

Telepresence Robots for Academics

Susan C. Herring

Department of Information & Library Science

Indiana University

1320 E. 10th Street

Bloomington, IN 47405 USA

herring@indiana.edu

ABSTRACT

Telepresence robotics is a sophisticated form of robotic remote control in which a human operator has a sense of being on location – that is, of being telepresent. I propose a demonstration of two telepresence robots, one floor model (VGo) and one tabletop model (KUBI). In this proposal, I describe the technology and briefly summarize the research that led to the purchase of the robots. The research focused on the telepresence needs of a mobility-impaired academic and included a user study as well as a review of the affordances of commercially-available telepresence robotic devices. The implications extend beyond uses of telepresence robots in cases of mobility impairment to academic contexts in general.

Keywords

Academe, communication, interaction, mobility impairment, robotics, teleconferencing, telepresence.

BACKGROUND

There is a growing need for technology to support remote participation in professional and personal activities, due to crowded highways and airways and an environmental imperative to reduce fossil fuel consumption. Moreover, for some people, such as mobility impaired individuals, remote participation is essential in order to work and remain professionally active.

However, currently popular teleconferencing tools (e.g., Skype, Adobe Connect) are limited in various respects. Even when video is added to audio communication, remote participants often cannot see or hear everyone at the remote location, may feel disengaged and fatigued (because more effort is required to pay attention), and may experience interactional frustration due to difficulty getting the floor and identifying who is speaking (e.g., Egido, 1990; Sirkin et al., 2011). Socially richer telepresence devices could help overcome these limitations.

One approach that has attracted recent attention is telerobotics, and specifically *telepresence robotics*, a sophisticated form of robotic remote control in which a human operator experiences a sense of being on location at the remote site. The perception of “being there” is the most common meaning of telepresence (cf. Lombard & Ditton, 1997). Several telepresence robots for use by individuals (as opposed to institutions or industry) have become commercially available in the past few years, and others are currently under development.

A considerable body of research exists on the design of telepresence robots. Research on usage contexts has mainly focused on tele-participation by able-bodied workers who either do not want to or cannot travel to work, or as an aid for the elderly or infirm (Michaud et al., 2007; Tsui et al., 2011), including as a way for sick children to attend school remotely (Fels et al., 2001). A third focus is on the use of telerobots for surveillance or as a substitute for humans in hazardous situations (e.g., Schultz, Nakajima, & Nomura, 1991). In contrast, little research addresses the needs of academic users, and even less of mobility-impaired academic users who want to remain professionally active.

In addition to these practical and scholarly motivations, I have a personal interest in telepresence robotics. My physical mobility is impaired as a result of a spinal cord injury from an automobile accident ten years ago. I use a reclining wheelchair and paratransit service to get to the university where I work, but moving from place to place is painful, and I am unable to travel by air. As a consequence, my participation in professional academic activities has been curtailed. However, I can type on a computer keyboard, and I routinely use Skype and Adobe Connect, although I find these tools unsatisfying, especially for delivering lectures and socializing at remote conferences, where more interactivity and mobility are desirable. Ever since I first heard of telepresence robots several years ago, therefore, I have been eager to investigate their possibilities.

An opportunity arose when, as a fellow at the Center for Advanced Study in the Behavioral Sciences (CASBS) in Stanford, California in 2012-2013, I met a hobby robotocist



Figure 1. Pi Robot (before and after modifications)

who offered to modify a robot he had built for research purposes as a telepresence robot.¹ Over the course of eight months, we conducted a research project to identify my telepresence needs, as a case study of a mobility-impaired academic user, in a variety of contexts; this involved successive modifications to the robot, known as Pi Robot (Figure 1). We also reviewed and piloted currently available telepresence robotic devices to determine which, if any, met those needs. Each part of this project is summarized briefly below.

USER CASE STUDY

The goal of the user case study was to determine the telepresence needs of a mobility-impaired academic in different contexts of use, in order to suggest directions for telerobot design. The user's a-priori needs included delivering lectures remotely at conferences, socializing at conferences, remote teaching and advising at the user's home university, and participating remotely in student defenses, faculty meetings, etc. A secondary goal was to create a usable telepresence robot as a proof of concept, as we did not initially expect to find a commercial robot that would meet the user's needs, based on a web search of available telepresence robots conducted in fall 2012.

The method employed was participatory design, defined as research in which developers and users work together in an iterative process to design and develop the technology to improve the quality of the users' work life (Blomberg & Henderson, 1990). Pi Robot was modified in usage trials based on the user's feedback in successive steps, focusing first on user control of the robot, navigation around the CASBS campus, one-on-one communication with fellows

and staff, and finally communication in groups of four to nine participants. At first I (the user) controlled the robot from my CASBS office; in later trials I controlled it from my home located about eight miles from CASBS, to simulate a telecommuting-to-campus scenario. About a dozen trials in total were conducted with Pi Robot. In the course of these trials, we identified a number of basic desiderata for a telepresence robot for academic use:

- Navigation: It should have an easy-to-use interface; smooth movement; variable speeds; obstacle indicators
- Camera should show a wide angle and allow zooming
- Audio should be able to receive wide-range input; output should be loud enough to be heard by an audience
- Video display should show the user's face close to actual size
- Robot height should be close to human-like sitting and/or standing
- It should be packable (able to be dis-assembled; lightweight)
- It should be robust and durable
- It should be affordable

These desiderata are not unique to mobility-impaired users; they apply in general to academic users who are unable or do not wish to travel as much as their jobs require.

Pi Robot came equipped with a pan and tilt camera and navigation features (including obstacle detection and avoidance), but no communication capabilities. The main modifications to the robot involved adding a web-based user interface, a Nexus tablet to enable two-way audio/video calls via Skype, and an external speaker to amplify the audio output (see Figure 1). However, although Pi was successfully converted to a telepresence robot for research purposes, it is somewhat fragile and was never intended to be a commercial product.

COMMERCIAL ROBOT EVALUATION

Robot Comparison

We subsequently conducted a comparison of four commercially-available telepresence robots (Figure 2). By early spring of 2013, two new robots had entered the market: the Beam and the Double. In addition, we identified



Figure 2. Commercially-available telepresence robots

¹ R. Patrick Goebel, who is also the CASBS network administrator.

	Audio	Video & Cameras	Navigation	Other
Beam (\$16,000+; annual contract)	6 mic array; built-in speaker	17" display; 2 cameras (1 looking down); fish eye effect from wide- angle cam	Overlay mouse nav + keyboard. Curved path indicator; lack of obs/ cliff avoidance.	Dual wifi interfaces for smooth network transitions; manual docking. Support for 4G USB modems.
Double (\$2,000)	via Skype	from iPad (+ downward view)	Difficult from tablet; keyboard interface not working. Delayed stop; no obstacle avoidance.	Self-balancing; telescoping height. Plug in to recharge, tablet needs to recharge separately.
VGo (\$6,000+; annual contract)	360 degree 4 mic array; woofer and tweeter speakers	6" display (tilt to look down)	Overlay mouse nav + keyboard; obstacle and cliff detection.	Self-docking; lights; camera; speech-to- text; audio in/out and USB port. 4G LTE version available.
TeleMe (1,650+)	via Skype	from tablet or iPad; bracket pans and tilts (tilt to look down)	Mouse or joystick navigation; no keyboard interface. Obstacle indicators.	Plug in or manual dock to recharge; tablet charges together with robot. Support for 4G USB modems.

Table 1. Key features of four commercial telepresence robots

the VGo and the Teleme as likely candidates.² Between February and April 2013, we piloted each robot remotely, and we also viewed the Double and the VGo on location.

Each robot was found to have advantages and disadvantages, as well as some features we had not foreseen in the user case study. Table 1 summarizes some key features of each robot. The two less expensive options, the Double and the Teleme, are essentially rolling iPad stands. We were most impressed with the VGo (<http://www.vgocom.com/>), which, despite a somewhat small video screen, delivered the most features for a moderate price, including lights, a built-in high-quality still camera, and self-docking to recharge the robot's battery.

Lightweight Telepresence Solutions

The robots in Table 1 are not suitable for one-off conference attendance or presentations, due to their size (they range from 4' to 5' tall, and the lightest, the Double, is 16 lbs.; the Beam is heaviest at nearly 100 lbs.), cost, and vulnerability to damage or theft. We therefore considered more lightweight options, ranging from an iPad carried around by human proxies to small telerobots that hold an iPhone such as the Botiful (<http://www.botiful.me/>).

We determined that the best solution for academic use was the KUBI (<http://revolverobotics.com/meet-kubi/>), a tabletop telerobotic stand made by Revolve Robotics that holds an iPad or tablet computer (Figure 3). The KUBI is lightweight, elegant in appearance, and inexpensive (under \$300). It allows the user to pan and tilt the display to follow who is speaking in a conversation, which was found in the user case study to be the movement that most effectively created a sense of telepresence (see also Sirkin et al., 2011).

The KUBI was not slated to ship until July 2013, but we were able to get a pre-production loaner for three weeks in May 2013, and we ran usage trials with it at CASBS similar to those described above for Pi Robot. The KUBI was most useful in group meeting situations, where orienting to the current speaker enhanced interactivity but where movement around the environment was not necessary. A disadvantage of the KUBI is that it requires a human handler to move it.



Figure 3. KUBI telerobotic stand

² We eliminated from consideration the Jazz Connect (because it is based in France), the Anybot QB (because it has a very small video screen), and telerobots designed for medical, shopping, and home use.

A TWO ROBOT SOLUTION

In the final analysis, no single device met all the telepresence needs of the mobility-impaired academic user. The telepresence robots are not lightweight enough to travel easily (in addition to other limitations), and the best lightweight device for purposes of academic communication is not mobile. Perhaps in the future such a device will become available; one outcome of the user case study was a set of specific design recommendations for telepresence robots for academic use (not included in this paper). In the meantime, I opted for a two-robot solution.

The VGo telepresence robot will be kept in the department where I teach and be used for interacting remotely with students and colleagues one-on-one and in group situations such as teaching and meetings. An advantage of the VGo (and other telepresence robots) not mentioned above is that as a novel technology, it has a high “cool” factor that makes it attractive to students.

The KUBI telepresence robotic stand will travel with my colleagues and/or co-presenters to academic conferences and other distant events, along with an iPad or tablet. In situations where no one I know is traveling to the event, the event organizers will be encouraged to purchase a KUBI of their own and to borrow an iPad or tablet from someone at the remote site. This is feasible, because tablet computer ownership is increasingly common, the KUBI is inexpensive, and it can be put to other uses after my presentation/participation.

DEMONSTRATION

At the 2013 ASIS&T meeting, I will demonstrate how the VGo and the KUBI work. I will explain how to use the control interface for each, and (with an assistant) demonstrate two-way communication through each device. Depending on available space and crowd size, conference participants may be permitted to experience remotely controlling the devices themselves.

The demonstration requires reliable wireless network coverage in the demonstration space. The robots are battery powered, but a power strip would be helpful as a backup power source. Sufficient space is needed for the VGo (and my reclining wheelchair) to move around, along with a table on which to set up the KUBI.

CONTRIBUTION

The research reported here, although focused on the needs of a mobility-impaired user, is not restricted to cases of mobility impairment (nor is it intended to represent all such cases; see, e.g., Tonin et al., 2011). Telepresence robotic devices have recently become available for purchase by individuals, and telerobotic stands such as the Double and the KUBI are becoming increasingly affordable. More people will use telepresence robotic devices to interact with and exchange information with other people in the future, in university and other settings. As such, the new technology described here should be of interest to information

scientists, especially those interested in human-computer interaction and computer-mediated communication.

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