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"Please Press Floor B": Engendering Trust in a Guide Robot

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Abstract

For assistive robots (in roles such as carers, guides, companions, and assistants) to be most effective, they will need to engender trust in their users. The ROBO-GUIDE (ROBOtic GUidance and Interaction DEvelopment) project is an interdisciplinary project bringing together engineers and scientists working in computational neuroscience, control systems, formal verification, natural language, and psychology, to address how such a system can be designed. This paper outlines our approach, which focuses on the key trust influencers: safety, verification, communication, and behaviour.

Keywords Assistive robotics; Guide robot; Mobile robotics; Robot trust; Human-robot interaction.

1. Introduction

The ROBO-GUIDE project aims to develop a guide robot that can operate in a safe, reliable way, inside a large working building filled with people who are not, on the whole, familiar with robotic technology. As the robot is relied upon to assist others, it is also important that interactions are naturalistic and promote cooperation.

A novel scenario, which we are investigating in our current work, is how the robot navigates between floors using a lift [1]. This is a particularly complex challenge, in which the robot is required to: navigate into and out of the lift safely, without causing injury or damage; interact through natural means with other lift users to request assistance in controlling the lift; and operate in a trustworthy and reassuring manner around others in a closed and close-proximity environment.

These issues are all relevant to the wider field of assistive robotics. For example, Rosenthal et al. [2] highlight the importance of a symbiotic human-robot relationship, whereby a robot that asks for assistance from a human can complete its role more efficiently; Dixon et al. [3] show the need for formal verification in assistive robots to ensure safe operation, and engender trust; and Kulyukin [4] examines the appropriateness of natural language as an interface for interaction with assistive robots, highlighting its potential in applications requiring human intervention.

In this paper we describe these key concepts, which are all considered as important in promoting trust in robotic systems [5], and our methodological approaches to them.

2. Safety

Any system deployed around members of the public must be verifiably safe in its operation. To show this a safety case can be constructed [6], which produces an argument that demonstrates why a system is safe to operate in particular conditions; this can be presented using Goal Structured Notation (GSN) [7].

In the case of a robot guide, it is essential to be able to demonstrate why the robot is safe: it will lead guests through a building and have to navigate past other, potentially unwary, building users. In order to understand the robot and how it must behave within the environment, we must understand the boundaries of operation. This will involve developing an understanding about the operational requirements of the robot.

A key safety concern, arising from the application described here, surrounds the robot's interaction with other building users. As such, we are developing safety patterns for use in the design of such systems [8].

3. System Verification

During operation, the robot will make a number of decisions about how to act in the environment. It is important that these decisions be verified against a specification describing how the robot is expected to perform [8], which must consider both operational safety and task performance.

As the robot is to operate in close proximity to unsuspecting humans, a significant amount of testing is required to ensure it performs safely. However, due to the complex and unpredictable nature of the environment, it is not possible to perform a fully exhaustive set of tests. Therefore, it is also necessary to formally verify the decision making of the robot to ensure it will never intentionally act in an unsafe way.

A particular challenge faced by the robot is in using a lift to change floors. This is complicated by the reliance on human bystanders to operate the lift, which can potentially result in the robot finding itself on the wrong floor. Once again, it is necessary to formally verify the decision making of the robot to ensure that, if this happens, it is able to recover its position.

It is important to consider the balance of safety and performance when verifying the decision making of the robot. For example, a perfectly safe robot may simply decide to park itself in the corner of a room so as not to pose a hazard to anyone, but of course it will likely never achieve its goal (with the exception of the goal *park in the corner of the room*). Conversely, a goal-driven robot may drive the fastest route to the goal without stopping, but this is likely to be dangerous to other building users. The perfect robot would achieve a balance somewhere between the two.

4. Natural Language Communication

To facilitate human-robot interaction (HRI) we chose to use speech as the most natural form of human communication. This has several advantages for control applications [9]: it requires no special user training, is information rich, and is 'hands-free'. Previous work on natural language and mobile robots has mainly focussed on command systems where users can convey instructions for the robot to perform. However, in our project the robot should use language spontaneously and naturally as part of navigating around a busy working environment. Ideally the robot should interact with humans in the vicinity, both to offer assistance as a guide and to request assistance where necessary.

In addition to using speech to communicate with other building users, there are situations wherein the robot can use speech to communicate with other devices via existing human-machine interfaces. One such example is the lift used in our current experiments, which announces both the floor and direction of travel.

5. Promoting Helping Behaviour

To ensure the robot gets help from humans, for example to open doors or operate the lift, we look to social psychology and factors of user trust and situational ambiguity.

Successful interpersonal cooperation identifies trust as its foundation [10], as the completion of tasks involving two agents requires that both individuals trust each other. This human-human theory of cooperation has analogues in trust promotion within HRI [5]. We are aware that interaction with robots in cooperative environments presents a novel scenario for many people, and could lead to uncertainty in how to behave around the robot. Ambiguity also results in substantial detriment to pro-active helping behaviour [11]. To ensure that humans aid our robot most effectively we must consider just how trustworthy our robot is perceived to be, so that human agents give helping behaviour freely and comfortably. The ROBO-GUIDE platform will therefore be required to communicate a clear plan or intention of its task to reduce ambiguity, as well as allow a human to understand in as clear a way as possible its limitations and its requirements for help. As such the robot will be designed to influence its perceived trustworthiness using a combination of affective and cognitive trust markers [10] in the language it uses to convey its intentions; for example by using friendly statements, and clearly communicating its aims: "*Please press floor B; I can't reach the buttons!"* [12].

6. Conclusions

We have introduced the ROBO-GUIDE project, and outlined considerations to ensure the robot is safe, reliable, naturally communicative, and promotes helping behaviours. By considering these factors together, we endeavour to provide a framework for developing assistive robots that engender trust in their use.

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