A Centralized-Distributed Cooperative Merging Eco-Driving Control Strategy for CAVs Platoon at On-Ramp Area

Junhong Xie
School of Automation, Northwestern Polytechnical University, Xi'an, Shaanxi, China

Jianzhong Chen *
School of Automation, Northwestern Polytechnical University, Xi'an, Shaanxi, China

Abstract

Connected and automated vehicles (CAVs) platoon hold great potential for alleviating traffic congestion, ensuring traffic safety, and reducing exhaust emissions. Current research on ramp merging control strategies has mainly focused on single vehicle cooperative control. To ensure that vehicles can maintain the form of a platoon and achieve eco-driving in the merging process, this paper constructs a centralized-distributed control architecture and proposes an eco-driving control strategy for cooperative CAVs platoon merging. An improved first-in-first-out (IFIFO) merging sequence (MS) decision algorithm is developed in the centralized control level to eliminate the speed difference between the ramp and mainline vehicles. According to the inter-platoon and intra-platoon consensuses, the distributed eco-driving controllers are designed for the leader and following vehicles respectively, which consider the car- following interaction, multiple preceding vehicles' state information, and previous multi-time step speed error. The stability of single platoon and multiple platoons is analyzed based on the Routh-Hurwitz criterion. Simulation results demonstrate that the proposed control strategy improves the driving speed, decreases exhaust emissions, and ensures the ramp and mainline platoons can reach a stable driving state after completing collaborative merging.

Keywords

Connected and automated vehicles (CAVs) platoon; Cooperative merging; Eco-driving strategy; Consensus control; Stability analysis.