INTEGRATED TRAFFIC SIGNAL AND VEHICLE TRAJECTORY CONTROL IN A MIXED TRAFFIC CONDITION

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Traffic signal control plays an important role in regulating the traffic flows at signalized intersections. With the connected and automated vehicle (CAV) technology, the speed of the CAVs can be planned in a fuel-efficient way with the information from the traffic signals. Both traffic control strategies and vehicle trajectories significantly impact the performance of the intersection operation.

In this paper, a decentralized integrated control strategy of traffic signals and CAV trajectories is proposed, focusing on the mixed traffic condition. In mixed traffic, RVs are driven by humans without any connectivity. CVs are also human-driven vehicles, but can broadcast real-time vehicle information. CAVs not only broadcast vehicle information but also can be operated with planned trajectories generated by computers. Besides, the proposed integrated control strategy only requires a low vehicle automation level (e.g., Level 2), which is already commercially available in some vehicle models (e.g., GM Super Cruise). Another highlight of this work is that the proposed framework is decentralized, which means that traffic signal optimization and vehicle trajectory planning are distributed to individual intersection controllers and vehicles, leading to a reduction of computational burden. Moreover, the trajectory planning of each CAV is not independent. CACC platoons can be formed, split, and interrupted dynamically depending on the traffic environment (e.g., behaviors of nearby RVs and CVs, signal timing, etc.), to further increase the intersection capacity and improve the fuel economy. A state transition diagram is proposed to accommodate different operating scenarios for CAVs. A mixed integer linear programming problem is formulated to optimize the traffic signal with the objective of minimizing the total delay.

A simulation model of a real-world intersection intersection of Plymouth Rd. and Murfin Ave. (Ann Arbor, MI) is built in VISSIM. Experiments are done for different mixed traffic conditions by varying the penetration rate of the CAV, CV and RV. The simulation results show the mobility and fuel economy benefits from the integration of eco-trajectory planning and signal optimization. The delay reduction can be as high as 18.7% under high penetration rate of CAVs, compared to actuated signal control. Sensitivity analysis confirms that the performance of the proposed model improves with the increase of penetration rates, in terms of total delay, fuel consumption as well as emissions.