Intuitive Interface For MR Scan Plane Prescription

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Introduction: Conventional user interfaces for MR scan plane prescription make use of the mouse and keyboard as input devices. Specifying an oblique orientation for a scan plane through the reference volume using such interfaces requires an indirect software-based approach involving a combination of actions that must be learned by the user. The use of 3D input devices has already shown considerable promise in improving user experience and task performance towards a variety of data visualization applications [1, 2, 3, 4]. We propose a new 3D interface model that aims to provide an intuitive means of prescribing a scan plane through a reference volume in MR. The model uses a hand-held rectangular panel that is manipulated by the user in free space, resulting in corresponding manipulations of the prescribed plane through the volume. The model aims to reduce the cognitive demand associated with scan plane prescription by taking advantage of the proprioceptive and motor capabilities of the user. We describe a user study in which we evaluated the effectiveness of a preliminary implementation of this interface model relative to a mouse-based interface.

Materials and Methods: We implemented the interface model using a lightweight hand-held rectangular panel that was tracked using an electromagnetic motion tracking system (Aurora, NDI). Two five degree-of-freedom sensor coils were attached to opposite corner points on the panel, and a mathematical model was applied to determine the position of a third corner point using the data from the sensor coils. The position and orientation of the panel within the tracking volume was then determined, enabling the application of a mapping between the position of the panel and the position of a scan plane within the reference volume. In order to allow offline evaluation of the model, we developed a software application to allow manipulation and visualization of a cross-sectional plane in a pre-acquired DICOM dataset. The software was written in Python 2.3 using VTK 4.1 and Atamai 1.0 classes, which included support for mouse-based interactions with the cross-sectional plane. The panel interface methods were developed in C++ and the SWIG interface compiler was used to generate Python wrappers in order to add support for the interface to the visualization application. We then conducted a user study in which participants were asked to find specific targets in a DICOM volume of a specially-designed target phantom. Participants were randomly assigned to one of two groups, and each of the groups was assigned different axial and oblique targets (Fig 1) following an independent-measures design in order to eliminate the effects of target location learning by the participants. The order in which the targets were presented was based on a 4x4 Latin Square design for each group, where one dimension represented the target and the other dimension represented the four participants in the group, for a total of eight participants. The NASA Task Load Index (NASA-TLX) workload rating was used to assess workload factors of interest, including mental demand, frustration and effort. Each target acquisition was also timed in order to compare user performance using each interface.

Results: Participant responses to the NASA-TLX rating for each interface indicated lower average values for each workload factor when rating the panel interface. We found lower overall average workload values for the panel interface ($p=0.021$), and were able to identify statistically significant differences for mental demand ($p=0.041$), effort ($p=0.018$) and frustration ($p=0.010$) (Fig 2). Average completion times for axial target acquisition was comparable between the two interfaces, with no statistically significant difference observed ($p=0.195$). However, the average completion times for each oblique target acquisition were markedly lower using the panel interface ($p=0.0047$).

Discussion and Conclusions: Based upon the results from the study using the pre-acquired DICOM volume, we conclude that the use of panel interface for scan plane prescription would involve significantly less workload than the mouse-based interface, and the performance results indicate that it would be more efficient as well. The absolute mapping of the tracked panel to the scan plane requires that the user be able to save the prescribed slice when it is found, such as through a push-button on the panel, which is a straightforward implementation matter. Furthermore, the continuous tracking associated with the panel interface makes it especially appealing for use in real-time applications where the time required for scan plane prescription can be a limiting factor.

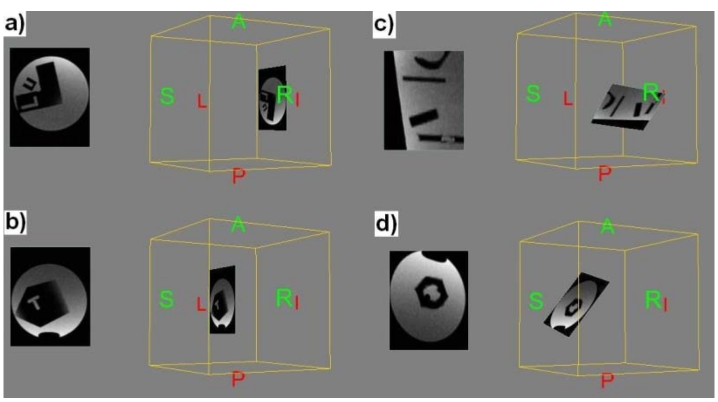

Figure 1: Axial (a and b) and oblique (c and d) targets acquired by participants

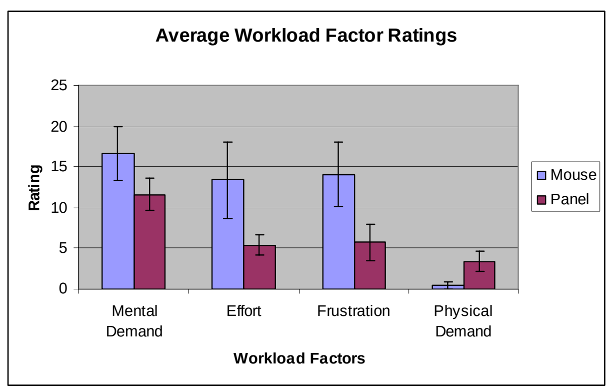

Figure 2: Average workload factor ratings for target acquisition using each interface

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