Lab 3: Position Control

Exercise 1. (*Preparation*)
For this lab, you should be familiar with

a) MATLAB's *System Identification Toolbox*

b) `ModelPredictiveControl` class in TEAMREPO/+cmmn/

Exercise 2. (*Model identification*)
The goal of this exercise is to identify the model parameters of the state-space model you created in the previous lab sheet.

a) Conduct an experiment to collect data for model identification. Think about what control inputs you want to send to your system, what middleware period you want to use and what `valid_after_stamp` you need to set in your vehicle command.

b) Analyze the data from your experiment using the System Identification Toolbox (MATLAB App or `ssest`), to identify the parameters to a state-space model.

c) Provide the model in TEAMREPO/+cmmn/longitudinal_model.m.

> ⚠ Set the middleware's period in the lab control center "Parameters" tab according to your expectations for the control loop period in the high-level controller.

Checkpoint 1

Get a tutor to check your work. You should be able to

- reason about the middleware period you used for model identification
- show and save your (updated) state-space model for longitudinal motion
- show and save a single plot containing the input used for identification, the plant output and the model output

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Exercise 3. (*Position control of path tracking vehicle*)
The goal of this exercise is that a vehicle follows a reference position on a path using path tracking mode. Use the folder TEAMREPO/+pmpc for this exercise. A state-space model of a vehicle with the input v_{in}, and the outputs s and v, which are the distance traveled and the speed, respectively, is given in TEAMREPO/+cmmn/longitudinal_model.m.

Follow the reference position s_{ref} given as

$$s_{\text{ref}}(t) = 1.1 \cdot t + 0.5 \cdot \sin t + s_0, \tag{1}$$

where $s_0 = s(t = 0)$ is the starting position of the controlled vehicle. Create an object of the class `ModelPredictiveControl` for your controller. The following constraints on the input should be considered

$$\begin{aligned} v_{\text{min}} &= 0\,\text{m/s}, & a_{\text{min}} &= -1\,\text{m/s}^2, \\ v_{\text{max}} &= 1.5\,\text{m/s}, & a_{\text{max}} &= 0.5\,\text{m/s}^2. \end{aligned} \tag{2}$$

Convert the constraints on the acceleration to constraints on your input change and provide a reference trajectory over the complete prediction horizon for model predictive control.

> The file `TEAMREPO/+cmmn/plot_platooning.m` visualizes all relevant data for the final exercise of this lab series. You can extend its functionality to also generate the desired plots for this exercise.

Checkpoint 2

Get a tutor to check your work. You should be able to

- show a vehicle following the reference trajectory given in Equation 1
- show a plot of the vehicle's position and the reference position
- show a plot of the vehicle's speed and speed constraints
- show a plot of the vehicle's acceleration and acceleration constraints

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