Design of Moral Interactions for Service Robots in Public Environments

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Abstract

In the future, social robots will be a common sight in public spaces, performing tasks that human workers would perform and engaging with the public in roles such as security guards, store clerks, receptionists, etc. Robots' ability to serve customers in a friendly manner is the subject of numerous research projects nowadays, and as a result, the quality of their services is constantly rising.

However, human-employee service is not limited to simply providing friendly service. They make an important contribution to maintaining a polite and comfortable atmosphere in public spaces. They stop visitors' low moral behaviours (e.g. vandalism, and shoplifting) or norm-violating behaviours (e.g. queue jumping, and being noisy) through actions such as admonishing or by mere presence. Yet, existing robots in public spaces have little to no capability to prevent visitors' inappropriate behaviours; neither people consider them a moral entity. Indeed, only a few works have attempted to develop such capabilities for robots. Unfortunately, without such capability, robots are not ready to work on behalf of human employees in public spaces.

This thesis focuses on designing moral interaction capabilities for the robots that serve in public environments. We define *robot moral interactions* as "engagement with people while attempting to maintain a high level of morality in the robot's own and others' behaviours." We particularly focus on moral interactions that aim to prevent or stop inappropriate behaviour by visitors in public spaces. We attempt to address four challenges with designing such moral interaction capabilities: people's less compliance with robots, negative perspectives about the robots that attempt to regulate people, revealing people's perceptions and interactions with robots that execute moral interactions in public space, and a lack of knowledge in developing reliable robot systems to operate in the real world.

Our first study (Chapter 3) focuses on developing an acceptable admonishing service for a robot that tries to stop an individual's inappropriate behaviours. We also study how people perceive such an admonishing robot. As our example, we develop an acceptable admonishing service for a real-world shopworker robot. We want to include an admonishing capability for the robot while still projecting a positive image. We propose *harmonized design of friendly and admonishing service* as our solution. Based on the findings of our interviews with the shop staff, we suggest three design principles to achieve harmony: a friendly impression, zero erroneous admonishments, and polite requests. The results of our 13-day field study at a shop show that many customers and shop staff have a positive impression of the proposed robot, which indicates that the harmonized design could be a successful approach for an acceptable admonishing service.However, a few customers preferred human admonishing service due to the demerits of the robots', which need to be further studied and improved in the future.

In our second study (Chapter 4), we aim to develop a robot that can promote compliance and diminish people's negative attitudes in a scenario where it controls a crowd by instructing and admonishing in a public area. Furthermore, we aim to investigate people's impressions and interactions with a robot that provides such a service. We consider managing a queue of people as our example scenario. We propose *imbuing a professional impression in the robot* as our solution by mimicking the queue management role of the human security guard which is already socially acceptable and effective. We also present three design features to achieve a professional impression for the robot: duties, professional behaviour, and professional appearance. We have deployed our robot for queue management at a public event for 10 days and have investigated visitor interactions and impressions of the robot. Our field trial results show that many visitors complied with the robot, although some ignored it. Furthermore, our interview results, including the opinions of a few admonished visitors, indicate the majority of them have a favourable impression of the robot. Still, a portion of visitors pointed out the demerits of the robot. Thus, exhibiting the image of a professional security guard and performing admonishing as one function, among others, could be a successful approach for effective and acceptable crowd handling. However, the demerits of the robot need to be further addressed in future studies.

Our third study (Chapter 5) attempts to create a robot that can indirectly exert social pressure to discourage people's norm-violation behaviours without causing

a negative impression. Furthermore, we aim to address the technical complexity and lack of knowledge of developing such a robot to autonomously work in real life. As our design concept, we propose to *exert social pressure through friendly behaviour*. Considering a shopworker robot as our example scenario, we have developed a robot to recognise visitors' shopping actions and express its awareness by giving friendly remarks that fit those actions. We demonstrate how to develop such a robot system to autonomously work in a real shop by integrating real-world data into the robot development process and offering solutions to several practical issues. Our 11-day field trial at a hat shop shows that such behaviour by a robot can create positive impressions in many visitors, yet the effectiveness of the robot in preventing norm-violation behaviour remains unclear and needs long-term data collection. Further, the field trial reveals that several visitors had negative impressions due to the demerits of the robot, which need to be further studied and improved in the future.

The robot designs proposed in this thesis provide some guidance for developing acceptable and effective service robots with moral interaction capabilities in a future society. Furthermore, the observations and interview results of our field studies broaden the knowledge of how people interact with and perceive robots with moral interaction capabilities in the real world. Thus, the findings of this thesis offer perspective on the development and deployment of robots with moral interactions in public spaces.