Master study
Systems and Control Engineering
Department of Technology
Telemark University College
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SCE4006 Model Predictive Control with Implementation

Exercise 8

Task 1: Chemical reactor with time delay

We are in this exercise to study the chemical reactor in Exercise 6 . The process model for the behavior from the feed rate, u, to the composition of product B, $y^- = x_2$, out of the reactor is given by the non-linear model

$$\dot{x_1} = -k_1 x_1 - k_3 x_1^2 + (v - x_1)u, \quad (1)$$
$$\dot{x_2} = k_1 x_1 - k_2 x_2 - x_2 u, \quad (2)$$
$$y^- = x_2, \quad (3)$$

There composition out of the reactor is here measured with a delay of $n_\tau = 4$ discrete time samples, i.e.,

$$y = y^-(t - \tau) \quad (4)$$

where the transport delay is

$$\tau = n_\tau \Delta t \quad (5)$$

and where Δt is the sampling interval.
The reaction coefficients are given by $k_1 = 50$, $k_2 = 100$, $k_3 = 10$. The following steady state values for the states and control variable are given: $x_1^s = 2.5$, $x_2^s = 1$ and $u^s = 25$. The composition of product A in the feed rate into the reactor is assumed as a constant disturbance, $v = 10$.

a) Include a transport delay of n_τ samples in the process model. Simulate the system with the MPC strategy and investigate if the algorithm is sensitive for uncertain transport delay.

b) Find a linearized discrete time model for the reactor which includes the delay as 4 additional states. You may use the linearized discrete time model from Exercise 6 and extend this model with the additional delay states.

c) Extend your MATLAB simulation program from Exercise 6 in order to handle the delay and using MPC.