# PRESENCE IN MULTIMODAL INTERFACES

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- Theory on presence from the perspective of telecommunications and virtual environments.
- Presentation of subjective and objective measures of presence.
- How interfaces that support the modality touch affect perceived presence in distributed environments.
- Description of research that focus on how haptic force-feedback affect perceived presence measured by subjective and objective measures and task performance.

## Introduction

Today's interfaces support modalities like vision, hearing, and touch in varying degree. Media affect the process of communication and collaboration between people in distributed meetings in different ways due to which modalities it supports. It has been argued that media differ in their capacity to carry data that is rich in information (Short et al., 1976; Daft & Lengel, 1986; Rice, 1993). People therefore prefer to solve collaborative tasks that are equivocal and emotionally complex, either in face-to-face meetings or in a sufficiently rich medium. In order to collaborate people need to build and sustain relations, trust and mutual interdependencies (McGrath & Hollingshead, 1994). Informal communication between colleagues supports this social process to sustain collaboration (Kraut et al., 1993). Informal communication is conceptualised as communication that is spontaneous, interactive and rich.

Technological advances make it possible to meet in socially rich distributed environments through three-dimensional Shared Virtual Environments (SVE), audio and video. Because of this, concerns about the degree of reality and presence in those distributed environments have been raised. Both the research communities of telecommunications and virtual reality have studied the concept of presence. The ultimate vision is implicitly to replace real face-to-face meetings with equally satisfying distributed ones or even to make distributed meetings give added value in comparison to face-to-face meetings (Schloerb, 1995; Hollan & Stornetta, 1992).

The technology can not fulfill that vision yet, as there are just to many variables to take into consideration.

In this paper I will present a review of research regarding the concept presence, measures of presence and the impact of haptic force-feedback on presence. Finally I describe a future study that aims to further accumulate knowledge about the impact of haptic force-feedback on presence, measured by objective and subjective measures.

## Theory on presence

In the 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 (Slater & Wilbur, 1997; Hendrix & Barfield, 1996; Minsky, 1980; Sheridan, 1992; Held & Durlach, 1992). Witmer & Singer (1998) define presence as the subjective experience of being in one place or environment, even when one is physically situated in another. Applied to teleoperations, presence is the sensation of being at the remote work site rather than at the operator's control station. Applied to a virtual environment, presence refers to experiencing the computer-generated environment rather than the actual physical locale.

Heeter (1992) recognises that presence is a subjective experience but divides the concept presence into three dimensions, personal presence, social presence and environmental presence. Personal presence is according to Heeter a measure of the extent to which and the reasons why a person feel as if she/he is in a virtual world. Social presence refers to the extent to which other beings both living and synthetic exist in the virtual world and appear to react to you. Environmental presence refers to the extent to which the environment itself appears to know that you are there and reacts to you.

Social presence theory (Short et al., 1976) evolved from research about efficiency and satisfaction in the use of different communication media. Social presence is in this theory conceived to be a subjective quality of a medium and is not to be defined objectively. Short et al (1976) regard social presence as a single dimension that represents a cognitive synthesis of several factors such as capacity to transmit information about facial expression, direction of looking, posture and non-verbal cues as they are perceived by the individual to be present in the medium. These factors affect the level of presence that is the extent to which a medium is perceived as sociable, warm, sensitive, personal or intimate when it is used to interact with other people. Social presence varies between different media, it affects the nature of the interaction and it interacts with the purpose of the interaction to influence the medium chosen by the individual who wishes to communicate.

## Measures of presence

Presence researchers are primarily interested in the subjective experience of the participant's own presence within an environment. Frequently used subjective methods to measure presence are Likert style questionnaires, multidimensional scaling and real-time scaling. Different operational definitions have been formulated in order to construct questionnaires that measure presence (Short et al., 1976; Witmer & Singer, 1998; Schloerb, 1995). Presence defined as "being there"

in virtual environments have been measured by several dimensions of factors (Witmer & Singer, 1998). Examples of such are: control factors, sensory factors, distraction factors and realism factors. Social presence questionnaires are constructed around four dimensions that differentiate social presence: unsociable-sociable, insensitive-sensitive, impersonal-personal, cold-warm (Short et al, 1976). A semantic differential technique is used with bipolar seven-point scales. The method of constant stimuli is a highly controlled way of measuring an individual's perception of changes in a controlled environment. In an article Schloerb (1995) presents a way to define subjective telepresence by the method of constant stimuli. He suggests that subjective telepresence exists only when a person cannot distinguish between the real and the mediated environment. To make the real environment and the distributed environment look the same one has to transform the real environment so that it for example is vaguely perceived. Continuous assessment methodology is sensitive to time-varying information in subjective presence judgements when a medium is constantly changing regarding how much sensory information it provides the subjects. A study shows that subjective presence ratings are subject to considerable temporal variation due to variations in the stimulus material. For example, increased sensory information through addition of stereoscopic and motion parallax cues enhances the subject's sense of presence (Ijsselsteijn & Ridder, 1998).

Usually objective measures of presence are obtained through controlled experiments. Examples of such measures are task accomplishment, automatic responses and physiological measures. The measure of task accomplishment is a way of determining in what degree a system is usable and can be measured through frequency, time and quality of accomplished tasks (McLeod, 1996). In relation to presence the argument is that the higher the degree of presence the higher is the accomplishment of tasks by subjects. Automatic responses like flinching, ducking, tight grasp of objects are objective measures that have been suggested to measure presence in media environments (Freeman et al., 1998; Slater & Wilbur, 1997; Held & Durlach, 1992). Physiological measures of autonomic arousal (Lombard & Ditton, 1997) include cardiovascular parameters like heart rate and systolic and diastolic blood pressure (Wastell & Newman, 1996; Johansson & Aronsson, 1984), respiration, pupil deletion, perspiration measured by GSR (galvanic skin-response), blood-sugar level and erect skin-hair.

Researchers have started to recognise the need to combine methods in order to understand the concept of presence. Held &Durlach (1992) stress the importance of studies of the relations between the subjective and objective measures of presence.

## Haptic force-feedback

When people interact in face-to-face meetings there is a certain ritual that take place. This ritual depend on a number of things like, what is the background to a meeting, who attend the meeting, what status do seating positions imply and so on. Another ritual is related to physical contact and physical manipulation of common objects. In western culture people shake hands when they meet and when they part, which has a potential meaning as a sign of friendliness, as a contract of a certain relationship, and as a means of starting and ending an interaction. This physical interaction, gestures and body movements, and also common manipulation of objects is almost impossible to perform in an efficient way in today's distributed environments.

A social fact that is often neglected is that people are adjusting to perceived physical contact and closeness in distributed environments even if such is not possible just as people strive for equilibrium of intimacy in the real world. The Social presence theory relates to the concept of intimacy (Argyle and Dean, 1965) that is relevant in order to explain this behaviour. People are both attracted to and repelled by other people in a communication situation and therefore they strive for equilibrium of intimacy through for example seating position (the more intimate people are the closer they sit). Factors that affect the level of intimacy are physical distance, eye contact, smiling and topics of conversation. According to Short et al (1976) the concept of social presence should be included in the list of factors that contribute to level of intimacy. Another issue of importance is the impact on social dynamics of having the possibility to do interactive acts in an environment even if you would not do them due to social rules in the real and/or the distributed environment. These arguments should help to put more focus on the functionality surrounding the representation of people and physical interaction in interface design.

The human modality touch has not been supported much in interfaces until now. However, some studies suggest that if people get the possibility to "feel" the interface they manipulate the interface faster and more precisely (Ishii et al, 1994). Studies on the effect of tactical force-feedback has been performed and results indicate in one study shortened task completion times when tactical force-feedback supports the interaction (Gupta et al. 1997). In another study the subject's performance was significantly improved when the task was drawing in an interface (Hurmuzlu et al., 1998). Research on the applicability of haptic feedback in interfaces for blind people (Sjöström, 1997) has shown that haptic feedback supports navigation in and usage of computer interfaces. One study has shown that haptic communication could enhance the feeling of togetherness in groups working together mediated by a multimedia system (Ho et al., 1998; Durlach & Slater, 1998).

## Experimental study

The main aim of this study is to test the hypothesis that an SVE (three-dimensional Shared Virtual Environment) that supports the modality touch will increase the perceived feeling of presence in it. Another aim is to evaluate the objective and subjective measures of presence used in this study.

The independent variable in this experiment is the interface condition with two treatments, SVE-audio-haptic and SVE-audio-only. The dependent variables are perceived virtual presence, perceived social presence, perceived task performance and task performance. The subjects perform a number of collaborative tasks in both conditions. In the VR/audio/haptic condition both subjects are able to hand over an object to each other in the virtual environment and when doing so they hold it at the same time and get haptic feedback from it. In the VR/audio/haptic condition subjects are also able to hold on to and tap at each other's index finger. In the VR/audio-only condition the subjects can hand over objects to each other in the virtual environment but haptic feedback is not mediated. Moreover they can not hold on to or tap each other's index finger in the VR/audio-only condition. A force-feedback device, PHANToM (SensAble Technologies Inc.) is used to convey the user a sense of touch and feel of virtual objects. Headsets provide audio communication via a telephone connection.

The subjective experience of presence is measured by questionnaires that measure perceived presence, perceived social presence and perceived task performance respectively. Social presence is measured with a questionnaire that considers the dimensions: unsociable-sociable, insensitive-sensitive, impersonal-personal, cold-warm (Short et al., 1976). Presence is measured with a questionnaire that considers: control factors, sensory factors, distraction factors and realism factors (Witmer & Singer, 1998). Task performance is measured by time to perform tasks.

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. 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. Results showed that haptic force feedback significantly improves perceived virtual presence in the collaborative distributed environment. The results also showed a tendency that haptic force feedback increases perceived social presence, but the difference is not significant.

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