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Predictive Motion Control Considering Body Attitude Constraints for Four in-Wheel Motor Vehicles

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***Abstract*— The utilization of in-wheel motors in electric cars is a typical method for providing power, allowing for strategic power distribution. These motors are integrally linked to the suspension system, and the resultant output torque engenders a substantial vertical force due to the presence of anti-pitch geometry. The coupling between driving torque and vertical force precipitates body attitude oscillations during driving or braking, thus impacting the ride comfort significantly. A promising avenue for modulating the body attitude in in-wheel motor-driven vehicles involves a rational distribution of driving torque between the wheels. Considering the constraints of body attitude, this study introduces an innovative control scheme employing a learning model predictive control (MPC) framework. The objective of this technique is to determine the total driving torque, the additional roll moment and pitch moment, and the additional vertical force. Then, a transfer matrix is used to calculate the required wheel moment to satisfy the desired additional moment and vertical force. Finally, a Simulink/Modelon co-simulation test is conducted to validate the effectiveness of the proposed control scheme. The results show that the performance of the proposed controller is improved compared with the default controller. Notably, the proposed scheme successfully maintains vertical acceleration, roll angle, and pitch angle within the specified limits, affirming its effectiveness.**

I. RESULT

The CDC 2023 conference introduces a noteworthy benchmark problem aimed at addressing the optimization challenges pertaining to body motion control. This paper is devoted to presenting an innovative control scheme employing learning model predictive control (MPC) in response to this benchmark problem. The benchmark entails two particularly demanding tasks. The first task involves achieving precise speed tracking on a rugged and slippery straight road, while the second entails successfully executing trajectory tracking for the ISO double lane change maneuver on rough terrain. Due to time constraints, this study focuses solely on completing the second task. The subsequent section outlines the outcomes of the second task, while the results for the initial task will be provided in future updates.

The simulation result of vertical acceleration, roll angle and pitch angle are presented in Fig. 1. The results indicate a notable decrease in vertical acceleration when comparing the default controller to the proposed controller. The roll angle and pitch angle are both observed to fall within the specified range. Therefore, the controller that has been developed

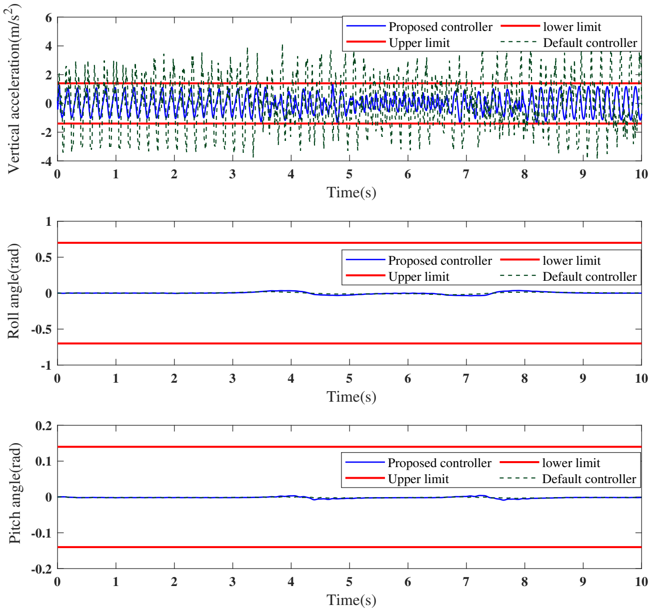

Fig. 1. Simulation result of vertical acceleration, roll angle and pitch angle.

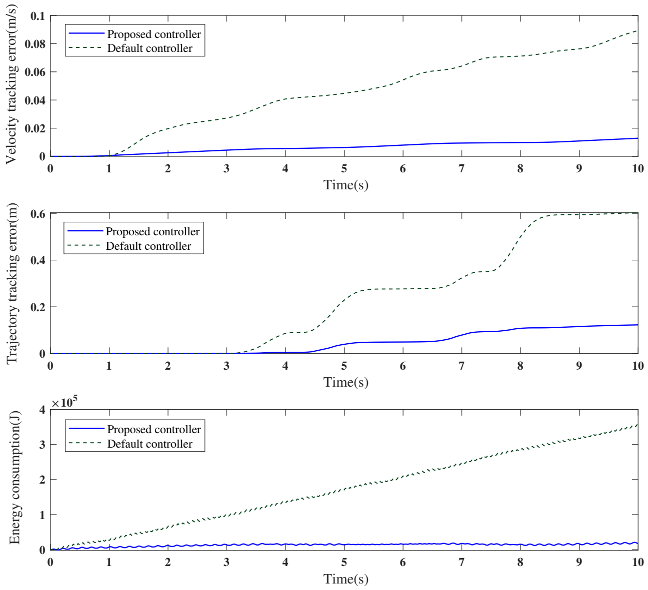

Fig. 2. Simulation result of performance indicators.

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demonstrates the ability to significantly enhance the overall level of ride comfort.

The outcomes for these three performance indicators are illustrated in Figure 2. When comparing the default controller, it can be observed that the tracking error of both velocity and trajectory is much reduced. The cumulative error for speed tracking is found to be below 0.015, while the cumulative error for trajectory tracking is seen to be below 0.12. Additionally, while employing the proposed controller, the energy usage is reduced to one-twentieth of that of the default controller.