**Networked Model Predictive Control
for Multi-Vehicle Decision-Making**
Mar 15-19 2021, B. Alrifaee, P. Scheffe

Informatik 11
Embedded Software

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UNIVERSITY

Exercise 1. (*Centralized platoon control*)

Your goal in this exercise is to realize a platoon using centralized model predictive control (CMPC). Use the folder TEAMREPO/21_central_platoon_control for this exercise.

a) Choose a communication structure for the networked control system (NCS) and reason about your choice. Draw the resulting graph representing the agent interaction you designed.

b) Find a suitable state-space representation of the NCS consisting of all agents. Draw a sketch of the coordinate system(s) you are using.

c) Control the vehicles to drive in a platoon using CMPC.

Aim to maintain a constant reference distance d_{ref} between the center of gravitys of consecutive vehicles of

$$d_{\text{ref}} = 0.5\,\text{m}. \tag{1}$$

Apply the following state constraint on the distance and the input and change of input constraints:

$$
\begin{aligned}
d_{\text{min}} &= 0.3\,\text{m} & v_{\text{min}} &= 0\,\text{m/s} & a_{\text{min}} &= -1\,\text{m/s}^2 \\
& & v_{\text{max}} &= 1.5\,\text{m/s} & a_{\text{max}} &= 0.5\,\text{m/s}^2
\end{aligned}
\tag{2}
$$

If quadprog gets stuck in infeasible regions, think about possible reasons. Implement a slack variable for the distance in the class ModelPredictiveControl using the exact penalty method.

> In order to implement the exact penalty method, have the slack variable appear in the linear term of the cost function with a high weight (e.g. 10^6) and constrain it to be positive.

d) Evaluate the CMPC developed in Task c) using the following scenario:

Vehicles with IDs 1, 2, 3, 5 and 7 form a platoon. Vehicle 7 is the leading vehicle, while the others follow in descending order. The vehicles start in distances unequal to their reference distance as given through the initial poses of the simulated vehicles. Use Equation 1 as the reference distance and Equation 2 as the constraints. The platoon should follow the speed profile given by

$$
v_{\text{ref}} =
\begin{cases}
0.5\,\text{m/s}, & 0\,\text{s} \leq t < 15\,\text{s} \\
1.4\,\text{m/s}, & 15\,\text{s} \leq t < 25\,\text{s} \\
0.8\,\text{m/s}, & 25\,\text{s} \leq t < 35\,\text{s} \\
0.0\,\text{m/s}, & 35\,\text{s} \leq t.
\end{cases}
\tag{3}
$$

All vehicles in the platoon should reach the same velocity and aim to reach the inter-vehicle reference distance d_{ref}. Stop the experiment at $t = 40\,\text{s}$.

Examine the controller's performance with plots of the inter-vehicle distances, the vehicles' velocities and accelerations.