# Telepresence Robot for Home Care Assistance

**F. Michaud[†], P. Boissy[‡], H. Corriveau[‡], A. Grant[§], M. Lauria[†], D. Labonté[†], R. Cloutier[†], M.-A. Roux[†], M.-P. Royer[‡], D. Iannuzzi[§]**

[†] Department of Electrical Engineering and Computer Engineering, Faculty of Engineering
[‡] Research Center on Aging, Sherbrooke Geriatric University Institute
[§] Department of Bichemestry, Faculty of Medicine and Health Sciences
Université de Sherbrooke, Sherbrooke (Québec) CANADA J1K 2R1
{francois.michaud}@USherbrooke.ca

## Introduction

The demographic imperative of an aging population and its impact on the reorganization of health care systems worldwide create unique opportunities to look at new approaches in delivering health care services. The concept of teleoperated assistive mobile robots to support the provision of home telehealth services is one solution that is worth investigating (Katevas 2001; Pollack *et al.* 2002; Cesta *et al.* 2003): for instance, sensors and actuators required in assistive tasks are made mobile in the home, decreasing the cost and the complexity associated with instrumenting a home. With a team of robotics, clinical and geriatric experts, we initiated in 2003 the design of a new robotic platform for this type of application, and more specifically for elderly people that have disabilities living at home.

The first challenge is to design a system that would be useful. Many different uses can be imagined for a home care assistive robot, such as manipulating and transporting objects, navigation assistance, cleaning, monitoring, etc. While these ideas can lead to interesting technological development, they may not address real needs. On the other hand, users do not necessarily know what new technology can do, so it may be difficult to outline needs, constraints and specifications for home care assistive robots.

Another challenge is that homes are complex environments presenting a great variety of conditions (e.g., doorsteps, carpets, hard floor, stairs, objects of all sort, constrained space). With the current technology, it is unrealistic to believe that such machines can operate right away autonomously in homes; limits in structural, perceptual and processing capabilities are still too important for their efficient and secure uses. A teleoperated system is therefore more realistic, exploiting technological capabilities already available and relying on human interventions to compensate for the robot's limitations.

This paper presents our iterative design methodology addressing these issues for the development and validation of a robotic telepresence system for home care assistance.



## Preliminary Studies

Three types of preliminary studies were conducted in our project: telerobotic systems in home environments; focus groups with healthcare professionals and elderly people; interviews with system users to model the health information architecture. The objective of these studies was to gather more information to come up with good initial specifications for the telerobotic system.

### Telerobotic Systems in Home Environments

Teleoperating a mobile robot in a home environment is an endeavor fraught with challenges. Robot's locomotion and perceptual modalities must be adapted to homes (e.g., stairs, door steps, obstacles of different types of material and size). Ensuring the safety of the individual in the home where the robot is used and the safety of the robot itself are primary concerns (Nokata & Tejima 2004). The quality of the robotic teleoperation user interface and the operator experience in teleoperating the robot are two factors that seem to have a direct impact on the safety and performance of such systems. The expertise of the operator is also an influence. Expert and novice operators have been shown to have differing opinions regarding the utility and usability of different features in user interfaces (Olivares *et al.* 2003).

Therefore, we conducted a pilot study to evaluate two conceptually different user interfaces for teleoperated mobile robotic systems, with trained and untrained operators (Labonte *et al.* 2006). This study aimed at identifying locomotion and structural requirements for the new robotic platform, as for user interface requirements for improved efficiency and security of novice operators of mobile robots. The objective was to identify critical elements that must be considered in the design of such system.

Field trials were conducted using two commercial robotic platforms: one specifically designed for telepresence application (the CoWorker, made by iRobot inc., which uses visual waypoint navigation); the other being a generic research platform (the Magellan, made by iRobot inc., to validate laser-mapped position point navigation). A first set of trials (2 homes and 5 operators – 1 expert, 2 roboticists and 2 clinical researchers) was conducted in 2004. Even though we did not have enough operators to derive solid conclusions regarding the influences of the user interfaces in relation to the operators (we noted that untrained operators performed better using position point navigation, while trained operators had better performance with waypoint navigation), we found the experience rich in information. In addition to characterizing physical constraints (measurements of different elements such as doorsteps, corridors, doorframes; carpets that are not fixed to the floor; instability of the platform when going over a doorstep and the effect on the video stream), we had to address the difficulty of conducting user study in homes. Coming up with a good evaluation methodology and following a rigorous experimental protocol revealed to be a non-trivial task. We explored the use of a method comparing operator performances with respect to the performance of an expert, thus eliminating potential bias from the robotic platform and the environment. This approach may provide a solution to the problem of extracting information for designing better user interfaces (Scholtz *et al.* 2004). Therefore, conducting preliminary trials revealed to be very useful in getting a holistic view of the issues to addressed in our project, and to prepare the methodology in the different studies as the project progresses.

### Focus Groups

Motivated the practical nature of the application in addition to its technical challenges, we put efforts on identifying and addressing the actual needs in telehome care interventions. Considering the abstract nature and novelty of a concept such as using teleoperated mobile robots in telehealth applications with elderly users, the objectives of this study (Boissy *et al.* 2006) were to explore with healthcare professionals involved in geriatric care and potential client (the elderly) the concept of in-home mobile robotics in order to 1) conduct a preliminary needs assessment, 2) identify potential target applications, 3) identify check list items needed for the development of an prototype that could be used in pilot testing of these applications.

Focus group interviews are planned discussions facilitated by a moderator and designed to obtain attitudes and perceptions relating to concepts, products, services on a defined area of interest (Krueger 1994). A trained moderator independent to the research team conducted focus groups interviews with two target groups consisting of 8 healthcare professionals (HP) and 6 community living elderly (CLE). This study was approved by an ethical review board and participants gave their written informed consent prior to taking part in the focus group interviews. The concept of an in-home telepresence robot was illustrated using a photograph of a mobile robot, and participants were then asked to suggest potential health care applications. Interview data derived from the transcript of each group discussion were analyzed using qualitative induction based on content analysis.

The shift from a traditional hospital-centred model of care in geriatrics to a home-based model creates opportunities for using telepresence with mobile robotic systems in the context of telehome care. It was perceived by healthcare providers and community-living older adults with disabilities as a means of accomplishing specific tasks such as: (1) facilitating the provision of care for older adults living at home; (2) enhancing their safety; and (3) giving caregivers some respite and support. A robotic telepresence service would not replace healthcare professionals or family members, but could supplement them in providing care. Robotic telepresence was also seen as a way of reducing the travel time of healthcare professionals, especially for interventions that are of short duration (e.g. monitoring of injuries, verification and follow-up with the family). Results suggest that the perceived capabilities offered by teleoperated mobile robotic systems in the home could be used to assist multidisciplinary comprehensive patient care through improved communication between patients and healthcare professionals and offer respite to caregivers.

### Health Information Architecture

This study aims at identifying how a telepresence robotic system can be integrated to the health care information system. This difficult question requires addressing information management (flow and content for each user) in clinical care, to facilitate health care management, training and continuous improvement with technological progress. The roles of different users (e.g., health professionals, biomedical engineerings, roboticists), the activities associated with these roles as for the sources and information content linked with these activities must be specified. We also have to establish how data coming from the robot be integrated to the health information system. To do so, we adapted the Zachman framework (Zachman 1987), and conducted interviews with a representative set of users. We are currently in the process of analyzing the information gathered.

## System Design

Using the information gathered with the preliminary studies, we decided to design a mobile videophone robotic platform, thereby known as Telerobot. The first prototype is shown left in Figure 1. Locomotion is realized using two motorized wheels and four omnidirectional wheels attached to rocker-boggie suspension to minimize disturbances of the video streams coming either from the bottom camera for teleoperation (placed underneath the laser range finder), or the two cameras fixed on the top shelf.

Video user interfaces are common in telerobotic systems (Goldberg 2000), and intelligent interfaces are becoming increasingly important as users face increasing system complexity and information overload. The quality of the teleoperation user interface and the operator experience in teleoperating the system are two factors that have a direct impact on the safety and performance of such systems (Olivares *et al.* 2003). An optimal teleoperation user interface must provide pertinent information about the system states and conditions (objects, persons, free space, data, etc.) in conjunction with an efficient command system to the operator, with reasonable cognitive load for sustain and adequate uses.

More specifically, we found that in home environments, the presence of small obstacles, corridors and doorways substantially increase the level of difficulty for both trained and

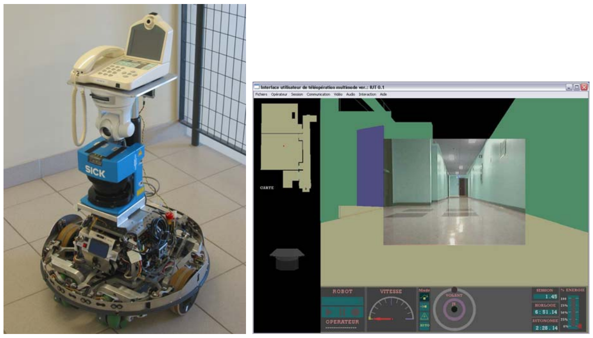


Figure 1: Telerobot with the augmented display interface.

untrained operators. A user interface combining the advantages of waypoint navigation and position point navigation could potentially improve operator performances. For enhanced safety and performance of inexperienced operators, one of our user interface prototypes combines the advantages of waypoint navigation (from a 2D map of the environment) and position point navigation (from images coming from the robots navigation cameras). As shown right in Figure 1, the central window shows a 3D model of the environment, on which the camera view is placed. This should facilitate understanding of the environment compared to just using video images with 2D map and sensor reading representations, which provide limited perspective and require a high level of cognition and complex mental models (Ricks, Nielsen, & Goodrich 2004). A 2D map and a robot sensors representations are placed on the left side windows. Controls are on the bottom window.

## Evaluation

Validation of Telerobot and the user interfaces in controlled laboratory conditions are currently being executed. Trials with a representative set of operators (n=36) were conducted to analyze the influences of the graphical interfaces on teleoperation tasks. Additional tests will be done to characterize Telerobot's locomotion and navigation (e.g., localization is required to match the 3D model with the video stream) capabilities. Once completed, we will be able to proceed with testing Telerobot in homes with no elderly people involved, conducting trials with a representative set of operators, focussing this time more on the control metaphors of the user interface. Videos will be taken to generate cases that will be used in focus groups, in a subsequent design iteration.

## Conclusion

This paper presents the first iteration in our project of designing a telepresence robotic system for home care assistance. We believe that adopting an iterative elucidation process inside a requirements engineering activity (Bray 2002) is the right solution for the work described in the paper. There are just too many factors (ranging from robotics, human and environmental) to take into consideration to start elaborating design specifications without conducting preliminary trials and assess their combined effects, or to initiate extensive testing in home environments to quantify the usability of the system in such settings.

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