Assignment 5

Due: Thursday, 22nd October at 5 pm

Problem 1: SISO System: Setting up DMC Algorithm **(2+1+1+2 points)**

This is a hand-written problem. Although, you can do it in MATLAB, I will suggest doing by hand (except for matrix multiplication) to get yourself used to solving by hand.

In the previous assignments, you developed step-response model for the first-order system:

$$G(s) = \frac{5}{\tau s + 1} e^{-0.15s}, \qquad \tau = \frac{1+a}{2} \text{ a} = \text{Last digit of roll number}, \qquad \Delta t = 0.5$$

I will upload a snipped of code that will generate S matrix for you. Please use this to construct the following that will be required for SISO DMC Algorithm

1. With $p = 5$ and $m = 2$ as the prediction and control horizons, respectively, please compute the matrix $\mathcal{S}^U$ used in DMC algorithm for future predictions: $\mathcal{Y}_p(k) = \mathcal{M}\tilde{Y}(k) + \mathcal{S}^U \Delta U$
2. Let the output weights be $Q = 1$ and input weights be $R = 0.5$. Please compute the Hessian $\mathcal{H}$
3. If the constraints are $-0.1 \le \Delta u(k) \le 0.1$ and $0 \le u(k) \le 1$, please express the left-hand side of the constraint equation $C\Delta U(k) \le c_{\text{RHS}}$.
4. If the previous inputs were $u(k-i) = 0$, compute the RHS of the constraint equation, i.e., c_{RHS}

This problem is worth double points if submitted before 5 pm on Monday 19th October.

Problem 2: Step-Response Model of Reactor **(3 + 3 points)**

In Problem-3 of the previous Assignment, we considered a step response model for a reactor, with $\Delta t = 0.2$ and with $n_u = 1$, $n_y = 2$, and $n = 25$ steps in the step-response model. As in the previous assignment, the model parameters will be provided as a $(n_y.n) \times 1$ matrix `Smodel`.

5. With $p = 5$ and $m = 2$ as the prediction and control horizons, respectively, please compute the matrix $\mathcal{S}^U$ used in the DMC algorithm and report it in 10×2 matrix `bigSu`.
6. Let the output weights be $Q = \begin{bmatrix} 0.25 & 0 \\ 0 & 1 \end{bmatrix}$ and input weights be $R = 0.1$. With these values, please compute the Hessian $\mathcal{H}$ and report it in a 2×2 matrix `Hess`.

Problem 3: Step-Response Model for **(4 + 4 points)**

In Problem-3 of the Assignment-2, we considered a step response model for the following two-input two-output system (with sampling interval $\Delta t = 2$ and $n = 25$)

$$G(s) = \begin{bmatrix} \dfrac{2}{40s^2 + 16s + 1} & \dfrac{0.5}{20s^2 + 7s + 1} \\ \dfrac{1.2}{10s^2 + 5s + 1} & \dfrac{1}{36s^2 + 12s + 1} \end{bmatrix}$$

As in the previous problem, the $(n_y.n) \times n_u$ matrix `Smodel` will be provided to you.

Like the previous two problems, you will compute the matrices $\mathcal{S}^U, \Gamma^y, \Gamma^u, \mathcal{H}$. However, unlike the previous problem, you will not know the values of p and m. You will write a MATLAB function `[bigSu,Hess]=mimo_dmc_fcn(p,m)`, where `p,m` are accepted as inputs and and the matrices `bigSu` ($\mathcal{S}^U$) and `Hess` ($\mathcal{H}$) are returned as outputs.

7. For input values of p and m, please compute the matrix $\mathcal{S}^U$ used in the DMC algorithm. This must be returned by your function as a $(2p \times 2m)$ matrix `bigSu`.

8. Let the output weights be $Q = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$ and input weights be $R = Q = \begin{bmatrix} 0.25 & 0 \\ 0 & 0.25 \end{bmatrix}$. With these values, please compute the Hessian $\mathcal{H}$ and report it in $(2m \times 2m)$ matrix `Hess`.