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Design and Modelling of Autonomous Articulated Heavy Vehicles

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ABSTRACT

The advancement of autonomous technologies presents transformative opportunities for heavy-duty transportation, particularly for articulated vehicles such as tractor-trailers, which face inherent challenges in maneuverability, stability, and safe operation. This study addresses the design and modelling of autonomous articulated heavy vehicles (AAHVs), focusing on integrating advanced sensor systems, robust control algorithms, and high-fidelity dynamic models to enhance operational safety and efficiency. A modular framework is proposed, combining multi-body dynamics to capture the complex kinematic and dynamic interactions between the tractor and trailer, with real-time trajectory planning and path-following control strategies. Key innovations include a hierarchical control architecture that adapts to varying payloads, road conditions, and articulation angles, alongside a collision-avoidance system leveraging LiDAR and vision-based perception. High-fidelity simulations validate the model's ability to mitigate jackknifing risks, optimize fuel efficiency, and ensure stable navigation in constrained environments. Results indicate a 22% improvement in path-tracking accuracy and a 15% reduction in energy consumption compared to conventional systems. This work underscores the potential of AAHVs to revolutionize freight logistics by addressing critical safety and sustainability challenges, while providing a foundational framework for future research in autonomous heavy vehicle systems. Simulation outputs demonstrate significant improvements in maneuverability, fuel efficiency, and safety metrics compared to traditional human-operated systems. The proposed methodologies address key challenges such as jackknifing prevention, lane-keeping during sharp turns, and adaptive speed regulation in adverse weather conditions. Furthermore, the scalability of the developed models and control strategies makes them suitable for diverse applications, from urban freight delivery to off-road operations. This study contributes to advancing the state-of-the-art in autonomous heavy vehicle technology, paving the way for safer, greener, and more reliable transportation solutions. Future work will focus on real-world deployment and regulatory compliance to facilitate widespread adoption of AAHVs in industrial and public domains.

Keywords- autonomous driving control, motion planning, co-simulation, articulated heavy vehicles, dynamic modelling, trajectory tracking, stability control, sensors