A Pedestrian Perspective on Autonomous Vehicles

Kai Holländer
LMU Munich
kai.hollaender@ifi.lmu.de

ABSTRACT

In the future we expect automated vehicles to become a major part of everyday traffic. Along with this groundbreaking change in mobility pedestrians are forced to interact with such technology. In mixed traffic situations (i.e., manual, semi-automated and autonomous vehicles share a road) it might be crucial for non-motorized traffic participants to know which entity is in control. For example, when considering to cross a road, the degree of automation and the presence of human drivers could influence the decision. Moreover, it is not clear whether conventional communication channels such as turn signals and brake / reversing lights meet the challenges of autonomous traffic. I expect that interaction between automated vehicles and pedestrians includes safety critical challenges which are directly related to acceptance and success of the emerging technology. I want to contribute to the future of autonomous mobility by providing design guidelines on how to support pedestrians in their decision making process in mixed traffic. Furthermore, I want to explore new designs for human-vehicle communication.

CCS CONCEPTS

• **Human-centered computing → Human computer interaction (HCI)**.

KEYWORDS

autonomous driving; car-to-pedestrian communication; external car displays;

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1 INTRODUCTION

Currently, the degree of vehicle automation increases from manual to semi-automated and eventually autonomous driving [9]. As a result, drivers can engage in non-driving-related activities and are not required to observe their surroundings permanently [10, 12]. Hence, direct driver-to-pedestrian communication will not be possible unconditionally in the future. This lack of communication is a direct side-effect of increasing automation. However, when interacting with automated vehicles pedestrians benefit from confirmation that they have been detected [13].

Furthermore, cars seem to evolve from a personal status symbol to a practice-based community object [1, 9]. Future vehicles could represent public transport units rather than private property. Hence, occupants of a car could change regularly. Thus, an individual could interact with an autonomous car in the role of a driver, occupant and pedestrian within one single journey. However, neither researchers nor the industry seem to investigate pedestrian-to-car communication heavily, yet. For car manufacturers one reason might be that their main customers are the drivers of the product and thereby the most important target group for new developments.

Taking a pedestrian perspective on cars by seeing them as interactive ubiquitous computing systems offers new possibilities for interaction applications. One approach is implementing external car displays. Such displays can be attached on the surface of a vehicle and indicate a car's intentions, messages from occupants, traffic information or advertisements [3, 4]. Furthermore, autonomous cars could be integrated in smart-city concepts. For example, by indicating environmental conditions (e.g., local air pollution) to passers-by.

1.1 Challenges

There are four main challenges regarding investigating the interaction of pedestrians and autonomous vehicles. Firstly, streets are multi-user environments and thereby very complex. Thus, scalability needs to be thought of. While we simulate one pedestrian facing one car in a study this scenario is rather unrealistic in a real life context. For example, at an intersection in a big city there will probably be many pedestrians and many cars. Secondly, pedestrians and cyclists are diverse. Hence, new concepts should be understandable for people of all ages, cultural backgrounds and educational states. Thirdly, there is a lack of mental models. Mental models support intuitive understanding and long-term memory of functionality [2]. However, finding universally valid mental models in the domain of autonomous driving is still an open challenge. Fourthly, methods to measure, develop and quantify proposed solutions should be developed from scratch or at least adopted from other contexts. Fore example, the adoption of the User-Centered-Design process to external car displays [7] or the DALI [11] questionnaire, which is a version of NASA-TLX [6] matched to fit in the driving context.

1.2 Resarch Goal

Autonomous driving includes manifold benefits e.g., less accidents, less traffic jams, less air-pollution and advanced accessibility to mobility for handicapped people [9]. However, trust is a crucial aspect for acceptance of new technologies [5, 8]. Hence, creating trustworthy systems by increasing safety and comfort will support the success of autonomous driving and is one of my research goals.

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I am aiming to develop design guidelines to support communication between pedestrians and cyclists with autonomous vehicles. For example, by investigating five different designs for external car displays in a currently running Virtual Reality (VR) study. This seems a promising approach since it is not clear whether conventional communication channels such as turn signals, brake lights, reversing lights and horn meet the challenges of autonomous traffic.

Furthermore, introducing new ideas for future vehicles in smart city concepts provides many interesting research opportunities. This is especially challenging, since the technology needed for in-the wild studies is not available yet.

1.3 Research Questions

In the following I present the research questions which I intend to investigate within the next two years of my PhD program. However, details and specific attributes for the realization of this investigations are not yet fix.

- How do autonomous cars influence pedestrians behavior?
- How do pedestrians influence traffic with autonomous cars?
- How could autonomous vehicles communicate to other road users (and vice versa)?
- How to conduct studies about a technology which is not yet available?
- Development of pedestrian-centered design approaches and toolkits.

2 CURRENT & FUTURE WORK

So far I conducted studies with questionnaires, a VR-walking simulation and a driving simulator. In November 2018 I am going to present a paper about mobile device usage during planned takeover processes (shift from automated to manual driving) at MUM conference in Cairo.

Currently, we are investigating five different design approaches for external car displays. Afterwards, a study about pedestrians gaze behavior (in VR) is planned. The results from the VR study will later get compared with results from a Wizard-Of-Oz study. In this follow-up study we plan to transfer our VR-setup to the real world. Besides getting valuable information about gaze behavior we hope to provide insights about the validity of pedestrian studies in VR. Furthermore, an investigation of the influence of pedestrian behavior on traffic flow is planned, supported by an AI traffic simulation. Studies regarding overtrust in automation and well-being are additionally in preparation. Upcoming explorations will include observations in the wild and investigations with a Wizard-Of-Oz approach.

I hope that some of the input at IUI conference will help me to finalize, exchange and gather new ideas and approaches. Moreover, I want to take part in discussions about research methods in general and discuss with other researchers about their projects. Additionally, I am more than happy to start collaborations with colleagues from other fields.

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