order to transform, and view data as images in order to allow an understanding and insight into the generated data (i.e., to make sense of the large data the techniques generate) [2]. Visualization technology makes it possible to provide a multimedia tool for medical instruction, diagnosis, and research, whereby the structure and function of human organs are explored interactively [2].

Recently we have begun development of a dynamic MRI stereoscopic visualization system whereby the presented visuals are augmented with auditory cues (sonification) and a Nintendo Wii remote ("Wiimote") controller, allows the user to easily manipulate the visualization. In this paper we describe our work in progress and present a preliminary overview of the system.

2. OVERVIEW

The system itself is comprised of three components: i) stereoscopic visualization, ii) sonification, and iii) interaction (input/output). The details of each component are provided below.

2.1 Stereoscopic Visualization

Currently, visualization consists of rendering the three-dimensional MRI data of either single or multiple two-dimensional slices of data 3D (e.g., "voxels"); the data can be viewed as individual slices on any of the three planes (sagittal, coronal, and transverse). Figure 1 provides a sample rendering across each of the three planes. The data to construct the renderings illustrated in Figure 1 was obtained from the 2010 IEEE Visualization Contest and consists of two data sets: i) an MRI brain scan of a patient with an inter-cerebral metathesis, and ii) an MRI and CT brain scan of another patient with a glioma [6] (in this work, only the MRI dataset is being used). To ensure real-time rendering rates, the system dynamically adjusts the level of detail based on the zoom level. Stereoscopic rendering is accomplished using the OpenGL graphics API and displayed using a passive stereo dual projector system.

2.2 Sonification

Auditory display is the use of non-speech sound to present information, and sonification is a specific type of auditory display that refers to the mapping of data onto parameters of non-verbal sound, such as pitch, volume, timbre, dura-

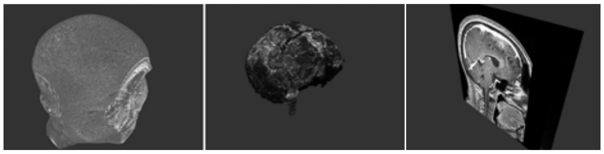

Figure 1: Varying viewing modes. Clockwise from top-left: filtered views of the brain, and tumour, and sagittal slicing view with no filter.

tion, frequency, amplitude, and rhythm in a computer interface [4]. We are currently examining a number of mappings between MRI data and auditory parameters to determine whether the presence of sonification augments visualization in a meaningful manner. The goal is to provide auditory feedback regarding occluded voxel data that is not visible to the user. Although sonification has been successfully applied for analyzing biomedical data (e.g., sonification of electroencephalogram data [3]), research on sonification of multivariate image analysis (including MRI data) has only recently begun [5]. Wakefield *et al.* [1] are developing and testing a three-dimensional virtual environment that provides multi-modal interaction using biofeedback data and claim that this environment allows real-time sonification and visualization of the user's brain activity using biosignal sensors, including user interaction with static audio-visual functional MRI data.

Sonification enables us to provide multi-modal feedback so the user can focus on visualizing muscle-tissue/bone while planning the surgery and still be able to have knowledge of the location/presence of tumor cells. For example, voxels corresponding to a region of interest, such as a brain tumor, may be obscured by the voxels corresponding to the brain and skull. However, by mapping the regions representing the tumor map to a particular pure tone whose frequency and/or intensity varies relative to the position of the on screen cursor (whose position can be calculated using ray-casting), the user can be alerted to the presence of a tumor even when it is obscured. This technique may be applied to multiple regions of interest, each emitting a unique sound allowing each region of interest to be clearly distinguished. Sonification can reduce the frequent need of switching between rendering modes to analyze multiple data sets. In addition, it may be a useful tool in neurosurgical planning as it can be used for surgical planning.

2.3 Interaction

Interaction is accomplished using Nintendo's Wii remote-controller ("Wiimote") whereby a user is able to interact with and manipulate objects in the virtual 3D world using gesture recognition and pointing. For example, the user can orient the rendered MRI data in order to view it from different angles. The Wiimote "face buttons" allow the user to toggle between different rendering modes (e.g., rendering the entire data set, a single slice of data on one of the three planes, or a region of interest such as a tumor). Using the Wiimote's infrared pointing capabilities, the user is able to control a cursor which, as previously described, is used in conjunction with the sonification system. This gives the user full control over the orientation of the MRI data and can enable a simple "point-to-zoom" gesture that is both intuitive and usable in this context.

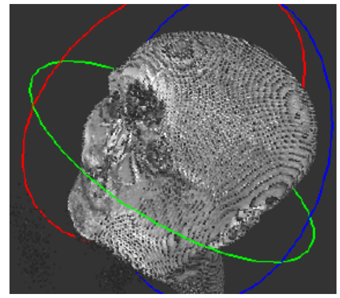

Figure 2: Using the Wiimote to orient MRI voxel data.

3. CONCLUSIONS

This paper has described preliminary details regarding an ongoing project that seeks the development of a system for MRI visualization that is augmented with auditory information in order to provide a quick overview of occluded information not visible to the user. We are planning to add haptic feedback to the system to enable the user to be presented with three display modalities and study the interaction between sonification, visualization, and haptic feedback along with their effectiveness to isolate and analyze interesting regions in the MRI data. In addition to viewing MRI data, we are confident the multi-modal interaction techniques developed here will be transferable to other domains including virtual reality and gaming.

4. ACKNOWLEDGMENTS

The financial support of the National Science and Engineering Research Council of Canada (NSERC) is gratefull acknowledged. The MRI dataset used to render the images shown in Figures 1 and 2 is courtesy of Professor B. Terwey, Klinikum Mitte, Bremen, Germany.

5. REFERENCES

[1] G. W. et al. The allobrain: An interactive stereographic, 3D audio immersive environment. In *Proc. CHI 2008*, pages 268–271, Florence, Italy, April 5-10 2008.

[2] J. L. et al. Study and application of medical image visualization technology. In V. G. Duffy, editor, *Lecture Notes in Computer Science (4561)*, pages 668–677. Springer-Verlag, 2007.

[3] T. Hermann, P. Meinicke, H. Bekel, and H. Ritter. Sonifications for eeg data analysis. In *Proc. ICAD 2002*, pages 268–271, Kyoto, Japan, July 2-5 2002.

[4] G. Kramer. An introduction to auditory display. In G. Kramer, editor, *Auditory Display: Sonification, Audification, and Auditory Interfaces*, pages 1–77. Addison-Wesley, Reading, MA. USA, 1994.

[5] T. W. Nattkemper. Multivariate image analysis in biomedicine. *Journal of Biomedical Informatics*, 37(5):380–391, 2004.

[6] B. Terwey. MRI dataset from the IEEE Visualization Contest 2010. http://viscontest.sdsc.edu/2010/data.html, 2010.