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Torque distribution control strategy based on dynamic axle load for 8 In-Wheel Motor Drive Vehicle

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Abstract

Compared with conventional internal combustion engine vehicle, the vehicle with multi-wheel independent technology has apparent advantages on vehicle dynamics control and driving force distribution. The target system of this study is the vehicle driven by wheel hub motors (8×8). The model of some key components is built, including the vehicle dynamics, suspension, wheel hub motor, tires. The dynamic system model of 8×8 vehicle is modeled and co - simulated with Matlab/Simulink. The controller takes the vehicle longitudinal velocity and the yaw rate as the observation object. The rules have a greater advantage in the engineering applications. And the algorithm is fast, so it can improve the vehicle maneuverability in a certain extent.

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Keywords: In-wheel motor drive; torque distribution; dynamic axle load

1. INTRODUCTION

At present, Multi-axle in-wheel vehicle, such as 8×8 and 6×6 has the advantage of fast marching and strong off-road capability[1]. The research on 8-wheel independent drive control for multiple rounds of vehicle related is less. There are only some solutions of simple dynamic modeling and simulation similarly at home, and only simple solutions are introduced abroad, the related research of scholars at home and abroad, usually adopt off-line simulation method to establish the vehicle dynamics model and the integrated control system[2].

By adjusting the driving force of the drive wheels, produce a yawing moment acting on the vehicle, and control the yawing moment to improve the automobile dynamic performance. The technology is an

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important part of modern automotive active safety technology (DYC) [3]. In the control system, yawing angular velocity and centroid side-slip angle are the main control variables. The yawing moment required of cars is mainly based on the two variables and the vehicle state feedback. For vehicle drove by wheel hub motor, we can individually control each the drive/brake torque of the motor[4].

2. The vehicle system and the vehicle dynamics model

In order to reflect dynamic characteristics of the 8 x 8 wheel motor drive vehicle of each direction more fully, in this paper, its 22 degrees of freedom nonlinear model is established based on vehicle dynamics. These degrees of freedom are as follows: the vehicle mass center along the x axis longitudinal motion speed vx, vehicle mass center along the y axis vy, lateral movement speed of body center of mass along the z axis vertical velocity vz, body roll Angle velocity ω x, roll Angle Φ, pitching Angle velocity of the body ω y, pitching Angle θ, vehicles around the z axis horizontal pendulum angular velocity ω z, yawing Angle ψ, eight wheels respectively around its central axis rotation angular velocity ω i(l,r), and 8 spring quality under vertical movement zwi(l,r). The model can meet the demand of the simulation and reflect the vehicle movement state better.

Based on the second law of Newton's second law and ruler could discern the vehicle motion equation:

(1)Longitudinal motion equation :

$$m\left(\dot{v}_x - v_y\omega_z + v_z\omega_y\right) = \sum_{1}^{4}\left(F_{xil} + F_{xir}\right) - mgf_r cos\alpha_{grade} - mgsin\alpha_{grade} - \frac{1}{2}C_D A_f \rho_a v_x^2 \quad (2.1)$$

(2) The lateral motion equation:

$$m\left(\dot{v}_y - v_z\omega_x + v_x\omega_z\right) = \sum_{1}^{4}\left(F_{yil} + F_{yir}\right) \quad (2.2)$$

(3) Yawing motion equation:

$$I_z\dot{\omega}_z - \left(I_x - I_y\right)\omega_x\omega_y = \frac{D_b}{2}\sum_{1}^{4}\left(F_{xir} - F_{xil}\right) + L_1\left(F_{y1l} + F_{y1r}\right) + L_2\left(F_{y2l} + F_{y2r}\right) - L_3\left(F_{y3l} + F_{y3r}\right) - L_4\left(F_{y4l} + F_{y4r}\right) + \sum_{1}^{4}\left(M_{zil} + M_{zir}\right) \quad (2.3)$$

(4)The vertical motion equation:

$$m_b\left(\dot{v}_z - v_x\omega_y + v_y\omega_x\right) = \sum_{1}^{4}\left(F_{zsil} + F_{zsir}\right) \quad (2.4)$$

(5) Roll movement equation:

$$I_y\dot{\omega}_y - \left(I_y - I_z\right)\omega_y\omega_z = \frac{D_b}{2}\sum_{1}^{4}\left(F_{zsir} - F_{zsil}\right) + m_b g H_e sin\phi + m_b a_y H_e cos\phi \quad (2.5)$$

(6)The pitch motion equation:

$$I_y\dot{\omega}_y - \left(I_z - I_x\right)\omega_z\omega_x = -L_1\left(F_{zs1l} + F_{zs1r}\right) - L_2\left(F_{zs2l} + F_{zs2r}\right) + L_3\left(F_{zs3l} + F_{zs3r}\right) + L_4\left(F_{zs4l} + F_{zs4r}\right) + m_b g H_b sin\theta - m_b a_x H_p cos\theta \quad (2.6)$$

(7) tire force relationships:

$$F_{xi(l,r)} = F_{xwi(l,r)}cos\delta_{i(l,r)} - F_{ywi(l,r)}sin\delta_{i(l,r)} \quad (2.7)$$

$$F_{yi(l,r)} = F_{xwi(l,r)}sin\delta_{i(l,r)} + F_{ywi(l,r)}cos\delta_{i(l,r)} \quad (2.8)$$