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A Study on Lateral Stability Control of Distributed Drive Electric Vehicle Based on Fuzzy Adaptive Sliding Mode Control

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Abstract
This paper presents a joint sliding mode control algorithm with fuzzy adaptive gain to address the problem that the lateral stability of distributed drive electric vehicles is affected by system parameter perturbation and external environment disturbances under steering conditions. The control system is designed by considering the influence of road conditions and tire nonlinearity, taking the yaw rate and sideslip angle as control variables. The difference between the expected value and the actual value of the control quantity is taken as the input to obtain the expected front-wheel angle for feedback correction. Aiming at the problem that it is difficult to obtain the critical driving state parameters of vehicles and to directly measure the road adhesion coefficient which affects the vehicle's lateral stability, this paper presents a simplified unscented Kalman filter observer which is designed to dynamically estimate the vehicle state parameters and road adhesion coefficient for the lateral stability controller. Based on CarSim and MATLAB/Simulink, a co-simulation model is developed and verified under different working conditions. The results reveal that the proposed lateral stability control algorithm effectively reduces the front wheel steering angle, improving the vehicle's handling stability while reducing the driver's operating burden and improving driving safety.

Keywords Distributed drive electric vehicle · Fuzzy adaptive sliding mode · Lateral stability · UKF

1 Introduction

Under the dual pressure of environmental pollution and energy crisis, energy saving, environmental protection, and safety are the three prime themes of automobile development. The development of electric vehicle technology has become an effective way to solve these two problems (Zhang et al., 2018; Zhu et al., 2015). The distributed drive electric vehicle (DDEV) has attracted the extensive attention of scholars and automobile manufacturers because of its unique power system and transmission system. The torque of each driving wheel can be controlled independently, which brings significant advantages for vehicle chassis dynamics control (Chen et al., 2017; X et al., 2020).

The estimation of vehicle state parameters is one of the critical points in the research of the DDEV, and its accuracy directly affects the dynamics control of vehicle chassis (Wang et al., 2018). Accurate acquisition of key state variable parameters is also the premise of achieving lateral stability control. At present, using low-cost sensors and information fusion based on vehicle dynamics equation, we can get some critical parameters (such as vehicle sideslip angle and road adhesion coefficient) that are unmeasurable or expensive to measure (Wei et al., 2018). Many scholars have conducted in-depth research on vehicle parameter estimation. Chen designed the longitudinal force observer (LFO) based on the adaptive high-order sliding mode observer (HSMO) (Chen et al., 2018). The lateral vehicle speed and yaw rate are estimated simultaneously based on the estimated longitudinal force, combined with the strong tracking filter (STF). Chu proposed a state parameter observation algorithm based on an Unscented Particle filter, which

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