Safety Implications of Automated Vehicle Providing External Communication to Pedestrians

Exploring the different communication interfaces between AVs and pedestrians and what makes them successful.

Identifying the Need

Automated vehicle (AV) communication with pedestrians and vulnerable road users (VRU) is a critical research question for AV's acceptance by the general public. This research topic is not only a design question, but also a complicated research question associated with other critical aspects of AV deployment, including safe operation domains, infrastructure upgrade for segregating VRUs from AVs, traffic regulation for mixed-mode driving, and standardization and education.

What is the goal?

This study explored pedestrians' interaction with highly automated vehicles and the effectiveness of various categories of information communicated through the external interfaces on the AV. We are attempting to discover what kind of information source pedestrians use when decision-making while interacting with an AV.

Project Description

In this project, we attempted to increase our understanding of what occurs between pedestrians and AVs with the use of external interfaces. We developed five external interfaces, including text, symbol, animated eye, a combination of text and symbol, and speed.

These interfaces communicated five types of information, including 1) intent of AV; 2) advice to pedestrians of what to do, 3) AV's awareness of pedestrians, 4) combination of intent and advice, and 5) vehicle movement (i.e., speed).

We tested the interfaces through two field studies at uncontrolled intersections with crosswalks. The Wizard of Oz method was used, in which an experimenter worked as a driver in an instrumented vehicle and wore an "invisible" outfit effectively simulating an AV interacting with a pedestrian. The interfaces were displayed on an LED panel mounted on the AV. We used an iterative design process for conceptualizing the external interfaces and conducted two phases of user studies.

Projected Benefits to California

Pedestrians' perception and trust in an AV's safety is critical for their ultimate success. Although there is no significant difference in response time between any scenarios, pedestrians' subjective ratings (including effectiveness, easiness to understand, usefulness, safety, and trust) were significantly different among the external interfaces.

The results imply that for the text interface, both the information (i.e., vehicle intent) and the design of the interface led to higher safety perception and trust of the AV, in comparison with the animated-eye interface.

The speed interface (including the message it conveyed and the interface design) was significantly easier for pedestrians to understand and led to significantly higher safety perception. It confirms that properly designed external interfaces are beneficial for enhancing the safety perception and trust of the AV. Results of subjective ratings confirm that properly designed external interfaces are theoretically beneficial for enhancing the safety perception and trust in the AV. This is even more important for the future when more mixed levels of automated vehicles are sharing the roads. When interacting with an AV, pedestrians do not need significantly less or more time to cross the intersection in comparison with the time needed when interacting with conventional human-driven vehicles.

This research was done with sponsorship from Caltrans.

What is the progress to date?

This project has been completed. From this study, we have gained further understanding of the interaction between pedestrians and AVs. This is a complicated and critical research question for the development of vehicle automation. This study concludes that vehicle speed is the

most important information source for pedestrians' decision-making when they interact with AVs.

Results showed that the external interface on the AV did not change the decision time for pedestrians to cross. However, the vehicle movement patterns (e.g., slowing down the vehicle speed) continued to be a significant cue for pedestrians.

All participants perceived the communication of the ADS's intent (e.g., "stopping" which was written on the LED panel) and the advisory information from the ADS (e.g., an icon that indicated it was safe for pedestrians to cross). These were both more effective than trying to convey the awareness of the ADS (e.g., an icon with an open or closed eye).

Pedestrians felt that the interfaces were easy to understand (e.g., the text interface and symbol interface), and the subjective rating system showed that participants' confidence in their safety was enhanced when interacting with the ADS. In a few cases, external interfaces were used as the most important information source. In most cases, they were used as the supplementary information source for pedestrians' decision-making.

Overall, there is a need to enhance AV's ability to communicate its movement or intent.

Final Report

Safety Implications of Automated Vehicles Providing External Communication to Pedestrians (escholarship.org)

Images

About the Author

Dr. Pei (Peggy) Wang has been an assistant research engineer at the California PATH program since June 2017. She received her Ph.D. in Human Factors and Ergonomics from Tsinghua University, and formerly worked at General Motors China R&D as an HMI researcher.

She has been involved with research in cross-cultural studies of in-vehicle speed systems, data analytic studies for Apple Carplay usage, and driving styles studies for automated vehicles. Since her role began, she has led the human-factors team in PATH while conducting research projects funded by Caltrans, SB-1, and industrial consortiums.

Dr. Wang is currently working on evaluating driver compliance behaviors in addition to assessing drivers' responses to eco-driving applications.

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