Depth Judgment Measures and Occluders in Near-Field Augmented Reality

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Abstract

This poster describes a tabletop-based experiment which studied two complimentary depth judgment protocols and the effect of an occluding surface on depth judgments in augmented reality (AR). The experimental setup (Figure 1) broadly replicated the setup described by Ellis and Menges [1998], and studied near-field distances between 30 and 60 centimeters. We collected data from six participants; we consider this to be a pilot study.

These distances are important for many AR applications that involve reaching and manipulating; examples include AR-assisted surgery and medical training devices, maintenance tasks, and tabletop meetings where the participants are jointly interacting and manipulating shared virtual objects in the middle of the table. Some of these tasks involve "x-ray vision", where AR users perceive objects which are located behind solid, opaque surfaces.

Ellis and Menges [1998] studied tabletop distances using a setup similar to Figure 1. They used a closed-loop perceptual matching task to examine near-field distances of 0.4 to 1.0 meters, and studied the effects of an occluding surface (the x-ray vision condition), convergence, accommodation, observer age, and monocular, biocular, and stereo AR displays. They found that monocular viewing degraded the depth judgment, and that the x-ray vision condition caused a change in vergence angle which resulted in depth judgments being biased towards the observer. They also found that cutting a hole in the occluding surface, which made the depth of the virtual object physically plausible, reduced the depth judgment bias.

The experimental setup (Figure 1) involved a height-adjustable tabletop that allowed observers to easily reach both above and below the table. We used two complimentary dependent measures to assess depth judgments: we replicated the closed-loop matching task (*Task* = *closed*) of Ellis and Menges [1998]; observers manipulated a small light to match the depth of the bottom of a slowly rotating, upside-down pyramid (the target object). In addition, we used an open-loop blind reaching task (*Task* = *open*), in order to compare the closed-loop task to a more perceptually-motivated depth judgment. Our occluding surface was composed of circular foam-core covered with a highly-salient checkerboard pattern; when observers saw the occluder (*Occluder* = *present*, otherwise *Occluder* = *absent*) it was presented 10 cm in front of the target. We used a factorial, within-subjects experimental design; observers made binocular stereo depth judgments.

Figure 2 shows the results by task, occluder, and distance; the results are grouped by task for clarity, and should be judged relative to the 45° veridical lines. Figure 3 shows the results by task and occluder, expressed as *normalized error* = *judged distance / veridical distance*. All conditions underestimated the veridical distance of 100% to some degree. The closed-loop task replicated the finding of Ellis and Menges [1998]: the presence of the occluder biased the depth judgment towards the observer. The perceptually-based open-loop task resulted in greater underestimation; the larger error is unsurprising given that fewer depth cues are available in the open-loop task. Interestingly, in the open-loop condition observers judged the target to be farther when the occluder was present.

We consider this to be a pilot study; we plan to collect data from a larger number of participants and otherwise improve the experimental setup and design.

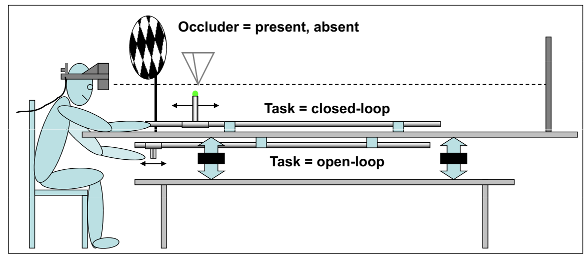

Figure 1: *Experimental setup.*

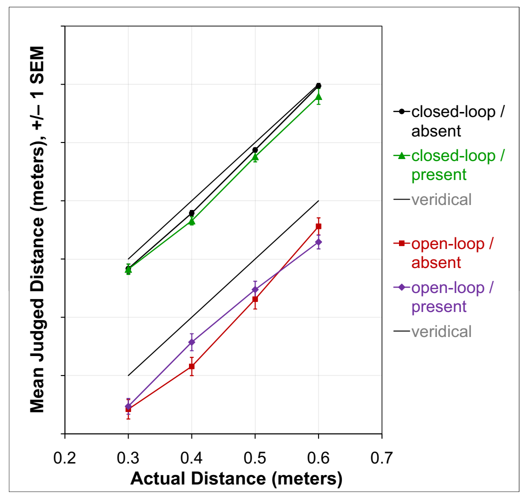

Figure 2: *Depth judgments by task, occluder, and distance.*

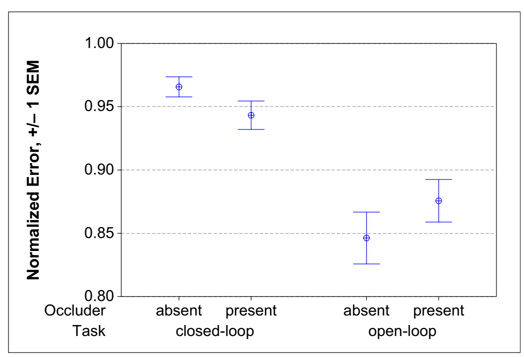

Figure 3: *Depth judgments by task and occluder.*

References

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