The Effects of Virtual Character Animation on Spatial Judgments

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Abstract

Inaccurate perception of distances is a known problem within virtual environments. We hypothesize that the inclusion of virtual characters within these environments can improve an observer's ability to judge distances and achieve accurate spatial understanding. We have conducted an empirical study using a desktop display of a small scale environment to evaluate the validity of this concept. We investigated whether the presence and quantity of virtual human characters, as well as the naturalness of their locomotion animations, could improve egocentric and exocentric distance estimations. Preliminary results suggest that static or properly animated characters could improve exocentric estimations, and properly animated characters could reduce egocentric distance compression errors.

1 Introduction

Accurate spatial understanding is important in virtual environment (VE) applications that take advantage of users' natural perceptual capabilities and sense of reference. For example, virtual worlds are common for design environments, such as those supporting architectural design [e.g., 1]. While immersive VEs offer the potential for natural perception of virtual models, error in judgments of size and distances is a known problem for both egocentric and exocentric measurements. Many past studies suggest that egocentric distance (the distance between the observer and a specific location in the environment) is generally underestimated in VEs [e.g., 3, 5]. Conversely, object sizes and inter-object distances, or exocentric distances, tend to be overestimated [e.g., 7].

While the absolute causes for these discrepancies are not [7] clearly understood and related to properties of the display, it may be possible to aid spatial understanding in 3D virtual environments through scene content. Previous work has provided strong evidence that information naturally extracted from object motions [2, 6] and locomotion cycles of animated virtual characters [4] can serve as additional spatial and scalar cues. We intend to formally investigate whether such references can be used to improve environmental understanding and distance judgments of an environment and objects of known scale to provide a superior understanding of a virtual world, supporting more effective applications that rely on environmental spatial knowledge.

A number of studies provide evidence that could help rationalize why animation could support improved spatial interpretations. Stappers and Waller [6] and Hecht et al. [2], for example, provide support for the idea that object motion and acceleration can be used to determine spatial scale and distances. Calderón et al. [1] reported that designers felt that walking characters were more helpful than static references for communicating scale in architectural design; however, the validity of such claims have not been formally evaluated. Jokisch and Troje [4] concluded that observers can naturally use the general relationship between character size and the frequency of its walking cycle to estimate character scale. This work confirmed that people can naturally extract locomotion information in order to get a sense of scale for the animated character.

We conducted an exploratory investigation to evaluate whether characters help observers to better judge other sizes and distances within the environment. While we are planning parallel studies on multiple immersive displays for future work, our preliminary study used a desktop display to provide insight about factors that are expected to be relevant to any platform.

2 Method

We conducted an exploratory study based on a small-scale indoor environment. For this environment, we built a scaled virtual representation of a real-world room (Figure 1). Both versions of the environment contained common, inanimate objects to serve as landmarks and help provide a sense of space and scale. The real world environment was used as a baseline for comparisons of spatial estimations in the VE. The experimental conditions control how virtual characters were presented within the environment. Non-realistic characters were used to limit uncanny-valley-type distractions. The virtual conditions were viewed through a 15-inch laptop screen. A between-subjects design was used so that each participant completed the task in one of six conditions:

- **Real Room:** The real-world version room with no characters.
- **Empty Virtual Room:** The VE contained no virtual characters. This level represents the control for spatial judgments within the VE.
- **Static Character:** The VE included an inanimate character in a static pose. This level tested for the possibility that human scale is used to improve estimations.
- **Bad Animation:** The character glided through the environment without locomotion animations, occasionally popping into other poses. The movement was not natural human locomotion. This condition was meant to help determine the importance of realistic human motion.
- **Full Animation:** The scene includes a single character moving through the VE with natural walking and turning animations from motion-capture data.
- **Multiple Animated:** Two characters walked through the scene. This level tested whether additional characters could affect the ability to utilize locomotion cues for spatial understanding.

Of 25 participants. four were in each of the virtual conditions and five were in the real-room condition. The task required each participant to view the environment while verbally reporting six estimations of exocentric distances and object sizes. Next, perception of egocentric distances (the distances from the observer's position to a target object within the environment) was evaluated using a method based on a blind throwing technique [5].

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For the throwing evaluation method, the participant was taken to a wide open, real world area and required to take three practice throws to a target location in the real world. The participant was then blindfolded and asked to imagine the room from the same vantage point from which the environment was previously viewed. The experimenter described five targets on the floor of the recalled environment. For each target, the participant tossed three bean bags to the perceived locations of the targets within the virtual world. The distances from the participant to the location the bag hit the ground was measured. The distances to the three throws were averaged to produce a single egocentric estimation for each target.

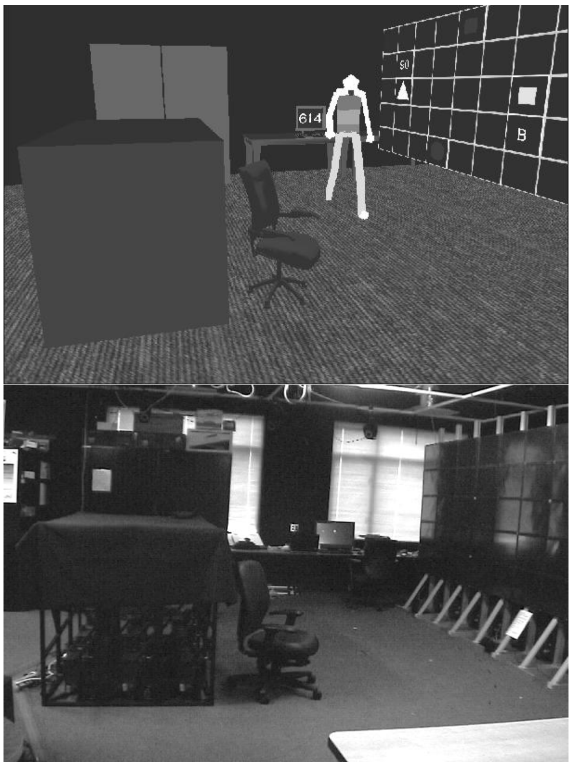

Figure 1. Virtual and real versions of the environment.

3 Results and Discussion

As this was only a small exploratory study, significantly more data is needed in order to submit any claims about the effects of characters on distance perception. Nevertheless, our results reveal interesting outcomes for consideration in further work.

The results for the exocentric evaluation (Figure 2) shows that estimation errors were considerably lower in the real room, static character, and full animation conditions. The average errors for the empty room, bad animation, and multiple character conditions are approximately double those of the other conditions. This may suggest that a static character is more useful for providing a sense of scale than previously thought. Higher error for the bad animation condition might suggest that a static character is more useful than a poorly animated character. The relatively higher error for the multiple character condition could suggest that observers have greater difficulty extracting scaling information from a walking avatar in a busy scene, or perhaps the close proximity of the characters made it difficult to estimate the scale the environment relative to a single character.

Bag-throwing results are summarized in Figure 3. The average absolute error percentage was the lowest in the multiple character condition and the full animation condition had the second lowest error. A perhaps more interesting result is seen in the comparison of the average net error percentages. These results indicate the general tendency to overestimate or underestimate distances. Because all average net error percentages are negative across all conditions, this can be interpreted to mean that the general size of the environment was underestimated. Figure 3 reveals that these net average errors were much less severe for the full animation and multiple avatar conditions. This evidence may suggest that the presence of animated avatars does reduce the amount of distance compression in a virtual environment. Follow up investigations and significantly more data are needed for confirmation.

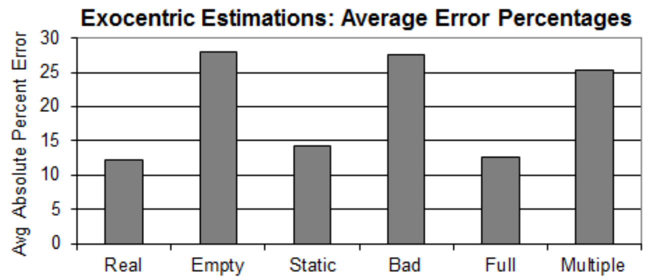

Figure 2. Estimation error for verbal estimation.

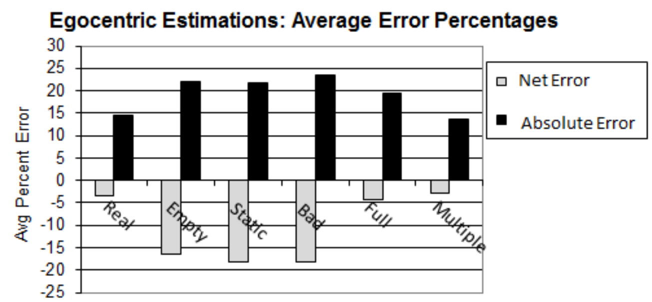

Figure 3. Relative error percentages for egocentric bag throwing.

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