Telepresence Robots Roam the Halls of My Office Building

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1. INTRODUCTION

Commercial telepresence robots can be thought of as embodied video conferencing on wheels. When a robot driver operates a telepresence robot, there will be people physically present with the robot in the remote environment. The robot driver may have a conversation with a colleague (direct interaction) or pass office workers in the hallways (indirect interaction [7]). Scholtz defines a bystander as a person who "does not explicitly interact with a robot but needs some model of robot behavior to understand the consequences of the robot's actions" and does not have formal training about the robot [5, 6]. In this paper, we discuss design guidelines for increasing the social acceptability of telepresence robots based on a series of studies conducted at Google in Mountain View, CA over a period of two months. These guidelines are a result of our observations on how telepresence robots were perceived by the general office population (i.e., bystanders) with respect to acceptance and privacy.

2. USER TESTS

In July and August 2010, we examined office-related use cases in a series of studies using two prototype telepresence robots (Anybots' QB [1] and VGo Communications' VGo [9]). Our goals were to understand use-cases for telepresence robots [8] and what hardware and software features telepresence robots should have [2]. Thus, the focus of our studies was largely on the robot operator and the person or people physically present with the telepresence robot who were interacting with the remote robot driver.

We conducted three experiments in Building 45 (Fig.1) over a period of two months. It is important to note that general office population (i.e., bystanders) could have been exposed to 62 hours in which the telepresence robots were actively used (Study 1: 37 hours, Study 2: 12 hours, and Study 3: 13 hours). Also, for the duration of the experiments, our two QB and two VGo robots were set up in the cubicle space marked as the Study 1 training area in Fig.1 adjacent to the Study 1 start location (marked as a circle with the number 1).

Study 1 was designed to gather novice users' impressions of the telepresence robots. We ran Study 1 every afternoon from 3 to 6pm for all of July and August with a total of 37 robot operators. Participants trained for an average of 10 minutes on how to use the robot and were then asked to drive the robot from the Study 1 start location through a cube environment to a designated conference

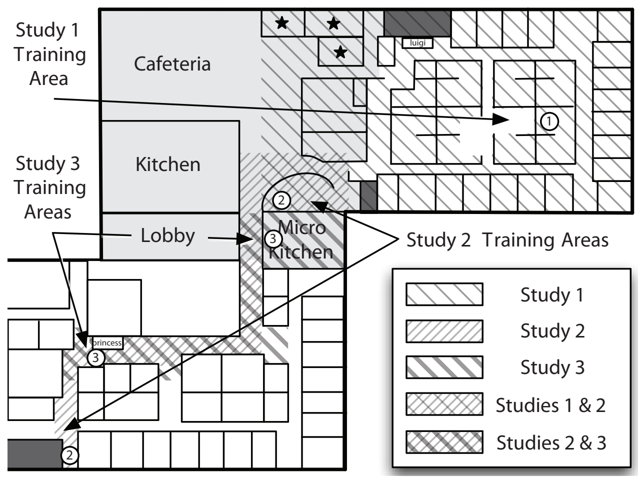

Figure 1: Study 1 explored novice users' initial impressions of operating the telepresence robots in a cubicle area (top right) and small conference rooms (marked as stars). Study 2 compared the quality of the QB and VGo robots with the EVO Android phone. Study 3 investigated an ad-hoc scenario involving movement while simultaneously having a conversation. The circles with the number indicate the starting locations for each study. The light gray background color indicates noisier social environments, and the white indicates quieter office areas.

room (marked as stars). While the robot was in the general office area, we muted the robot operator's audio; however, both the QB and VGo robots make an announcement when an operator logs in. Once the participants arrived at the conference room, we enabled the audio on the robot, and the participants had a short one-on-one conversation with a person already in the conference room.

We ran Studies 2 and 3 during the last two weeks of August. We scheduled consecutive 60-minute sessions from 8am through 3pm. Studies 2 and 3 used approximately the same hallway areas shown in Fig.1. Training for each robot occurred in the immediate vicinity of the start location. The aim of Study 2 was to compare the video streams from the QB and VGo robots against a Sprint EVO Android phone using Qik [4]. Since the focus of the study was the video quality, the robots' audio was muted. Study 2 had 12 participants. They were instructed to follow an experimenter using one robot from one starting location to the other Study 2 start location. Participants used the other robot to return to their origin.

The aim of Study 3 was to investigate an ad-hoc scenario involving movement while simultaneously having a conversation. Thus, the robots' audio was enabled. While conversing, one participant initially operated the robot (robot driver) and the other participant walked next to the robot (walker). Then, the participants switched roles. There were 13 sessions (6 VGo and 7 QB) with 24 participants (2 per session). For two sessions, one participant did not show up and an experimenter substituted for the missing role.

3. DESIGN GUIDELINES

At the end of August, we asked the general office population who had seen the robots in the hallways about their experiences. We distributed an anonymous online survey.[1] We also placed comment boxes at the Luigi printer (Study 1) and the Princess printer (Studies 2 and 3); we asked bystanders to rate their overall experiences with the telepresence robots as their officemates (1 = hated it, 7 = loved it). We received a total of 10 responses (4 online, 3 Princess, and 3 Luigi). Throughout the summer, we noted comments from the bystanders in B45 regarding the robots which were either directed at us as the robots' handlers (2 positive, 3 negative) or overheard (2 negative). It should be noted that we did not receive any neutral responses or comments. Based on the results of our studies and feedback from our participants and bystanders, we believe that all telepresence robots should have the following features:[1]

Volume control for both the robot driver and also the person physically with the robot, or automatic volume adjustment which factors in the ambient noise and how far away a person is standing from the robot. The primary justification for this recommendation comes from Study 3 in which pairs of participants had a walking conversation through the robot. One start location was near the cafeteria and kitchen; thus, the ambient noise level was quite high. It was difficult for the participants to converse because they could not hear each other. Once the robot driver moved beyond the kitchen area, there was little ambient noise and the robot driver's voice coming out of the robot was loud for the nearby offices and cubes. During one Study 3 run, when entering the quieter office area, a bystander requested that we turn down the VGo robot's volume. We were able to turn the volume down to 70%;[2] the QB robot did not have volume control. From the three responses collected at the Princess printer, all commented that the robots were "too loud."

Identification of the robot driver beyond picture and voice. The Study 1 experiment began with the robot operators using the QB robot which only had two-way audio communication.[3] Because identification of a person could only be determined through a robot driver's voice, it was unclear to the office population *who* was driving the robot. One bystander in the Study 1 area reported almost physically removing the robot from his immediate office area due to the lack of identification.

For people without impaired face or voice recognition (prosopagnosia or phonagnosia, respectively [3]), a photo, video, or voice can be used to identify a person. However, in the office use case, a bystander must have contextual knowledge such as potential teammates the robot driver might be visiting or a recurring meeting. We believe that a name, email, and/or employee identification overlaid on a telepresence robot's video of the robot driver will provide a bystander with sufficient information to know who is operating the robot. Identification is important for all telepresence robots intended for use by multiple robot drivers.

Visual indicators for when the robot is occupied and other robot states. The current generation of commercial telepresence robots are teleoperated; a robot driver is actively engaged and directly controls all of the robot's movements. It is sufficient to know if a telepresence robot is inhabited or not. QB has blue LED rings around its "eyes" and a profile picture[3] appears on the screen to signal when the robot is in use; the LEDs and screen are off otherwise. When a robot driver calls into the VGo, the robot's clear floor lights and red-green LEDs on either side of the video screen flash. When the call is auto-answered or accepted by a person physically present with the robot, the camera tilts up from being downward (parallel with the floor) to facing outward (parallel with the screen), the screen shows the driver's video, and the LEDs show green to indicate that the robot is in use. The screen and lights are off and the camera faces downward when the VGo is not in use. Even with these visual indicators, three of four bystanders reported in the online survey having difficulty knowing when either of these robots were in use.

The status signals on telepresence robot's status should indicate to bystanders if the robot driver is present and/or active. The VGo driver has the ability to mute the call, which means that he or she is present but not active; the LEDs show red and the screen shows a muted message. In one survey response, the bystander specifically noted wanted to know the robot's status of transmitting audio and video. The status of a driver's presence and activity will be increasingly necessary as telepresence robots incorporate high-level autonomous navigation behaviors. For example, a robot driver may provide a destination to the robot ("go to destination") and check his or her email while the robot navigates to the room. In this "go to destination" scenario, the driver is present but not active, similar to a muted VGo call. At the end of a meeting, a driver could request the robot to go back to the robot room ("return to charger") and log out. In the "return to charger" scenario, the driver is not present but the robot is still active, therefore, turning off the occupancy status lights may not provide sufficient information to a bystander.

4. ACKNOWLEDGMENTS

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[1] Additional information such as survey details and a full list of guidelines will be available at http://robotics.cs.uml.edu/telepresence.

[2] Since these studies, a VGo driver can now control the robot's output volume.

[3] Starting in August, the QB robot showed a profile picture of the robot operator. Two-way video is planned.