CH 5120: Modern Control Theory

Project 2

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}), 4 states and all these 3 outputs are measured.

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

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

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 the system at $Y^{SP} = [\,0.03\ 0.25\ 375]'$ respectively.
c) Choose various cases where the objective is to control any one or two of the outputs. 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 set point 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:

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

   $$y_k = Cx_k$$

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

   b. Model 3

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

   $$y_k = Cx_k$$

   where b is fixed bias. Use $b = [-0.01 \quad 0.004 \quad 0.03]$

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

f) Report the effect of changes in x_0, control horizon and prediction horizon on the MPC performance.

References:

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