Calibration and Depth Matching Accuracy with a Table-Mounted Augmented Reality Haploscope

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Abstract

In many medical Augmented Reality (AR) applications, doctors want the ability to place a physical object, such as a needle or other medical device, at the depth indicated by a virtual object. Often, this object will be located behind an occluding surface, such as the patient's skin. In this poster we describe efforts to determine how accurately this can be done. In particular, we used a table-mounted AR haploscope to conduct two depth-matching experiments.

Figure 1 shows our AR haploscope, which was originally designed and built by Singh [2013]. We experimented with different methods of calibrating the haploscope, with the goal of being able to place virtual AR target objects in space that can be depth-matched with an accuracy that is as close as possible to physical test targets. We eventually developed a calibration method that uses two laser levels to generate vertical fans of light (Figure 1). We shoot these light fans through the AR haploscope optics, where it bounces off of the optical combiners and onto the image generators. We first set the fans parallel, in order to properly model an observer's inter-pupillary distance (IPD). Next, we cant the fans inwards, in order to model different vergence distances.

We validated this calibration with two AR depth-matching experiments. These experiments measured the effect of an occluding surface, and examined near-field reaching space distances of 38 to 48 cm. Experiment I replicated a similar experiment reported by Edwards et al [2004], and involved 10 observers in a within-subjects design. Figure 2 shows the results. Errors ranged from –5 to +3 mm when the occluder was present, –4 to +2 mm when the occluder was absent, and observers sometimes judged the virtual object to be closer to themselves after the presentation of the occluder. We can model the strong linear effect shown in Figure 2 by considering how the observers' IPD changes as they converge to different distances. Experiment II replicated Experiment I with three experienced psychophysical observers and additional replications. The results showed significant individual differences between the observers, on the order of 8 mm, and the individual results did not follow the averaged results from Experiment I.

Overall, these experiments suggest that IPD needs to be accurately modeled at each depth, and the change in IPD with vergence needs to be tracked. Our results suggest improved calibration methods, which we will validate with additional experiments. In addition, these experiments used a highly salient occluding surface, and we also intend to study the effect of occluder salience.

Acknowledgements

This material is based upon work supported by the National Science Foundation, under awards IIS-1320909 and IIS-1018413, to J. E. Swan II.

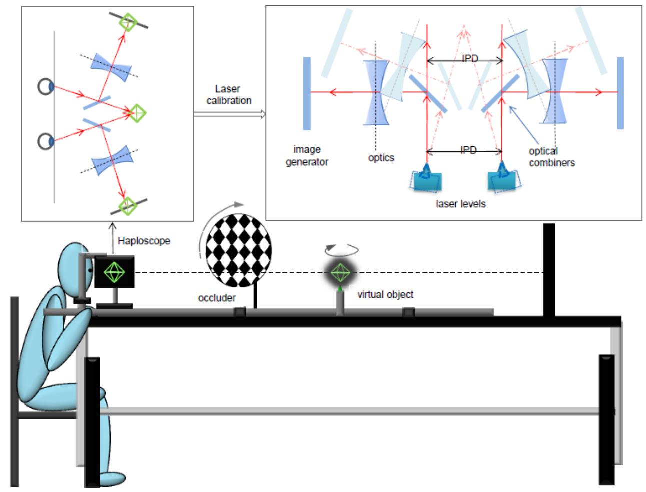

Figure 1. *The AR haploscope and calibration.*

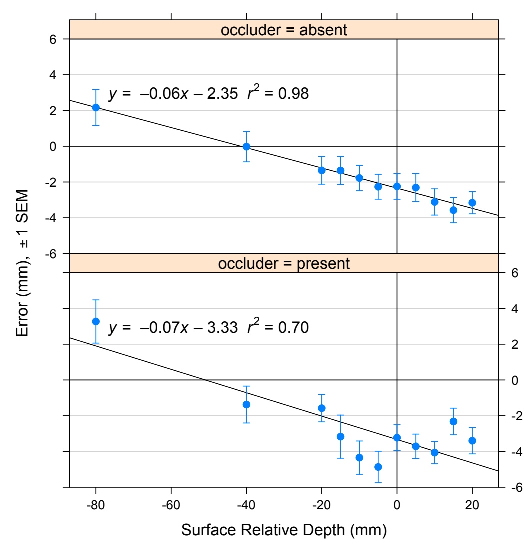

Figure 2. *Experiment I results.*

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