Socially Acceptable Robot Navigation Across Dedicated and Shared Infrastructure

Socially acceptable robot navigation

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This extended abstract elaborates on some of the research questions we face in the design of two modular robot service platforms, which will be deployed in the new corporate facilities of a large Korean technology company. The goal is for the robots to autonomously navigate using dedicated infrastructure (special service elevators and transit lanes) when possible, and be able to seamlessly navigate potentially crowded, public spaces and shared infrastructure.

CCS CONCEPTS • Human-centered computing • Interaction design • Interaction design theory, concepts and paradigms

Additional Keywords and Phrases: autonomous agents, social acceptability, robotic platforms, interaction design

1 INTRODUCTION

Questions around what amounts to socially acceptable behaviour for autonomous agents are not new to the HRI community. We draw in particular on a body of work that has highlighted the challenges involved in making complex AI systems and decision making transparent to lay users, when encountering these systems in shared spaces and infrastructure [2,15]. We take this challenge from an Interaction Design perspective [12] across several indoor and outdoor scenarios involving two robot platforms developed by our organization. These will include delivering parcels and food orders for indoor scenarios and transporting employees between buildings on a semi-open campus for outdoor scenarios. The platforms will have some dedicated infrastructure (such as dedicated elevators in a specific office building), but will also have to be able to utilize shared infrastructure and spaces at times. The platforms are built around a centralized processing robot "brain" to keep the robot relatively simple and modular to keep unit costs contained. From a design point of view, the solutions adopted to make the robots' behaviour appear more socially competent or transparent will consequently have to be relatively simple. To some extent, therefore, our system will be a black-boxed [7] service or infrastructure with an underlying technology that remains largely hidden to the user. A more positive way of framing this would be to say that the robots should at the same time integrate seamlessly with and effectively disappear or sublimate into the service they provide [9].

2 THE SCENARIOS

As mentioned in the introduction, our research focuses on both indoor and outdoor scenarios. The outdoor scenario involves on-road robots and vehicle-pedestrian interaction in crosswalks. We believe autonomous vehicles need to provide a replacement mechanism for eye contact between drivers and pedestrians at crosswalks. Previous research has focused on communication mechanisms that could overcome this limitation, such as intent displays to indicate the vehicle's intentions, e.g. [8]. While different alternatives have been proposed, many of them have been evaluated in controlled settings that do not consider realistic situations found in real-world scenarios, such as the interaction with multiple pedestrians at the same time [10]. At the same time, studies show that people still rely on legacy factors such as vehicle motion [3], which proves the importance of working both on vehicle behaviour in combination with other types of displays.

In this position paper, we will, however, discuss the indoor scenario in greater detail. This scenario involves robots sharing elevators with employees and visitors in our corporate headquarters. It potentially raises issues of proxemics and cultural preferences [6], and requires distinctions between what might be characterized and reduced to rules easily built into the robots' navigation behaviors and more nuanced matters of etiquette that would require the robots to identify things like human gaze and posture and "read" their interactional meaning and valence. This work could also provide a baseline for more complex interactions designed to enhance the robots' flexibility, including robots requesting assistance to operate elevators not explicitly designed for their use and not integrated into the robotic platform's infrastructure. This work builds on work done in the context of collaborative robotics [14] aimed at creating robots capable of compensating for their physical (ability to manipulate the environment) or perceptual limitations by eliciting human assistance.

The current state of the art for robots using elevators relies mainly on vocal interfaces, with the robot announcing their intention to enter the elevator and where they will position themselves (5). While this can be an effective strategy, it clearly places the burden of making the interaction work on the people sharing the elevator with the robot. This may be socially acceptable if the interactions are occasional (as might be the case, for example, with delivery robots in a hotel where any given guest might encounter the robot once during their stay). In an office environment with service robots performing routine tasks, encounters with robots in elevators are likely to be a daily occurrence for the people working in the building, which means that negotiating the use of elevators through loud verbal announcements could quickly become tiresome.

A different and far more ambitious technology and interaction design paradigm might be to develop a platform capable of reading non-verbal behaviour and the social context. This understanding could enable robots that treat people as agents that are occupying a shared space with rules to follow with respect to things like order of service (priority) and priority, rather than just obstacles to be avoided. This of course presents a substantial challenge as there is a semantic gap to be bridged between detecting things like posture and predicting movement (intentionality) and making dynamic and contextually appropriate decisions in what is a straightforward for us but quite nuanced social interaction.

3 DISCUSSION

In our approach to the elevator scenario, we attempted in the first instance to gain some understanding of what we might call the "practice" of taking the elevator. While it is in many ways a straightforward accomplishment (arguably more than driving a car in traffic), it is also constituted of practices which are methodical and accountable, with normative components and nuanced, often non-verbal use of space and resources. We analyzed approximately

16 hours of video data gathered by placing a video camera in the elevator lobby of one of our company's research labs. We adopted an ethnomethodological analytic orientation [4] to understand the specific practices of waiting for, entering and exiting an elevator.

We do not go into all the findings in detail here, but for the purpose of this discussion, we will focus on how the order of service is managed (who enters the elevator first when multiple people are waiting). What our observations reveal is that there is a general first-come-first-served principle that is applied, but it is a weak one. People do not form proper queues, especially where multiple elevators are linked to a single call function. In this common scenario, people often drift towards the lobby's centre and only position themselves clearly in front of a door when the elevator lights indicate it will be the next available elevator. However, the elevator lights are not fully reliable as the elevator status may change, and the next available elevator may, in fact, be at the other end of the lobby. In such cases, people moving back and forth across the lobby ("chasing" the next available elevator) may lose or have to renegotiate their priority in the order of service.

This seemingly obvious and easily accomplished behaviour would present serious challenges if we wanted a socially competent robot to mimic it. What [1] describes as "the order of waiting" is constituted of both ordered and disordered formations, with demarcations and affiliations that are constantly produced and renegotiated. Even if we had computer vision technology capable of reliably and dynamically detecting things like posture, orientation, distance and displacement with respect to other people and elevator doors [13], gaze and facial expression, and computing the semantically and situationally appropriate reading of the situation, it is still doubtful that it would be the best approach to a seamless interaction.

One of the problems that concern us here and that we think is of interest to the HRI community is that, as [11] observed many years ago, the breakdowns in the interactions between technology and its users were often instantiated by what could be described as the illusion of social competence. Therefore, the design challenge we pose is how to have an agent that can effectively navigate shared spaces with people, with a focus on safety and minimal disruption, but without necessarily being burdened with the normative expectations of being perceived as a fully socially competent agent. The question in our minds is that displaying socially competent behaviour may amount to less transparency rather than more. From a design point of view, there may be a certain expediency to have robots with elegant but direct interaction mechanisms that encourage users to, for example, limit their attempts at engaging with the service robots to what is clearly part of their tasks and within their scope and not beyond.

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