CHALMERS
UNIVERSITY OF TECHNOLOGY

SSY281 - Multi Predictive Control

Alternative formulations of MPC

Micro Assignment - 11

ID-Number 43

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0.1 Question 1: Find representation of A,B,C from Hankel Matrix

Let we have the Hankel matrix as shown below

$$H = \begin{bmatrix} 0 & 0.5 \\ 0.5 & 1 \end{bmatrix} \tag{1}$$

We could find the representation of A,B,C by converting the step responses to state space model. The corresponding pulse responses are $H(0) = 0$ (assume D = 0), $H(1) = 0$, $H(2) = 0.5$, $H(3) = 1$, $H(k) = 0$ for $k > 3$. Since the pulse response becomes 0 after 3 steps and we have only 1 input and output (SISO system), we need at most 3 states.In order to get a finite impulse response (FIR) model, all the eigenvalues of the A matrix have to be zero. Hence, one possible choice of A is

$$A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & 0 & 0 \end{bmatrix} \tag{2}$$

Let we assume B is determined as follow

$$B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} \tag{3}$$

This does not uniquely determine B and C. Then, $C = [c_1, c_2, c_3]$ can be determined uniquely from the equations below

$$CB = [c_1, c_2, c_3] \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} = c_3 = 0 \tag{4}$$

$$CAB = [c_1, c_2, c_3]] \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} = [c_1, c_2, c_3]] \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} = c_2 = 0.5$$

$$CA^2B = [c_1, c_2, c_3]] \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & 0 & 0 \end{bmatrix}^2 \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} = [c_1, c_2, c_3]] \begin{bmatrix} 0 & 0 & 1 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} = [c_1, c_2, c_3]] \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix} = c_1 = 1$$

Therefore $C = [1, 0.5, 0]$ and D=0 due to our assumption.

0.2 Question 2: Effect of short control horizon

The effect of short control horizon (M) on RHC would be that we would have reduce the complexity of the method as we limit the number of optimization variable. This will in turn improve computational efficiency as well as the feasibility of the solutions. On the other hand, too short control horizon will give inaccurate predictions, hence poor performance of the RHC.

0.3 Question 3: Compare PFC vs RH controller in optimality and complexity

PFC's major strength is in its simplicity. However, its weakness is for processes with more complex dynamics. For some unstable processes and some stable processes it is not straightforward and not possible to get optimal performance from PFC. PFC deals with constraints in a heuristic manner (e.g.in a way which does not yield the true constrained optimal solution in general).

RHC has better ability to handle complexity. One of the major advanatages of RHC is its flexibility; users can set it up and tune it for their own specific needs and with very little effort beyond the basic algorithm.(e.g. MPC is flexible in terms of the models and performance indices that it can utilise).

1 REFERENCES

[1] Maciejowski, J.M. Predictive Control with Constraints.Pearson Education Ltd. 2012. Chapter 4
[2] SSY281 - Multi Predictive Control Lecture Notes