Motorcycle Adaptive Cruise Control Using Model Predictive Control with Integrated Sensor Fusion

International Journal of Robotics and Control Systems • Article • 2025 •
DOI: 10.31763/ijrcs.v5i6.2113

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Abstract

Motorcycle safety remains a critical challenge due to the inherent instability and complex dynamics of two-wheeled vehicles, particularly in longitudinal control and car-following scenarios. This study addresses this challenge by developing a Motorcycle Adaptive Cruise Control (MACC) system based on Model Predictive Control (MPC), specifically tailored to motorcycle dynamics. The research contribution is the integration of longitudinal and lateral MPC control with a sensor fusion framework to manage speed regulation, safe following distance, and path-following under motorcycle-specific constraints. The proposed system employs MPC to predict future vehicle states and compute optimal acceleration and steering commands while respecting safety, comfort, and stability constraints. Radar-and vision-based sensor fusion is used to estimate relative distance, relative velocity, and lane geometry, providing reliable perception inputs for the controller. A comprehensive MATLAB/Simulink simulation framework is developed to evaluate system

performance under straight-road, curved-road, and mixed-traffic scenarios, including lane changes and vehicle cut-ins. Simulation results demonstrate accurate velocity tracking, consistent maintenance of safe inter-vehicle distances, and stable path-following performance, with lateral deviations remaining below 0.5 m on straight segments and 1.2 m on curved paths. Longitudinal acceleration remains within predefined comfort limits, indicating smooth control behavior. The integrated controller adapts effectively to dynamic traffic conditions while maintaining safety margins. The findings confirm the feasibility of MPC-based MACC for motorcycles under simulated conditions. However, the results are limited to simulation-based validation, and real-world deployment will require further investigation of computational feasibility, sensor uncertainties, and experimental testing. This work contributes toward the development of scalable and reliable adaptive cruise control systems for motorcycle autonomy. © 2025 The Authors. trical and Engineering.

Author keywords

Adaptive Cruise Control; Advanced Driver Assistance Systems; Model Predictive Control; Motorcycle Dynamics; Path-Following Control; Sensor Fusion

Funding details

Details about financial support for research, including funding sources and grant numbers as provided in academic publications.

Funding sponsor	Funding number	Acronym
Ministry of Higher Education, Malaysia See opportunities by MOHE ↗	FRGS/1/2023/TK02/UIAM/01/1	MOHE
Ministry of Higher Education, Malaysia See opportunities by MOHE ↗		MOHE

Funding text

Funding: The authors would like to extend their sincere gratitude and appreciation to the Ministry of Higher Education Malaysia for research grant FRGS/1/2023/TK02/UIAM/01/1 Optimal Deceleration Formulation Based on Reinforcement Deep Learning for Energy Generation from Regenerative Braking Mode of an Electric Motorcycle.

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