Exploring Socially Intelligent Recharge Behaviour for Human-Robot Interaction

Amol Deshmukh and Ruth Aylett
School of Mathematical and Computer Science
Heriot-Watt University, Edinburgh, United Kingdom
{a.deshmukh, r.s.aylett}@hw.ac.uk

ABSTRACT

In this paper we try to highlight the need for social intelligence during the recharge activity of mobile robots and report a study performed to investigate people's attitude towards recharge behaviour of an office robot.

Categories and Subject Descriptors

I.2.9 [**Artificial Intelligence**]: Robotics

General Terms

Human Factors, Algorithms, Theory

Keywords

Robot Companions, Social Intelligence, Recharge Behaviour

1. INTRODUCTION

It has been predicted that in the coming years, social robots will be part of our daily lives in domestic and office environments. Social mobile robots will need to operate over a long-term period of time, days, weeks or even months to perform daily tasks; hence they will require sustainable social intelligence [1]. In order for robots to act as companions or assistants in social environments such as homes and offices, they should be capable of operating with a great degree of autonomy over a longer period of time. Usually mobile robots draw power from batteries and take hours to recharge. While the recharge behaviour is active, the companion robot may be prevented from performing its normal tasks and this may hinder the flow of human-robot interaction. Hence, it is important for social robots to manage their recharge behaviour in a socially intelligent manner. In this paper we report an experiment performed to study people's attitude towards an office robot in regards to recharge activity and how the robot's verbal behaviour can influence people's perception of the robot. We have summarised some preliminary findings from this study in this paper.

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2. MOTIVATION

Some earlier work [2] suggests that social abilities in a robot contribute to a sense of social presence for the user when interacting with a robotic companion and this leads to higher enjoyment and social acceptance. Some studies [3] indicate, battery life and long recharge time may break the users engagement between robots and their users and pose a challenge to long-term interaction. Due to health and safety reasons a robot charging or docking station cannot be placed in the middle of a room, so the robot can get occupied sitting in a corner of a room while recharging becoming inaccessible to the user. It is thereby important for social robots to optimise their availability, moreover they should also be able mitigate disappointment of not being being able to perform tasks while recharging in a socially intelligent manner.

3. PILOT LONG-TERM EXPERIMENT

In the first long-term experiments that were carried (March 2012) were mainly to evaluate the active, recharge and task performance time by team buddy (TB) an office assistant robot (based on Pioneer P3AT with enhanced superstructure, expressive head and a laptop PC). The robot has 6 lead acid batteries (12V, 7Ah each) offering an approximate operational time of 3 hours when fully charged (depending on usage). These batteries require about 3 hours to recharge. The office had 5 participants who continued with their normal routine work, the robot performed tasks like greeting them when they arrived in office in the morning, passing messages, giving them reminders (from their Google calendars), auto-recharge, carry the phone etc. During the 10 days the robot performed 216 total tasks (average 21 tasks/day) with average active time of 7 hours/day (weekends were excluded).

The activity log showed that out of the total available time, 240 hours (10 days) the robot was active for 70 hours (time when users were present in the office), total time spent during task performance and home position was only 2.7 hours (3.8% of total active time) and recharging 33.5 hours (47% of total active time). The results from this pilot experiment clearly show that the robot spent most of the time recharging and was unavailable to perform tasks. The feedback received from the participants indicated that TB's unavailability during recharge was certainly not desirable and led to disappointment. Mobile social robots can try to mitigate user's disappointment with an apology which can be effective in making the robot seem more competent, making the participants feel closer to and liking the robot more [4].

4. USER STUDY

Following the results from the pilot long-term experiment a more focused WoZ study was conducted (November 2013), to specifically investigate how people rate a moving robot against a stationary robot (during recharge activity), and while performing tasks. The two main hypotheses for this experiment were, *H1: People will prefer the moving robot more than stationary robot, H2: People will rate the apologetic robot better than the neutral robot while the robot is recharging.* The participants entered into a room and were asked to mark an exam paper seated on a desk. The experiment had two parts, first session (Part A) was the same for all participants, although the participants were not aware that the experiment has two sessions. The TB greeted them initially and then performed two tasks namely message delivery and call delivery after fixed time intervals of 2 minutes. The tasks involved the robot navigating from a default location in the room to user's desk and then performing a verbal action using an artificial synthesised voice.

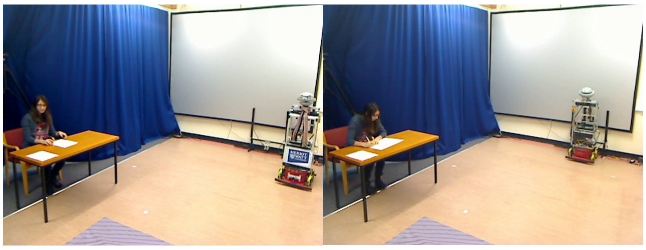

Figure 1: Experiment room: Part A (left: moving TB), Part B (right: stationary TB while recharging)

The participants then answered a questionnaire after the first part and then were sent back to the room being asked to try and envisage that some time has passed between first part (morning time) and now (evening). The robot performed the same 3 tasks (greet, message, call) from a recharge station in the room. In the Part B, second part of the experiment, there were two conditions, the first condition was the neutral condition where the robot was using more direct verbal communication. In second condition, the robot was apologetic and provided more explanation about it's situation and it's limitation for not being able to move due to recharging activity. Examples of the verbal communication are stated below for greeting task.

Part A - Greeting: "Hello, good morning. I am the Team Buddy of this lab. My name is Alex, hope you have a good day. My battery is fully charged"

Part B - Greeting (Neutral condition): "Good evening, good to see you back. My battery is low, so i am recharging now.."

Part B - Greeting (Apology condition): "Good evening, good to see you back, sorry my battery is low, so i am recharging now, I cannot come there.."

The study had 46 participants (28 Male, 18 Female). We randomly assigned the participants for the two conditions in Part B, 23 participants interacted with neutral version and 23 with apologetic version. After second part the participants were specifically asked in questionnaire "Which team buddy would you prefer Part A or Part B?", 65% preferred Part A, 20% preferred Part B and 15% preferred both. In some other questions asked about TB's behaviour, the participants were asked to rate the TB on a 7 likert scale (1-Disagree strongly to 7-Agree strongly). The results shows higher average ratings for the apologetic TB in comparison to neutral TB in regards to: I felt in company of the TB, TB's recharge behaviour was acceptable, I felt neglected while TB was recharging, The TB was available to interact with me. These preliminary results supports both hypothesis H1, H2 and also conform with earlier long-term HRI studies performed with stationary and moving robots [5].

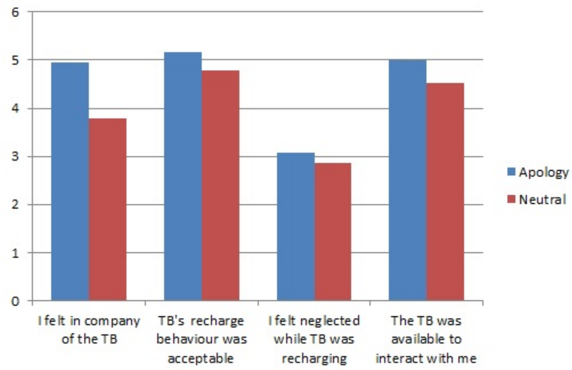

Figure 2: Average rating, (Apology: n=23, Neutral: n= 23)

5. CONCLUSION

The results from the pilot long-term experiment indicates the need of socially intelligence during recharge activity of mobile robots operating in social environments. From the user study it is clear that using verbal apologies can be effective in mitigating disappointment and give users a sense of companionship even when stationary during recharging. The results from the user study is still preliminary and is subjected to further detailed analysis in the future.

6. REFERENCES

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