CH 5120: Modern Control Theory

Project 1

Consider the fluidized catalytic cracker model (nonlinear model) given in Balchen et al. (1992). A linearized discrete state space model for this FCC is presented below and parameters in the model are given in linssmodel.mat. There are 2 inputs (F_a and F_{sc}), 5 states and all these 5 states are measured.

$$x_{k+1} = A\,x_k + B\,u_k$$

$$y_k = x_k \qquad \text{(Model 1)}$$

a) Write a general code for implementing MPC such that it can be used to control any system with above state space form. (Hint:You should have a handle on the number of output variables to be controlled.)

b) Implement MPC to control any 2 variables among 5 output variables to their corresponding set points (y^{sp}) using the given state space model, starting at t=0.
   Use $y^{sp} = [-0.1 \;\; 0.05 \;\; -0.4 \;\; 0.6 \;\; -0.4]^T$. Assume x_0. Use desired profile as step change at t=0, i.e. $y^d(k) = y^{sp} \quad \forall \;\; k > 0$, while implementing MPC at any instant.

c) Comment on the MPC performance when used to control different sets and number of output variables.
   Are you able to get good control in all these cases with the same input variables? What changes in the input profiles can be observed for these cases?

d) Use a suitable desired profile other than a step change and repeat parts (b) and (c).

e) Introduce disturbance effect $d_k = y_k - y_{k/k-1}$ while implementing MPC. Use model 1 in the MPC implementation. For generating output measurements (plant data), use

   a. Model 2:

$$x_{k+1} = A\,x_k + B\,u_k + w_k$$

$$y_k = x_k$$

   where w_k is stochastic part. Use $N(0, \sigma)$ for w_k with a suitably chosen σ.

   b. Model 3

$$x_{k+1} = A\,x_k + B\,u_k + b$$

$$y_k = x_k$$

where b is fixed bias. Use b = $[-0.01 \quad 0.003 \quad -0.02 \quad 0.07 \quad -0.04]^T$;

Does controller control the states to their set points irrespective of stochastic effects and bias in the measurements?

f) Report the effect of changes inx_0, control horizon and prediction horizon on the MPCperformance.

References:

Balchen, Jens G., Dag Ljungquist, and Stig Strand. "State—space predictive control." *Chemical Engineering Science* 47.4 (1992): 787-807.