Assessment of immersive medical virtual reality visualization using 3D Slicer

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INTRODUCTION: Virtual reality (VR) systems typically consist of a tracked head-mounted-display (HMD), tracking stations, and tracked controllers, which immerses users in a virtual environment. The applications for these systems range from simulation training to entertainment. Recently, applications in the medical field have also been explored. For instance, VR systems are showing promise as training simulators for complex medical procedures [1]. Our aim was to extend 3D slicer, an open-source medical image analysis and visualization platform, with VR capabilities and to evaluate 3D Slicer as a VR platform as well as the feasibility of using VR for the medical field.

METHODS: The requirements for the VR extension are: intuitive controls for seamless navigation of virtual environments, maintaining high performance rendering to prevent motion sickness, convenient import and visualization of medical imaging data, and the platform must be open-source with a permissive license. The platform extends 3D Slicer which provides many tools for medical imaging and visualization such as image segmentation, surface modeling, and volume rendering [2].

We propose to assess the feasibility of using VR for navigating and comprehending 3D renderings by having participants complete tasks that require them to maneuver within complex virtual scenes. In this experiment, we will compare the stereoscopic display of VR to viewing 3D renderings on a 2D monitor. Participants must complete two tasks using both VR and mouse-monitor navigation. Each scene is designed to require constant reorientation. The first task consists of 8 hollow cubes with coloured integers, 1 to 8, inside the cube. The cubes have a small hole in one of the sides, which participants will navigate to, in order to identify the integer. The task is complete once they identify the colour of each of the 8 integers. The second task is a rendering of a brachytherapy phantom with just the catheters displayed. The catheters, on one side, are labeled with letters A to E, and on the other side, integers 1-5. The goal of this task is to correctly map each letter to the corresponding integer. This task was designed users to navigate the scene to find better angles of view, as the catheter renderings intertwine at some sections, making it hard to follow from just one angle. Each task is done twice – once using mouse-monitor navigation, and once using VR navigation with the HTC Vive HMD and controllers. For each task, we created slightly modified scenes for the two modalities to avoid bias in the results. We had participants complete one task with both modalities before introducing the next task. The tasks are timed until completion.

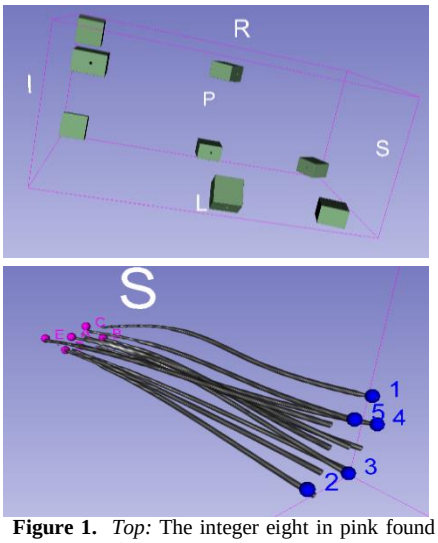

Figure 1. *Top:* The integer eight in pink found inside one of the eight cubes. *Center:* Eight cubes created by the Segment Editor tool in 3D Slicer. *Bottom:* Volume renderings of bracytherapy phantom using the Volume Rendering tool in 3D Slicer with only the catheters visualized.

RESULTS: 5 participants conducted our experiments. Results show a significant decrease in total time needed to complete the tasks using VR. For the box task, the mean completion time using mouse-monitor was 7 minutes and 52 seconds—compared to 4 minutes and 24 seconds using VR. Furthermore, the mean number of revisits (where participants navigated to a cube they had already identified) for mouse-monitor navigation was greater than VR navigation – 11.6 revisits vs 5, respectively. This result is corroborated in the catheter task. The mean completion time using mouse-monitor was 3 minutes and 57 seconds, compared to VR's 2 minutes and 37 seconds.

CONCLUSION: Our work extended 3D Slicer with VR capabilities. Users are able to create 3D medical scenes and visualize them with ease. Further, our experiment results demonstrate the usefulness of the intuitive controls of VR navigation for medical scenes in comparison to mouse-monitor navigation.

REFRENCES: [1] N. E. Seymour et al., *Annals of Surgery*, 2002 [2] A. Fedorov et al., *Magnetic Resonance Imaging*, 2012

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