Poster: Exploring 3D Volumetric Medical Data using Mobile Devices

Teddy Seyed   Francisco Marinho Rodrigues   Frank Maurer   Anthony Tang

Department of Computer Science, University of Calgary

ABSTRACT

Medical imaging specialists have traditionally used keyboard and mouse based techniques and interfaces for examining both 2D and 3D medical images, but with newer imaging technologies resulting in significantly larger volumes of 3D medical images, these techniques that have become increasingly cumbersome for imaging specialists. To replace traditional techniques, using mobile devices present an effective means for navigating and exploring complex 3D medical data sets, as they provide increased fluidity and flexibility, leveraging people's existing skills with tangible objects. 3D interactions using mobile devices may provide benefit for imaging specialists, but little is known about using these interactions in the medical imaging domain. In this paper, we explore the design of 3D interaction techniques using mobile devices and preliminary feedback from imaging specialists suggests that these interactions may be a viable solution for the medical imaging domain.

Keywords: Mobile devices, medical imaging, isometric interactions, isotonic interactions, 3D navigation.

Index Terms: H.5.2 [Information interfaces and presentation]: User Interfaces— Input Devices and Strategies, Interaction Styles

1 INTRODUCTION AND MOTIVATION

Imaging techniques such as magnetic resonance imaging (MRI), computed tomography (CT) and X-Rays are now commonplace tools for medical investigations by imaging specialists (such as radiologists) [1]. These medical investigations ultimately provide evidence for important medical decisions, such as choice of treatment or avoiding risky surgeries for patients.

Many of the imaging techniques (such as MRI and CT) produce multiple 2D cross-sections (or volumetric slices) of scanned tissue, and consequently, imaging specialists examine these images in "abstract 2D" [2], where a human body is examined by considering these 2D cross-sections and mentally reconstructed to fit anatomical structures [3]. Traditionally, imaging specialists have preferred this 2D visualization approach with keyboard and mouse-based interfaces over 3D visualizations because 3D interaction techniques with keyboard and mouse based interfaces were less practical than 2D ones, as the 3D images were hard to interpret on flat, 2D screens [3]. 2D navigation tools are still currently preferred in medical imaging [4], despite the increasing volume of images and need for 3D visualizations and interactions.

Because a proper evaluation of 3D volumetric data in medical imaging requires 3D visualization and interactions, there is significant prior work into 3D interaction techniques to draw upon when designing interactions for navigation and manipulation of 3D

*email: {teddy.seyed, fm.rodrigues, frank.maurer, tonyt} @ucalgary.ca

IEEE Symposium on 3D User Interfaces 2014
29 - 30 March, Minneapolis, Minnesota, USA
978-1-4799-3624-3/14/$31.00 ©2014 IEEE

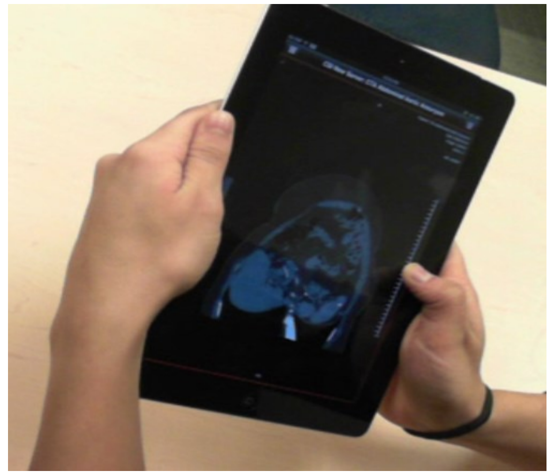

Figure 1: An imaging specialist exploring volumetric medical data by positioning an iPad in physical space and tilting an iPad.

visualizations. However, the fundamental challenge is that conventional interaction devices are inefficient/inappropriate for navigating large 3D data sets. Techniques in the research literature to address this challenge include virtual reality [5] and digital tabletops [6]. The difficulty with many of these techniques is that in the context of medical imaging, some of the input mechanisms may be obtrusive (e.g. virtual reality and its associated hardware) or require additional training to be properly utilized [7]. These are all impediments to the medical imaging domain, as imaging specialists interpret information rapidly and need to focus on diagnosis tasks, instead of figuring out an interface or input mechanism.

In recent years, several authors have argued that users need interaction techniques that can leverage their existing physical and spatial reasoning skills (e.g. [8]). These techniques typically leverage tangible objects as an interaction mechanism, where moving the object in physical space allows one to navigate a viewport in virtual space. In this work, we apply these ideas to the domain of medical imaging. As illustrated in Figure 1, we use a free-moving tablet, where the tablet shows reconstituted 2D slices of the 3D dataset (i.e. these slices are composited from multiple CT or MRI scan slices). Our preliminary explorations are discussed in this work, and present new requirements for such tangible interaction techniques for medical data.

2 TECHNOLOGY PROBES

To address some of the challenges the medical imaging domain introduces to 3D interactions, we utilized a technology probe approach [15], developing two simplistic probes each utilizing a different 3D interaction technique. This allowed for a preliminary examination of different 3D interaction types as well as a means of stimulating discussions with medical imaging specialists. The technology probe approach argues that inspiration and information is received through the use of simple probes and through them, both domain experts and designers are challenged to think of new ways or new technologies that address specific design problems.

We developed two technology probes with different 3D interactions: a spatial *position* based probe, which draws upon the metaphor of utilizing a mouse, but in 3D space and a *rate-based* probe, which draws upon the metaphor of using an airplane joystick and tilting in a 3D space. In both probes, the interactions specifically manipulate the view around a fixed center point of a 3D volume, and touched-based input (e.g. pinch-to-zoom and panning) manipulates the scale of the 3D volume. These probes were built by modifying an existing mobile iPad application provided by a local medical imaging company and incorporated gyroscopic and accelerometer information that was then mapped to arbitrary 3D medical volumes.

The deliberate choice was made to use a tablet device (and it's built in technologies), as a majority of imaging specialists already use tablet devices comfortably, albeit not necessarily for medical imaging tasks.

3 Preliminary Design Sessions

In our preliminary design sessions, we were interested in not only comparing the 3D interaction techniques through the technology probes, but also how medical imaging specialists would respond to these techniques. If they felt a better sense of understanding of an arbitrary 3D medical dataset for medical imaging professionals and they create informed decisions quicker, then they provide value for the domain. The design sessions focused primarily on qualitative feedback, as we asked three highly trained medical imaging specialists to perform simple navigation tasks utilizing each of the 3D interaction techniques.

4 Discussion

The preliminary design sessions with medical-imaging specialists revealed several insights into 3D interactions for the medical imaging domain that weren't previously discussed in the literature. In our sessions, we confirmed prior results from Zhai [9], where it was found that position-based interaction techniques were better suited for users than rate-based techniques. Prior work however, especially in the context of medical imaging, hasn't shown that rate-based techniques still provide value. This suggests the need for hybrid interaction modes (a combination of position-based and rate-based techniques) that allow medical imaging specialists to perform a variety of different tasks. For example, with a hybrid interaction technique, they would be able to easily explore a 3D volumetric dataset quickly and then be able to perform more detailed exploration, as mentioned by several of the medical-imaging specialists.

An important consideration for designing 3D interaction techniques arose when observing the use of the probes and examining feedback from the imaging-specialists, as "Navigation" and "Manipulation" 3D tasks were performed in discrete steps. This discreteness may arise from the familiarity of 2D interaction techniques and interfaces, which follow these steps discretely. Maintaining some familiarity to these techniques may also impact the learnability of future 3D interaction techniques and interfaces. This implies that future 3D interaction designs in the medical domain need to take into account the interactions that medical-imaging specialists are familiar with, as noted by one of the imaging-specialists in the study. Significant amounts of research into 3D interactions have focused on shifting away from 2D input techniques to create new interactions, but the medical imaging domain seems to suggest that those techniques still need to be considered.

One particularly interesting comment made by an imaging specialist regarding context and the impact new interactions have, provides an interesting backdrop to the considerations of designing 3D interactions in the medical-imaging domain. A large majority of the 3D interactions, techniques or prototypes that have been created or adapted for medical imaging in the research literature haven't fully considered their effect on the entire chain. For instance, some work only focuses on solely the physician without considering the medical images before or after a physician uses it. Having a disconnected chain when researching and developing novel 3D interaction techniques can hinder their adoption, not only in the medical-imaging domain, but also other domains that require 3D interactions.

5 Conclusion

Undoubtedly, medical imaging plays a crucial role in medical treatment. The vast amounts of volumetric 3D data that newer imaging techniques have created, has resulted in opportunities to improve navigation and exploration for medical-imaging specialists, who are tasked with making sense of the data. The research presented, serves as an early starting point for designing future 3D interaction techniques that take into account the practices of medical-imaging specialists. The technology probes were designed in collaboration with the medical-imaging domain and served to identify and learn, moving forward. However, as discussed, other aspects of the domain need to be considered, particularly the familiarity imaging-specialists have with 2D input and technologies.

Acknowledgements

We would like to thank our colleagues in both the ASE lab and the iLab at the University of Calgary, as well as Calgary Scientific Inc. for their support. This research was partially funded by the NSERC SurfNet Research Network.

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