Designing a Service Robot for Public Space
An "Action and Experiences" - Approach

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ABSTRACT
When we think of service robots for public spaces, we often consider human-like systems that socially interact with users in short-term and dynamically changing scenarios. Many design assumptions exist for this type of robot, but what about for a service robot that needs to interact with people in a very task/role-oriented manner? This paper presents a research-through-design approach, which explores the idea of a "luggage-carrying robot guide" for train stations which supports travellers. Contrary to the classical paper describing the requirements, design, implementation, and evaluation of the robot, this work presents an exploratory design study. An interdisciplinary team composed of two industrial designers, a roboticist, and a social scientist performed a study with users to establish a design space for the aforementioned service robot.

Categories and Subject Descriptors
J4 [**Computer Applications**]: Social and Behavioural Sciences – *Psychology. H5.2 [Information Systems]: Information Interfaces and Presentation – User Interfaces.*

General Terms
Design, Experimentation, Human Factors.

Keywords
Design study, service robot, public space.

1. INTRODUCTION
The development of robots, which are capable of safely navigating in densely populated environments, has made substantial progress in the last decade. Numerous researchers and designers have already thought about the design space for service robots [1], however in many cases social robots are considered to be the "right solution" and not "just" autonomous service artefacts. An example for the design of a social service for public context, is e.g. the sociable trash can [3]. In this paper we present an exploratory design study for developing a design space for a service robot, which to our conviction hardly needs sociable aspects: An autonomous artefact that should carry people's luggage and guide them the way, e.g. at a train station. We therefore followed the "Human Action and Experience" model proposed by Fernaeus [2]. Fernaeus points out four areas of use qualities: physical manipulation, perception and sensory experiences, contextually-oriented actions, and digitally mediated actions. In our work we used this model as a starting point to explore our first mock-up of the artefact in the wild with three potential end-users.

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2. EXPLORATORY DESIGN STUDY
Following the model of Ferneaus, this study is based on the proposed guiding questions [2], such as: How do people physically handle or manipulate the device? What emotions and interpretations do the features of the artefact express? How do people act around the system?

2.1 The Service Robot Mock-up
Our mock-up comprised a differential drive mobile platform, an installation for luggage, different handles, a simulated card reader for authentication, a simulated touch screen with destination icons, and a smiling face on the other side of the touch screen. Participants were only told two main interaction paradigms: (1) put the card into the card slot to start the usage of the cart and (2) indicate the destination by pushing the according button on the touch screen (see Fig.1).

Figure 1. Mock-up

2.2 Environment and Tasks
A train station is considered as main application context for the robot, but we conducted the study due to safety reasons and on legal grounds in the entrance hall of the university department. In terms of environmental factors this surrounding offers everything needed, such as stairs, wheelchair ramps, doors and hallways of different sizes. Specific locations were labelled to give the user the impression of a real train station with places such as metro station or taxi stand. The study was set-up as Wizard-of-OZ study in which the robot was remote-controlled. Participants were told to try the baggage cart with a given suitcase in four common situations for a traveller arriving at an unknown train station. In all cases the robot was controlled to drive a predefined path. Firstly, the user was told to go to the metro station. Secondly he/ she was asked to use the cart to visit the rest rooms. In this case we obviously and intentionally miss-guided the user to an incorrect place next to the toilettes before we simulated a recovering behaviour. Thirdly, the user had to take a taxi. For this action the robot had to drive over a steep ramp. Finally, we provoked

an intuitive reaction by asking the user to stop the robot as it was passing by the participant during the final interview. Two of our participants were older adults 60 plus and one participant was a technical affine 30 plus year old with his daughter. We considered that older people and technical affine people and kids would have interest in the robotic artefact. Behaviour annotation of the video data and qualitative interviews were used as measures. All participants were successful in completing the pre-defined situations.

3. RESULTS

3.1 Physical Manipulation

All participants intuitively put the suitcase in the correct place; however, it was interesting to observe how they interpreted the other handles of the cart. One participant used it as an umbrella holder and another one for her coat and handbag, even though she did not consider it the ideal place for it (it was just a handle not a tray); she stated*: "If I have a baggage cart, I want it to carry everything for me not just my suitcase!"* Physical interaction with the cart could only be observed twice with our second participant who tried to push the cart via its handle over the ramp when it got stuck. Only the younger participant tried to stop the cart in the fourth task by stepping in front of it, the other two participants entered the card in the slot while the cart was driving. However, one of the older adults tried to increase the speed of the cart with hand gestures ("follow-me") and by increasing her walking pace and made a gesture that the cart should stop when the destination was reached.

3.2 Perception and Sensory Experiences

The usage of the mock-up touch screen was intuitive from the beginning for all participants. It is noteworthy to say that for the two older adults the wizarding was convincing. They explained us during the trial that they had to push the button on the touch screen really hard to get the system moving. However, the display of a face on the other side of the touch screen was unclear for two of the three participants and not even noticed by the third one. Interestingly the second situation where the cart drove by the toilettes, only the younger participant blindly followed the cart and did not even notice that he had already passed the goal. The second participant noticed the goal and took all his belongings (except the card) and let the cart continue its route. The third participant noticed that the cart had passed the designated area, but continued following: *"What should I do? I cannot loose my cart and the suitcase"*.

3.3 Contextually Oriented Action

All participants commented that the scenarios were realistic for them, but that they would not use the cart for such small luggage as our demo suitcase. All of them experienced the cart as too slow and therefore two participants sometimes walked next to it or in front of it (what they claimed they would not do in "real life"). Other bystanders in the surrounding observed the cart, but nobody tried to interrupt the interaction or approached us and asked to try it. Only one of the older adults actively observed how bystanders reacted on him when he walked behind the cart and he commented after the trial: *"On a real train station people would shake their heads and I would not use such a thing just for the fun of it"*, however, the older female stated *"People would jealously stare at me because I have that cart and they have to carry their stuff!"* The robotic artefact was never experienced as a threat by our participants, but all of them preferred to approach a standing cart.

3.4 Digitally Meditated Actions

The two older adults mentioned that they had to adjust their way to the capabilities of the robotic artefact, i.e. using ramps instead of stairs, but they also stated that they accepted this side effect so that they did not have to push the cart themselves and orientate in an unknown environment. The younger participant mentioned that he was missing a visualisation where the cart was heading to. Overall, the mediated action via card slot and touch screen as main input modalities were intuitive and clear for all participants. However, in one case a participant pressed the wrong icon and there was no option to change that, but the participant found a suitable solution for herself, namely removing the card from the slot and starting the interaction again.

4. IMPLICATIONS FOR DESIGN

Our exploratory design study helped us to identify for major aspects for the further development of our mock-up. The robotic artefact needs to be bigger to hold larger suitcases and needs intended planes for putting handbags and hooks for coats, umbrellas etc. Handles can bear the risk that users might try to push the cart which could negatively impact navigation. The touch screen needs to be mounted higher or lower to reduce the risk of "blind following" and it should visualize the current action plan, instead of a face. The navigation speed needs to be increased and it should adapt to the speed of the user. Input aborts for the touch screen design need to be considered. To conclude, the "Human Action and Experience" model by Fernaeus [2] was beneficial for us to derive relevant design implications for a robotic baggage cart at a very early design stage. Moreover, it became obvious for us that for our application context, there is no need of any human-like cues in the appearance design, but only in the interaction design, e.g. using gestures for "follow-me" "stop" etc.

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