Electrical & Computer Engineering

D E F E N S E

Louisiana State University

Robust Adaptive Control and Disturbance String Stability for Heterogeneous Uncertain Nonlinear Vehicle Platoons

a dissertation to be defended by

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Abstract—This dissertation investigates cooperative control of heterogeneous vehicle platoons, including both autonomous electric vehicles (EVs) and gasoline vehicles (GVs), under predecessor-following (PF) and bidirectional (BD) topologies. The platoon systems are inherently nonlinear and subject to unknown and uncertain parameters due to wear, ageing, varying road conditions, and environmental disturbances. To address these challenges, we propose scalable distributed adaptive control laws that explicitly cope with parameter uncertainties and model nonlinearities.

The proposed control framework achieves velocity synchronization and safe inter-vehicle distances (IVDs) in the absence of disturbances, while ensuring disturbance string stability (DSS) in the presence of worst-case energy-bounded disturbances without requiring known bounds. The results are global, independent of initial conditions, and robust to parameter uncertainties and exogenous disturbances, which stand in sharp contrast to existing results in the literature. Importantly, the global asymptotic stability (GAS) and DSS properties of the platoon systems hinge on the linear control part, even though nonlinear residual errors persist. Furthermore, a passivity-based approach is employed to rigorously analyze DSS for EV platoons, while linear matrix inequality (LMI)-based algorithms are developed for efficient controller design in GV platoons.

Numerical simulations of both EV and GV platoons under PF and BD topologies confirm the effectiveness of the proposed distributed adaptive control laws. The results demonstrate superior performance compared to existing methods, validating the robustness, scalability, and practical viability of the proposed approach for cooperative vehicle platoon control.

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