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Reinforcement Learning Based Motion Control of 4-in-Wheel Motor Actuated Electric Vehicles

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Abstract

The automotive industry has witnessed a remarkable transition towards Electric Vehicles in recent years. This shift has been primarily driven by the need to reduce carbon dioxide emissions and the advancements in battery and electric drive technologies. Among the various electric vehicle variants, 4-in-Wheel Motor-Actuated Electric Vehicles have emerged as a notable option. This variant possesses a distinctive feature of independently controlling all four motors, which leads to improved maneuverability and efficiency. To fully leverage these advantages, an optimal control strategy is required to ensure both precise motion control and energy efficiency. Achieving this objective presents a significant challenge.

To address this challenge, two reinforcement learning based strategies are proposed: Proportional-Integral-Derivative (PID) control and Direct Torque control. The first strategy involves implementing four independent PID controllers, one for each motor. An adaption mechanism is employed to handle changing operating conditions and disturbances. This mechanism enables the controller to continuously update its parameters. The second strategy employs a Direct Torque control approach, where the reinforcement learning agents directly learn the optimal torque to each wheel using an actor-critic framework. Both approaches leverage recent advancements in reinforcement learning application for continuous control to achieve energy efficiency and precise control over each wheel, taking advantage of the ability of deep neural networks to handle large action and observation spaces.

To evaluate the performance of the PID and Direct Torque controllers for 4-In-Wheel Motor-Actuated Electric Vehicles, benchmark driving scenarios such as velocity profile tracking and a lane change maneuver at a constant speed are employed. The results demonstrate that the reinforcement learning based controllers can smoothly track reference velocity and execute lane changes while consuming less energy. These findings highlight the potential of the reinforcement learning based controllers to enhance the efficiency and maneuvering capabilities of 4-In-Wheel Motor-Actuated Electric Vehicles.

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