Modelling of Automotive Systems

509H3

Project 2

Project 2 Vehicle Lateral Dynamics and Steering Control

1. Vehicle Lateral Dynamics Modelling in State Space Form

Based on the bicycle model, derive the motion of equation for a cornering vehicle:

a) using variables to derive the equation of motion

y – lateral displacement of centre of gravity

ψ – yaw angle

b) introduce state-variables using variables to derive the equation of motion

$$\begin{Bmatrix} y \\ \dot{y} \\ \psi \\ \dot{\psi} \end{Bmatrix}$$

c) using state variables

e_1 – distance between c.g. and centre line of road

e_2 – orientation error

to derive the state space equation

$$\dot{e} = Ae + B_1\delta + B_2\dot{\psi}_{des}$$

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(Continue)

2. Simulation of a Cornering Vehicle with Automated Steering Control

Using SIMULINK and the model in state-space built in previous section:

a) Simulate open loop system of the above, indicate the stability when with a constant desired yaw rate $\dot{\psi}_{des}(rad/s)$ and a steering angle δ (such as square wave);

b) Simulate the closed loop lane keeping system (with feedback control). i.e. the steering angle is controlled by a feedback. The arbitrary road profile (desired yaw rate $\dot{\psi}_{des}$) can be assumed as square wave. Comment on position error and orientation error.

The feedback is set as

$$\delta = -Ke$$

where

$$K = \begin{bmatrix} k_1 & k_2 & k_3 & k_4 \end{bmatrix}.$$

The dynamic system with feedback becomes

$$\dot{e} = (A - B_1 K)e + B_2 \dot{\psi}_{des}$$

You can choose a set of vehicle parameters, such as

$$C_{af} = C_{ar} = 80000N/rad, l_f = 1.00m, l_r = 1.40m$$

$$m = 1500kg \cdot m^2;\ I_z = 2900, V_x = 100km/h.$$

c) Discuss the effect and performance of feedback control.