METHODS FOR VALIDATING THE USE OF VIRTUAL SIMULATION GENERATED FROM A COMPUTER GAME FOR ENVIRONMENT AND BEHAVIOUR RESEARCH

CHUMPORN MOORAPUN
Faculty of Architecture, Design and Planning
University of Sydney, Australia
cmoo5187@usyd.edu.au

Abstract. This paper shows that computer game technology can generate virtual environments for use as research settings in environment and behaviour research. It illustrates the development of a simulation of a retail shop generated by the game engine Counter-Strike. In addition, this paper suggests methods to interface with this virtual shop. Lastly, it proposes methods to assess the validity of the simulation of this virtual shop.

Keywords. Computer simulation, validating virtual simulation, virtual environment, game technology.

1. Introduction

Due to the development of computer and software technology, computer simulations have been used in a number of environmental studies (Frey et al, 2007). However, computer simulations have some problems because of the cost of software and high-end computer hardware to run the software and the ‘reality’ of the virtual environment.

The development of computer game technology may be able to solve these problems. Game technology can generate real-time virtual environments that seem highly realistic, but the costs of generating the virtual environment and of computer hardware are low (Fritsch and Kada, 2004). Based on these advantages, some environmental researchers have used computer game technologies in simulation (Cubukcu and Nasar, 2005; Frey et al, 2007).

Although game technology can create a high quality virtual environment (VE), the realistic level of virtual environments is still an important question. Cubukcu and Nasar (2005) generated virtual environments by using the computer game “Quake III Arena”. However, they did not scientifically study the how realistic the VE was.

This paper suggests how to assess the level of realism and a method to test the validity of VEs. It starts with the development of a VE generated from the Counter-Strike® (CS) game engine. In addition, it introduces methods to interface with this VE. Lastly, it describes three scales to be used to assess the realistic level and the validity of the VE.

2. Developing the Virtual Environment Generated from CS

Frey et al (2007) discuss computer games such as Quake III Arena®, Counter-Strike®, Half Life® or Unreal Tournament® and argue that they allow game players to change the virtual environments. These games are categorised as First-Person Shooter (FPS) games. FPSs provide source codes and a log file that can modify virtual environments to fit with the players' purposes.

Among FPS games, the current research has chosen CS as the platform. CS was invented and developed by the Valve Corporation. It was launched in 1999, after which the numbers of users has increased considerably around the world. It is also on-line game, so that users are gathered as a Counter-Strike community. It is easy to find technical support.

The source code of this game engine can be purchased from the Counter-Strike website (http://www.steampowered.com). One program is called "Hammer Editor (HE)". In addition to these, HE provides game elements such as physics, graphical user interface (GUI), network functionality, and sound. It has been developed for better rendering performance and graphical quality by using the latest computational technology.

In the current research, HE is used for generating a simulation of the Southrom Pearl Duty Free Shop in Sydney, Australia, part of the author's research on architectural variables related to way-finding performance and ultimately to shopping behaviour. HE can create all architectural features, furniture and products, after which textures are mapped on these models. The furniture, products and light can be allocated in the environment of the virtual shop in a very similar manner as they are allocated in the real shop (see Figure 1). Finally, the starting point of the player is set, and the virtual shop is ready for the game player, or research respondent.

Figure 1. The virtual shop generated from HE (right) compared with the real shop (right).

3. Interface with Virtual Environment generated from Counter-Strike®

Although customers can walk through and navigate in retail shop environments, they cannot perform these activities in virtual shops without using input and output devices. These devices help customers to interface with the virtual environment and to perceive and perform their activities in the VE.

3.1. INPUT DEVICES

Input devices are tools to interface with VEs, called "physical controllers" (Sherman and Craig, 2003). Examples include keyboards, (space) mouses, touch screens, gloves and joysticks. Choosing the suitable input device is very important, because it affects how participants interface with the VE.

The input device is used for way-finding and moving around the virtual shop. A keyboard is generally used for computer games, in conjunction with a computer screen. It is fixed with the computer station, and it may be difficult to move around with the participants. Due to this reason, a joystick and 3D mouse may be more suitable (see Figure 2). They are designed to help participants to navigate freely in VEs. Choosing between the two should be matched with the output device.

Figure 2. Illustrations of a 3D mouse (left) and joystick (right).

3.2. OUTPUT DEVICES

Output devices are tools to display VEs. These include stereo and mono displays of flap/curved screens, caves and head-mounted displays. Participants can see VEs via these output devices, and they can feel immersed into the VE. Different output devices can make participants feel more or less immersed.

There is a wide spectrum of output devices from simple to complex devices. Each device has a different level of immersion. The level of immersion can be divided into full immersion (360), semi-immersion (<360) and non-immersion (Kalawsky, 2000). Example devices for full immersion are head-mounted displays (HMD), caves and simulators, whereas computer screens are considered as non-immersive. Large or small multiple screens and curved screen are examples of semi-immersive devices.

However, immersion and presence are slightly different. Immersion is directly related to the physical extent of sensory information, whereas presence is meant as a mentally perceptual parameter or feeling of “being there” (Kalawsky, 2000). Therefore, a fully immersive device may not lead to a high level of presence.

In addition, some fully immersive devices may have some negative effects. For examples, a HMD with a tracking system and space ball may make participants feel fully immersed in VE, but they tend to greatly underestimate spatial dimension compared with using the computer monitor and HMD without a tracking system (Henry and Furness, 1993).

Banos et al. (2004) state that there is no significantly difference between the sense of presence from a computer monitor, big screen and HMD, but HMD has highly negative effect compared with the others. In terms of realism, the big screen can make participants experience more realism than the other devices. In addition, an HMD with a tracking system may make navigation more difficulty, and tends to be physically heavy.

Because of these effects, this paper suggests that the big three screens may be the most suitable output device (see Figure 3). Although it is considered as a semi-immersive system comprising three large screens with three projections for displaying VE, the size of these screens may lead to participants feeling immersed in the VE and the experience more realistic.

Based on this output device, the input device should be a (space) mouse or 3D mouse, preferably a wireless mouse, so participants can move freely in the virtual shop.

Figure 3. An example of a three-screen output device from The University of Sydney Sentient Lab.

4. THE VALIDITY OF VIRTUAL SIMULATION GENERATED FROM COUNTER-STRIKE®

A most important research question is how to assess the validity of any virtual environment vis- -vis the real environment is meant to simulate, or, in this case, the VE of the shop generated from Counter-Strike. Certain researchers have used VE as research settings (Bishop and Rohrmann, 2003, Cubukcu and Nasar, 2005, Foreman et al., 2005), but the knowledge regarding the validity of the VE is not widely known.

Therefore, this section discusses different methods that may be used to measure the validity of VE, followed by the methods and measurements to be used specifically in environment and behaviour research. There are at least three methods that can be used for testing the validity of VE.

The first method is to compare user's responses to the virtual vis- -vis the real-world environment on affective responses. If a VE is suitable, affective responses to the VE should be similar to that from the real environment, eg, the real shop. If not, the VE needs to be revised, and the affective validity measure re-assessed. However, it may be difficult to make the both affective responses the same. Therefore, the patterns of affective response from the two different environments should be statistically quite similar. Considerable controversy surrounds the statistical question of how best to assess the similarity of VE and real environments, or to assess a minimum of statistically significant differences in responses. This paper recommends a fourth comparison in terms of affective responses to the real and VE environments, such as the PAD scale (Donovan and Rossiter, 1982, Donovan et al., 1994, Mehrabian and Russell, 1974). This scale of measuring affective response has not previously been used to compare virtual vis- -vis real environments.

The second method is for measuring the quality of the realism of the VE. Some researchers have evaluated only the quality of the VE (Cubukcu and Nasar, 2005), whereas other researchers have compared the realism of VE with the real environment (Bishop and Rohrmann, 2003). Assessing the quality of realism of the VE requires a comparison between the virtual and real environment.

Bishop and Rohrmann (2003) evaluated the realism of a virtual and real environment of a park. They created two sets of scales. One is an overall rating for realism rating, and the other is a rating of eight main environmental features such as shadows, lighting, buildings, vegetation, colours, traffic, benches/bins/signs and pace. The advantages of this method are not only the comparison between two environments, but the researchers can indicate the environmental features that are not perceived as 'real' and need to be modified.

The third method is the method for assessing the feeling of being there or presence. Banos et al. (2004) used an ITC-Sense of Presence Inventory (ITC-SOPI) to measure the feeling being in a VE. It was divided into four dimensions: physical space, engagement, ecological validity and negative effects. This ITC-SOPI consists of two parts. The first part consists of 6 items of respondent's impressions after experiencing a VE. The second part consists of 38 items of respondent's impressions during travelling in a VE. Both parts use a five-point Likert-scale (1 = strongly disagree and 5 = strongly agree).

In terms of modification of VEs, the realism level of both overall and environmental features rating can indicate which parts of the VE are required to be modified, eg, the eight environmental features of shadows, lighting, interior space, products, colours, textures, signs and furniture. In addition to this, ITC-SOPI can be used to assess the sense of presence.

According to these three types of measurements for the validity of VEs, a VE (and the simulated shop in the case of this research) can be modified until satisfactory levels of similarity or validity on all four responses are achieved between virtual store environment and real store environment. In addition, statistically satisfactory levels of test-retest reliability must also be achieved.

5. CONCLUSION

This paper proposes the use of a VE generated by CS in environment-behaviour research. The VE of the current research is a simulation of a retail shop for way-finding and consumer behaviour research, but the techniques can be expanded to all areas of EBS research. This research also recommends the use of 3D mouse and three-screen sentient lab as input and output devices.

However, critically overlooked in most previous research and writing on the topic, virtual environments require assessing the quality of this computer simulation. This paper proposes three principle measurements for the validity of VEs. The first measurement is the comparison of affective response influenced by virtual and real environments. The second measurement is to assess the realism of the VE and the comparison between the two by using the scale adapted from Bishop and Rohrmann (2003). The third measurement is the measurement of presence called "ITC-SOPI" from Banos et al. (2004) to increase the levels of presence and realism of the VE.

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