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Dynamic Performance Analysis of Autonomous Multi-Trailer Articulated Heavy Vehicles with Active Trailer Steering

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ABSTRACT

The increasing demand for efficient freight transportation has led to the development of autonomous multi-trailer articulated heavy vehicles (MTAHVs). These vehicles, equipped with advanced control systems such as active trailer steering (ATS), offer significant potential for improving safety, maneuverability, and fuel efficiency. This paper investigates the dynamic performance of autonomous MTAHVs with ATS under various driving conditions. Through a combination of theoretical modeling, simulation studies, and experimental validation, we analyze the impact of ATS on vehicle stability, lateral dynamics, and path-following accuracy. The dynamic performance of autonomous multi-trailer articulated heavy vehicles (AHVs) equipped with active trailer steering (ATS) systems is a critical area of investigation for enhancing safety, stability, and maneuverability in modern transportation. This study explores the impact of ATS on the lateral dynamics, yaw stability, and overall controllability of multi-trailer AHVs under varying operating conditions. By employing advanced vehicle dynamics models and Trucksim/MATLAB/Simulink simulation frameworks, the research evaluates key performance metrics such as lateral acceleration, yaw rate, articulation angles, and off-tracking during high-speed maneuvers and tight cornering scenarios. Results demonstrate that active trailer steering significantly mitigates undesirable dynamic behaviors, including jackknifing and trailer swing, while improving trajectory tracking accuracy in autonomous operations. Furthermore, the integration of ATS with autonomous control algorithms enhances the robustness of path-following capabilities, particularly in complex driving environments. The findings underscore the potential of ATS as a transformative technology for the next generation of AHVs, offering improved operational efficiency and safety for freight and logistics transportation industry. Future work will focus on real-world validation and optimization of ATS strategies to address challenges in diverse traffic and environmental conditions.

Keywords- autonomous driving system, multi-trailer articulated heavy vehicles, active trailer steering, dynamic performance, vehicle stability, off-tracking reduction, autonomous freight transportation, motion planning, co-simulation