A Multimodal Medical Sculptor

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Abstract. This work introduces the design of a multimodal application allowing the user to sculpt 3D medical data. We are considering interaction modalities such as blowing and gesture to segment the 3D data visualized. Besides we present a multimodal platform for the rapid development of multimodal interactive systems as a central tool for an iterative user-centered design process.

Keywords: multimodal interaction, medical application, 3D interaction, OpenInterface.

1 Introduction

The growing interest in multimodal interface design is inspired largely by the goal of supporting more transparent, flexible, efficient, and powerfully expressive means of human-computer interaction. Multimodal interfaces are expected to be easier to learn and use, and are preferred by users for many applications. Such systems also have the potential to function in a more robust and stable manner than unimodal recognition systems involving a single recognition-based technology, such as speech, pen, or vision [1].

Likewise, the ratio of users' multimodal interaction increased significantly as the tasks became more difficult. Analysis of users' task-critical errors and response latencies across task difficulty levels increased systematically and significantly as well, corroborating the manipulation of cognitive processing load [1]. For these reasons in this work we have applied multimodal interaction to medical applications. Tasks requiring manual segmentation of occluded organs (such as liver segmentation) is a difficulty and loaded task. In this case the whole user interaction focus might be placed on the task space. It means that using the same interaction paradigm and providing interaction techniques that avoid changes in the user interaction focus could facilitate and increase the task performance. In next sections this work introduces the design of a multimodal application allowing the user to sculpt 3D medical data. We are considering interaction modalities such as blowing and gesture to segment the 3D data visualized. Besides we present a multimodal platform for the rapid development of multimodal interactive systems as a central tool for an iterative user-centered design process.

2 System Overview

To develop a multimodal system is necessary to have interaction modalities and mechanisms for modalities fusion. An interaction modality can be defined as the composition of a language plus a device. For instance <blowing + microphone> and <gesturing in the physical space + webcam>. Mechanisms for modalitites fusion inform the manner these modalities will be combined. For instance some fusion mechanisms such as redundancy, equivalence, complementary and assignment are described in [2]. In our implementation the two interaction modalities are complementary i.e. the user should blow in the microphone and move the marker in front of the webcam to inform the multimodal command *erase* + *position* to the 3D medical sculptor (see Figure 1). However the gesture modality alone is capable to produce the movement of the selected virtual hand metaphor in the medical viewer.

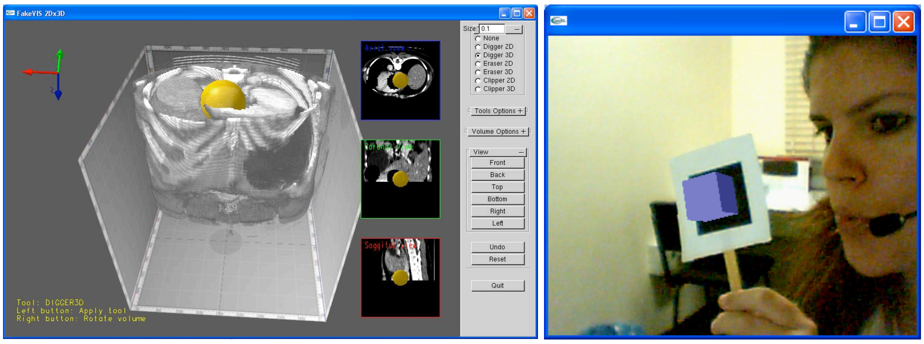

Figure 1. Interaction components of the multimodal medical sculptor.

2.1 OpenInterface

OpenInterface[1] is an open source platform for the rapid development of multimodal interactive systems as a central tool for an iterative user-centered design process. It is a component-based architecture allowing the integration of heterogeneous native interaction components as well as the connection between components to develop new multimodal application. Each component is registered into OpenInterface Platform using the Component Interface Description Language (CIDL described in XML). The registered components properties are used to compose the execution pipeline of the multimodal application. This execution pipeline is sent to the OpenInterface Kernel (C/C++) to run the application.

[1] http://www.openinterface.org

2.2 Interaction Components

To develop our multimodal medical sculptor we integrated into the OpenInterface platform three components for interaction: one component for noise detection, one for gesture detection and one for medical visualization (i.e. the sculptor) described as following.

Medical Sculptor Component

This component provides a set of tools for volume sculpting. These tools were described by [4] and had used three-dimensional geometries associated to the metaphor of the virtual hand [3]. The virtual hand is represented as different cursors and its formats reproduce in three dimensions the performance areas on the volume 3D. The sculpting tools are Rubber 3D, Digger 3D and Clipper 3D.

The Eraser 3D tool eliminates voxels inside a virtual cylinder. The virtual cylinder consists of an infinite line and a circular region around this line. This region is calculated using a projection plane, a 2D point P on this plane and the radius r of the tool (Figure 2a). The selection of a voxel for elimination is done by first projecting its center into the projection plane. For each projected center, a distance d to P is computed. Every voxel with $d < r$ is removed.

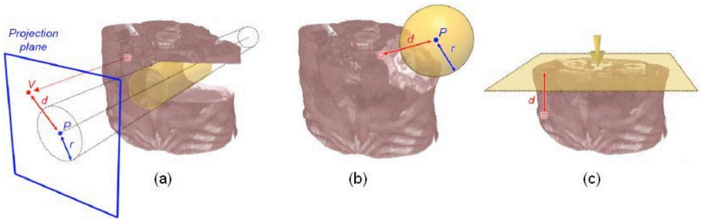

Figure 2. (a) Eraser 3D (b) Digger 3D (c) Clipper 3D.

Another tool, the Digger 3D (Figure 2b) eliminates voxels in the interior of a virtual sphere. The region is defined using a 3D point P and a ray r specified by the user. The selection of a voxel for removal is done calculating the Euclidean 3D distance d of its center to P. The voxel is removed if $d < r$. The Clipper 3D tool (Figure 2c) eliminates voxels situated above of a plane defined by the user. The selection of a voxel for removal is made by calculating the minimal distance of its center to the clipping plane. The distance is calculated by the dot product of the voxel coordinates and the plane coefficients. Voxel is eliminated in case the distance is negative.

Additionally to 2D and 3D mouse interactions described in [4] we added new multimodal interaction. Now we can move the cursor position with gesture interactions and apply the tools using noise detection.

Noise Detector Component
The NoiseDetector component provides a single command that can be activated using a microphone. The technique is simple and doesn't require much processing. The component takes small sound buffers from the microphone and when it detects a sufficient noise, it calls a callback function passing *true* (otherwise, it passes *false*). In this implementation, it passes *true* when more than 40% of the samples (absolute value) are greater than 0.8 (their maximum value is 1.0). The best way to generate such noise is by blowing directly into the microphone. Each time the noise is detected a single event is sent to the medical viewer resulting the erase interaction at the position indicated by the gesture detector component.

Gesture Detector Component
The Gesture Detector component uses the ARToolkit[2] library to capture the 3D user position in the physical space. We are using a webcam while the user is moving a printed marker in the physical space to control the 3D medical viewer. Each time this component detects the marker in the video image its position is sent to the medical viewer component resulting the translation (x, y, z axis) operation of the selected virtual hand metaphor.

3 Conclusion and Future Works

We presented in this work a multimodal medical sculptor including three interaction components: gestures detector, noise detector and the medical viewer and sculptor. The OpenInterface platform was used to connect these components. Next step will take account the multimodal user interaction evaluation compared to the interaction modes using 2D and 3D mouse as described in previous work [4].

Acknowledgments. The authors would like to thank CNPq - Brazil.

References

1. Oviatt, S. L. Multimodal interfaces. In The Human-Computer Interaction Handbook: Fundamentals, Evolving Technologies and Emerging Applications, J. Jacko and A. Sears, Eds. Lawrence Erlbaum Assoc., Mahwah, NJ, 2003, chap.14, 286-304.
2. Bouchet, J., Nigay, L., and Ganille, T. ICARE software components for rapidly developing multimodal interfaces. Proceedings of the 6th international conference on Multimodal interfaces ICMI 2004, ACM Press (2004), 251 – 258.
3. Bowman, D. A., and Hodges, L. F. 1999. Formalizing the design, evaluation, and application of interaction techniques for immersive virtual environments. Journal of Visual Languages and Computing 10, 1, 37–53.

[2] http://sourceforge.net/projects/artoolkit/

4. Huff, R.; Dietrich, C.A.; Nedel, L.P.; Freitas, C.M.D.S. and Olabarriaga, S.D. Erasing, Digging and Clipping in Volumetric Datasets with One or Two Hands VRCIA 2006 (ACM International Conference on Virtual Reality Continuum and Its Applications), 2006, 271-278