Presence in a Distributed Virtual Environment

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Abstract

Collaborative Virtual Environments (CVEs) involve the use of a distributed architecture, and advanced interactive user interfaces to create a ‘shared’ sense of space where users located in different physical locations can interact. An important objective is to provide users with an illusion that the machine mediated experience is not mediated. The extent of this illusion is measured by the sense of ‘presence’ experienced. We explore ‘shared presence’ in a Cooperative Virtual Environment, that is providing the participants with a sense of presence of others in the environment, thus having a feeling that they are directly cooperating with real people. We describe our prototype system for a ‘non-immersive’ distributed virtual environment. We provide preliminary results on factors which increase the sense of ‘shared presence’ in a virtual environment. These include the use of avatars to represent the participants, providing simple communication and interaction with the environment. Our prototype has served as a good basis for our future work towards shared presence by highlighting areas that require attention, (such as providing communicative behaviour to avatars) and indicating good prospects such as the importance of how one represents the avatars.

1 Introduction

Virtual environments that can be simultaneously shared by a number of participants located in different geographical locations, provide new possibilities for communication and collaboration, with a lot of potential and enhancements for the way we work and exchange information. However, in order for such systems to be successful, they need to provide the participants with a realistic experience. We postulate that the sense of presence can be used as a measure of how effective a virtual environment is.

Providing a high sense of presence means providing the participants with a sense of 'being there'. In other words, with a sense of being in the place specified by the virtual environment rather than just seeing images depicting that place, and forgetting being in the lab, in favour of the virtual world.

In this paper we explore 'shared presence' (refer to Section 3.2) in a Cooperative Virtual Environment, that is, the extent to which participants regard the other participants as being really present in the environment. We present a preliminary exploration into the means to increase the sense of shared presence in a distributed virtual environment. In order to do this, we have developed a prototype system of a 'non-immersive' multi-user virtual environment. This prototype is a test bed to investigate different techniques which increase the sense of shared presence in the virtual environment.

The next section provides some background on networked virtual environments, and Section 3 provides some background on presence. Section 4 describes the distributed architecture used by the system. Section 5 presents a preliminary exploration into some ways in which shared presence might be enhanced in a virtual environment. Section 6 describes some experiences with the system, while Section 7 presents directions for future work and conclusions.

2 Networked Virtual Environments

A networked virtual environment is a distributed simulation of a *virtual world* in which multiple users interact with each other in real-time, even though those users may be physically located in different geographical places. These environments usually aim to provide users with a sense of realism by incorporating 3D graphics and sound to create an immersive experience, but they can use different user interfaces, such as a text interface, or a graphical user interface (GUI).

Singhal and Zyda [1] describe the main features of networked virtual environments as follows:

- A shared sense of space: All users are presented with the illusion of been in the same place.
- A shared sense of presence: participants are represented by a virtual representation, called *avatars*. When a participant enters a virtual environment, he/she can see the other participant's avatars and the other participants can see the new participant's own avatar.
- Real time interaction: multiple users, located in different physical locations, interact with each other in real time. In other words, users should be able to see each other's behaviour as it occurs.
- A way to communicate: Virtual environments also strive to enable some sort of communication among participants. This communication may occur by gesture, by typed text, or by voice.

3 Presence

3.1 What is Presence?

Presence has been defined by Lombard and Ditton [2] as ‘the perceptual illusion of non-mediation’. This definition says that providing a sense of presence is providing the user with an illusion that the experience is non-mediated. By a non-mediated experience they mean that the experience is experienced without any technology in the way. This illusion of non-mediation occurs when a person does not perceive the existence of a medium in his/her environment, and behaves as if the medium is not there.

Romano *et al* [3], believe that it is possible to have a high level of presence in a virtual environment without having to stimulate every sensory system of humans. In fact, many current virtual environments successfully generate a sense of presence by stimulating only the visual and audio senses. This is significant for producing presence in virtual environments, since constructing a fully immersive virtual environment is expensive.

3.2 Categories of Presence

Slater *et al* [4, 5] classifies presence into *personal* presence and *shared* presence. These two types of presence are related, but are conceptually different forms of presence.

Personal presence relates to the sense of ‘been there’, and having a feeling of presence yourself. Personal presence has two manifestations: *subjective* presence, which refers to what an individual will express in response to questions about ’being there’. One can think of subjective presence as ‘being a verbal and necessarily conscious articulation of a state of mind’ [5]. The other manifestation is *behavioural* presence, where the individual acts as if he/she was present in the environment, and exhibits behaviour to support this. This type of presence can be seen as ‘automatic, unplanned non conscious bodily responses’ [5] to stimuli.

Shared presence relates to the feeling of presence in others in the virtual environment. It has two aspects, for each individual: first, the sense of presence of other individuals in the virtual environment, and second the sense of being part of a group and a process, i.e., being present in a group and in the process which the group is working on during the meeting.

3.3 Factors Influencing Presence

There are a number of factors which contribute to a high sense of presence in a virtual environment. The more obvious ones are high graphics update rate, low latency, and high degree of interactivity [6].

Lombard and Ditton [2] describe known and suggested factors which affect the sense of presence. They indicate that the visual display characteristics (such as image quality, image size, viewing distance, colour, dimensionality, etc.), sound characteristics (such as sound quality and 3D sound), and interactivity affect the sense of presence.

Durlach and Slater [7] indicate that in a shared virtual environment, it seems likely that the sense of presence will be increased by enhancing interaction with the environment. They also indicate that the sense of presence will be increased even more by interactions where the environment changes are the result of collaborative work by a number of participants. For example, moving heavy objects which require cooperative lifting.

Slater *et al* [4] indicate that the notion of a virtual body (or avatar) is one of the main ways of creating a sense of shared presence. They note that the way one represents other participants in the environment is crucial for shared presence. They also indicate that the static existence of others is not enough to create a sense of shared presence, and that there must be the possibility of interaction and the exchange of information.

3.4 Unresolved Issues in Presence

There has been relatively little research conducted to investigate the factors that contribute to a sense of presence and the consequences that it produces. Lombard and Ditton [2] indicate that 'it has not yet been carefully explicated, operationalized, or studied', and that 'Previous discussions of presence have typically been based on informed conjecture rather than research'. Held and Durlach [8] say that 'There is no scientific body of data and/or theory delineating the factors that underlie the phenomenon'. Durlach and Slater [7] indicates this lack of research by noting that there are a lot of important unresolved issues concerning presence in a virtual environment. These issues include (a) the definition of presence, (b) how to measure presence, (c) which factors enhance presence, (d) the relation of presence to work performance.

4 System Architecture

In order to investigate shared presence in a distributed virtual environment, we have developed a prototype of such a system. This prototype is intended to be a test bed to provide a preliminary exploration on different techniques to increase the sense of shared presence and support collaboration in such an environment.

The system uses a *distributed model* [9] as the communication model. Here, each program maintains its own local copy of the database as well as performing the rendering. When a program makes a change to its database, a message is sent to the other programs so that they update their local databases. This distribution model is much more scalable that the *client-server* model, where a central server has a centralized database and thus the server becomes a bottleneck. In the *distributed model*, however, the scalability problem is changed from being a bottleneck (in the centralized model) to one where there are many connections and messages.

In order to reduce the number of connections and thus the number of messages being sent, we use UDP multicasting [10]. Using unicast communications, if there are *n* participants in the environment, then when one participant makes a change, he must be connected to *n-1* other participants and send *n-1* messages. Using multicasting, the participant can simply send one single message which allows all the other participants (who must be subscribed to the same multicast group) to read that single message.

This significantly reduces the number of connections and messages being send during database updates. Using multicast also simplifies the programming, since a participant joining a session in progress does not have to establish *n-1* connections with the other processes [9]. The new participant only needs to know the multicast group address to listen to broadcasts and send updates.

Since UDP multicasting is an unreliable protocol, the system also has a TCP/IP server which provides reliable stream communications. In other words, the system provides different degrees of reliability to gain better real time performance. It provides a protocol that guarantees the reliability of certain packets by using TCP connections, and does not guarantee reliability for frequent non-critical data such as the state of the participants (position, direction...).

Figure 1 shows the distributed architecture of the system. During initialisation, the client makes a connection to the TCP server, and receives the multicast group address from the server. It then subscribes to the multicast group which allows him/her to listen for messages and send messages to all the participants in the same multicast group. Once a client quits, it sends a message

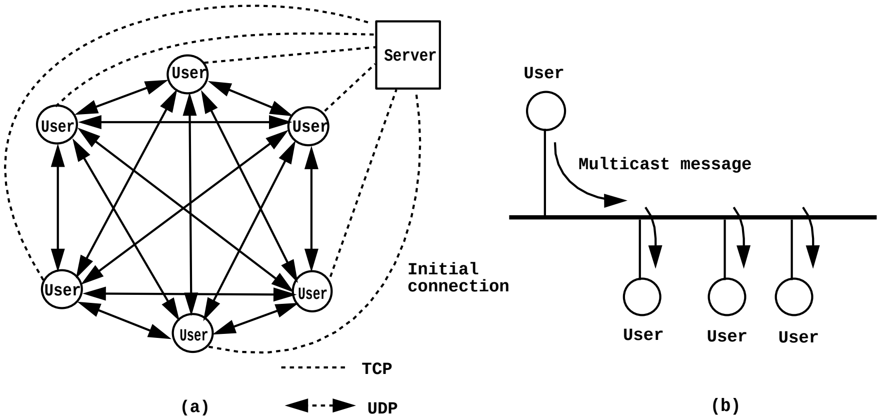

Figure 1: The system uses a Distributed Model together with a Client-Server model (a) and UDP Multicasting (b)

to the TCP server, which closes the connection and indicates to the other client that a client has left the system.

The system uses OpenGL [11] to perform the rendering, and uses Glut3.6 for the window and menu systems. The system has been tested on SGI workstations running IRIX 5.3 and 6.2.

5 Enhancing the Sense of Shared Presence

In this section we present a preliminary exploration of ways in which shared presence might be enhanced in a cooperative virtual environment. These include the use of avatars, providing simple communication and interaction with the environment.

5.1 Virtual Representation of Participants

In order to create a sense of shared presence, issues such as participant location, participant or group identity, participant attitudes, availability etc, must be addressed [12, 13]. These issues are addressed by using virtual representations of participants or *avatars* [14].

In a multi-user virtual environment, a user's avatar has a main purpose: to signal the presence of that user to any other users who are currently in the environment. This provides other users with this user's location and point of view, which also facilitates awareness of ongoing activities.

The way one represents other participants in the environment is a major issue in enhancing the sense of shared presence . Some persons might find it easy to maintain the sense of presence of others with just crude representations of avatars. Others might require fully functional avatars, with gestures and facial expressions [4].

In order to fulfill the above requirements, the system provides the users with different avatars of varying complexity. It provides some body-like avatars and some simple avatars composed from a few basic graphics objects. The avatars do not possess any functionality in terms of gestures or facial expressions. The avatars positions and orientations are updated in the 3D space to indicate the viewpoints of the different users in the virtual world (see Figure 2).

There are several pieces of information that the avatars convey in order to enhance shared presence:

- Presence: The avatar indicates its owner's presence in the Virtual Environment.

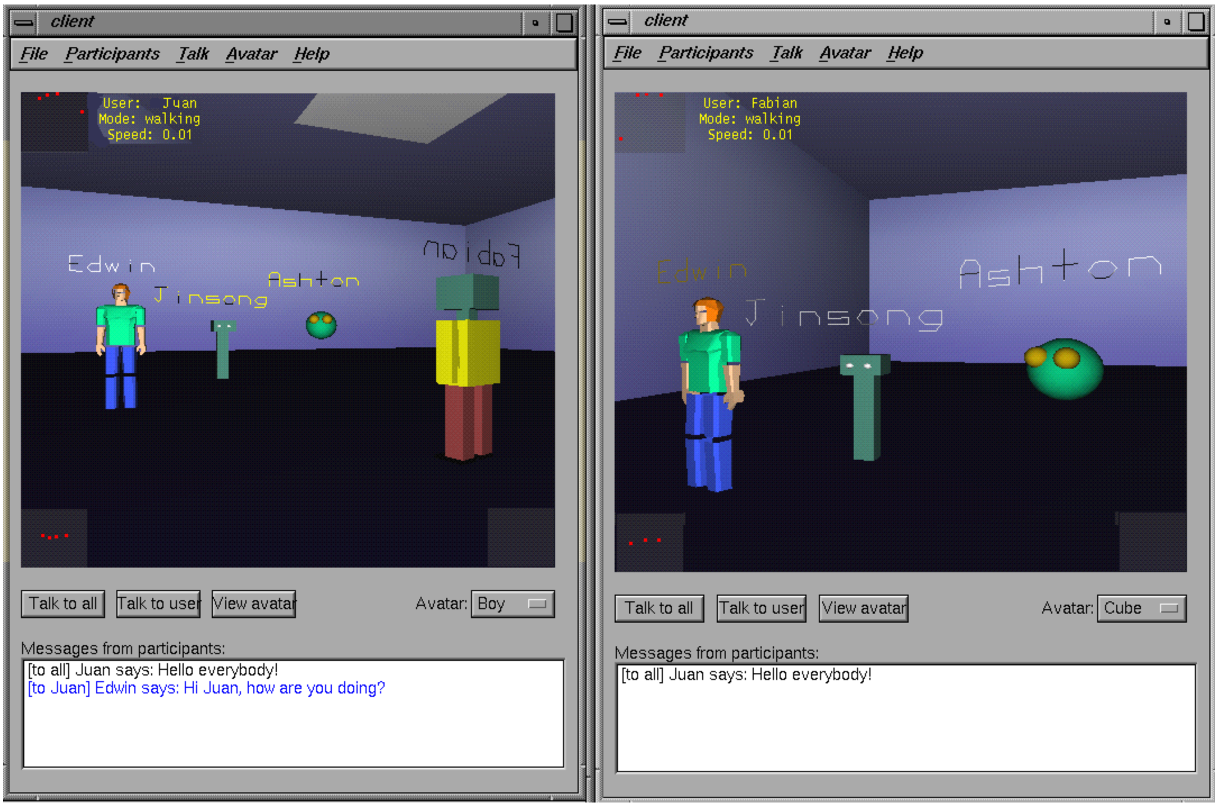

Figure 2: A session showing the views of two participants.

- Location: The avatar shows the position and orientation of the participants.
- Identity: The avatar indicates that it represents a user, and not any other object in the environment. It is also possible to differentiate that user from any other users, and it is possible to recognise who an avatar represents by using a text label with the user's name.
- Viewpoint: The avatar conveys the user's current viewpoint, which helps convey what the user is looking at and hence interested in.

In order to address the question of knowing who are you collaborating with, the systems keeps a menu of all the participants collaborating in the virtual world. This menu is updated every time a new participant joins or a participant leaves the collaboration session.

5.2 Navigation

Virtual reality technology gives users the freedom of navigation, meaning that each participant can independently explore the environment to find out who else is there, what are they doing etc.

There are two types of navigation metaphors which are used by the system for individual navigation, the *walk* metaphor and the *fly* metaphor.

The *walk* metaphor allows the user to move forward and backwards, and to turn left and right. There is also the possibility to individually change the x, y and z coordinates, for example allowing the user to move up and down (by changing the y coordinate).

The *fly* metaphor allows the participants to move their heading vector in any direction, thus enabling the participants to 'look around' in the virtual world. It also allows the participant to move in the direction of the heading vector, thus allowing the participants to 'fly' in the virtual world.

Navigation in the virtual world is facilitated by providing navigation aids, such as 2D maps of the world. There are three such maps, a front map, a back map and a map seen from the top. These maps indicate the current position of the participants in the virtual world (see Figure 2).

5.3 Interaction

The participants can interact with the environment by picking objects and moving them around.

The system implements a simple ownership mechanism: If a participant clicks on an objects which is owned by no one, he becomes the owner of the object. Other participants cannot select this object until the owner releases the selected object. In other words, a participant cannot select objects which are owned by other participants.

As a primary focus of group interaction, there is the issue of efficient communication between participants. Communication is provided by a text based chat interface where users can type messages and send them either to all participants, or only to a specific participant. More sophisticated tools such as video and audio will provide more efficient communication, and can be considered as future improvements.

6 Experiences Using the System

The system addresses the issue of shared presence mainly by using different avatars to represent the collaborating participants. This is a simple but very effective way to create a sense of presence of others in the environment. The system provides a variety of avatars. Some avatars are body-like, while others consist of basic geometric shapes (such as spheres and blocks). We found that, contrary to what one would think, semi-realistic avatars (such as the *boy* avatar in Figure 2) are less appealing than totally unrealistic ones (such as spheres, blocks or cartoon like avatars). This might be because in a virtual environment, the users have the possibility to take virtually any form they please, and so form other than our own and in particular humorous ones, are probably more appealing and effective.

We found that the avatars are very static and that one needs to provide communicative behaviour to avatars. This includes providing gestures and facial expressions which are an important part of conversation since they can be used to convey visual cues to other participants.

We found that the issue of knowing whether a particular user is available for interaction was not supported. A user has no way to tell if another participant is available to engage in a conversation or not. For example, a user might be busy having a private conversation with another user and does not want to be disturbed. There is also the issue of knowing if the person behind the avatar is there or not. This problem arises because there is a strong separation between the avatar and the 'mind' behind it in a non-immersive virtual environment. In fact the person may have popped out of the lab for a few seconds leaving an empty avatar in the environment. This causes a number of problems such as the wasted effort involved in talking to an empty avatar. As a result it might be important to explicitly show the availability of users.

We believe that the system is successful in creating a sense of shared presence, and that it shows that it does not take a very complex system to enable some people to have a sense of shared presence in a multi-user virtual environment.

The prospects of this system encourage further work, and we are currently looking at DIVE [15], an existing distributed virtual environment which we can use to perform a full investigation into the issue of shared presence in a virtual environment.

7 Conclusion and Future Work

We have developed a prototype of a 'non-immersive' distributed virtual environment to provide a preliminary exploration on 'shared presence'. Such a prototype has been used to explore how shared presence can be enhanced by using different avatars, providing simple communication via a text chat interface, and providing interaction with the environment by allowing users to move objects around. We believe that the use of simple avatars and simple communication techniques (such as text interaction) are sufficient for some persons to maintain a sense of presence of others in a non-immersive virtual environment. This is evident from the high popularity and success of computer games such as Quake [16].

As future work, we will continue the investigation of factors affecting shared presence. These include investigating issues such as providing gestures and facial expressions to the avatars. Communication between participants could be improved by providing audio and video capabilities. There is also the issue of identifying ways to measure shared presence in a virtual environment and conducting experiments with test subjects to evaluate the factors affecting shared presence.

This system has provided a useful exploration of shared presence in a virtual environment. It has served as a good basis for our future work towards shared presence by highlighting areas that require attention, and indicating good prospects.

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