Exploiting Change Blindness to Expand Walkable Space in a Virtual Environment

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Abstract

We present a technique for exploiting change blindness to allow the user to walk through an immersive virtual environment that is much larger than the available physical workspace. This approach relies on subtle manipulations to the geometry of a dynamic environment model to redirect the user's walking path without becoming noticeable. We describe a virtual environment which was implemented both as a proof-of-concept and a test case for future evaluation. Anecdotal evidence from our informal tests suggest a compelling illusion, though a formal study against existing methods is required to evaluate the usefulness of this technique.

Index Terms: H.5.1 [[Information Interfaces and Presentation]: Multimedia Information Systems—Artificial, augmented, and virtual realities; I.3.6 [Computer Graphics]: Methodology and Techniques—Interaction techniques; I.3.7 [Computer Graphics]: Three-Dimensional Graphics and Realism—Virtual reality

Keywords: virtual environments, real walking, locomotion

1 Introduction

Real walking in a virtual environment has been shown to provide advantages over common alternative travel techniques, including a greater sense of presence [10], faster navigation with fewer collisions [9], superior performance on search tasks [5], and benefits for memory and cognition [11]. Advances in wide-area tracking technology have made real walking possible for a variety of applications, but the usefulness of this locomotion technique is limited to applications where size of the virtual environment does not exceed the dimensions of the physical walking space. To overcome this limitation, we implemented a recently proposed method that exploits change blindness to prevent the user from walking outside the boundaries of the physical tracking area [8]. This technique relies upon subtle manipulations to the geometry of the environment model to redirect the user's walking path without being noticeable.

Various methods have been introduced to overcome the physical space restrictions of real walking. *Redirected walking* introduces a rotational discrepancy between the real and virtual world which allows the user to explore environments considerably larger than the physical tracking space [4]. Several recent studies have investigated the detectability of the visual-proprioceptive conflict introduced by this rotation [1] [7] [6]. Alternatively, a *scaled translational gain* technique can be used to increase the forward step size of the user to allow travel over greater virtual distances [2]. When these techniques fail to prevent the user from exiting the physical workspace, a *reorientation technique* can be used to stop and rotate the user before they cross the boundary of the physical walking area [3]. In all of these cases, the rotational or translational gain must be applied gradually, since abrupt changes in motion would be easily detectable by the user. The technique described in this paper, however, maintains an exact mapping between the user's physical and virtual motions, and subsequently does not introduce this visual-proprioceptive conflict. However, the environment must be carefully designed to support this type of navigation.

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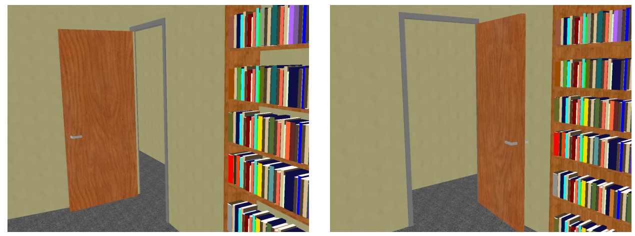


(a) Before Change (b) After Change

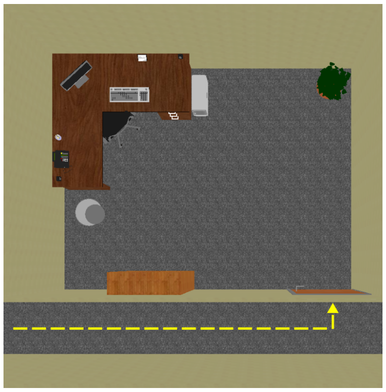
Figure 1: An example of a "door switch," in which the doorway to exit a room is rotated by 90 degrees along with the adjoining corridor. Users exiting the room will proceed down the hallway in a different direction than when they entered.

2 Technique Overview

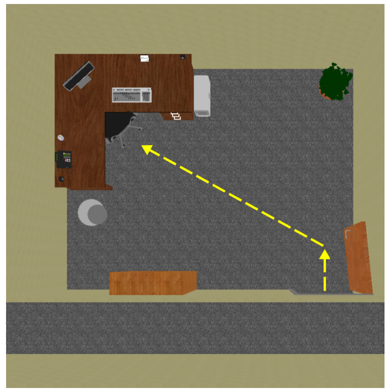
Change blindness is a phenomenon that occurs when a person fails to detect a change in an object or scene. This is often the result of overusing top-down processing strategies, where the person's concepts, expectations, and memory influence the recognition of the scene. Since usually the architecture of an environment does not suddenly change in the real world, these assumptions may carry over into the virtual world. Thus, subtle changes to the scene that occur outside of the user's field of view may go unnoticed, and can be exploited to redirect the user's walking path. Figure 1 shows an example modification where the doorway to exit a room is rotated, causing users to walk down the virtual hallway in a different direction than when they first entered the room. These "doorway switches" can be used to allow the user to explore an environment much larger than the physical workspace. Figure 2 shows a dynamic virtual office building which demonstrates this technique using two virtual rooms; however, this process can be repeated to allow navigation through an arbitrary number of rooms. To evaluate the usefulness of this approach, we expanded this example environment, creating a virtual office building with a total of 12 rooms and 2352 sq. feet of navigable space. Utilizing the demonstrated method, the user can seamlessly walk through the entire environment in a 196 sq. foot tracking area. The environment is designed to be explored by visiting each room in order, and users are instructed to activate a computer monitor in each room. It should be noted that if the user does not follow the intended order of rooms, a reorientation technique would need to be applied.

3 Discussion and Future Work

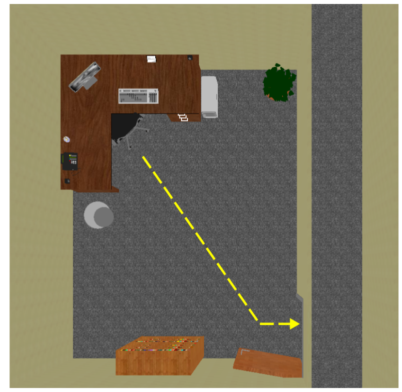
Our informal tests of the virtual environment using a Virtual Research VR1280 head-mounted display have suggested a compelling illusion. Anecdotal evidence indicates that it is difficult to detect the changes to the virtual environment model, even when users are aware that the environment is being manipulated. As we do not yet



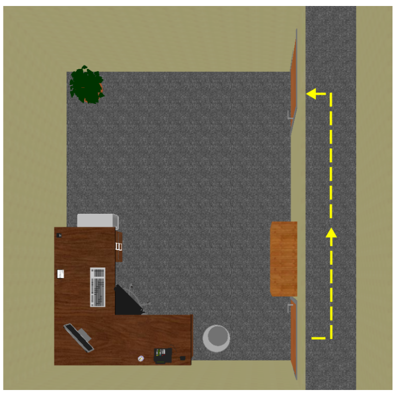
(a) **State 1**: The user approaches the doorway to the first room.



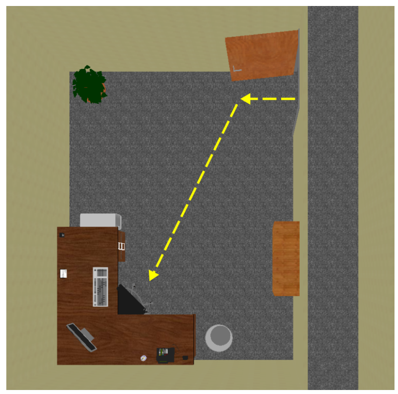
(b) **State 2**: The user enters the first room and walks towards the desk to activate the computer monitor.



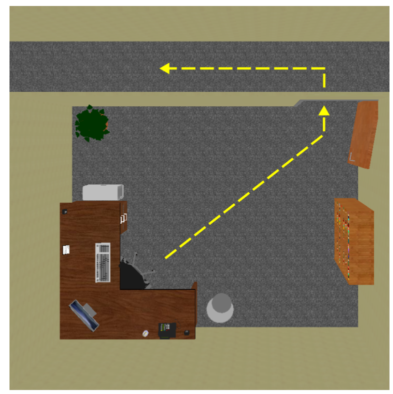
(c) **State 3**: When the user activates the monitor, the corridor and the door to exit the room are instantly rotated by 90 degrees. The user then turns around and exits the room.



(d) **State 4**: When the user enters the hallway, the second doorway is added, and the contents of the room are swapped with the next room.



(e) **State 5**: The user enters the second room and walks towards the desk to activate the computer monitor.



(f) **State 6**: When the user activates the monitor, the corridor and the door to exit the room are instantly rotated by 90 degrees. The user then turns around and exits the room.

Figure 2: A step-by-step explanation of the dynamic modifications to the virtual environment model which prevent the user from walking outside the boundaries of the 14' x 14' workspace. A single room in the environment fits exactly within the workspace area, and each one is swapped out dynamically as the user transitions between them.

have formal data to verify these observations, we are implementing an identical static model of the environment to compare our technique to alternatives such as redirected walking. Important criteria for future evaluation include noticeability to the user, impact on spatial orientation and learning, and user preferences. Finally, we also plan to develop general guidelines for utilizing change blindness techniques for navigation in virtual environments.

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