Egocentric Medium-Field Distance Perception in Projection Environments

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1 Introduction

Egocentric distance perception over distances of 2–20 meters has been extensively studied within real world environments and within virtual environments (VEs) using head-mounted displays (HMDs). Not as much investigation has been performed within projection-based VEs, partly because of measurement restrictions imposed by the limited spatial constraints of the projection-based hardware. A standard measurement technique is blind-folded walking, in which subjects observe the object, close their eyes, and walk to where they perceives the object to be. However, due to the limited space in front of projection-based displays, this technique is difficult to perform. To our best knowledge, there is only one technique, imagined walking [Plumert et al. 2005], applied in projection-based environments. We use and compare triangulated walking [Knapp 1999] to imagined walking and verbal estimation for projection-based environments.

2 Experiments and Results

We compare distance perception within an immersive room, a tiled display, and the real world. The immersive room measures 10 ft x 10 ft (floor) x 8 ft (height) and the tiled wall 18 ft (wide) x 9 ft (height). We selected a field for the real world environment that has very few visual interruptions. The VEs were modeled to look nearly identical to the outdoor environment. We created a high-resolution, 360-degree photo panorama from the outdoor environment for long range imagery, a Wang-tiled grass plane for the ground, and a textured box with shadows projected that was sized and textured to exactly match the target object used outside. We used active-stereo projection and head tracking in both systems. To measure distance perception we used three separate measurement techniques. Our choice of technique was constrained by the need to use the same methodology in all three environments and by the physical space limitations of the indoor environments. We also wanted to establish a baseline with results from [Plumert et al. 2005]. Verbal estimation means the subject observes an object, estimates its distance, and reports that distance. For imagined walking, subjects observe an object, then close their eyes and imagine walking to the object and stopping. The time the imagined walk takes is multiplied by the subject's actual walking rate to get the distance. In triangulated walking, subjects observe the object, turn 90°, observe the object again, close their eyes, and begin walking. The experimenter tells the subjects when to stop (at approximately 2.5 meters). Once stopped and with eyes still closed, the subjects turn and orient their whole body to face the object. Finally, the subjects point at the object's location. This direction is then triangulated to compute the estimated distance. For our experiment, subjects held a bean bag between their palms and pointed with both hands held together.

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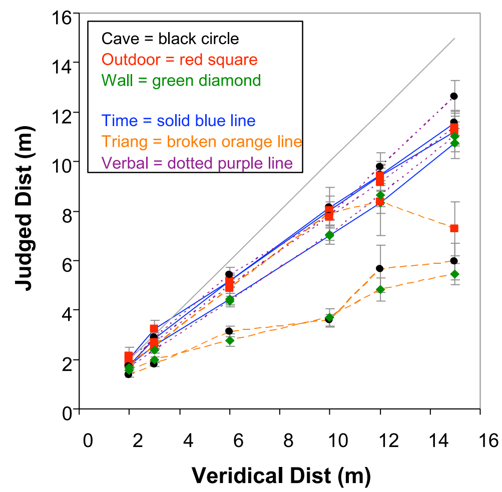

Figure 1: The general trend shows no significant difference between environments. This preliminary graph shows error in distance; however, for triangulated walking, this error cannot be assumed to be distributed normally—due to the transformation from angles to distances—as we assumed for verbal estimation and imagined walking. We plan to better transform the data as we continue our analysis.

When subjects were satisfied with the direction, they dropped the bean bag, and the experimenter placed markers between their heels and where the bean bag fell. We used a within-subjects design, but also designed to allow a between-subjects analysis. We counterbalanced environment presentation order, test type presentation order, environment follow order, and test type follow order. Each subject experienced all test types in all environments.

3 Preliminary Analysis and Conclusions

Twenty-three subjects completed the experiment (three subjects' data were eliminated). Our preliminary analysis of the data shows several interesting trends. Notably, there seems to be no significant statistical difference between distance perception in the three environments. Early indications show more compression of distance than we expected when using the triangulated walking technique in all environments. However, we believe there is a discrepancy from the transformation from the pointing to the estimates of distance. Verbal estimation results seem similar to previous results. (with the exception that there was no statistical difference between environments). Imagined walking time analysis will be more complicated as there seem to be significant order effects (likely due to fatigue and boredom). A common trend among subjects was to show increasing distance compression (in all environments) as the experiment progressed.

References

KNAPP, J. 1999. *The visual perception of egocentric distance in virtual environments*. PhD thesis, UC Santa Barbara.

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