Creating Human-Robot Rapport with Mobile Sculpture

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ABSTRACT

There is much discussion in the robotics community concerning the nature of people's impressions of robots. This pilot study employed the use of mobile robots coupled with artistic elements to create an environment conducive to human participation. PhotoBot took photos of participants (n = 16) in a gallery space and provided them with a physical copy of their image, while ProjectorBot displayed 3D Kinect imagery for participants to view. Participants completed a self-report measure of rapport (Bernieri's Rapport Criterion); the results of which suggest that they experienced a high degree of positive interaction with the robots.

Categories and Subject Descriptors

I.2.9 [**Artificial Intelligence**]: Robotics; J.5 [**Arts and Humanities**]: Arts, fine and performing.

Keywords: Mobile robots, human-robot interaction, kinect, rapport, sculpture

1. INTRODUCTION

To help make robotics more accessible (and acceptable) to the general public, there has been a trend in recent years toward "real world" human-robot interaction [3]. In addition to providing external validity from a methodological perspective, real-world deployments of robots afford researchers a chance to test out their sensing and motion algorithms in naturalistic settings. The recent release of the Kinect and Turtlebot robots, coupled with the ROS and PCL open-source communities, have made it very reasonable for members of our lab to design, build, and test ideas in real world settings.

We are particularly focused on non-verbal communication between people and robots, and for this work elected to focus on human-robot rapport. This is not a particularly easy concept to evaluate, particularly given the Turtlebot's limited expressivity. However, based on work by Walters et al. [8] and Byers et al. [4], we thought our robot displaying interesting proxemics behaviors while taking photographs might be a good starting point.

Inspired by efforts like Artbotics, where artists and computer scientists successfully collaborate to imagine new technological ideas [5], we formed a collaboration with the Art Department at St. Mary's College. Notre Dame computer science and engineering students worked with St. Mary's art students to conceptualize an idea they coined "technological nostalgia". High-tech robots could interact with participants by taking low-tech photographs (PhotoBot) and projecting 3D Kinect images (ProjectorBot).

HRI'12, March 5–8, 2012, Boston, Massachusetts, USA.
ACM 978-1-4503-1063-5/12/03.

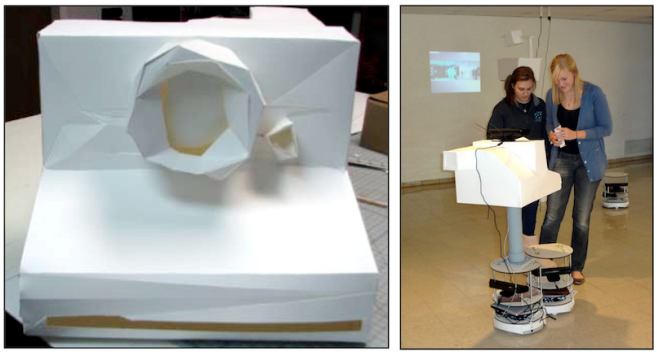

Figure 1. On left, the camera sculpture, on right, two participants interacting with PhotoBot (ProjectorBot is visible in the background).

In order to convey this notion, the artistic team developed sculptures that mounted atop the robots, and the robot team developed software to enable the robots to autonomously navigate and take and project photos.

We conducted our study at the Moreau Art Gallery at St. Mary's College, an open location with heavy foot traffic. After giving informed consent, participants were able to interact freely with the robots. They were encouraged to interact with PhotoBot and keep the photo taken of them, or ProjectorBot to see 3D images of themselves. They also could interact with two other Turtlebots (without sculptures) wandering around. Following the interaction, participants completed a self-report measure of rapport.

2. METHODOLOGY

2.1 Platform

Our main robots, PhotoBot and ProjectorBot, along with 2 additional sculpture-less robots, were built using the TurtleBot platform; a new mobile robot from Willow Garage that integrates an iRobot Create with a Microsoft Kinect sensor, allowing it to navigate its surroundings visually. The Create is a disc-like, wheeled platform, and the Kinect consists of an RGB camera and a depth sensor, which affords 3D motion capture and facial recognition.

PhotoBot and ProjectorBot each had a sculpture affixed to its top. PhotoBot's sculpture was a large Polaroid camera, and ProjectorBot's was a large overhead projector. (See Figure 1).

The interactivity between PhotoBot, the 2 sculpture-less robots, and the participants was direct. The robots autonomously traversed the gallery space using the open source *follower* program in ROS, following participants that moved within a certain distance of them. PhotoBot also ran a program that took

photos and sent them to an attached portable printer every 25 seconds. Participants were encouraged to take these photos home with them.

In contrast, the interactivity between ProjectorBot and the participants was indirect. ProjectorBot had a Kinect sensor affixed to its back and a mobile projector on its front; projecting images on one of the gallery walls. Due to power constraints of the projector, the robot was immobile during the pilot.

Aesthetically, the design of both robots was intended to reference out-dated modes of technology, taking advantage of "technological nostalgia." By using forms that are familiar yet obsolete—a vintage Polaroid camera for PhotoBot and an overhead projector for ProjectorBot—we hoped to encourage a comfortable, interactive relationship between the robots and human participants.

2.2 Measures

Traditionally, human-robot rapport is not an easy concept to test [6]; even human-human rapport is not particularly easy to measure. In the literature, the most well-validated measure is the Rapport Criterion developed by Bernieri et al. [2]. This is a self-report, summed measure based on theoretical work by Tickle-Degnen and Rosenthal [7]. The measure tests three main constructs of rapport: positivity, mutual attention, and interpersonal coordination [2]. Its application in previous studies had a Cronbach's α of .94, indicating high reliability; it also has high test re-test reliability (c.f. Balaam et al. [1]).

The Rapport Criterion seemed well-aligned with the aims of our pilot study, and was also successfully used recently to measure interactional synchrony with an ambient display devoid of sound and facial affect [1].

We instructed participants to rate their interaction with PhotoBot based on the following characteristics: well-coordinated (+), boring (-), cooperative (+), harmonious (+), satisfying (+), comfortably paced (+), cold (-), awkward (-), engrossing (+), focused (+), involving (+), intense (-), friendly (+), active (+), positive (+), dull (-), worthwhile (+), and slow (-) [1]. This was an 18-item, 9-point Likert scale, where lower values indicated a lower level of rapport ("Not at all") and higher values indicated a greater level of rapport ("Extremely") [2]. Rapport scores for each participant were calculated by summing each rating after reversing the negatively worded items.

3. RESULTS

16 participants completed the Rapport Criterion measure after interacting with the various 4 robots. There was 1 male and 15 female participants with ages ranging from 16 to 70 years. (The high number of female participants can be attributed to the art gallery being located at women's college.) Eleven participants interacted with PhotoBot, and six of these had their picture taken by PhotoBot.

The mean Rapport score was 101.00 ± 19.91, with a range of 59 to 128. The maximum total possible score was 144 and the minimum possible score was 0. The participant that scored 59 did not interact with nor get their picture taken by PhotoBot. Overall, there was not a significant difference in Rapport score among the group who had their photo taken by PhotoBot and among those who did not.

It appeared that the general consensus of the participants was one of intrigue, enthusiasm, and amusement. The participants tended to personify the robots and treat them as thinking beings. Some participants commented on the novelty and the essence of the robots. For instance:

"I've never really interacted with robots in this manner."

"The robot looked pretty shaky… maybe it's shy!"

4. DISCUSSION

We aimed to create an environment that was conducive to human-robot rapport. We achieved this goal, though in future trials, we plan to choose a location that has increased foot traffic to increase our sample size. To better integrate the artistic elements of a base and sculpture for PhotoBot, enhanced weight distribution needs to be incorporated in future designs to improve the stability of the robot. Due to time constraints and technical obstacles, the extent to which we had hoped the participants would interact with the robots was not attained. Regardless, the Rapport Criterion scores indicate that the pilot was an overall success. An extension of this study could analyze if there is a significant difference amongst rapport scores of those who interacted with robots containing an artistic element and those who interacted with robots lacking one.

5. ACKNOWLEDGMENTS

The authors thank the Moreau Art Gallery at St. Mary's for use of their facilities. We would also like to thank Ziqi Zhang for her assistance with data collection.

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