Presence and Co-Presence in Collaborative Virtual Environments

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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. In this paper, we describe two experimental designs which use subjective evaluation methods to asses *personal presence* and *co-presence* in a CVE. Personal presence is having a feeling of “being there” in the CVE yourself. Co-presence is having a feeling that one is in the same place as the other participants, and that one is collaborating with real people. The first experiment investigates the effects of avatar appearance and functionality (gestures and facial expressions) on presence and co-presence in a CVE. The second experiment investigates the effects of small group collaboration on co-presence in a CVE.

1 Introduction

Collaborative Virtual Environments (CVEs) 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 for the way we work and exchange information. CVEs are seen by many as the future in telecommunications [3, 16], where a multitude of people will be able to meet and interact with each other in the 3D space as if they where in the same real space, with a full range of sociological interaction provided. Several authors [2, 3, 16] have claimed that CVEs may support collaboration and interactivity in ways which go beyond what is possible using more familiar meeting room or teleconferencing technologies.

However, in order for such systems to be usable and successful, they need to provide the participants with a compelling experience and a high sense of *presence*, to convince them that they are present in the virtual environment, and that they are collaborating with real people.

Presence refers to the psychological sensation of "being there", having a sense of been in the place specified by the virtual environment rather than just seeing images depicting that place. We postulate that the sense of presence can be used as a measure of how effective a virtual environment is.

Slater *et al* [11] define presence as "a state of consciousness, the (psychological) sense of being in the virtual environment". Slater *et al* [8, 10] classifies presence into *personal presence* and *shared presence* (or co-presence). Personal presence relates to the subjective feeling of "being there", in the virtual environment, leading to a sense of "places visited, rather than images seen" [11]. Shared presence (co-presence) has two aspects: that of feeling that the other participants in the VE actually exist and are really present in the environment, and that of feeling part of a group and process.

In this paper, we present two experiments which investigate some of the factors which could increase the sense of co-presence in a CVE. These experiments are used to investigate:

1. The effects of avatar appearance, complexity, and functionality (gestures and facial expressions) on presence in a CVE.

2. The effects that small group collaboration has on presence in a CVE.

The next section presents the hypotheses we are trying to investigate with the presence experiments. Section 3 describes the first experiment, which looks at the effects of avatar appearance, complexity, and functionality on co-presence in a CVE. Section 4 describes the small group collaboration experiment, which looks into the effects of group collaboration on co-presence in a CVE. Section 5 presents direction for future work and conclusions.

2 Presence and Avatars: Hypotheses

It has been argued that the notion of having some sort of virtual representation (or *avatar*) of a participant is very important for presence, especially for co-presence [9, 1, 10, 13, 15, 6, 14, 12].

In this paper we investigate the following hypotheses:

- The notion that a virtual body is crucial to create a sense of co-presence. A participant requires information such as location (position and viewpoint of others), identity (*who* the avatar represents), and availability (conveying some sense of how busy and/or interruptible a participant is) to establish and maintain the presence of other participants in the VE.

- The way one represents other participants in the VE is very important to enhance the sense of co-presence. The important issue here is to determine how the appearance and functionality of the avatars affects co-presence. Here we will address questions such as: Are body-like avatars more effective than other virtual representations ? Are fully functional avatars, with gestures and facial expressions necessary or are crude representations of avatars sufficient to maintain the sense of co-presence ?

- Group collaboration and interaction with other participants in the environment should influence co-presence and vice versa. It is believed that simply having a visual representation of others is not sufficient to create a high sense of co-presence. Having the possibility to collaborate and interact with other participants should very much increase the sense of co-presence.

In order to investigate the mentioned hypotheses, we have designed two subjective experiments, described in Sections 3 and 4.

3 Avatar Representation and Functionality Experiment

In this experiment, we investigate the effects that avatar representation and functionality have on presence in the CVE. We try to answer the following issues:

1. Does the use of a 3D virtual environment and avatars create a sense of co-presence in the CVE?

2. The effect that unrealistic avatars (i.e. cartoon-like avatars, spheres and block avatars, etc) have on presence as opposed to human-like avatars.

3. The effect that avatar complexity and functionality has on shared presence in the virtual environment.

In order to investigate the above issues, we use two very similar experiment, which use the same VE and have the same experimental scenario. Only the avatars provided to the participants differ between experiments. In the first experiment, we investigate the effects of unrealistic avatars as opposed to human-like avatars. In the second experiment, we investigate the effects of avatar complexity and functionality on presence.

3.1 Experimental Task

The first experiment uses 24 participants, divided into 6 groups of 4 participants each. The second experiment uses 32 participants divided into 8 groups of 4.

Each subject firstly completes the Immersive Tendencies Questionnaire (refer to Section 3.4). Each subject is then introduced to the system, which involves learning how to move through the VE and how to control the avatar.

The participants have to firstly locate a table in the middle of the room and position themselves around it. The table has a book for each participant, and by clicking on the book, the participants are able to read a document.

The task consists of reading a story (4 short paragraphs) by accessing the book on the table. Once each participant has read the story, they have to agree on a ranking for the five characters in the story. The ranking is as follows: the best character is assigned a “1” and the worst a “5”. There is a white-board which has a simple grid with the names of the five characters of the story.

At the bottom of the board, there are five numbers which can be moved around the board, so that the participants can assign the rankings to each character. The four participants have to argue with one another and arrive to a group agreement. This task requires communication to argue or agree with the other participant's rankings.

The session takes 20 minutes, and after that, each user is required to fill a presence questionnaire (refer to Section 3.4).

Figure 1: The virtual environment used for the first experiment.

3.2 Collaborative Virtual Environment Prototype

The CVE consists of a conference room where multiple users can meet around a table and have a discussion (refer to Figure 1). Each participant has a book on the table which can be used to view a document. There is a white board where one can display a series of "slides". Participants are able to move around the room using the arrow keys or the mouse. Cooperation is basically supported by directly embodying the users in the VE using different avatars, and providing them with different inter-user communication facilities such as a spatial audio channel and a textual chat interface.

The CVE is implemented using the DIVE system [5, 4], which is a toolkit for the development of multi-user distributed virtual environments.

Figure 2: The avatars used for the first experiment.

3.3 Avatars

For the first experiment, we provide the participants with a range of avatars which include: unrealistic avatars (blockie, cube, sphere), cartoon-like avatars (dilbert, blockie95, legoman), semi-realistic human-like avatars (walkman, newt), and realistic human-like avatars (bob, man). Figure 2 shows the avatars available for the experiment. These avatars do not have any functionality in terms of gestures and facial expressions. Each of the four participant in a group has an avatar from one of these categories during the session.

For the second experiment, we provide a range of avatars which include: simple complexity with no functionality (blockie, cube), medium complexity with no functionality (dilbert), medium complexity with some functionality (dilbert with gestures only), high complexity with no functionality (bob, man), high complexity with functionality (bob with gestures and facial expressions). By functionality we mean that the avatars have a range of gestures (waving, raising arms, joy and sad gestures, movement of head such as no, yes, and perhaps gestures, walking) and facial expressions. Facial animation, based on the linear muscle model developed by Parke and Walters [7], provides the avatars with 6 expressions (happiness, surprise, sadness, anger, furious, and disgust). Figure 3 shows some of the facial expressions available.

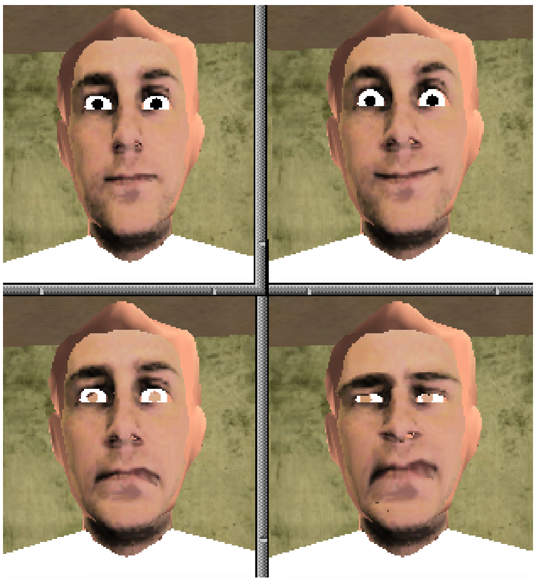

Figure 3: Some of the facial expressions available. From left to right, top to bottom: neutral, happy, sad, and furious.

3.4 Measuring Presence and Hypotheses

We measure subjective reported levels of presence and co-presence using a presence questionnaire based on the questionnaires developed by Slater *et al* [10, 8], and by Witmer and Singer [17]. In addition, the questionnaire will include items from the Immersive Tendencies Questionnaire (ITQ) developed by Witmer and Singer [17].

In the first experiment, there are two hypotheses we want to measure. One is that a sense of presence and co-presence is created by embodying the user in the VE by means of a virtual representation. The second hypothesis is that we expect realistic human-like avatars to create a higher sense of co-presence than unrealistic ones. These hypotheses are tested by measuring the following variables: The presence score, the co-presence created by realistic human-like avatars, semi-realistic human-like avatars, cartoon-like avatars, and unrealistic avatars respectively . All of these variables are measured using the presence questionnaire. In this experiment, we expect the presence score to be positively correlated with the co-presence score. Also, we expect the co-presence created by the more realistic avatars to be significantly greater than that created by the unrealistic avatars.

In the second experiment, there are two hypotheses which we wish to explore. The first one is that avatars with gestures and facial expressions will enhance the sense of co-presence. The other is that having realistic human-like avatars without any body movement could create a worst sense of co-presence than having unrealistic avatars without any body movement. This is because there is a conflict between the greater visual realism of the human-like avatar and the lack of bodily movement. On the other hand, having an unrealistic avatar makes it easier to understand that it is not functional. These hypotheses are tested by measuring the following variables: The presence score, the co-presence created by avatars with gestures and facial expressions, the co-presence created by static avatars. Here, we expect the co-presence score created by the avatars with gestures and facial expressions to be greater than that created by the static avatars.

Figure 4: The graphical user interface used to control the gestures and facial expressions.

3.5 Equipment

The equipment used are 3 SGI O2 workstations and an SGI Onyx RealityEngine2. The displays are 17” and 21” monitors.

The movement through the virtual environment is accomplish by using the keyboard or the mouse. Objects in the virtual environment are selected and moved using the mouse. The avatars with gestures and facial expressions have a graphical user interface where one can control the different gestures and facial expressions which the avatar can perform (refer to Figure 4).

4 Small Group Collaboration Experiment

This experiment is used to investigate collaboration and interaction between a small group of 3 users in a CVE, and the effects that collaboration and interaction has on co-presence in the CVE.

This experiment is based on the work done by Tromp *et al* [14], where they investigate small group behaviour in a CVE.

The specific aim of this experiment is to test whether co-presence is increased by collaborating and interacting with other participants in the CVE. We hope to get answers to the following questions:

1. Does the use of a 3D VE and avatars create a sense of co-presence?

2. Is having visual representation of others sufficient to create a high sense of co-presence, or is interaction and collaboration needed?

3. Does the sense of co-presence increase with collaboration and interaction with other participants in a CVE?

In order to answer these questions, we have developed two collaborative virtual environments, a high-collaboration VE and a low-collaboration VE. Both VEs are basically identical and only the task differs. In the high-collaboration VE, participants can communicate and interact with one another, and have to collaborate to solve the given task. In the low-collaboration VE, participants don't need to collaborate to solve the problem.

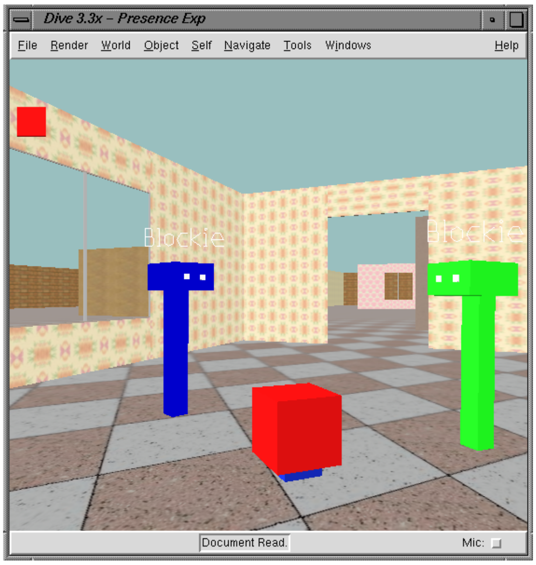

Figure 5: The virtual environment for the second experiment.

4.1 Collaborative Virtual Environment Prototype

The VE consists of a set of rooms which creates a maze-like set-up. Participants are able to move around the rooms using the mouse or the arrow keys. They are able to pick up objects by clicking on them, which attaches the object to their avatar. They are therefore able to move the object by moving themselves, and then release the object by clicking on it again. Participants can communicate with each other using a spatial audio channel and a textual chat interface.

In this experiment, all the participants have the same avatar, consisting of a 'T' shaped block avatar. The only difference between the participant's avatars is their colour being red, green or blue (see Figure 5). Since the participants cannot see their own avatar, a small square with the same colour as their avatar is displayed on the upper-left corner of the display to indicate which colour is associated with the user, and hence which objects he/she can pick up.

4.2 Experimental Task

The experiment involves 24 participants, divided into 8 groups of 3 users each.

The task consists to move different geometrical shapes (circles, cubes, pyramids) into specified rooms. Each room has the shape that has to be moves there, written on top of the door.

In the high-collaboration VE, each participant has a colour associated with their avatar, and each shape has two colours associated with it. The shapes are two "heavy" to be picked up by one user, and need two users to pick them up. In addition, only the two participants with the same colours as the shape can pick up a given shape. Picking up a shape involves having the two participants within a close range of the shape and having one of them click on the shape to unlock it and then the other click on the shape to pick it up. The shape gets attached to the avatar of the participant who clicked on it to pick it up, and he/she can move around with the VE and drop it in the appropriate room. The participants have to collaborate to move all the shapes to the required rooms. This task involves observation and talking, and it can only be solved by collaboration since two participants are needed to pick up a shape.

In the low collaboration VE, the task is basically the same expect that each shape has only one colour associated with it, and a shape can be picked up by a single user with the same colour as the shape. This means that participants don't need to collaborate to move the shapes around, and so this task can be completed without collaboration.

4.3 Measuring Presence and Group Collaboration

In this experiment, we measure subjective reported levels of presence and co-presence using a presence questionnaire based on the questionnaires developed by Slater *et al* [6, 8], and by Witmer and Singer [17]. In addition, the questionnaire will include items from the Immersive Tendencies Questionnaire (ITQ) developed by Witmer and Singer [17].

We also measure subjectively rated collaboration by making use of a post-experiment questionnaire. This allow us to make sure that the two worlds produced different levels of collaboration and group interaction. The subjective collaboration questionnaire is based on the work done by Tromp el al [14]. It assesses the degree of enjoyment, the desire for the group to form again, the degree of comfort with individual members, and the perceived collaboration of the other members of the group.

There are two hypotheses we want to test by means of this experiment. The first one is that a sense of presence and co-presence is created by embodying the user in the VE by means of avatars. The second hypothesis is that having visual representation of others is not sufficient to create a high sense of co-presence, and that group collaboration and interaction is required to enhance co-presence. These hypotheses are tested by measuring the following variables: The presence score, the co-presence score, and the collaboration score which measures the degree of collaboration and group accord.

In this experiment, we expect the presence score to be correlated to the co-presence score. We also expect the collaboration score to be greater in the high-collaboration VE, compared to the low-collaboration VE. We expect the co-presence score to be positively correlated with the collaboration score, so that a high collaboration score leads to a high co-presence score and vice-versa.

5 Conclusion

This paper describes two experimental designs which will be used to asses some of the factors which could influence presence and co-presence in a collaborative virtual environment. The first experiment investigates the appearance and functionality of the virtual representations of participants, and the effects they have on presence and specially co-presence in a CVE. The second experiment explores small group collaboration in a CVE, and the effects that group collaboration and interaction have on presence and co-presence in the virtual environment.

We have implemented two non-immersive collaborative virtual environment prototypes which will be used in the described experiments. Collaboration is supported by directly embodying the participants in the virtual environment, providing audio and text communications, and allowing interaction between them and the environment (e.g., moving objects around) Also, we have implemented a range of avatars having different levels of complexity, appearance and functionality (in terms of gestures and facial expressions).

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