Exploring Virtual Reality as a Validation Methodology

Nuria Pelechano[1]
[1]Universitat Politècnica de Catalunya, LSI dept.
c/ Jordi Girona 1-3, 08034 Barcelona, Spain
npelechano@lsi.upc.edu

Abstract. Virtual environments can be used as a test bed for validation of human behavior simulation techniques since they place people within a simulated situation from an egocentric perspective. We propose level of presence achieved by a human in a virtual environment (VE) as a metric for virtual crowd behavior. Using experimental evidence from the presence literature and the results of a pilot experiment that we ran, we explore the egocentric features that a crowd simulation model should have in order to achieve high levels of presence.

Keywords: Presence, egocentric features, validation, crowd simulation.

1 Introduction

An important practical problem for crowd simulation research lies in how to validate models. There is no quantitative data on how to validate human behavior when it comes to decision-making in this context. Controlled experiments are needed where human behaviors in response to different crowd models can be tested. For example, during a fire, which exit routes would people select? If either known leaders or strangers give instructions, how many people would follow them? What motion paths are taken?

In order to gather accurate information, it is essential to achieve *presence* so that a subject immersed in the virtual experiment will behave as close as possible to real life [4]. Classic presence work relied on questionnaires, but since questionnaires depend entirely on a user's subjective view of their experience, researchers have developed alternative methods. Those methods include behavioral [2], physiological and breaks in presence [5].

Our contribution lies in differentiating *external* crowd motion features from *internal* or *egocentric* features. The computer animation community has been primarily concerned with the former, as a good simulation will produce crowd movements that appear realistic to an outside observer. Egocentric features, on the other hand, are about what an active participant in the crowd simulation would perceive visually or kinesthetically.

For the purpose of this work we focused on three models that have been widely used for crowd simulation (social forces, rule based and cellular automata) and a hybrid approach, HiDAC. Further information can be found in Pelechano et. al. [3].

2. PRESENCE IN CROWD SIMULATION MODELS

The main egocentric features in a crowd simulation model, which we believe are significant factors influencing presence in VEs are shown in table 1.

Table 1. Egocentric features. (+) indicates feature present in the model, (-) means lacking, and (*) indicates that it has been included in latter models, but not in the original one.

Egocentric Features	Social Forces	Rule-based	CA	HiDAC
Shaking avoidance	–	+	+	+
Continuous Movement	+	+	–	+
Overlapping avoidance	+	*	–	+
Communication	–	*	–	+
Pushing	+	–	–	+

Shaking implies how much the agents appear to vibrate while trying to move. Discrete/Continuous movement means how the agent moves from one position to another, and whether it is discretized or continuous in space. Overlapping refers to whether multiple objects/agents can occupy the same space during the simulation. Communication represents the ability of the agents to exchange information about the virtual environment. Pushing implies having physical contact between the agents' bodies.

2.1 Experimental Evidence from the Literature

There have been many experiments to date studying which elements of a virtual environment could enhance or reduce presence. Slater et al. [5] discovered that when a whiteout occurs while a participant is immersed in a VE there is a break in presence. This effect also occurs, for example, if while navigating a VE the participant walks through a virtual object or agent. Therefore we need to eliminate overlapping.

According to Schubert et al. [5]: "Presence is observable when people interact in and with a virtual world as if they were there, when they grasp for virtual objects or develop fear of virtual cliffs." Interaction means "the manipulation of objects and the influence on agents". Hence to enhance the sense of presence, a participant must be able to manipulate virtual objects. One way a participant could feel as if they were affecting the virtual world would be by pushing other agents they came into contact with.

Another way of interacting that increases the sense of presence is through communication with the virtual agents. Some studies show that the heart rate of a participant increases when a virtual agent speaks directly to him [5].

Studies show that discontinuous movement or jerkiness reduces presence. Jerkiness can be observed when, for example, the VE suffers from low frame rate (Barfield and Hendrix [1]) Therefore we can expect that crowd models suffering from agents shaking continuously or appearing to move between large discrete positions will likewise diminish the participant's sense of presence.

3. PILOT EXPERIMENT

For this work we carried out a pilot experiment to closely study the behavior of people interacting with a virtual crowd in a scenario simulating a cocktail party (Fig 1). The user was immersed in the crowd using an eMagin Z800 3DVisor head mounted display (with a resolution of 800x600, field of view of 40 degrees and 60Hz refresh rate). In addition, participants wore four head sensors that are part of the ReActor2 suit, an optical motion capture system from Ascension Technology.

Each subject was placed in the same virtual environment (physical floor space was scaled to the virtual one by magnifying step sizes) with the same virtual characters. After a training phase, the subject was assigned the task of walking around the cocktail party, counting the number of red haired party-goers, and leaving when an alarm sounded. By videotaping the subject's behavioral response together with the scene we can study the response of the person to the behavior of the virtual crowd.

Fig. 1. Virtual crowd and a real person immersed in the crowd through a head mounted display.

4. INITIAL RESULTS AND FUTURE WORK

The goal of this pilot experiment was to examine whether participants interacting with a virtual crowd experience would react to the virtual crowd as they would in a real situation. From our experiments we have been able to observe that some participants did exhibit some behaviors consistent with the notion that they were responding to the crowd realistically. The results obtained for this study came mainly from participants' comments about their experience and from observing their behavioral response to the virtual crowd from the videos. Comments include:

- "The sense of crowd movement was most compelling during the evacuation."
- "I felt bad whenever I bumped into someone."
- "...everyone immediately started leaving and it made me really want to leave as well."

These examples show that some people do think about the interaction with virtual agents in a similar way as when they interact with real people.

By examining videotapes of participants' behavioral responses we observed people moving backwards after bumping into a virtual agent, stepping sideways to avoid a virtual agent walking into them, and turning their head to watch an agent walk around them.

The pilot experiment had background crowd noise as well as the noise of the bell. A participant reported after the experiment "*I don't remember if the tables or people made sounds when I bumped into them.*" This comment shows such a high level of presence that the person is not aware of what he has or has not heard during the experiment. In general participants were pleased that the background noise enhanced their experience in a virtual crowd, however several improvements were suggested by participants. For example, including stereo sound to enhance presence by being able to realize when, as a participant, you are bumping into a virtual object or person and making the sound localized and clearer as the participant approaches a small group of people engaged in conversation.

In the future we are considering using improved equipment to improve the experience, such as a CAVE® which offers higher resolution and wider field of view.

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References

1. Barfield, W., Hendrix, C. 1995. The Effect of Update Rate on the Sense of Presence within Virtual Environments. In Virtual Reality: The Journal of the Virtual Reality Society, 1(1), 3-16.
2. Freeman, J., Avons, S.E., Meddis, R., Pearson, D.E., IJsselstijn, W.A. 2000. Using Behavioral Realism to Estimate Presence: A Study of the Utility of the Postural Responses to Motion Stimuli. In Presence: Teleoperators and Virtual Environments, 9, 149-164.
3. Pelechano, N., Stocker, C., Allbeck, J. Badler, N. Being a Part of the Crowd: Towards Validating VR Crowds Using Presence. Seventh International Joint Conference on Autonomous Agents and Multi-Agent Systems. (AAMAS'08) Estoril (Portugal) May 12-16, 2008.
4. Sanchez-Vives, M.V., Slater, M. 2005. From Presence to Consciousness Through Virtual Reality. In Nature Reviews Neuroscience, 6(4), 332-339.
5. Schubert, T., Friedmann, F., Regenbrecht, H. 2001. The experience of presence: Factor analytic insights. In Presence: Teleoperators and Virtual Environments, 10(3), 266-281.
6. Slater, M., Guger, C., Edlinger, G., Leeb, R., Pfurtscheller, G., Antley, A., Garau, M., Brogni, A., Friedman, D. 2006. Analysis of Physiological Responses to a Social Situation in an Immersive Virtual Environment. In Presence: Teleoperators and Virtual Environments, 15(5), 553-569.