Leveraging Vehicle Connectivity and Autonomy to Stabilize Flow in Mixed Traffic Conditions: A Preliminary Analysis
Yujie Li, Sikai Chen, Paul (Young Joun) Ha, Jiqian Dong, Runjia Du, Aaron Steinfeld, Samuel Labi
a. Lyles School of Civil Engineering, Purdue University
b. Robotics Institute, School of Computer Science, Carnegie Mellon University

ABSTRACT
Emerging transportation technologies offer unprecedented opportunities to improve the efficiency of the current transportation system in the US from the perspectives of energy consumption, congestion, and emissions. One of these technologies is connected and autonomous vehicles (CAVs). With the prospective duality of operations of CAVs and human driven vehicles in the same roadway space (also referred to as a mixed stream), CAVs are expected to address a variety of traffic problems particularly those that are either caused or exacerbated by the heterogeneous nature of human driving. In efforts to realize such specific benefits of CAVs in mixed-stream traffic, it is essential to understand and simulate the behavior of human drivers in such environments, and microscopic traffic flow (MTF) models can be used to carry out this task. By helping to comprehend the fundamental dynamics of traffic flow, MTF models serve as a powerful approach to assess the impacts of such flow in terms of safety, stability, and efficiency. In this paper, we seek to calibrate MTF models based on empirical trajectory data as basis of not only understanding traffic dynamics such as traffic instabilities, but ultimately using CAVs to mitigate stop-and-go wave propagation. The paper therefore duly considers the heterogeneity and uncertainty associated with human driving behavior in order to calibrate the dynamics of each HDV. Also, the paper designs the CAV controllers based on the microscopic HDV models that are calibrated in real time. The data for the calibration is from the Next Generation SIMulation (NGSIM) trajectory datasets. The results are encouraging, as they indicate the efficacy of the designed controller to significantly improve not only the stability of the mixed traffic stream but also the safety of both CAVs and HDVs in the traffic stream. The paper’s results can therefore help relieve phantom traffic jams that are caused by irrational or spontaneous driving patterns of human drivers, which has been identified in the literature as one of the main causes of traffic congestion. Overall, the paper’s results are essential for effective real-world deployment of CAV controllers in mixed traffic environments during the CAV transition era.