Support for the touch modality in collaborative distributed environments

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ABSTRACT
An experimental study of supporting presence in a three-dimensional collaborative virtual environment is described. The aim of the experiment is to investigate if added haptic force feedback in such an environment affects perceived virtual presence, perceived social presence, perceived task performance and task performance. A between-group design was used. Seven pairs of subjects worked with an interface with graphic representation of the environment, audio connection and haptic force feedback. Seven other pairs of subjects worked with an interface without haptic force feedback, but with identical features otherwise. PHANToM, a one-point haptic device from Sensable Technologies Inc. was used for the haptic force feedback, and a program especially developed for the purpose provided the virtual environment. The program makes it possible for two persons placed in different locations to simultaneously feel and manipulate dynamic objects in a shared virtual environment. Results show that haptic force feedback significantly improves task performance, perceived task performance and perceived virtual presence in the collaborative distributed environment. The results show a tendency that haptic force feedback increase perceived social presence, but the difference is not significant.

Keywords
Presence, haptic force feedback, distributed collaboration, experiment.

INTRODUCTION
Different combinations of media like text, sound, video, pictures and even haptic force feedback support more or less modalities like vision, hearing and touch. These different media affect the process of communication and collaboration between people in electronic meetings in different ways [8,1,9,11]. Different media affect how realistic people perceive the medium itself and the interaction with other people through it. In the research area of virtual reality, one of the main goals is to generate an experience of being in a computer-generated environment that feels like reality and where people experience a high degree of virtual presence [13,10,4]. From the perspective of these findings, it is interesting to investigate what role the modality touch has in mediated interaction. When people collaborate in face-to-face meetings some of the interaction is physical, e.g. manipulation of common objects or handshakes. This physical interaction (gestures, body movements, and common manipulation of objects) is almost impossible to perform in an efficient way in today's distributed environments. However some studies suggest that if people receive the possibility to "feel" the interface, they manipulate the interface faster and more precisely [7]. Studies on the effect of tactile force feedback have been performed, and results indicate in one study shortened task completion times [3]. In another study the subject's performance was significantly improved when the task was drawing in an interface [6]. Haptic force feedback can support navigation in and usage of computer interfaces for blind people [12]. Some studies have shown that haptic communication could enhance perceived presence in groups working together mediated by multimedia systems [5,2].

The main aim of the following study was to test the hypotheses that a distributed CVE (three-dimensional Collaborative Virtual Environment) that supports the modality touch will increase the perceived virtual presence, perceived social presence, perceived task performance and improve task performance.

METHOD
The independent variable in this experiment was the interface condition with two treatments, CVE-audio-haptic and CVE-audio-only. The subjects performed five collaborative tasks in both conditions. The subjects where placed in different locations. The haptic device used in the tests was a 1.0

PHANToM, from Sensable Technologies Inc. (Figure 1) .

Figure 1. One subject doing task number three with the haptic force feedback device (PHANToM) together with another subject that is in another room.

A program that provided the virtual environment was especially developed for the purpose (Figure 2).

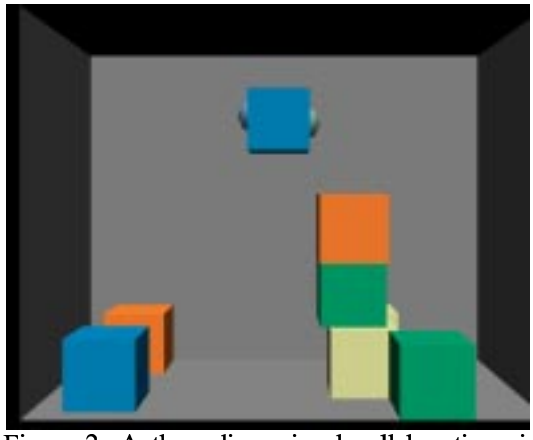

Figure 2. A three-dimensional collaborative virtual feedback environment with eight cubes and two spheres. Each sphere represents one subject.

In the test condition including haptic feedback the subjects got force feedback from the dynamic objects, the static walls and the other person in the CVE.

The subjects could simultaneously manipulate the dynamic objects that were modelled to simulate real cubes with form, mass, damping and surface friction. The subjects could also hold on to each other. This was simulated with a switch on the haptic device. In the condition without haptic feedback, the subjects got no force feedback, and could not hold on to each other. The haptic device functioned solely as a 3D-mouse. Audio communication was in both conditions provided through a telephone connection, using headsets in order to free both hands.

The subjective experience of presence was measured by questionnaires that measured perceived virtual presence [14] and perceived social presence [11] respectively. Perceived task performance was also measured by a questionnaire. Task performance was measured by the total time it took the pairs of subjects to perform the five tasks.

RESULTS

The results showed that haptic force feedback significantly increases task performance, which means that the tasks were completed in less time in the haptic force feedback condition (table 1). All pairs of subjects succeeded in completing all tasks, which means that it was possible to manipulate the PHANToM satisfactorily in both conditions. The questionnaire that measured perceived performance showed that the subjects in the haptic feedback condition perceived themselves as performing tasks significantly better (table 1). Results showed that haptic force feedback significantly improves perceived virtual presence in the collaborative distributed environment (table 1). The results also showed a tendency that haptic force feedback increases perceived social presence, but the difference is not significant (table 1).

Table 1. Experimental results regarding total time to complete tasks for the 14 groups and regarding perceived performance, virtual presence and social presence for the 28 subjects.

			Haptic feedback	No haptic feedback
Performance (minutes) (n=14)	F=6.25	p=0.028*	M=24	M=35
Perceived performance (n=28)	F=11.63	p=0.002**	M=83	M=71
Virtual presence (n=28)	F=25.5	p=0.0001**	M=174	M=142
Social presence (n=28)	F=2.58	p=0.121	M=42	M=38

*= significant at 95% level

**= significant at 99% level

CONCLUSIONS

The overall results show that if the modality touch is supported in a distributed CVE the interaction becomes faster. Task performance is improved, and the subjects rate their performance and perceived virtual presence to be higher. This implies that it is valuable to support the touch modality in interfaces. Finally a conclusion that can be drawn is that it is possible to lift objects and build simple constructions together in a distributed CVE.

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