Automotive Modeling and Model-based Control

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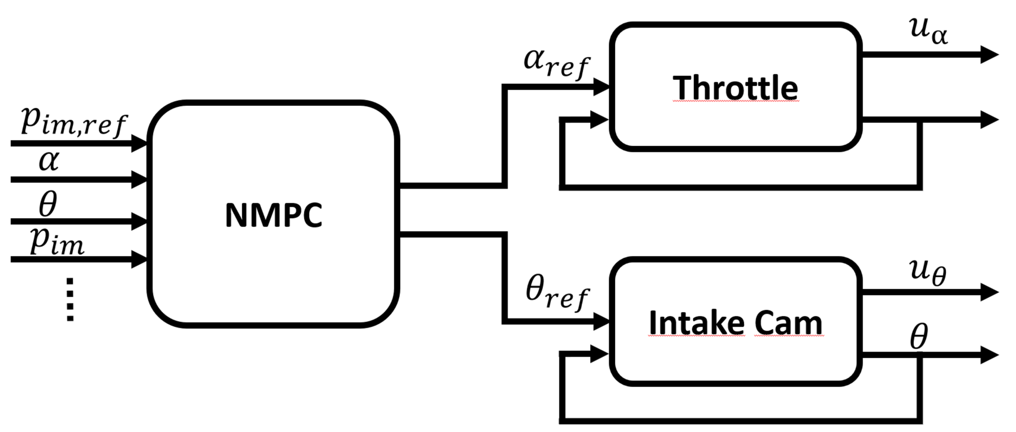
Real-Time Implementation of Non-linear MPC in Embedded Control for Engine Air-charge Throttle and Intake Cam Phase Actuators

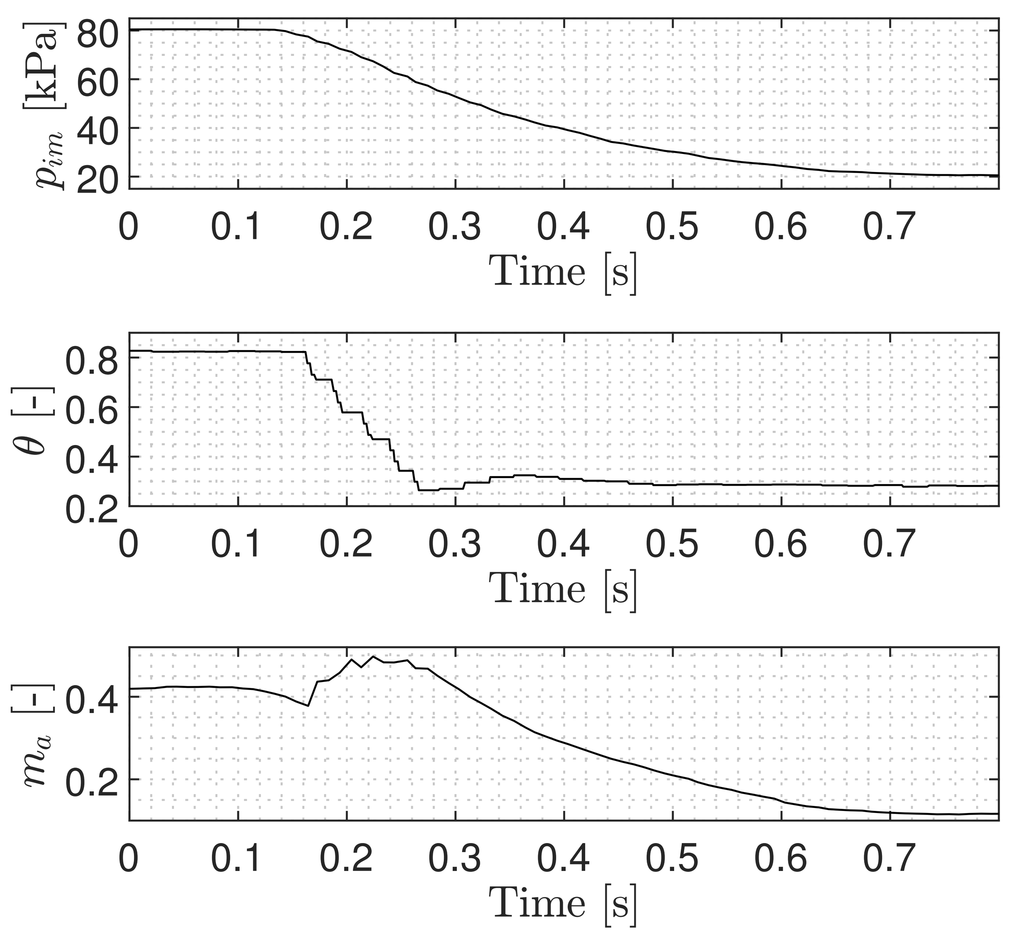
Supervisory Reference Governor of NMPC Design

Each actuator is actuated by a SISO-controller and the Nonlinear-MPC is acting as a supervisory reference governor and therefore demands actuator positions.



Cross-Coupling

In the beginning of a negative cylinder air charge transient the flow is increased, due to poor handling of cross-coupling between actuators.



Optimal Control Problem (OCP)

A nonlinear dependency between the desired actuator position and a state is seen below. It acts as a demonstration of how MPC design enables a systematic design for coordination between actuators by raising the level of abstraction through the design of the control objective.

$$\arg\min_{u} \sum_{k=1}^{N_p} \left(Z^T[k] Q_1 Z[k] + \Delta U^T[k] Q_2 \Delta U[k]\right)$$

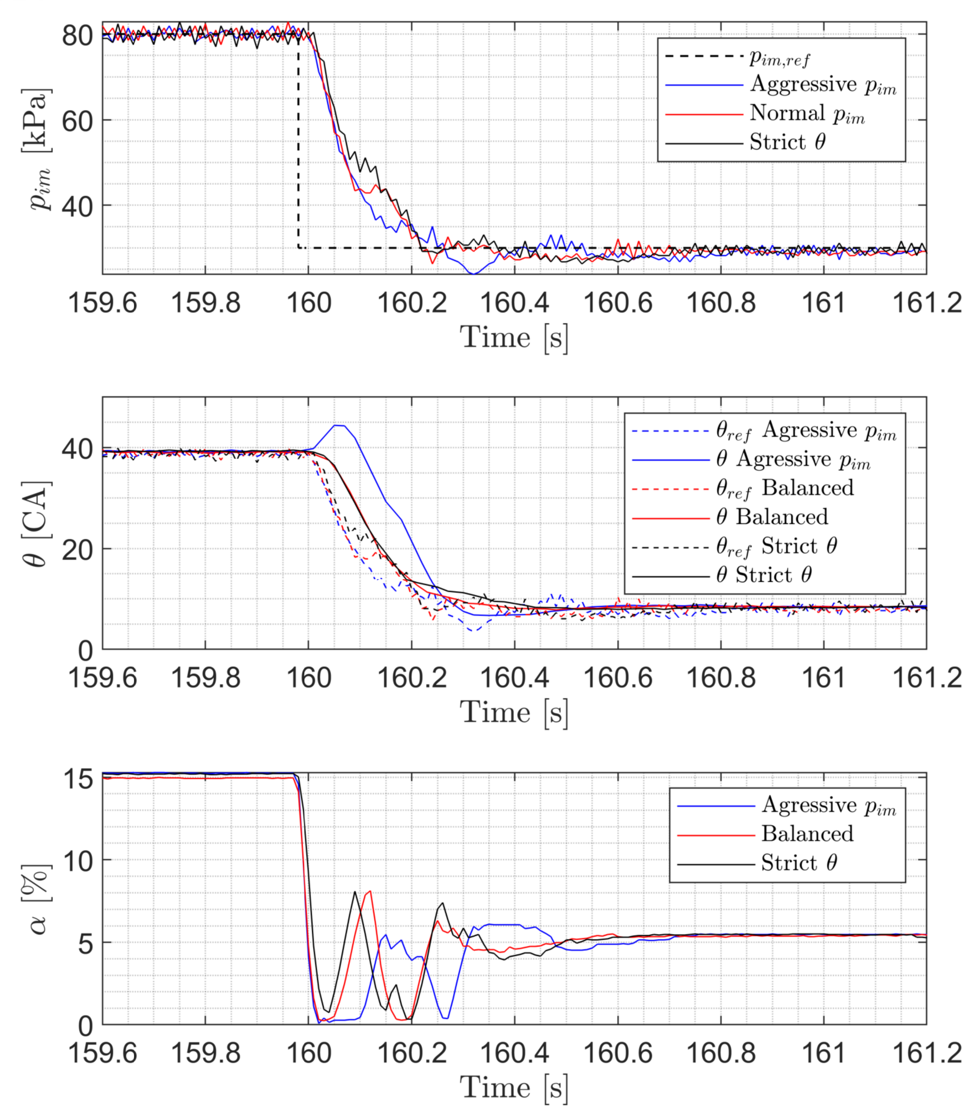
$$z_1[k] = p_{im,ref}[k] - p_{im}[k]$$

$$z_2[k] = \theta[k] - h(p_{im}[k])$$

$$z_3[k] = I_0 + T_s \sum_{k=0}^{k-1} z_1[k] \quad \text{(Integral action)}$$

$$h(p_{im}) = \begin{cases} c_1\sqrt{p_{im}} + c_0, & p_{im} > c_3 \\ c_4, & \text{otherwise} \end{cases}$$

In the aggressive setting below one sees a deviating behavior for the cam phasing as it tries to empty the intake manifold faster.



Truck Benchmark

A benchmark problem for energy efficient control of an electrified Heavy Duty Truck proposed as a challenge for the IFAC World Congress 2023.

Simulation Model

A full vehicle simulation model of a heavy-duty truck equipped with a fuel cell stack, battery, cooling system, and an electric driveline is provided.

Driving Scenario

The driving scenario is provided as road slope, altitude, and a desired trip time. The ambient conditions as pressure, temperature and relative humidity are changing throughout the driving scenario.

Temperature Control

As the durability of the fuel cell is affected by the combination of temperature and produced power of the fuel cell. The benchmark problem is formulated to emphasize this.

Fuel Cell Control

Control of the gas exchange for the cathode and anode side of the fuel cell.

Look-Ahead Control

Look-Ahead information of the driving scenario available for use.

Power Distribution Control

Control of the power distribution to and from the battery, fuel cell, electric machines, and auxiliaries.

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