The Effect of Haptic Feedback on Basic Social Interaction within Shared Virtual Environments

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Abstract. This paper describes an experiment that studies the effect of basic haptic feedback in creating a sense of social interaction within a shared virtual environment (SVE). Although there have been a number of studies investigating the effect of haptic feedback on collaborative task performance, they do not address the effect it has in inducing social presence. The purpose of this experiment is to show that haptic feedback enhances the sense of social presence within a mediated environment. An experiment was carried out using a shared desktop based virtual environment where 20 remotely located couples who did not know one another had to solve a puzzle together. In 10 groups they had shared haptic communication through their hands, and in another group they did not. Hence the haptic feedback was not used for completing the task itself, but rather as a means of social interacting – communicating with the other participant. The results suggest that basic haptic feedback increases the sense of social presence within the shared VE.

Keywords: Haptics, social presence, shared virtual environments.

1 Introduction

Virtual environments attempt to give people the impression of being in a real place through the use of technologies that deliver multisensory stimuli. Advances in recent years in the fields of computer graphics and audiovisual technologies, virtual environments (VE) have become very convincing in creating an illusion of a real environment for the visual and auditory sensory paths. However, there is still a major challenge with respect to haptics - to be able to simulate the sense of touch an force feedback to arbitrary parts of the body.

When one is experiencing a virtual environment, the audiovisual stimuli create most of the illusion of being in a real environment and can do this to a very high

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degree. But this illusion breaks as soon as participants fails to experience physically consequences of their actions. The sense of presence within the virtual environment somehow ‘breaks’ with the absence of haptic feedback.

In the case of shared virtual environments (SVE) where the participant interacts with another human or a machine, lack of haptic interaction imposes a limitation in achieving a sense of social interaction. Whenever a real social interaction occurs, the sense of touch is a very important aspect of this interaction. The special qualities that touch offers compared to the audiovisual modalities are its bidirectionality, by encompassing intention, manipulation, gesture and perception giving a unique sense of social presence which visual stimuli alone can not cover.

It has already been shown that haptic feedback enhances the sense of presence within mediated virtual environments [1]-[2]. Furthermore recent work has been carried out on the effect of haptic feedback while performing collaborative tasks within SVEs, showing that haptic feedback significantly enhances task performance when compared to performing the same task without haptic feedback [2]-[4]. In the above cases the haptic feedback was related to the performed task. Here we investigate if simply having haptic feedback at all, unrelated to the task, enhances the sense of being together that people may feel in shared interaction.

Such social presence requires a number of factors such as gestures, facial expression, posture, nonverbal cues, and touch [5]. The purpose of this study, however, is to examine the effect of introducing just a single one of these factors, namely touch, within a mediated environment and observe the effect it has in improving social presence. To do this we carried out an experiment involving a simple collaborative task, solving a jigsaw puzzle, with the haptic interaction coming into play only as a means of social interaction between the participants.

2 Materials

For the purpose of this experiment, a cloned personal computer was used with two displays, one for each participant. The image displayed on each participant’s display was the same, consisting of a window on the upper part of the screen containing the

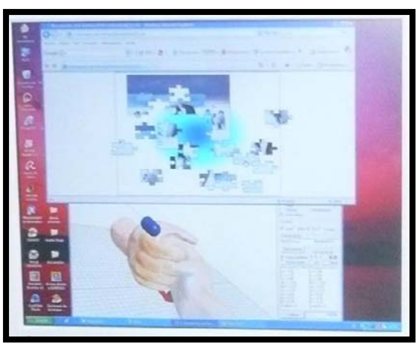


Fig. 1. View of the computer screen used by the subjects in the experiment showing the puzzle to be completed on the upper part, and the virtual thumbs on the bottom part of the screen

puzzle that needed to be completed, along with a window on the bottom part of the screen, depicting how the movement of his real thumb corresponds to that of his virtual one as well as his partners' virtual thumb (Figure 1).

Furthermore each participant was provided with a haptic device where they could place their thumb and exert forces to their partners' thumb. The force feedback from these devices controlled also the movement of the virtual thumbs depicted on the subjects' screens. Finally each participant used a mouse for interacting with the puzzle.

The haptic device consist of a mechanism that contains two motors, 4 bars with specially selected lengths to provide it with a wide workspace and a thimble connected to two small bars with their respective potentiometers providing the last three degrees of freedom. The structure that holds the motors of each module has been designed taking into account the gravity center, so that the weight of the bars does not affect the trajectories described by the operator's hand.

The Finger is connected to a base that provides the First degree of freedom. For a total of six degrees of freedom from which the three First ones are actuated and the other three measure position.

3 Methods

40 subjects were recruited by random selection, mostly from the academic community of UPM, their age varying from 20 to 50 years old. The subjects were both men and women and upon their selection and description of their task, they were asked not to comment or discuss with anyone regarding the experiment, in order for the subjects not to know whether they would be interacting with another human or a machine. The subjects were then sorted into 20 pairs; the pairs were then arbitrarily split into two groups, providing the two conditions for the experiment:

- one group having only visual feedback (without haptic feedback)
- the other one having visual plus haptic feedback

Once the participants arrived they were taken into different rooms without each one seeing their partner. Each room had the same setup, consisting of a computer screen, mouse and the haptic device. They were then informed about the task they had to perform and about how the haptic device worked.

The task consisted of solving a jigsaw puzzle in a cooperative manner. The task of completing the jigsaw puzzle was to be achieved by mouse based interaction designed for the non-dominant hand in order to be able to interact with the jigsaw pieces on the screen. Meanwhile, the thumb of the participant's other hand was placed inside a thimble of the haptic device (Figure 2).

When one participant had joined at most three pieces of the puzzle, he or she had to pass the turn to his partner by using the haptic device, in a sense of 'nudging' him/her. The other participant had to do the same task by joining pieces together, and on each turn the participant had to complete three pieces before passing the turn to the other.

Fig. 2. The current experimental setup involving one computer, two computer screens, two computer mice and two haptic devices. The participants try to solve a jigsaw puzzle collaboratively, by completing a part of the puzzle and then passing the turn to their partner by 'nudging' them through the haptic interface.

Once the task was completed each one of the participants was asked to complete a questionnaire consisting of 24 questions which were concerned with:

- basic demographic information such as gender age and computer literacy
- evaluation of the collaborative experience and also performance
- how the participant perceived his or her partner, and
- a standard questionnaire that assesses shyness [6]
- 7 questions about the extent of feeling socially present with the other person.

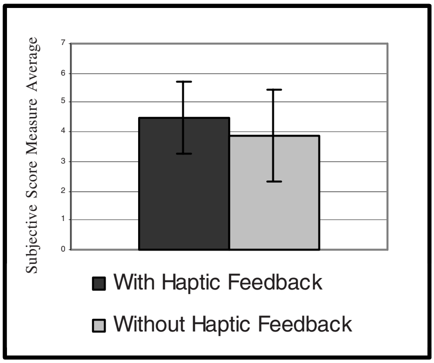
Each question had a scale of 1 to 7 with one (1) meaning less involved/satisfied and seven (7) meaning very much involved/satisfied. These questions were taken from [3].

These seven questions formed the response variable representing the concept of social presence, or 'togetherness' as in [3], The questions were scattered among the rest of the questions within the questionnaire, were the following:

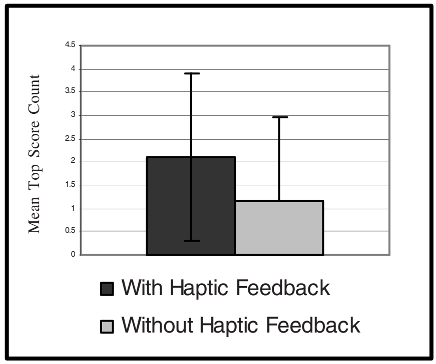
(1) To what extent, if at all, did you have a sense of being with the other person?
(2) To what extent were there times, if at all, during which the computer interface seemed to vanish, and you were directly working with the other person?
(3) When you think back about your experience, do you remember this as more like just interacting with a computer or working with another person?
(4) To what extent did you forget about the other person, and concentrate only on doing the task as if you were the only one involved?
(5) Did you feel as if playing a real game?
(6) During the time of the experience, did you often think to yourself that you were just manipulating some screen images with a pen-like device, or did you have a sense of being with another person?
(7) Overall rate the degree to which you had a sense that there was another human being interacting with you, rather than just a machine?

4 Results

Figure 3(a) shows the mean and standard deviation as calculated by taking the mean values of each of the participants' answers to the seven questions and averaging them over 20 participants for each group (with/without haptic), whereas figure 3(b) shows the mean and standard deviation of the average 'top score' count which was obtained by calculating the mean values of each participants' top score count out of the seven questions and then averaging these over 20 participants for each of the two groups.



(a)



(b)

Fig. 3. Chart (a) shows the mean and standard deviation, calculated over the average of the participants' scores from the seven questions dealing with the sense of social interaction with their partner (n=20 for each group), for each of group (with/without haptic feedback). Chart (b) shows the mean and standard deviation of the average top score counts of the participants for both groups (with/without haptic feedback - n=20 for each group).

The Figure suggests that haptic interaction does enhance the sense social presence. In order to test the significance of this we take the response variable as the number of 'high' scores amongst the 7 questions for each person, where 'high' is defined as a score of '6' or '7'. We call this response variable y. This is the same method as was used in [3]. Under the null hypothesis that people are assigning scores randomly this number should follow a binomial distribution (n=7). We therefore carried out a binomial logistic regression of y on the main independent variable (haptic or not haptic) and a number of explanatory variables. This was modified by the method described in (Breslow, 1984) [7], in order to relax the strict assumption that the responses follow a binomial distribution.

Table 1 shows the regression coefficients and their associated significance level. The fit shows that the haptic condition results in significantly higher reported social presence than the no haptic condition, and also that the social presence level is positively associated with being female, experiencing the setup as a real game, but is negatively associated with the degree of shyness.

The results were also analysed using standard normal regression using the mean of the 7 questions as the response variables. The results shown in Table 2 are qualitatively the same.

Table 1. Binomial Logistic Regression Analysis for social presence (y) (Deviance=37.8231, d.f.=35)

Variable	Estimate	P
Condition - no haptics (0) – haptics(1)	1.22	0.0015
Gender (M=0, F=1)	0.71	0.0349
Real Game	0.45	0.0009
Shyness	-0.41	0.0675

Table 2. Linear Regression Analysis for social presence using the mean questionnaire score (R^2=0.56)

Variable	Estimate	P
Condition (no haptics – haptics)	0.95	0.0076
Gender (F)	0.73	0.0716
Real Game	0.61	0.0000
Shyness	-0.44	0.0495

5 Conclusions

This experiment has shown that even very simple haptic interaction between people carrying out a shared task has the effect of enhancing their sense of being together. Here the participants were working on non-immersive desktop systems, and saw a representation of only the hand of the other person. Further work using an immersive system, where people have haptically enabled interaction while seeing and hearing full body representations of one another would be a significant and interesting challenge. The experiment described here was also artificial in the sense that the interaction was not across a network but enabled on one computer only (shared between the two). Once the interaction is genuinely across the internet there are other significant problems caused by latency and network delays and outages. Some of these issues were considered in [4]. The experiment desribed here though shows that it is worth the effort to haptically enable such interactions, if the intention is to provide a sense of togetherness between people.

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