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MPC based four-wheel hub motor vehicle linear driving and steering stability control*

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***Abstract*—Body stability control is an important research problem in vehicle control because it involves many aspects of vehicle comfort, operability and economy. Based on the simulation and research platform provided by CDC benchmark Challenge, this study carried out optimization control research on the control problems in acceleration and deceleration and lane change of passenger cars driven by four-wheel hub motors. In this study, the 8-dimensional transverse and 8-dimensional longitudinal dynamics models of the target vehicle were first built, and the key parameters of the target vehicle model were identified as the basis of model-based optimization control. The relationship between the vehicle active control torque and its distribution ratio and the pitch Angle, roll Angle and vertical acceleration is established, and the cost function and constraint conditions for optimization are constructed. The vehicle speed and path following control architecture based on model iterative optimization is designed, which meets the requirements of CDC benchmark Challenge.**

I. INTRODUCTION

In order to solve the problem of linear driving and steering stability control of four-wheel hub motor vehicles, the longitudinal and lateral dynamic models are established respectively, and the speed prediction model is established based on the dynamic model. According to the results of vehicle speed prediction and the constraint conditions of pitch Angle, side Angle and vertical acceleration on the torque distribution of four wheel hub motors, a controller is built to control the torque and transverse angle.

II. MODEL

In order to solve the problems raised by the two tasks, this paper first identifies the vertical and horizontal physical models based on the simulink model.

Task 1. Longitudinal dynamic model

The total resistance ΣF_t of a car driving on a flat road is generally composed of four parts, which are rolling resistance F_f, grade resistance F_i, acceleration resistance F_j and air resistance F_w. The formula for calculating the total resistance during driving is

$$\sum Ft = Ff + Fi + Fj + Fw \quad (1)$$

$$F_f = mgf\cos\alpha \quad (2)$$

$$F_i = mg\sin\alpha \quad (3)$$

$$F_j = \delta m \frac{du}{dt} \quad (4)$$

$$F_w = \frac{CDAu^2}{21.15} \quad (5)$$

Task 2.Horizontal control model

$$m(\dot{V}_x - V_y\gamma) + m_s h_s \gamma\dot{\varphi} = \sum_{i=1}^{2}(F_{xi}\cos\delta_i - F_{yi}\sin\delta_i) + F_{x3} + F_{x4} - mgf - \frac{C_D A_R \rho_R V_x^2}{2} \quad (6)$$

$$m(\dot{V}_y + V_x\gamma) - m_s h_s \ddot{\varphi} = \sum_{i=1}^{2}(F_{xi}\sin\delta_i + F_{yi}\cos\delta_i) + F_{y3} + F_{y4} \quad (7)$$

$$I_z\dot{\gamma} - I_{xz}\ddot{\varphi} = \sum_{i=1}^{2}(F_{xi}\sin\delta_i + F_{yi}\cos\delta_i)l_f - (F_{y3} + F_{y4})l_r + \frac{d}{2}(F_{y1}\sin\delta_1 - F_{x1}\cos\delta_1 + F_{x2}\cos\delta_2 - F_{y2}\sin\delta_2 + F_{x4} - F_{x3}) \quad (8)$$

$$I_x\ddot{\varphi} - m_s h_s(V_y + V_x\gamma) - I_{xz}\dot{\gamma} = m_s h_s g\varphi - (K_{f\varphi} + K_{r\varphi})\varphi - (C_{f\varphi} + C_{r\varphi})\dot{\varphi} \quad (9)$$

$$J_i\dot{\omega}_i + F_{xi}R = T_{2i} - T_{1i} \quad (10)$$

III. CONTROLLER

The MPC controller designed in this paper mainly consists of three parts: speed prediction model, cost function of energy consumption and speed deviation, optimization and torque distribution model, as shown in Figure 1.

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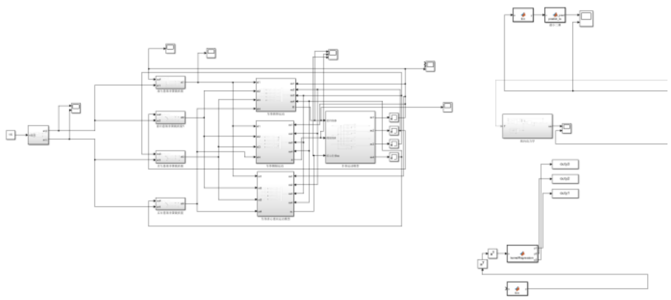

Figure 1 Controller

IV. RESULT

For the controller built above, the results tested in the first provided model are shown below in Figure 2 and Figure 3.

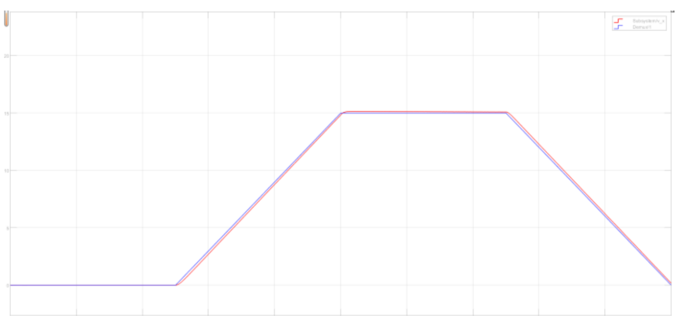

Figure 2 Velocity result

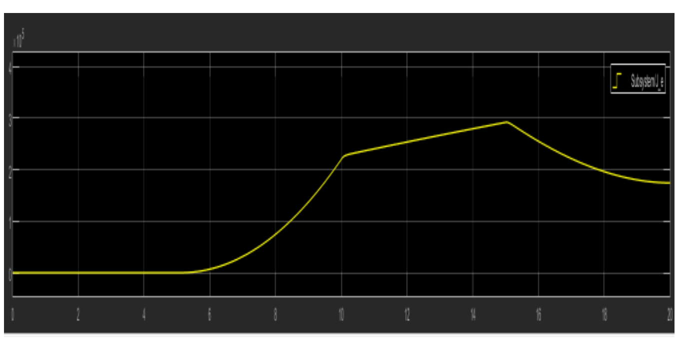

Figure 3 Energy consumption

As can be seen from the results shown in Figure 2 and Figure 3, the controller designed in this paper can make the pitch Angle and vertical acceleration meet the requirements, and the speed deviation and energy consumption are also low.