Human and Robot Drivers: Modeling Mixed Freeway Traffic

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It can be expected that automated vehicles and human-driven vehicles will coexist in the transportation network for quite some time. In order to support various traffic control tasks it is critical to develop a reliable model to understand the real-time traffic patterns in this mixed environment.

A new report from the National Institute for Transportation and Communities (NITC) contributes three new tools to help planners model freeway traffic consisting of both connected automated vehicles (CAVs) and human-driven vehicles (HVs).

RESEARCH OUTCOMES: THREE NEW TOOLS

A primary goal of this research is to lead in the development and deployment of innovative practices and technologies that stand to improve the safety and performance of the nation's transportation system. The project developed three important planning tools:

- A novel macroscopic traffic flow model which treats CAVs and human-driven vehicles as separate groups, with a new set of factors to represent the speed change of human drivers due to following CAVs in the traffic stream.
- An optimization function, grounded on the traffic flow model, to make real-time adjustment of CAV desired speeds for minimizing the total freeway travel delays.
- Data analysis from extensive simulation experiments, which reveals that there should exist a critical CAV ratio that can greatly reduce the speed difference between the two types of traffic, given the demand pattern.

KEY FINDINGS

Connected automated vehicles (CAVs) are typically equipped with communication devices (e.g., dedicated short range communications) and on-board sensors (e.g., Radar, Lidar, Cameras). Since CAVs base their speed on input from these intelligent systems, their built-in speed controls would impact the speed of human-driven vehicles (HVs) in the traffic stream.

The research team developed an optimization model for determining the desired speed profile for CAVs to account for the speed interactions between these two different "drivers" behind the wheel. Yang's proposed optimization model was based on a novel traffic state estimation model that can explicitly show the speed interactions between CAVs and HVs. Specifically, when an optimal desired speed is placed on a CAV, it may affect the speed of nearby HVs as they are sharing the road.

Considering that a conventional macroscopic traffic flow model would fall short of capturing such situations, this project implemented an extended model that treats CAVs and HVs as separate vehicle classes and their interdependency of speeds is represented by a set of impact factors.

Using simulations to evaluate the proposed system, results analysis revealed that the proposed models can effectively reduce freeway travel time of both CAVs and HVs. Further sensitivity analysis on CAV penetration rates also indicated that improving the CAV penetration rate would benefit the reduction of traffic delays. The proposed models can serve as the foundation of many other CAV applications on freeways, such as Cooperative Adaptive Cruise Control.

ABOUT THE AUTHORS

This research was conducted by Xianfeng Terry Yang, University of Utah.

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THE FULL REPORT and ONLINE RESOURCES

For more details about the study, download the full report **Vehicle Sensor Data (VSD) Based Traffic Control in Connected Automated Vehicle (CAV) Environment** at **https://nitc.trec.pdx.edu/research/project/1175**

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