Seven League Boots and Directed Flying: An Investigation of Navigation Modes in Large Virtual Environments

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Abstract

This study investigates the effectiveness of certain modes of navigation through a virtual environment presented to test subjects through a head mounted display. The two modes of navigation we examine are "seven league boots," which is a type of augmented walking, and "flying," which means navigating using a joystick. These two modes of navigation are to be compared through an experimental study measuring the accuracy of subjects' spatial perception using each of the two. This report is a rough draft of the final paper and does not include information on the results of the study, as it was written before the experiment was carried out. The complete paper should be available shortly.

1. INTRODUCTION

The central question addressed by this study concerns the problem of navigation in a virtual environment that is larger than the physical room available for use with a head mounted display. We wanted to compare the effectiveness of stationary joystick navigation and navigation using augmented walking, to determine whether the idiothetic cues provided by physical walking help subjects to perform better in tasks that depend on spatial orientation. Idiothetic information is that which is generated through movement, including vestibular signs, cues obtained from commands issued to the musculature, and proprioceptive signals [Chance et. al. 1998]. While previous studies have compared joystick navigation to walking with gain (e.g. [Williams et. al. 2006]), we wanted to look at a different type of augmented walking called "seven league boots." Ordinary gain multiplies the movement of the person wearing the head mounted display in all directions by a certain constant. The Seven league boots technique, while similar to ordinary gain, increases only movement in the user's facing direction. This allows the user to cover large distances in the virtual environment without suffering from sickness due to over exaggerated motion to the left and right.

In this experiment we compared Seven league boots with a gain of 10 to directed flying, also with a gain of 10 times the average walking speed. Directed flying is controlled by a wand tool with a button held in the user's hand. When the button is pressed, the user moves in the direction he is facing. In order to change direction or turn a corner, the user must pivot his body to face in the direction he would like to move.

2. EXPERIMENT

The goal of our experiment was to investigate how spatial orientation in an immersive virtual environment is affected by the user's means of navigation. We examined subjects' performance when using a technique we call "seven league boots", which provides walking with gain in the user's facing direction, with directed flying controlled by a joystick. We hoped to determine whether the idiothetic cues supplied by the augmented walking aid spatial understanding in the same manner as they do during normal walking. If so, this would indicate that augmented walking is preferable to joystick navigation through a virtual environment for tasks that demand an accurate perception of space.

2.1.1 Design

The experiment incorporated a within-subjects design with one condition, navigation mode. The two types of navigation we investigated were "seven league boots," or augmented walking, and directed flying. Each subject participated in two trails, one for each of the two navigation modes. The order of the trials was assigned randomly to the experiment participants so that half of the group completed the trial using augmented walking first, and half began with directed flying. Additionally, we used two sets of six targets during the experiment, which were placed in separate locations in our virtual environment to minimize the transfer of spatial information learned during the first trial to the second trial. The order in which subjects saw each target set was also randomly assigned.

2.1.2 Stimuli

A three-dimensional model of a fictional city was used as the setting for this experiment. It was implemented using OpenGL and consisted of buildings constructed from polygons with both brick textures and window and door textures randomly assigned to each building. The height of the buildings' stories and the dimensions of the doors and windows were based on measured quantities so that users would receive realistic spatial cues from the city model. Additionally, the buildings were randomly assigned color values to make them more distinguishable and to minimize the maze-like quality of the model.

For each trial, one of two possible target maps, locating the targets in the city, was selected. Each map specified a unique starting location that was marked by a red cube. The six targets in one target set were located around this point out of sight from where the subject was standing. The optimal paths to the targets had three different levels of complexity: requiring one turn, two turns, or three turns. Each of these was a 90-degree turn, and there were two targets with each of the three levels of complexity. The targets themselves were everyday objects such as a bicycle or trash can to make them more memorable. No object appeared in both of the target sets.

2.1.3 Procedure

Upon arrival, subjects were given written instructions detailing the procedure of the experimental trials and encouraged to ask questions about anything that remained unclear. Each subject participated in two trials separated by a 15-minute break.

The subject completed the same set of tasks during each trial, independent of navigation mode. At the start of the trial the subject was placed at the red starting location marker for the selected target set. For each target, the subject completed both a training phase and a testing phase. The training portion involved following an illuminated line along the path to the target, and then back to the starting location, two times. This process was intended to teach the subject the location of the target.

After completing this training phase, both the line path and the target were made invisible, and the subject was asked to find the location of the target without these visual aids, to determine how well its position had been learned. For this test, we measured both the distance error between the subject's stopping position and the target's actual location, and the time it took the subject to reach this destination. We asked the subject to say "start" directly before moving so that the experimenters could begin timing. When the subject reached the supposed target location she said "stop." At this point, the experimenters recorded both the time and the total distance error. This comprised the first experimental test.

The second round of testing measured how well the subject had learned the spatial location of the target through directional pointing. The subject was asked to stand at the target and use a wand tool to point in the direction of her starting location. Next, the subject navigated back to the starting location and pointed to the target from this position. For both of these tests, a black stick was visualized in the virtual environment to serve as a pointing guide. The movement of this stick was mapped to the movement of the physical wand held in the subject's hand. This wand tool has a button, and when pressed the black stick turned red to show the subject that the pointing direction had been correctly stored by the computer. This pointing guide was only visible during the pointing tasks, and turned off when the subject navigated from the target back to the starting location so that the wand tool could still be used to control directed flying. The completion of these two pointing tasks marked the end of the testing for this target.

The training and testing process was completed for each of the six targets. At the end of the second trial, an additional test was conducted. After completing the task for the sixth and last target, the subject was asked to return to this target's location. Standing at the sixth target, the subject used the wand tool to point from this position to each of the other five targets. These data were collected to provide a more general understanding of the subject's mental map of the space.

Thus, overall 53 ability assessments were made for each subject: for each of two navigation modes: for each of six targets, distance and timing accuracy to each target, and target-to-source and source-to-target pointing accuracy, for a total of 6 x 2 x 4 = 48 assessment; and finally, five final pointing measurements.

3. FUTURE WORK

While the experimental design for our study has been completed, the experiment has not yet been carried out. Therefore, gathering data is the next process that needs to be conducted. If analysis of the experimental results shows as expected that subjects perform better when navigating in the virtual environment using Seven league boots, future work may involve determining when the advantage provided by this type of augmented walking falls apart. For example, we would like to determine whether navigating with Seven league boots that have a gain of 20 have the same benefit as boots with a gain of 10. If the results show that subjects performed better when using directed flying to navigate, or that there is no noticeable performance difference when using one mode of navigation over the other, then future work may involve rethinking our understanding of spatial perception and investigating how this experiment differs from those that have found augmented walking to be preferable to joystick navigation.

Works Cited

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