Navigating in Public Space: Participants' Evaluation of a Robot's Approach Behavior

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ABSTRACT

The results from an empirical study on the impact of a robot's approach trajectories on its social acceptance are presented. An online survey presenting short videos of a robot (IURO - Interactive Urban RObot) approaching a person in a public space and asking for help was shown to the users. IURO either approached a walking or standing person. The results show that walking participants preferred to be approached from the front left or front right direction rather than frontally. However, when they are standing all three approach directions were acceptable.

Categories and Subject Descriptors

A.m [**Miscellaneous**]: Social Robots

Keywords

social robot, public space, approach behaviour

1. INTRODUCTION

In the context of robots performing tasks in public space the group of potential inexperienced users is big, namely every bystander encountered on the way. In the IURO project we are exploring a scenario in which a robot without any map knowledge (no Internet or GPS access) has to navigate from one point in a city to another, using only information acquired from encountered strangers on the street. In that scenario it is necessary that the robot will be accepted in public space, as otherwise its chances of receiving help will decrease. In the future, where there will be multiple robots present in the environment and the novelty effect is no longer present, a robot requiring help from a stranger should be able to encourage the interaction and initiate it in a socially acceptable way. In the presented study we wanted to learn more about people's preferences for IURO's approach direction in public space.

2. RELATED WORK

In robotic research, people for long time were only perceived as obstacles that must be avoided by robots while navigating in populated areas. This has changed in the recent years with the development of social robots. It was shown that a seated person prefers to be approached by a

robot in a fetch-and-carry task from the front left or right direction rather than frontally or from behind [1, 4]. Further research shown that there are other mediating factors, which can impact this preference, such as a person's experience with robots [2], gender [1] or in which part of the room she was standing or sitting [4]. This high context-dependence of approach behavior preferences emphasizes the need for validating these results in public space, which might differ from the previously explored domestic context. Satake et al. [3] proposed an approach model for robots which should initiate interaction in a shopping mall. However, while this model was successful in improving the robot's performance in initiating conversation, little is known whether people felt comfortable while being approached frontally.

A walking pedestrian approached frontally by an unknown robot might be afraid that it will not stop and collide with him. However, if a pedestrian is standing he could step aside in case of emergency. Therefore, we hypothesised that:

- H_1: People walking towards a robot will prefer to be approached either from the front left or front right rather than frontally.

- H_2: People standing in a public space will like frontal approach of a robot equally well as front left or front right trajectories.

3. METHOD

In order to have highly controlled conditions we have used a video-based method as proposed by Woods et al. [5], since it proved to provide reliable results for the hypotheses that we wanted to test. Short pre-recorded videos (approx. 15 sec) with audio of IURO's interaction with a human actor were used in the experiment (Figure 1). In each of these videos the robot approached the person from the (a) front left, (b) front right and (c) frontal direction and asked for the way to the assembly hall. After the actor showed the direction to IURO the video clip stopped. Furthermore, each of the above described approach trajectories was filmed in two conditions: (1) the approached person was walking and (2) the approached person was standing still. Thus, in total there were six videos. The actor was our colleague and he followed a prepared script.

4. PROCEDURE

The online survey with the videos was distributed via email on two scientific mailing lists, and to employees and students of a university via an online newsletter. It had a

Figure 1: Snapshot from the video showing the robot approaching a person.

one month run time (June 2011). The first part consisted of demographic questions, followed by 3 videos in which IURO approached either a walking (dynamic condition) or standing (static condition) person and asked him for the directions to the main assembly hall. The allocation was counterbalanced by chance. After each video which was displayed, the participants were asked to fill in a 5-point Likert scale (1 - strongly disagree, 5 - strongly agree) to state whether they liked the presented approach trajectory of IURO.

5. RESULTS

Overall, 182 participants answered the survey (94 participants saw the videos in the static and 88 participants in dynamic condition). There were significantly more male (n=118) than female (n=64) participants. The mean age of the participants was 33.42 years. Participants represented 41 countries. Over 60% of the participants have never been working in the field of HRI and never participated in a study in that field. However, 84% (n=153) of the participants were interested or very interested in technology in general and 73.1% (n=133) in robotics in particular.

In the dynamic condition, when the robot approached a walking person, Mauchly's test indicated that the assumption of sphericity had been violated [χ (2) $=$ 16.05, p $=$ .00] and the Greenhouse-Geisser correction has been applied for the ANOVA's degrees of freedom. There was a significant effect in the liking of the approach trajectories, F (1.71, 148.68) $=$ 4.35, p $=$ .02. Post-hoc comparisons showed that participants preferred when the robot approached a walking person from the front left side (M $=$ 3.46, SD $=$ .92) than frontally (M $=$ 3.18, SD $=$ .98) p $=$ .049 and front right side (M $=$ 3.51, SD $=$ .8) than frontally p $=$ .01. As we assumed in H_1, these results indicate that walking people should be approached from one of these sides, but not frontally.

In the static condition, Mauchly's test indicated that the assumption of sphericity had been met and no correction has been used. In contrast to the dynamic condition, when the robot approached a standing person, there was no significant effect in the preference of approach trajectories, which confirmed our H_2. In other words, people liked it the same when the robot approached them frontally or from a side.

The ANOVA revealed no significant relationship between the robot's approach behavior preferences and participants' age, experience with robots, gender or interest in technology.

6. CONCLUSIONS

The online survey presented in this paper gave insights on the approach behavior of the IURO robot. This study

further emphasized that approaching a human in a socially acceptable manner in public space is not a trivial task in HRI. A robot that wants to initiate an interaction with a stranger can impact its chances of receiving help even before it asks for help.

Based on the presented results, we could derive implications for the IURO's approach behavior in public space. If a person is standing in a public space, a robot can approach from any of the directions. This result goes in line with previous findings that a person standing in the middle of a room finds it acceptable to be approached frontally [4]. However, in case a robot approaches a walking person, it should come either from the front left or front right direction.

In this study we have used a video based method and we are planning to evaluate the presented findings with a real robot in public space. Furthermore, there was only one robot and actor used in the study and the results cannot be generalized until they are replicated with other robotic systems. Finally, there are other aspects of approach behavior, such as proxemic behavior or approaching a group of people, which can impact robots acceptance in public space and should be addressed in future studies.

7. ACKNOWLEDGMENTS

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