# Sense of Presence in a Robotic Telepresence Domain

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**Abstract.** Robotic telepresence offers a means to connect to a remote location via traditional telepresence with the added value of moving and actuating in that location. Recently, there has been a growing focus on the use of robotic telepresence to enhance social interaction among elderly. However for such technology to be accepted it is likely that the experienced presence when using such a system will be important. In this paper, we present results obtained from a training session with a robotic telepresence system when used for the first time by healthcare personnel. The study was quantitative and based on two standard questionnaires used for presence namely, the Temple Presence Inventory (TPI) and the Networked Minds Social Presence Intentory. The study showed that overall the sense of social richness as perceived by the users was high. The users also had a realistic feeling regarding their spatial presence.

**Keywords:** elderly, human-robot interaction, social richness, spatial presence, user-evaluation.

## 1 Introduction

Many countries today are faced with the problems of an aging society due to a decrease in rates of childbirth, increased life expectancy and the aging baby-boom generation.[1] When people get older, they are more likely to need medical, social and personal care services. In countries like Sweden, which are faced with a large aging segment in the population, a challenge is to provide such services despite a decreasing proportion of people who are active in the work force. Many elderly people prefer living independently in a familiar and residential setting for as long as possible [3]. This implies that there is an increasing need to support independent living of elderly people in their own homes. Research in assistive technologies is therefore aimed at facilitating independent living while also providing an increased sense of safety and security to the elderly. Examples include fall detectors, health monitors, medication reminders and appointment reminders.

[1] For example, in 2008 17.8 % of the Swedish population was older that 65. In 2020, the projected number is 22.8 % [1]. Further, the demographics are such that the majority of Swedish elderly live either alone or with their spouse [2].

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However, a major concern with many assistive technologies is that they can contribute to an enhanced feeling of isolation as the technology often removes the presence of the human in distributed care. Therefore, finding technological solutions which can promote independent living, safety at home and still enable an enhanced social interaction are of special interest. This is particularly true for the new generation of senior citizens who are expected to be active and productive long after the age of retirement and maintain a diverse social network encompassing family, friends and former colleagues.

Telepresence has long been advocated as a means to enable virtual face-to-face communications for people located at different places, particularly in the context of Telemedicine. Telepresence was coined already in 1980 by Marvin Minsky and it means that an operator receives sufficient information about the teleoperator and task environment, displayed in a sufficiently natural way, that the operator feels physically present at the remote side [4]. Robotic telepresence is a newer variant that proposes to integrate Information and Communication Technologies (ICT) onto robotic platforms and enable actuation in a remote location. With the arrival of video conferencing systems the step to developing social robotic telepresence systems is not long. Such a system allows a remote operator of a system to embody themselves within the shape of a robot in a remote environment. The first system of the kind was PRoP [5,6] and it allowed humans to project their presence into a real remote space and to roam around in that environment.

A number of factors seem to indicate that such systems are well-suited as a tool to enhance distributed care for the elderly. Firstly, an elderly person interacts with the robot in a natural and intuitive manner, and little additional learning is required. Secondly, the healthcare professional connecting to the robot from a remote location gains a greater level of control as they are allowed to move in the environment. This adds an enhanced level of safety and enables the caregiver to better assess potentially dangerous situations. Thirdly, the technology is suitable for a diverse group of elderly people ranging from the very mobile, who want to maintain contact with their local caregiver, to those who are less mobile, who want to gain a greater sense of safety. However, despite this potential, the deployment of social robotic telepresence systems in elderly homes must be backed up by user evaluations on first time experiences as well as long-term experiences to best understand problems and user needs.

It is however important to have all potential users in mind when performing evaluations. For example when developing products for elderly, who in many cases are in frequent contact with alarm services and health care personnel that might very well be future users of the system one should also evaluate them with these user groups. Other studies exist which investigate user perspectives of robotic telepresence, such as [7] where a mobile robot enabled remote workers to live and work with local workers almost as if they were physically present and [8] that showed that a socially expressive robot was found more engaging and likeable than a static one. However, these studies so far have not explicitly dealt with user groups that will work closely with elderly.

The work reported in this paper is a study of the experienced level of presence when using a social robotic telepresence system, the Giraff, with health care personnel and alarm operators. Presence was mounted around the 1990s and can be described as the sensation of "being there" and it is likely an important factor in acceptance of any video conferencing system. The study reported is based on data collected at training sessions with people working with health care in homes of elderly and alarm operators responding to alarms from elderly. We are interested in investigating whether adding the possibility to move in a remote environment in contrast with interacting through a traditional videoconferencing system has positive effects on the perceived presence. We are also interested in whether it is possible to measure spatial presence in a robotic telepresence system domain using a presence questionnaire originally designed for a different medium.

The paper is organized as follows. In Section 2 the Giraff system is described. Section 3 describes the methodology behind the study presented in this paper and includes information about the test subjects, the experiment and the questionnaire used. Section 4 outlines the results obtained in the study. The results are discussed in Section 5. Future work is outlined in Section 6.

## 2 The Giraff Robot

The robot used in the training sessions was the Giraff. It provides a means for achieving remote communication between two parties. On one end, there is a mobile robotic base equipped with a web camera, a microphone and a screen. A user interacts through the robotic device with a peer who connects through a client interface. The client interface on the other end allows the user to teleoperate the Giraff while speaking through a microphone and a web camera and receiving the real-time video and audio stream from the Giraff. Graphical depictions of the robotic device are given in Fig. 1. (a) and (b). The robot consists of a screen and web camera that are mounted on the mobile base.

Specifically, the camera and screen are mounted on a tilt unit which allows the remote user to control the field of view. A snapshot of the client interface is shown in Fig. 1 (c). This interface is designed to be as easy to use as possible, and does not require any special hardware such as a joystick. A standard computer, its pointing device (such as a mouse) and a web camera is sufficient. By holding down the left mouse button when pointing at any spot in the real-time video image, the robot will go to the place indicated by the cursor. To turn in place, a dragging motion with the mouse on the real-time video image can be made. The Giraff automatically moves

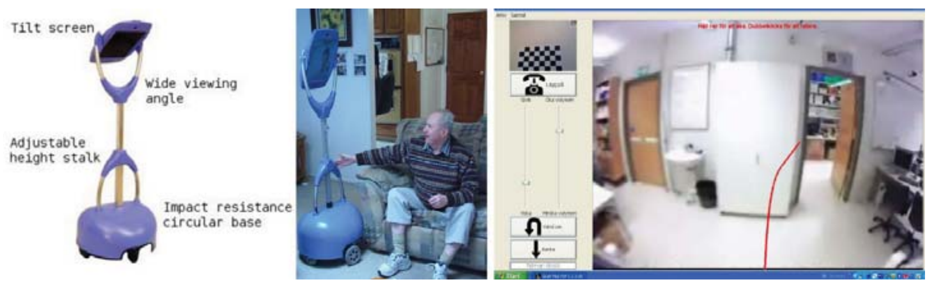


**Fig. 1**. (a) The Giraff robot (b) A conversation between an embodied teleoperator and an elderly (c) The Giraff client interface

**Table 1.** Technical Specifications of the Giraff Unit being used in the training sessions

| **Form Factor** |
|---|
| • Low center of gravity, ensuring stable operation even on wheelchair ramps.<br>• 14 kg weight and integrated carrying handle to allow carrying.<br>• 173 cm height |
| **Base** |
| • The base moves using a differential drive movement system.<br>• A patented suspension system allows the 15 cm wheels to climb small obstacles and rugs while maintaining the stalk in an upright position.<br>• Enabling speeds of up to two meters per second, a brisk walking pace.<br>• Both drive motors use encoders for accurate positional feedback. |
| **Wireless** |
| • Capable of supporting 802.11 wireless. |
| **Docking Station** |
| • A remote user can charge the Giraff by driving it onto the docking station. The docking station charges the batteries in under two hours.<br>• A full charge is sufficient to allow the Giraff to wander untethered for<br>• over two hours. |

until the camera is centered at the end of the point of the drag. The Giraff is intended to be used in forward motion but it can also move backwards. That movement is used when undocking from its charging station as well as to enable going backwards if being stuck. The technical specifications of the device used in the training session are described in Table 1.

The use of the Giraff platform as outlined in this paper is part of an ongoing study to evaluate social robotic telepresence systems used to promote social interaction for elderly users. This study funded by the Ambient Assisted Living framework (AAL Call 2) is one of many evaluations under the ExCITE project.[2] One use, which is particularly relevant in Sweden, is the Giraff as a remote monitoring device for ”Hemtjänst”. Hemtjänst is a domestic care service provided by the Swedish municipalities. Through this service, elderly citizens receive assistance at home from health care professionals according to their individual needs. These needs can vary greatly, from sporadic visits to several visits a day. The Giraff application could increase the ability of Hemtjänst to provide help and guidance to senior citizens who are difficult to reach. Another use of the Giraff within this context is in conjunction with the currently deployed alarm device: upon receiving an alarm, an operator may monitor the elderly person through the Giraff in order to assess what kind of assistance the user needs. We believe that the Giraff can be used as a complement to Hemtjänst and alarm services.

## 3 Methodology

In this section we describe the experiment in which we measured experienced social richness and spatial presence. The methodology consisted of inviting the users to a training

[2] The interested reader can find more information about the project ExCITE at http://www.excite-project.org.

session where they were allowed to use the system to make a remote visit to an elderly home. This visit was presented as an opportunity to train on steering and using the Giraff. The training session also served the purpose to collect data via questionnaires.

### 3.1 Subjects

The users trained in the presented experiment were 11 people working with health care in homes of elderly and 21 alarm operators responding to alarms from elderly. All users are to use the Giraff system in one of the testsites for the ExCITE project. The health care personnel came to the experiment in groups of two or three persons and had not seen any instruction movie or written manual before the training while the alarm operators came one by one and had all seen the instruction movie. This implies there may be a difference in experienced presence based on differences in methodology as well as prior knowledge. The average age of all users was $\mu$=42.45, $\sigma$=9.797. The health care personnel and alarm operators had a similar age spread. There were three men and 29 women being trained thus not allowing any gender comparisons in this experiment.

### 3.2 The Experiment

The training session took place in two smart-home environments that exist at AASS[3]. The locations were chosen to enable the users to make a remote visit with the Giraff to a home similar to a home of an elderly while at the same time allowing data collection with existing smart-home technology. The users were welcomed to feel comfortable in a home-like environment where a laptop connected to a headset and a mouse was placed from which they were to visit another home remotely. A graphical overview of the remotely visited room can be found in Fig 2. The blue cylinder symbolizes the Giraff and the blue office chair symbolizes a wheelchair. As can be seen in the figure, the smart-home has both bedroom, living room and kitchen.

The same test scenario was used for all subjects but as the health care personnel arrived in groups the people not currently driving the robot were allowed to follow the conversation beside the Giraff operator. The session began with informing the participants about the computer and its connected devices and then instructing them to make a visit as realistic as possible to a remote home with the Giraff, namely act as if they visited a real home and an elderly person. They were also asked to be attentive during the training session and to inform the elderly if they noticed strange things in the remote environment such as a fridge door left open and the sound of an alarm. Further, they were informed that they would be asked to fill in a questionnaire after completing the training session.

All users visited a person who pretended to be an elderly person in need of a wheelchair. The users were told to start the Giraff Application, log on to the Giraff server and to connect to a specific Giraff in a list of Giraffs. The 173 cm tall Giraff, the blue cylinder in Fig 2, was being charged. The Giraff is being charged by driving it forward into its dockingstation that needs to be placed against a wall. Thus, once connected remotely, the users were facing a wall. The connection scenario was thus similar to the one that would occur when connecting to a remote Giraff placed in a real

[3] AASS stands for Center of Applied Autonomous Sensor Systems (AASS) at Örebro University.

**Fig. 2.** A conceptual sketch of the training session environment. The Giraff is symbolized by the blue cylinder and the wheelchair by the blue office chair.

home-setting. Further the placement in the docking station allowed training in docking as well as undocking the Giraff. The users were told to undock the Giraff from the docking station by pushing the buttons **Backward** and **Turn** in the Giraff Application and to find the elderly person who was laying in the bed. Upon finding the elderly, the elderly person would move over to the wheelchair and ask the visitor to follow. The elderly first went to the kitchen where the door to the refrigerator had been left open. To allow some time for the visitor to notify the elderly, the elderly asked the visitor about a medical issue. The elderly then asked for help to find the remote control to the television which in most cases had been forgotten on the floor in between the sofa table and the television[4]. After finding the remote control, there would be a sound from an alarm in the bedroom. The visitors were given some time to notify the elderly about the sound but as some never noticed the sound the elderly would finally say good bye and tell the visitor to go back to the docking station and hang up the phone.

**The Questionnaire.** The questionnaire used was based on two standard questionnaires, the Temple Presence Inventory (TPI) [9] and the Networked Minds Social Presence Inventory [10]. The questions were asked in Swedish with minor adjustments of the questions. For all questions, a 7-number likert scale was used where “1 = Not at all” and “7 = To a very high degree”. Specifically, in the investigation presented within this paper, we are interested in spatial presence when applying the same measures to a robotic telepresence system domain. We are also interested in investigating whether adding the possibility to move in a remote environment in contrast with interacting through a traditional videoconferencing system has positive effects on the perceived presence. Data about age gender and if the users had used Skype or similar systems before was also collected.

## 4 Results

There was no significant difference between the response from the health care personnel and the alarm operators regarding the presence dimensions social richness and spatial presence when doing a one-way ANOVA-test. For that reason, only one mean and standard deviation value for each question is presented for all questions from here on presented. The values are based on all users at the training sessions.

[4] As the health care personnel arrived in groups, the remote control would be forgotten in different places for the 2nd and 3rd person driving the Giraff.

### 4.1 Previous Familiarity with Video Conferencing Systems

None of the participants had previously used Skype or similar systems for videoconferencing (μ=1.66, σ=1.405). This is a low score on a 1-7 likert scale where "1 = not at all" and "7 = to a very high degree". This implies there was a dual novelty of using the proposed system in the videoconferencing technology and in the added mobility of the robot.

### 4.2 Experienced Social Richness

Social Richness was measured by asking the users to make a circle on a scale 1 to 7 in all opposite couples presented to the left and right respectively in Table 2. The Mean (μ), Standard deviation (σ) and the internal consistency measure Cronbach's α for the dimension were calculated. An α-value higher than 0.8 but lower than 0.95 is generally considered as showing a good reliability. As such the questions regarding this dimension after our training session seem to measure the same variable, in this case social richness.

**Table 2.** Experienced social richness, α=0.89

| | **Mean (μ)** | **Standard deviation (σ)** | |
|---|---|---|---|
| **Remote** | 4.35 | 1.142 | **Immediate** |
| **Unemotional** | 4.23 | 1.257 | **Emotional** |
| **No response** | 5.60 | 0.932 | **Response** |
| **Static** | 5.03 | 1.643 | **Lively** |
| **Impersonal** | 4.61 | 1.606 | **Personal** |
| **Insensitive** | 4.55 | 1.480 | **Sensitive** |
| **Unsociable** | 5.00 | 1.461 | **Sociable** |

### 4.3 Experienced Spatial Presence

A number of questions were asked to gain knowledge of the users' experienced spatial presence. For all questions, a 7-number likert scale where "1 = Not at all" and "7 = To a very high degree" was used, The Mean (μ) and Standard deviation (σ) along

**Table 3.** Experienced spatial presence, α=0.76

| | **Mean (μ)** | **Standard deviation (σ)** |
|---|---|---|
| To what degree did it feel as if… ..the objects you saw were at the same place as you | 4.09 | 1.532 |
| ..the person you saw were at the same place as you | 4.19 | 1.512 |
| ..you could reach and touch the objects you saw | 2.66 | 1.516 |
| ..you could reach and touch the person you met | 2.81 | 1.674 |
| ..you were in the environment you met | 4.16 | 1.417 |
| ..the sounds came from specific different locations | 3.44 | 1.605 |
| I tried touching the objects I saw | 1.56 | 0.948 |
| I tried touching the person I met | 1.56 | 0.948 |

with Cronbach's α for the dimension were calculated and are presented in Table 3. The α-value for this dimension was lower but generally α-values between 0.6 and 0.7 are acceptable. As such the response indicates that the questions given regarding this dimension after our training session measure the same variable.

## 5 Discussion

An overall concern for the study is whether the novelty of using videoconferencing while further adding the possibility to move in the environment could potentially shift focus from interacting with the person visited to a focus on navigation and other technical issues. Subjective questionnaires as the ones used in our study cannot explicitly isolate the effect of this parameter. Nevertheless, overall the sense of social richness in the training session was high when taking in to account the unnatural situation for the users with the use of a new kind of medium for interaction, a new environment and meeting a new person (actor). As can be seen in Table 2, the users gave their preference to the right-side alternative in all opposite-couples. This indicates that the social richness was considered high on a first-time usage of the system.

We were also interested in whether it is possible to measure spatial presence in a robotic telepresence system domain using a presence questionnaire originally designed for a different media. The Cronbach's α-value for this dimension was an acceptable 0.76 and thus indicates it is a valid measurement technique even in this domain. The users also had a realistic feeling of their spatial presence. Users did not feel as if they could reach and touch the objects or the person ($\mu$=2.81, $\sigma$=1.674). Nor did they try touching the objects or persons. There were small indications that they still felt as if they were at the same place as the objects ($\mu$=4.09, $\sigma$=1.532) and the person ($\mu$=4.19, $\sigma$=1.512). The indication of feeling as if they were present in the environment was similarly high ($\mu$=4.16, $\sigma$=1.417).

However, the results did indicate a possible need for improving the sound presentation from the system as the users did not perceive whether sounds came from specific locations (e.g. a phone ringing in the background) ($\mu$=3.44, $\sigma$=1.605). This is supported by an observation made during the trials that only 75 % of the users notified the elderly about the sound of an alarm. We had also asked a question outside the presence scope regarding if it was easy or difficult to hear what the other person said ($\mu$=5.42, $\sigma$=1.43 where "1 = very difficult" and "7 = very easy"). As the Giraff is a communication device, it is important to pay caution to perception of sound with respect to noise, sound representation and volume.

It should be noted that although there was a difference in methodology and prior knowledge between the health care personnel and alarm operators, no significant difference was noted between the groups and their perceived level of presence in any of the dimensions of presence measured.

The study reported in this paper was performed in an artificially created setting in which users interacted with an actor whom they had never met before. While caution should be used in the interpretation of the results, overall it seems as if the questions from the spatial presence dimension on the TPI were adequate to be applied to the robotic telepresence system domain. We plan to regularly prompt the users in this study about their sense of presence throughout ExCITE.

## 6 Future Work

While measurements of two dimensions of presence were investigated in this paper also most of the other dimensions in the questionnaires presented in Section 3.3.2 were measured within the presented experiment. Two dimensions in the TPI-questionnaire (parasocial interaction and active interpersonal) were not developed for our sort of medium and were not used in our questionnaire The smart-home environment allowed video recording the training sessions with ten cameras from different angles and positions which will allow comparisons by answers in questionnaires and observations. Also data regarding the ease of use of the user interface was collected using a questionnaire. We plan to further investigate the data and correlations among them and present them in a separate publication.

As the trained users are part of the larger ExCITE project we expect to further question the same users about their experienced presence when using the Giraff on a long-term basis as it is our belief the perception will change when the novelty effect wears off.

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