A Little Unreality in a Realistic Replica Environment
Degrades Distance Estimation Accuracy

Lane Phillips and Victoria Interrante
University of Minnesota

Introduction and Previous Work

Non-Photorealistic Immersive Virtual Environments (NPR IVEs) have tremendous potential to empower the process of conceptual design in architecture, by enabling architects and their clients to experience and comparatively assess the 3D space of potential building layouts from a first-person perspective at a very early stage in the design process. To maximize the effectiveness of NPR IVEs, it is essential to understand the factors that influence the extent to which, and conditions under which, people are able to accurately interpret 3D spatial layout in them.

Previous research has shown that, in situations where people are unable to accurately estimate egocentric distances in a realistically rendered, head mounted display based, static immersive virtual environment, degrading the quality of the computer graphics does not significantly further impair performance [Thompson et al. 2004]. In studies evaluating egocentric distance perception accuracy in photo-realistically and non-photorealistically rendered replica environments (in which the virtual environment is an exact in situ copy of the actual real world environment), we have found that performance in the photo-realistic replica environment (figure 1- left) is statistically similar to performance in the real world, but that people significantly underestimate egocentric distances when the replica environment is rendered in a sparse, line-drawing style (figure 1- center) [Phillips et al. 2009]. Other work has shown that people experience higher levels of presence in immersive virtual environments when they are rendered with realistic lighting effects such as shadows and mirror reflections that dynamically update with user interaction [Slater et al. 2009].

Are people failing to accurately judge egocentric distances in the non-photorealistic replica environment because the unrealistic nature of the graphical representation interferes with their propensity to feel present in that environment? Or, are the increased errors better explained by the lack of fine detail in the line-drawing style textures? If it is the former, we might seek to enhance the effectiveness of the NPR IVE through efforts to promote a deeper sense of presence and better appreciation of the affordances for action in the VE; if it is the latter, we might be better served by seeking to improve performance through the use of a more detail-rich NPR rendering style.

Our Experiment

We created an optimally detail-rich non-photorealistic replica environment (figure 1- right) by replacing all of the white pixels in our original NPR textures with colors obtained from the corresponding registered photographs of the room. Nine naïve participants were immersed in the virtual environment and asked to make 20 independent judgments of egocentric distance by taking visual aim at a randomly placed target on the floor of the room and walking without sight to its presumed location. Participants subsequently made 10 similar judgments in the actual room, as an individual control. Statistical analysis of the results indicated that, as a group, participants significantly underestimated distances in the hybrid NPR replica environment, relative to in the real world \(F(1,18) = 7.77, p = 0.012\). Comparison with the results of our earlier experiment indicated that relative performance in the hybrid NPR replica environment was significantly worse than in the realistic replica environment \(F(1,18) = 5.55, p = 0.033\), and not significantly different than in the sparse NPR replica environment \(F(1,16) = 1.76, p = 0.204\).

Discussion and Future Work

We have informally observed that the extreme realism of our photorealistic replica room environment, in conjunction with its known co-location with the real room, often evokes in participants the impression that they are wearing a see-through camera. In such a situation, it is not surprising that people feel empowered to act on the virtual representation as if it were actually real. Our present study suggests that reducing the realism of this experience, even by just a little bit, fundamentally affects how people are inclined to act on what they see through the HMD.

In future work, maintaining the plausibility of the illusion that what one is seeing is actually real, or at least functionally equivalent to reality, may be key to enabling people to make valid design decisions about 3D spatial layout based on a virtual reality preview.

---


This research was supported by a grant from the National Science Foundation (BSF-0713587), by the University of Minnesota through the Digital Technology Center, and by the Linda and Ted Johnson Digital Design Consortium Endowment and Lab Setup Funds.