Essential Features of Telepresence Robots

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I. Introduction

Contemporary telepresence robots can be described as embodied video conferencing on wheels. Over the last decade, companies such as Anybots, HeadThere, InTouch Health, iRobot, RoboDynamics, VGo Communications, and Willow Garage have produced these robots with the intention of being used for a wide variety of situations ranging from ad-hoc conversations at the office to patient rounds at medical facilities. When comparing these first generation telepresence robots, there are few similarities between them, if any. Each company designed their own robot for the application of telepresence, and all arrived at very different robots. Our goal was to understand what the essential features should be for the next generation of telepresence robots. In July and August 2010, we conducted a series of studies for several office-related use cases [1] at Google in Mountain View, California, with two telepresence robots: Anybots' QB [2] and VGo Communications' VGo [3] (in beta and alpha testing respectively). In this abstract, we outline what features we believe are necessary for all telepresence robots based on the results of our studies with the QB and VGo robots.[1]

II. User Tests of Telepresence Systems

Study 1: Initial user impressions. The aim of this study was to evaluate how easy it was to use the robots and also gauge the participants' impressions of the robots after initial interactions. We conducted a between-subjects study in which 24 participants used either the QB or the VGo and a within-subjects study in which 6 participants used both robots. The participants were asked to perform three tasks. The first task involved driving the robot from an unknown starting location, moving through a cube area to a specified conference room. The second task involved having a short one-on-one conversation with one of the experimenters, and the third task involved a whiteboard interaction. All three tasks occurred in one 60 minute session. In a post-experiment questionnaire, the participants described what features they liked about the robots, which they disliked, and what features if any were missing. We also asked the participants for their thoughts about the robots height and the camera.

[1]We will present the details and results of the studies in the full paper.

Study 2: Remote user interactions. The aim of this study was to evaluate if telepresence robots could be used in formal, conference room meetings. We selected 6 remote participants who had recurring meetings with teammates in Mountain View. The participants, located across the United States and Europe, used the robots to attend their meetings in place of their normal video conferencing setup. Meetings ranged in length from 15 to 60 minutes, and participants used the robots for one up to eight meetings.

Study 3: Video comparisons. The aim of this study was to compare the video streams from the QB and VGo robots against a Sprint EVO Android phone. The EVO phone streamed video through the Qik [4] application using its wireless internet connection. We conducted a within-subjects study in which 24 participants used both the QB and the VGo robots with the EVO phone mounted on each. A session took 60 minutes. We asked the participants to rate the video from the robot and EVO with respect to field of view, latency, ability to perceive scale, contrast, resolution, color depth, and quality of degradation while driving the robot.

Study 4: Walking conversations. The aim of this study was to investigate an ad-hoc scenario involving movement while simultaneously having a conversation. We felt this was an important scenario that needed to be explored, as mobility is the characteristic that differentiates telepresence robots from video conferencing technologies. We conducted a between-subjects study with 24 participants in which one person operated the robot (robot driver) and had a walking conversation with another person who was physically present with the robot (walker). Both participants walked with and drove the robot. A session took 60 minutes. We asked the participants to rate their ability to operate the robot while talking, how useful they thought autonomous robot behaviors would be, and the height of the robot.

Study 5: Bystander impressions. At the end of August, we asked the general office population who had seen the robots in the hallways about their experiences. We created an anonymous online survey and placed comment boxes in two locations. We received a total of 10 responses. Throughout the summer, we also noted people's comments regarding the robots which were either directed at us or overheard.

Fig. 1. Telepresence robots (left to right): Anybot's QB, HeadThere's Giraffe, InTouch Health's Remote Presence 7, iRobot's Co-Worker, RoboDynamics' Tilr, and VGo Communications' VGo, Willow Garage's Texai. (Not to scale)

III. Features and Recommendations

Based on the results of our studies and feedback from our participants, we believe that telepresence robots should have the following features:

- Low latency video at the expense of resolution, color depth, and contrast while in motion.
- High enough video resolution to read signs less than 6 feet away with sans serif fonts with character height at least 5/8 inch [5] while not in motion.
- Graceful video degradation as packets are lost.
- The ability to switch access points such that the user does not notice a pause or gap in the video (1 to 2 seconds).
- A coupling of robot commands and video to prevent further robot movement after video connection with the robot has been lost.
- A main camera that can pan, tilt, and zoom independently of the robot's base and has a field of view with a wide enough angle to emulate peripheral vision when fully zoomed out.
- A dedicated camera to show the view around the base of the robot.
- Audio quality comparable to that of a land line phone conversation free from echo, feedback, and dropped audio.
- 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.
- Adjustable height with at least "sitting" and "standing" heights that can be adjusted independently by the robot driver.
- Speed such that it is able to keep pace with a person walking.
- A map of the environment integrated into the interface which shows where the robot is in real-time.
- Low-level autonomous navigation behaviors such as "drive straight" and "drive through the doorway."
- High-level autonomous navigation behaviors such as "follow this person" and "go to destination."
- Visual indicators for when the robot is occupied and other robot states.
- Identification of the robot driver beyond picture and voice.

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