What´s happening right now? Passenger Understanding of Highly Automated Shuttle's Minimal Risk Maneuvers by Internal Human-Machine Interfaces

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Abstract

Remote Operation (RO) is a promising technology, that could close the gap between current vehicle automation functionalities and their expected capabilities especially when focusing on the „Unknowable Unknowns" problem of hidden operational design domain (ODD) borders within AI-based highly automated vehicles (HAVs) (Koopman & Wagner, 2017). It is unlikely that vehicle automation systems will be created in the foreseeable future, that are capable of solving every possible situation they are confronted with (Schneider et al., 2023). A possible way to overcome these technological limitations is to incorporate a human operator and benefiting from his problem-solving skills in novel situations (Cummings et al., 2020). New communication technologies allow for this human support by remotely interacting with vehicles and therefore supporting numerous vehicles at once (Zhang et al., 2021). On the other hand, this would lead to the inability of HAV passengers to interact with a human driver, unlike in manually driven vehicles, where no human driver will be inside the shuttle to support and inform passengers, if necessary (Meurer et al., 2020). The absence of a human diver, who can reassure and comfort passengers in these automated systems, could lead to novel passenger insecurity patterns (Meurer et al., 2020). This is particularly relevant in unfamiliar situations with a high level of uncertainty like minimal risk maneuvers (MRMs). MRMs are maneuvers in which the vehicle tries to minimize risk, for example by stopping in a safe manner. These controlled stopping maneuvers can be triggered by "Unknowable Unknowns" outside the vehicles ODD and are likely to lead to passengers´ confusion and uncertainty (Koo et al., 2015).

The passengers confusion may further increase due to the opaque nature of AI-based automation systems, where it is not always clear, what the vehicle´s/AI´s reasoning behind its action is (Cysneiros et al., 2018). The issues in understanding complicated AI-based systems, are in part the result of increasingly complex algorithms (Eschenbach, 2021). One possible scenario is, that passengers in automated Shuttles, will be confronted with an HMI, which doesn´t depict the systems reasoning behind its actions well enough. As a result, passengers will not be able to explain HAV behavior, especially during MRMs, which will result in lower trust and acceptance

towards HAVs in general. In order to better understand a HAV´s behavior, the reasoning of its algorithms need to be more explainable to the vehicle´s users (Schmidt et al., 2021). In part, this may be achieved by giving certain information about the AI´s decision making (Guidotti et al., 2018) or by giving examples as an explanation to certain behavioral patterns (Cai et al., 2019). In order to deal with this confusion and uncertainty, Human-machine interfaces (HMIs) could be utilized, by giving information regarding these MRMs and reduce these insecurities by increasing the passengers understanding of the HAV-system. (Koo et al., 2015; L.F. Penin et al., 2000). Though for the individual user this information about specific algorithms and their existence is not central, the existence of an AI-system and relevant key information might be sufficient for an informed user and should be incorporated in the HMI information (Dahl, 2018).

The present study investigates how systemic explanatory transparency via different approaches of onboard HMI of an automated shuttle bus (ASB) is able to reduce this uncertainty and may lead to a better understanding of the vehicle´s AI´s reasoning and its behavior during an MRM that might result in higher trust, understanding and subjective safety (Oliveira et al., 2020). For this purpose, we designed several interfaces for the communication between the HAV and the passengers with varying degrees of (exemplary) information, concerning the situation that led to the MRM and the vehicle´s interpretation of that situation. The MRM information consisted of vehicle status, delay times, specific MRM information and the involvement of a teleoperator. The involvement of a teleoperator was explained as a process consisting of multiple steps for supporting the vehicle´s automation. The MRM information was incorporated in a basic map-based interface and gave information about the ASB´s route, passengers destinations, time and the vehicle´s operational status.

The resulting HMI variants were presented via pictures in an online questionnaire study and evaluated in regards to understandability and usability. In addition to the varying amounts of given information, different design choices were evaluated as well. Results of the study aim to provide insights in the informative needs of SAV passengers during the performance of MRMs. This research aims to improve future designs of HAV HMIs and to support passenger experiences while using highly automated shuttle busses.

Keywords: Human-Computer Interaction, Highly Automated Vehicles, Remote Operation, XAI

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