Handling Identification Homework

Vehicle Dynamics, Planning and Control of Robotic Cars

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Assignment

This homework enables you to understand how the vehicle steering behavior can be identified with simulated maneuvers. You are supposed to attach the solution of the following homework in the final report that you are going to deliver before the oral exam.

Exercises

Exercise 1 - sine steer maneuvers

It is required to complete the following tasks:

Exercise 1.0

- For this exercise, you are going to use the vehicle model that you implemented in MATLAB & SIMULINK. It is useful for you to add to your SIMULINK diagram a low-level longitudinal regulator (PID-based) that implements a cruise controller (this task was already done for you). Use the new file

  `Vehicle_Model_2Track.slx`

  that is provided in the folder

  `Patch_VehicleModel_DoubleTrack`

  and copy the vehicle model that you developed inside the `Vehicle Model` block.

  Also use the new versions of the MATLAB scripts

  - `initialize_environment.m`
  - `dataAnalysis.m`
  - `getVehicleDataStruct.m`

  My advice is that you take the files

  - `Vehicle_Model_2Track.slx`
  - `initialize_environment.m`
  - `dataAnalysis.m`

- `getVehicleDataStruct.m`
- folder `Longit_Controller`

you copy all of them from the folder `Patch_VehicleModel_DoubleTrack`, and you paste them to the folder of your vehicle model (the one you used for the previous homework).

Exercise 1.1

- Perform a set of sine steer maneuvers, with driver steering wheel angle $\delta_D = \delta_{D0}\sin(2\pi f t)$. Use an amplitude $\delta_{D0} = 5°$, and repeat the test at 3 different levels of vehicle speed $u = \{50, 80, 100\}$ km/h.
  Hint: carefully choose the sine frequency f so as to try to preserve almost steady-state conditions. You can use longer simulation times (by changing the T_f parameter) if needed.
- For each of the previous tests, plot the associated handling diagram. What is the steering behavior of the vehicle (neutral/understeer/oversteer)? Which parameters appear to be changing and how is the shape of the diagram modified as you increase speed?
  Hint: remember that you feed the vehicle model with δ_D, but in the handling diagram you need to consider the steering angle δ at the wheel (in radians). Also pay attention to change the initial conditions for the vehicle speed.
- Referring again to the previous tests, fit the handling diagrams using a polynomial as a function of the lateral acceleration a_y. Is a linear fitting enough? If linear fitting is sufficient, what does the slope of the line represent?
  Hint: you can use the provided file `fitting.m` as a baseline for the fitting.
- Observe the resulting shape of the diagrams. Do the obtained curves pass through the origin, for simulation times greater than zero? If not, what does this imply?
  Hint: try to plot the yaw rate Ω and the steering angle δ on the same graph.

Exercise 1.2

- Now carry out other 3 sine steer maneuvers, with these data:
  1. $\delta_{D0} = 70°$, $u = 50$ km/h;
  2. $\delta_{D0} = 24°$, $u = 80$ km/h;
  3. $\delta_{D0} = 12°$, $u = 100$ km/h.

Are the handling diagrams adding some new information with respect to the previous ones? Why? In particular, what happens for relatively high lateral accelerations? Does the steering behavior change?

- Repeat the fitting of the new diagrams, again only as a function of a_y. What is the minimum order of a polynomial that enables a proper fitting?
- Are the fitting coefficients constant for all the three speed levels? What does this imply?

Exercise 2 - constant steer maneuvers

- Carry out a constant steering maneuver, with $\delta_D = 10°$, initial speed $u_i = 20$ km/h, final speed $u_f = 40$ km/h. Plot the resulting speed profile and handling diagram (you are not required to fit it). Describe the steering behavior of the vehicle in these conditions, also reporting and commenting the vehicle center of mass path (which you find already plotted by the `dataAnalysis.m` script).
  Hint: once again, plot only the vehicle behavior in conditions close to steady - state.
- Repeat the previous maneuver, now with $\delta_D = 24°$, initial speed $u_i = 50$ km/h, final speed $u_f = 80$ km/h. Plot the resulting speed profile and handling diagram (you are not required to fit it). Describe the steering behavior of the vehicle in these conditions, also reporting and commenting the vehicle center of mass path.
- What are, according to you, the pros and the cons of the constant steer maneuver with respect to the sine steer test?
  Hint: for example, consider how easy it may be, for each of the two tests, to identify the general steering behavior $K_{us}(a_y, u)$. Also try to think which maneuver might more successfully be carried out by a real human driver.