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Exploring the Effects of Meaningful Tactile Display on Perception and Preference in Automated Vehicles

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Introduction

Vehicles on the roadway are becoming semi- or fully autonomous. Although these vehicles can drive automatically, hazardous conditions (e.g., bad weather or construction zones) could render the vehicle's system limitations and may prompt the vehicle to suddenly request the driver to take over. A possible solution to this human-machine interaction issue may lie in tactile displays, which can present status, direction, and position information while avoiding sensory (e.g., visual or auditory) channel overload. However, limited work has attempted to investigate the effects of meaningfully tactile signals on takeover performance. This study synthesized literature investigating the effects of tactile displays on takeover performance in automated vehicles and then conducted a human-subject study to design and test the effects of six meaningful tactile signal types and two pattern durations on drivers' perception and performance during automated driving.

Study Methods

The team first performed a literature review, including articles that conducted human-subject experiments on takeover performance utilizing tactile displays as takeover requests. The team found a total of 18 articles and categorized them into informative and instructional signal groups. Takeover performance in these studies were highlighted, such as response times, workload, and accuracy. The team then conducted a human-subject experiment involving 16 participants that used a driving simulator to present 30 meaningful vibrotactile signals, randomly across four driving sessions measuring for reaction times (RTs), interpretation accuracy, and subjective ratings.

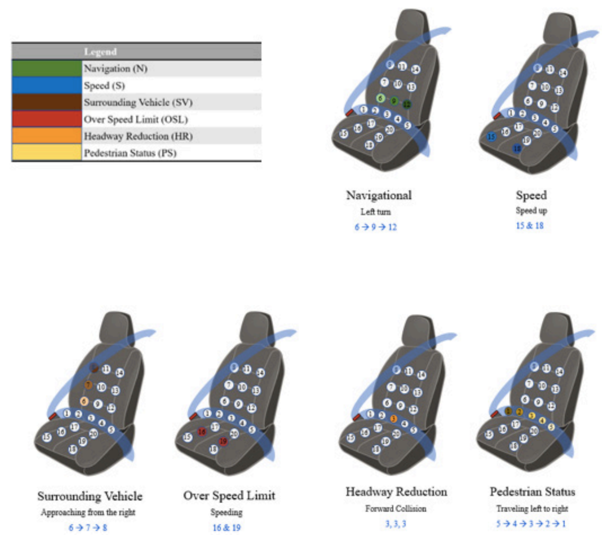
Findings

Results from the literature suggest that tactile displays can be used as takeover requests. Placed in various in-vehicle locations (e.g., seatback, pan, belt, hands, wrists, and steering wheel), they can produce vibrotactile patterns to convey more meaningful and complex information, such as the location, urgency, and direction of in-motion objects in the surrounding environment during the takeover. These tactile displays can help improve drivers' performance during the takeover and can be used to assist in the design of human-machine interfaces (HMI) for automated vehicles. The experiment yielded results that illustrated that higher urgency patterns were associated with shorter RTs and higher intuitive ratings. Also, pedestrian status and headway reduction signals presented shorter RTs and increased confidence ratings compared to other tactile signal types. Finally, the surrounding vehicle and navigation signal types yielded the highest accuracy.

Tactile displays can present meaningful vibrotactile patterns to improve drivers' performance during the automated vehicle takeover.

Policy/Practice Recommendations

The professional practice recommendations that stem directly from the research findings include providing an HMI tool that can assist drivers with perceptual, cognitive, and physical impairments, including but not limited to deaf, autistic, and older drivers, by helping them make faster decisions in various complex driving scenarios with increasing accuracy and subjective satisfaction in automated driving. In addition, the findings contribute empirical evidence to automated driving literature to guide future studies, as well as engineers, scientists, and designers, that study the effects of meaningful tactile displays in the next generation of human-automation interaction.



Note: Example Pattern Descriptions for All Six Warning Signal Types

About the Authors

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To Learn More

For more details about the study, download the full report at transweb.sjsu.edu/research/2164

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