How humans behave and evaluate a social robot in real-environment settings

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ABSTRACT

Behavioral analysis has proven to be an important method to study human-robot interaction in real-life environments providing highly relevant insights for developing new theoretical and practical models of appropriate social robot design. In this paper we describe our approach to study human-robot interaction by combining human behavioral analysis with robot evaluation results. The approach is exemplified by a case study performed with a social robot receptionist in real-life settings. Our preliminary results are encouraging, as many behavior categories could be successfully related to certain evaluation patterns. With our analysis we hope to add a useful contribution to social-robotic design concerning user modeling issues and evaluation predictions.

Keywords

Social robots, Non-laboratory environment, Behavioral analysis, Quantitative evaluation

INTRODUCTION

Newest technological advances in engineering and computer science have moved from their industrial ‘playground’ into our daily life. Since more and more robots become our social partners as healthcare assistants, museum tour guides or receptionists there is an increasing trend to evaluate them outside the lab, i.e. in the environment where they are meant to function. One method of studying human-robot interaction outside the lab is behavioral analysis. The method is commonly used in psychology to acquire knowledge about human social interactions by analyzing body posture, facial expressions, gestures and verbal behavior.

RELATED WORK

Behavioral analysis has been used by several researchers in the human-robot interaction area with different purposes. Sabanovic et al. [1] applied observational analysis with the purpose of improving the interactive capabilities of two social robots. Watanabe et al. [2] deployed behavioral analysis of human non-verbal interactions to develop a speech driven embodied interaction robot, while Breazeal [3]

used the method to prove the salience of non-verbal cues in cooperative task-oriented interactions between humans and the robot Kismet. In our study we applied behavioral analysis to determine several behavior categories with the purpose of investigating whether these categories have specific evaluation patterns associated with them. The approach is exemplified on a case study performed with a social robot receptionist. Since it can be easily applied to different social robotic interaction contexts (i.e. healthcare, education, entertainment, etc) we consider the approach as having general validity.

METHODS

Experiment set-up

The study was performed during the two-day annual exhibition *TechFest* organized in October 2009 at I²R (Singapore) where 120 visitors spontaneously interacted with the social robot, Olivia. Olivia’s tasks were to inform and entertain visitors by presenting information about building amenities, daily horoscope and by playing a simple game consisting of recognizing and tracking different objects. Attached to the robot was a touch screen where additional information cues were displayed. Visitors could interact with Olivia using speech or the touch screen. Olivia’s personality was designed with highly extrovert features; using an emotional intonation and many gestures Olivia often added a very personal touch to her talk: visitors were informed not only about building amenities or horoscope but also about Olivia’s family members living in the building, about her preference for *kaya* toast or her passion for swimming. A conversation with Olivia typically lasted around 3-4 minutes. Olivia was accompanied by a human assistant standing at 2-3 meters distance. Visitors were free to talk with the assistant and ask questions about the robot, if they wished to.

Evaluation questionnaire

After interacting with Olivia the visitors were approached by the assistant and asked whether they would like to fill in an evaluation questionnaire. In this way we obtained evaluation data from 88 persons. The

questionnaire was organized in three categories referring to the robot's social skills, interaction features and users' feelings during the interaction.

Behavioral analysis

The interaction was recorded with three hidden cameras placed around the robot. We used the recording to annotate visitors' behavior concerning gaze, reactions to robot's humor, speech patterns, degree of participation and body posture.

RESULTS

The visitors' gaze behavior can be described as falling into the following categories: gazing predominantly at the screen (type 'A'), gazing predominantly at the robot (type 'B'), and mixed gazing at both screen and robot (type 'C'). The gaze behavior annotations did not include interaction sequences where the visitor's attention was intentionally guided in a particular direction, e.g. to the screen or to game objects. Results showed that 37.3% of the visitors exhibited a gaze behavior type 'A', 34.7% type 'B' and 28% type 'C'.

Regarding visitors' mimics and reactions to robot's humor we differentiated between 'positive' and 'negative' reactions. 'Positive' reactions were expressed in both verbal and non-verbal form, i.e. interjections, hilarious answers to robot's humor, smiles or laughs. As 'negative' reactions we considered the lack of response to the robot's humor and the display of a general serious attitude. Statistics revealed that 68% of the visitors smiled during the interaction and 50% had a positive reaction to the robot's hilarious talk. According to a χ^2 test we found significant correlations between gaze behavior type 'A' on one side, and 'negative reactions' to robot's humor (χ^2 , $p=.001$) and lack of smiling (χ^2 , $p=.040$) on the other side.

Further, we investigated visitors' speech behavior focusing on the input shortness, polite markers and whether they approached the assistant while interacting with the robot. Most of the visitors (65.27%) preferred to use keywords instead of sentences (34.73%). Significant correlations were found between both gaze behavior type 'B' and 'C' and the preference for using sentences (χ^2 , $p=.000$). Only 27.6% used polite markers, e.g. greetings or thanks. 40.8% approached the assistant while interacting with the robot.

Despite predominant answer shortness on visitors' side we distinguished between two types of communicative behavior, i.e. degree of participation among visitors: a highly-interactive type and a low-interactive type. A highly interactive type showed initiative in conversation, asking the robot additional questions and using mainly speech to communicate. A low-interactive type used predominantly the touch screen to interact, had no conversation initiative and often relies on assistant's help. The majority of visitors (60%) belonged to the low-interactive type. The low-interactive type correlated significantly with the gaze type 'A', and with the preference for using key-words (χ^2 , $p=.000$).

The body postures refer to the position in which visitors kept their arms and hands: 9.3% crossed their arms around their body, 2.7% placed a hand on the shoulder, 10.7% kept their hands alongside their body in a rigid position, 1.95% put both hands on their hips, 17.3% locked their hands at the back, 12.65% had their hands busy with bags or other objects, 13.3% hid their hands in their pockets, and 16.9% held them together in front of the body. Only 15% of the visitors placed their hands on the touch table in an attempt to get closer to the robot. Significant correlations were found between the low-interactive type and the tendency to hide hands behind the back or in the pockets or to keep them rigidly alongside the body (for all χ^2 , $p=.000$).

Finally, we investigated how the behavior categories mentioned above related to evaluation patterns. According to a Mann-Whitney significance test visitors displaying gaze behavior type 'A' felt more in control of the conversation than visitors with other gaze behavior types (U , $p=.019$). On the other side, people displaying gaze behavior type 'C' found the interaction to be easier (U , $p=.020$). Visitors, who smiled during the interaction evaluated the robot's ability to express humor better (U , $p=.023$). Participants, who reacted to robot's hilarious talk evaluated its ability to express personality much better than those who did not (U , $p=.032$). Visitors, who did not pay attention to the human assistant evaluated the robot's ability to express emotion (U , $p=.032$) and its capacity to respond fast ($p=.044$) better than visitors who approached the assistant. People using keywords to communicate with the robot indicated a higher degree of concentration during the interaction, than those who used sentences (U , $p=.010$).

CONCLUSION

In this paper we present some first observations gathered from an exploratory study performed with a social robot receptionist. The outcome is encouraging, since the results of the objective behavioral analysis were consistent with those obtained from the subjective evaluation questionnaire. In the future, we plan to enrich our annotations with additional behavior categories, such as more detailed observations about gestures, mimics and response latencies. Further, we plan to use the results for the development of an evaluation prediction model.

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