Reading the Mind of a Bus: Challenges for Transparent Interaction with Automated Vehicles

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Abstract
Communicating the situation awareness of an automated vehicle to traffic participants is important to maintain trust and efficiency of traffic and transport. In this workshop position paper, we present major challenges and open gaps in this area and illustrate these with the example of an urban automated bus line currently under development.

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Automated driving, autonomous driving, automated vehicles, trust, acceptance, interaction design

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous

Introduction
In the next years, computing technology will increasingly take over the control of vehicles from human drivers. This technology trend opens up many opportunities for logistics, individual mobility and urban landscapes. Automated vehicles can also foster intermodal personal mobility, in order to flexibly cater for the so-called "first and last mile". For greater passenger comfort and on-demand flexibility,
automated buses are often smaller than conventional buses, with a capacity of 8-16 persons. They also tend to abandon a driver seat and classical controls such as the steering wheel and pedals (see an example in Figure 1). While such autonomous minibuses can eventually be a very attractive means of transport, it is likely that there are initial acceptance barriers. Until now, bus passengers have trusted the education and experience of their drivers. In a fully autonomous vehicle, this sense of trust in machine decision and control needs to be built up.

In this workshop position paper we point out that autonomous vehicles should communicate their situational awareness and decisions in an efficient way to passengers and other road users, in order to build up and maintain trust. We first provide some background and state of the art on acceptance and trust of automated driving and then we list related challenges. Our considerations are grounded in the currently starting project auto.Bus [13], in which AIT Austrian Institute of Technology is implementing an automated bus line in the city of Vienna, together with partners like traffic solutions supplier SIEMENS, bus designer manufacturer Navya and public transport provider Wiener Linien.

**Trust and transparency**
User acceptance of autonomous vehicles and other autonomous systems is massively dependent on the level of trust with regard to the technology [1]. While there is quite some literature available on this topic, most of the research on trust in automated vehicles is concerned with the driver-vehicle interaction, but not in fully automatized cars. In such research, often the trust calibration is of central importance (i.e. when drivers can trust and when they should take over control [2,3,4]. Even studies that specifically deal with trust in driverless vehicles from a passenger’s perspective look at the variation of control opportunities [5].

A widely unexplored problem is related to the development opportunities in a fully automated vehicle, in which the passive passenger without control options is the focus of interest. A specifically interesting aspect in this regard is the transformation of the car’s intelligent information processing into a signaling system understandable for humans.

The topic of vehicle-pedestrian-communication in the context of autonomous driving and related trust aspects have already been discussed in the research domain. For example, Anaya et al. [6] conducted a study on the minimal communication distance, that is, the distance that is necessary to give pedestrians sufficient time to react, and they built a WiFi-based solution for car-to-car communications. Clamann et al [7] developed a prototype and compared the success of different signaling methods in a simulated automated vehicle, with regard to the fastest and safest decisions resulting from these signaling methods. From the perspective of the automotive industry, Nissan developed a signaling system, for which a text display near the windshield and bidirectional light signals were sent to facilitate awareness towards other traffic participants [8]. Google and Honda even went as far as patenting their own sets of signals and audible warnings [9,10].

However, for these vehicle-pedestrian communications approaches so far no systematic studies have been conducted that evaluate their comparative strengths and weaknesses in terms of comprehensibility,
acceptance, efficiency, as well as their potential of simultaneous and directed communication to different traffic participants.

**Challenges for transparent interaction**
Within the currently started project auto.Bus, these issues related to transparent interaction are tackled. Our initial collection of research challenges for transparent communication to passengers and road users is described in the following, and we hope to discuss and extend it during the workshop.

**Transparent interaction for passengers**
We will look for novel approaches for the communication with vehicle passengers in order to reduce the likelihood of manual emergency stops. As a foundational activity we believe that it is necessary to explore in which situations driving maneuvers appear incomprehensible and in which way required maneuvers can be communicated to the passengers to ensure them the system is working properly. Also, acceptance and trust effects through sharing of vehicle knowledge and planned decisions should be measured and modeled, in order to.

As a next step building on this requirements research, design guidelines are required to mediate a sense of safety in specific situations also in the absence of a human driver, e.g. in the case of a single travelling woman during night time. To this end, also the level of detail and presentation mode (e.g. map representation vs simple but quick text messages), the placement of the display, and different urgency levels need to be defined. Presentation styles also need to be mapped with the available information from the Interaction models involving sharing vehicle knowledge.

**Transparent interaction for road users**
The autonomous bus needs to be able to communicate its intentions to surrounding road users and has to ensure people that the system is aware of their presence. The effectiveness of different interaction and communication options need to be explored. This can comprise visual information on displays mounted in the front and back of the bus or by other elements on the bus signalizing different messages (e.g. “you can go first” or “please give way”), or acoustic communication options.

It appears important that not only road users are being informed through “broadcast messages” to everyone around the bus. Rather, the investigation parallel directed communication, i.e. the communication to individual persons near the bus in analogy to the eye-contact to a bus driver, could be beneficial. Approaches developed for personalized pervasive displays, such as [11,12] should be taken as a reference here. Also, rather than simplistic one-way messages, concepts for the bidirectional interaction and possible interaction steps between pedestrians and the bus should be explored. In the context of our project auto.Bus, we envisage to attain this goal by combining the novel developed object classification and semantic scene recognition mechanisms with rules and models for signaling to human users.

**Conclusions and Outlook**
The above challenges cannot be solved in their full complexity in a single research project. Nevertheless, we believe that the auto.Bus project can provide first comparative research results with the benefit of interdisciplinary expert-based and empirically grounded co-operation between autonomous systems.
engineering, human-computer interaction, traffic engineering and traffic psychology.

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**References**