Language of Driving: Studying Human-factors in Autonomous Driving

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ABSTRACT

In a scenario in which autonomous driving is part of our daily environment driver-to-driver communication channels as much as car-to-driver human–machine interfaces (HMI) must be well established in the framework of intelligent transportation. In such a situation users must cope with driverless and autonomous vehicles, both as passengers and as agents sharing the same urban domain. This research reports the new challenges of connected driverless vehicles, investigating an emerging topic, namely the language of driving (LoD) between these machines and humans participating in traffic scenarios. This work presents the results of a field study conducted at Tallinn University Technology campus with the ISEAUTO autonomous driving shuttle, including interviews with 176 subjects communicating using LoD. Furthermore, this study combines expert focus group interviews to build a joint base of needs and requirements for AVs in public spaces.

1 INTRODUCTION

Autonomous vehicles (AV) are one of the dominant topics in engineering research society, and a large number of private and academic organizations are investing resources to develop effective autonomous agents that will be populating our streets in the coming years. One major dilemma faced by autonomous cars is understanding the intentions of other road users and how to communicate with them [4]. Though localization, mapping, route planning and control of AVs are widely studied, and the literature already offers working solutions in static environments, road users are non-static complex interactive agents having their own goals, utilities and decision-making systems [1], and their study is an emerging research topic. Human-AV-interaction (HAVI) with pedestrians must take these interactive agents into account in order to predict their actions and plan accordingly. Mode and intent of communication from the AVs to other road users are two fundamental requirements for the future of transportation systems. Clear messages and information are necessary to avoid misunderstandings between vehicles and pedestrians leading to unexpected behaviors, unnecessary vehicle yielding, or dangerous situations. The current driving domain is dominated by human drivers and well-established communication channels based on human to human (eyesight, head positions, gesture) and machine to human (speed, direction, sound) cues [2]. This is supported by well-established and defined methods to communicate the vehicle status and intentions. This situation will slowly shift to a mixed agent domain where autonomous vehicles will coexist together with human drivers. The fast development of these technologies foresees a future scenario where autonomous vehicles will be taking over road traffic and the presence of human controlled agents will be minimal. Nevertheless, the presence of human agents or other road users in the traffic flow will probably endure. In this context AVs should be able to communicate their status in a clear and understandable way, by making use of specific Human Machine Interface (HMI) systems, as much as interpret human decisions by detecting pedestrians' movement cues and behavioral patterns [5]. HMI solutions taking into consideration the new Language of Driving (LoD) between machines and human agents, need to be assessed and validated through user-based research studies. Furthermore, different road user's needs, and abilities should be taken into consideration. Pedestrians and AV shuttle passengers might vary in different contexts or moments of the day. Scenarios like big hospital compounds, schools or simply residential districts need to be considered with children, elderly people, and other fragile user groups being involved in testing and assessing HMI solutions for AV buses.

This work is a summary of the research conducted in [3], and presenting results from a real-world experimental study carried out at Tallinn University of Technology campus and involving 176 pedestrians interacting with the ISEAUTO autonomous driving shuttle. For further details about the iseAuto autonomous shuttle and connected research please refer to [6]. We present here the results from the survey collected during the experimental sessions. The survey and interview results are evaluated via focus group interviews with key public sector representatives from the Ministry of Economic Affairs and Communications, Estonian Transport Administration, and the City of Tallinn. Based on the findings, we propose an architecture for a Mixed Reality (MR) simulation application aiming at designing, testing and assessing external and internal HMIs for AV shuttle interactions with pedestrians and passengers. This approach can deliver fast prototyping of different design solutions, repeatability, and an inclusive and safe testbed for interface validation with human agents. VR technologies and devices could easily integrate physiological sensors and motion tracking systems to optimize the understanding of the street user response to AV movements and behavior allowing for fast adaptation to different requirements and user skills and abilities.

Our vehicle currently provides several signaling symbols to pedestrians by means of a LED light panel. A blinking red cross pattern is used when the ISEAUTO shuttle detects an object that is on its way, and it is intended to alert people when a dangerous situation might occur. Eventually, the signal aims to warn the pedestrians that they should not cross the street. Animated green arrows are displayed when the vehicle detects agents next to, or on, a crosswalk. The green arrows are an invitation to cross. The last symbol, vertical stripes, communicates that the AV detected a pedestrian crossing (see Fig 1).

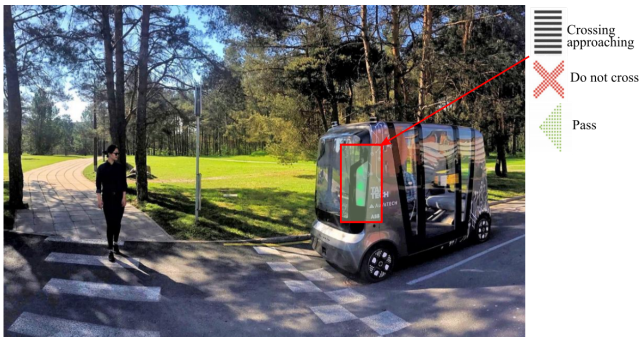

Figure 1: ISEAUTO shuttle signalling to the passenger that a pedestrian is detected, and it is safe to cross the road.

2 SURVEY SUMMARY AND INTERVIEWS' CONCLUSIONS OF THIS STUDY

As autonomous vehicles are novel traffic agents, people seem to be very positive about them in their reactions and their assessment. At the same time, many cannot compare them other than against the usual public transport. One of the most important outcomes from the interviews is that people wish, and wait for, the first and last mile shuttles to come into operation and serve more specific destination needs as the lengthening of the existing public transport is meant for masses. The interviews took place in fair weather conditions and interviewees did not have heavy items to carry. Nevertheless the users foresee the advantages of AV in unexpected circumstances for instance in adverse weather. The first and the foremost important factor in using AV services is safety. The passengers rated safety with high marks, at least in an area (the university campus), with not particularly heavy traffic. Although the bus was driving on a public road with some overtaking of parked cars, and being overtaken by other faster vehicles, according to the answers, the passengers felt comfortable regardless of their gender or age, but most people are not expecting AVs to be driving fast, and neither for long distances. The machine requires adequate means for communication, to be able to make humans feel safe in traffic as much as the ability of responding to human interactions and signals. At the present, the channels supporting vehicle to user communication are limited to visual signage, lights and audio signals, recorded or in real time. Moreover there are limitations in the embodiment of such visual signals in the vehicle. These signs have to be universally understood, and translatable in an instant. Building many different signals on the vehicle requires time consuming design, prototyping and extensive testing, as in the current stage only 3 different signals were tried out (see Table 1). These were visible and people understood the red cross and green arrow by the colors already - red always signals that something needs your attention and green is giving "the green light". The crossing zebra sign was confusing (the sign for letting people know that the shuttle is acknowledging the pedestrian crossing), and turning the sign into green arrows, once it has stopped to show that it is safe to cross. There are some other ways to communicate in language of driving, like the text in the front panel with short, but well understood, messages, but then the language might be an issue, unless it says "stop" or something universally understood, still to be tested thoroughly as it can be considered an open field of research.

3 CONCLUSIONS

This paper summarizes the finding of our previous research in the emerging topic so-called language of driving (LoD) in connection to transportation systems. The study was conducted during a pilot project in the city of Tallinn using our custom ISEAUTO autonomous driving shuttle and field interviews. The research reports the responses from 53 participants inside the vehicle and 176 road users interacting with the AV shuttle outside. According to the questionnaire results, people feel safe onboard, but, from human-to-vehicle interaction point of view, people are still interested in knowing whether the bus is remotely operated or fully automated. Furthermore, the signaling (communication) from the bus to other road users was perceived as comprehensible, though with some limitations involving the position of the signals on the bus and the specific type of signals shown. Signals appearance, function and their position can be developed more efficiently using VR technology before adopting them in the AVs. The adoption of an XR based experimental setup offers many advantages which can support the faster definition of an inclusive, and standard LoD for AVs. The adoption of advanced visualization and interaction technologies grants extended testing on a wider range of users and in a larger number of use cases. Simulated scenarios allow the easier assessment of usability and acceptance of the system by providing valuable solutions for real world user experiments, criticalities and issues. Future works will integrate the available hardware technologies in a multi scenario application developed for AR/VR testing and assessment, while recruiting users of different ages and with diverse abilities.

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