

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

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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].

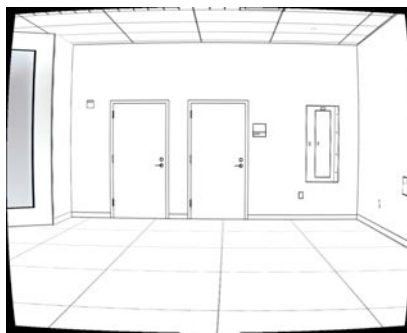
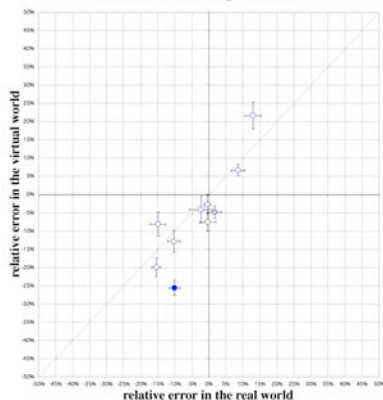
Are people failing to accurately judge egocentric distances in the non-photorealistic replica environment because the unrealistic nature of the graphical representation interferes with their propensity to feel present in that environment? Or, are the increased errors better explained by the lack of fine 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

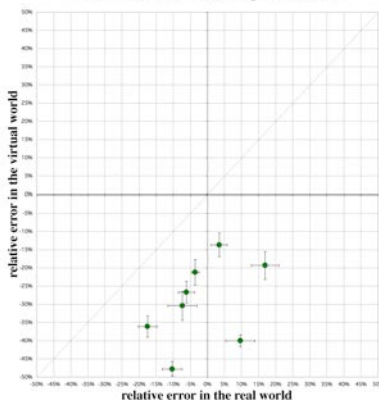
We created an optimally detail-rich non-photorealistic replica environment (figure 1- right) by replacing all of the white pixels in our original NPR textures with colors obtained from the corresponding registered photographs of the room. Nine naïve participants were immersed in the virtual environment 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 $\{F(1,18) = 5.35, p = 0.033\}$, and not significantly different than in the sparse NPR replica environment $\{F(1,16) = 1.76, p = 0.204\}$.



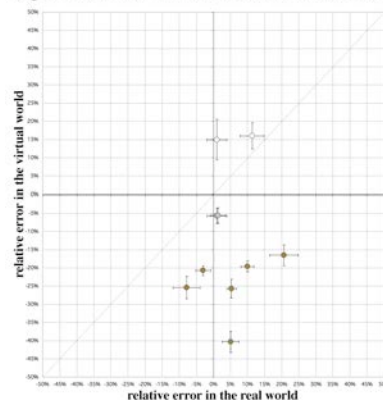
Photorealistic Replica Room



Non-Photorealistic Replica Room



Replica Room with NPR lines over Photo Texture



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.

- [1] William B. Thompson, Peter Willemssen, Amy A. Gooch, Sarah H. Creem-Regehr, Jack M. Loomis and Andrew C. Beall. (2004) Does the Quality of the Computer Graphics Matter when Judging Distances in Visually Immersive Environments?, *Presence: Teleoperators and Immersive Virtual Environments*, 13, 5, (October 2004), 560-571.
- [2] Lane Phillips, Brian Ries, Michael Kaeding and Victoria Interrante (2009) Distance Perception in NPR Immersive Virtual Environments, Revisited, *ACM/SIGGRAPH Symposium on Applied Perception in Graphics and Visualization*, pp. 11-14.
- [3] Mel Slater, Pankaj Khanna, Jesper Mortensen, Insu Yu. (2009) Visual Realism Enhances Realistic Response in an Immersive Virtual Environment, *IEEE Computer Graphics and Applications*, pp. 76-84, May/June, 2009.