Effect of Navigation Methods on Spatial Awareness in Virtual Worlds

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Abstract. This manuscript discusses navigation methods which would help users to build and maintain their own mind map so that they do not lose their awareness in a virtual world. An experiment in an impact of three navigation methods of **Key**, **Click** and **Auto** on spatial awareness is conducted. **Key** is a method that enables the user to hit keys and/or manipulate the mouse to control the player freely. **Click** is a method that enables the user to click on each of pre-defined viewpoints in order to let the player jump onto it. **Auto** is a method that the player walks automatically at a constant speed along a pre-defined path. The result shows that **Key** or **Auto** methods have a better performance for spatial awareness.

Keywords: Navigation methods · Spatial awareness · Virtual worlds · Interface design

1 Introduction

A virtual world is now commonplace in games. It is a three dimensional computer-generated space and players can move around freely in it. A consumer game of Grand Theft Auto is a good example. In the game, there is a tremendously big virtual city where a lot of buildings, roads, bridges, restaurants, shops, bars, gas stations, factories, harbors, theme parks and other things exist. The sun rises in the morning and sets in the evening. Rivers flow into the sea and smoke rises from chimneys, and transportation like cabs, buses, trains and ships runs across the city. Players can walk along the sidewalk, ride a bicycle in the park, and drive a car on the highway. Other applications of virtual worlds include distance learning, open house, rehabilitation of claustrophobia, and therapy of communication disorders. Thus there are a wide range of applications.

A common device to display a virtual world to users is a high-definition wide screen. A sequence of images (screen images) to be displayed on the screen is

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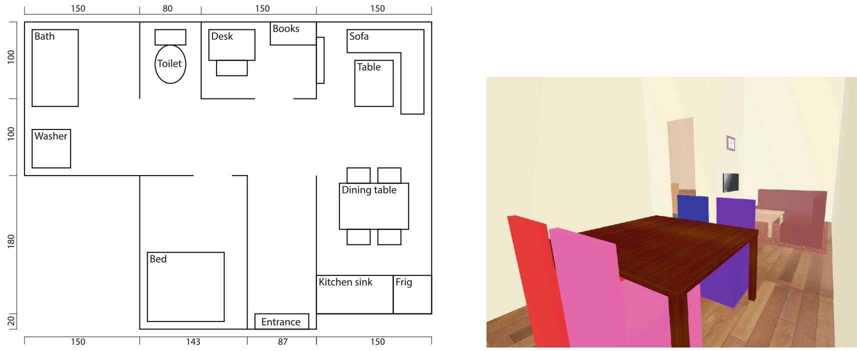

Fig. 1. A virtual house used in our experiment. A floor layout of the house (left) and a screen shot that is taken from the kitchen (right).

taken by a virtual camera in the virtual world. The virtual camera functions as a user's viewpoint. In other words, the user sees what the virtual camera sees. Another device is a head-mounted display. A head-mounted display is a goggle-type display and it gives users a highly immersive environment. Users perceive as if there was an ultra-wide screen before their eyes. In addition, a built-in head-tracking sensor is usually attached to the head-mounted display and it enables users freely turn their heads in order to look at something they want to see in the virtual world. These two devices are now mainstream.

As regards navigation techniques in a virtual world, computer mice and keyboards are often used. To control players, there are several options of mouse-key combination. One example is that the player turns when the user moves the mouse horizontally. The player also moves forward/backward when the user hits W/S keys. Another is that the player turns left/right and moves forward/backward when the user hits A/D/W/S keys. These navigation techniques and the display devices mentioned above are generally accepted by a wide range of applications that utilize virtual worlds.

One concern is a lack of spatial awareness that stems from discrepancy between the user's physical movement and the player's virtual movement. For example, the player moves around in the virtual world while actually the user is in a real chair and looking at his/her computer screen, resulting in unaware of the player's current position in the virtual world. This is called the getting-lost problem. Paraskeva et al. [1] discussed properties of spatial awareness and showed that there is a significant impact of gender on it. This poster discusses three navigation methods which would help users to build and maintain their own mind map so that they will not lose awareness of the player's current position.

2 A Virtual House and Navigation Methods

Figure 1(left) is a floor layout of a virtual house used in our experiment. The floor is 530 cm by 400 cm, and there are everyday things such as a dining room,

Fig. 2. Design of navigation methods. The pre-defined viewpoints for **Click** method are shown to the left and they are rendered as green cubes as shown in the screenshot in the center. The pre-defined path for **Auto** is shown to the right. (Color figure online)

Table 1. Elapsed time to complete sketches.

Navigation methods	Elapsed time
Key	08 min 30 s
Click	11 min 09 s
Auto	07 min 29 s

a study, a bedroom, home furniture and home appliances. Figure 1(right) shows a perspective view from the kitchen. Using this virtual house, three navigation methods are evaluated.

Three navigation methods are **Key**, **Click** and **Auto**. **Key** is a method that enables the user to hit W/A/S/D keys to let the player move forward/step left/move backward/step right, respectively and manipulate the mouse to let him/her look around. **Click** is a method that enables the user to click on each of pre-defined viewpoints in order to let the player jump onto it. **Auto** is a method that the player walks automatically at a constant speed along a pre-defined path.

Figure 2(left) shows the pre-defined viewpoints used in **Click** method. Each viewpoint is represented by an arrow in the figure, which is rendered as a green cube in the virtual house shown in Fig. 2(center). The user can click on the cube to jump onto it. Figure 2(right) shows the pre-defined path used in **Auto** method. The path starts at the entrance and goes through rooms, and comes back to the entrance.

3 Experiment and Results

Twelve subjects between the ages of 22 and 24 were asked to move around freely in the virtual house with the given navigation method. At the same time, they were asked to figure out and sketch the floor layout as precisely and fast as possible. After that they were asked to complete a questionnaire with a five-level scale (strongly yes 5 to strongly no 1):

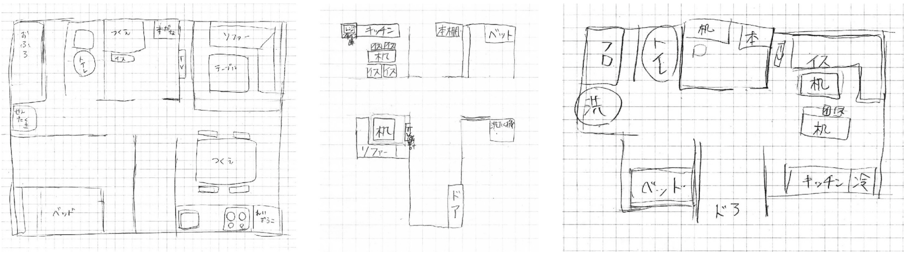

Fig. 3. Three representative sketches of the floor layout drawn by subjects given **Key** method, **Click** method and **Auto** method in order.

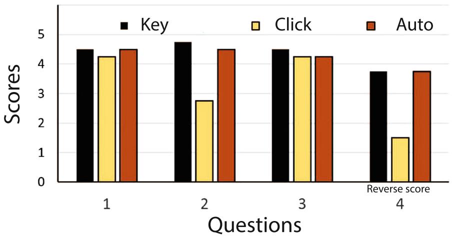

Fig. 4. Questionnaire result. (Color figure online)

Q1 Did you feel as if you were moving in the virtual house?
Q2 Was it easy to locate yourself in the virtual house?
Q3 Was it easy to remember spatial relations between home furniture?
Q4 Did you feel you were lost?

Table 1 shows the average of the elapsed time for subjects to finish their sketches. From the table, subjects given **Auto** method draw sketches more quickly than the others. Figure 3 shows three pieces of representative sketches drawn by subjects. The left one was drawn by a subject given **Key** method. The center and the right ones were done by ones given **Click** and **Auto** methods, respectively. From the sketches, subjects given **Key** method draw a more precise floor layout than the others. Figure 4 shows scores obtained from the questionnaire and it shows **Key** method has greater scores on average than the others.

Above all the results, **Key** or **Auto** methods have the potential for helping users to build and maintain their own mind map.

4 Conclusions

This manuscript discussed navigation methods which would help users to build and maintain their own mind map so that they do not lose their awareness in a virtual world. An experiment in an impact of three navigation methods of **Key**, **Click** and **Auto** methods on spatial awareness was conducted. The result showed that **Key** or **Auto** methods have a better performance for spatial awareness.

In the future work, we are going to conduct further experiments using various virtual houses and floor layouts.

Reference

1. Paraskeva, C., Koulieris, G.A., Coxon, M., Mania, K.: Gender differences in spatial awareness in immersive virtual environments: a preliminary investigation. In: Proceedings of the 11th ACM SIGGRAPH International Conference on Virtual-Reality Continuum and its Applications in Industry (VRCAI 2012), New York, USA, pp. 95–98 (2012)