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Analysis of Disengagements in Semi-Autonomous Vehicles: Drivers' Takeover Performance and Operational Implications

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Autonomous Vehicle (AV) technology is quickly expanding its market. Current vehicles on US roads still require the presence of a human driver, who is supposed to monitor the safe operation of the vehicle at all times. Should a failure of the autonomous technology occur, the human driver is supposed to immediately takeover control in a safe and efficient manner. This study thus analyzed the reactions of human drivers placed in simulated autonomous technology failure scenarios.

Study Methods

The study was executed in a human-in-the-loop setting, within a high-fidelity integrated car simulator capable of handling both manual and autonomous driving (Figure above). A population of 40 individuals was tested, with metrics for control takeover quantification given by response times to the takeover request and vehicle drift from the lane centerline after takeover. Independent variables considered for the study were the age of the driver, the speed at the time of disengagement, and the time at which the disengagement occurred (i.e., how long automation was engaged for). The three independent variables for this study were chosen to answer specific operational questions in relation to the use of semi-AVs on US public roads: Will there be constraints on the maximum speed the systems can be operated at? Will there be constraints on the maximum time the system can be operated for? Should semi-AVs be sold only to people within a certain age range (not too young/not too old)?

Findings

The tests were executed in a simulated 7.6 miles closed-loop track that resembled a highway environment. Analysis of the results collected from the tests shows that:

- High speed settings yielded worse performance for all test subjects, with a drift increase of over 116%. Higher speeds also led to more pronounced changes in the level of trust in the technology as well as higher reported nervousness and fear in the experience.

- Unintentional lane departures were recorded in 69% of the cases. Still, all but one participant described their control takeover as “successful”.
- Older participants performed best in terms of both maximum drift and comparison between conventional driving and driving after AT failure.
- We observed low accuracy in recollecting and estimating the speed of the vehicle, as well as a tendency to overestimate the duration of engagement of the technology. One quarter of the participants also recollected the wrong reaction to the takeover request: they thought they had braked in response to the takeover request, but actual measurements indicated that they had accelerated instead.

Speed of the vehicle had the highest impact on driver takeover performance.

Policy Recommendations

From a regulatory standpoint, the preliminary results point to the importance of setting up thresholds for maximum operational speed of vehicles driven in autonomous mode when the human driver serves as back-up, perhaps warranting a lower speed limit than conventional vehicles. This research shows that the establishment of an operational threshold could reduce the maximum drift and lead to better control during takeover. Unintentional drift also attests to the need for discussions on possible dedicated lane usage for autonomous vehicles and separation from conventional traffic, as well as for the possibility of increasing lane width in dedicated lanes for semi-autonomous vehicles. With regards to the age variable, neither the response times analysis nor the drift analysis provide support for any claim to limit the age of drivers of semi-autonomous vehicles.

About the Authors

Dr. Francesca Favaro is an Assistant Professor in the Department of Aviation and Technology in the College of Engineering at San Jose State University. Prior to joining SJSU she earned a PhD and MS in Aerospace Engineering at the Georgia Institute of Technology, and MS and BS in Space Engineering at Politecnico di Milano, Italy. Dr. Favaro research interests lie in the broad field of system safety and risk analysis, with an emphasis on system engineering concepts and the safe integration and embedding of new technologies and the consistent update of regulations and certification practices. In 2016 she founded the RiSA2S lab, which deals with Risk and Safety Assessment of Autonomous Systems such as drones and self-driving cars. In 2017 she became a research associate of MTI and started collaborating as expert in the realm of autonomous vehicles. Her interests are currently focused on the safe integration of autonomous systems within US public roads as well as the National Airspace. She particularly focuses on bridging the gap between the technology world and the current regulatory panorama. Dr. Favaro has authored several journal publications and conference proceedings on a variety of topics, and has been interviewed by multiple media outlets including the Wall Street Journal, Wired Magazine, and Verge Tech forum as a leading expert in the field of automation safety. Dr. Favaro is an FAA Aviation certified Advanced Instructor, a certified Remote Pilot for drone commercial operations, and a solo-endorsed pilot.

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To Learn More

For more details about the study, download the full report at transweb.sjsu.edu/research/1710

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