2.153 Adaptive Control

2019 Problem Set #4

Out: Wednesday Oct 23
Due: Wednesday Oct 30 1159pm, jegaudio@mit.edu

Problem 1

Simulate the scalar adaptive system below for the different values γ in your designed adaptive law when $a_m = -1$, $k_m = 1$, $a_p = 1$, and $k_p = 2$.

$$\dot{x}_p = a_p x_p + k_p u$$
$$\dot{x}_m = a_m x_m + k_m r$$

Problem 2

Simulate the "revised design" adaptive PI controller for the DC motor as given in Lecture 13. Use $J = 2$ and $B = 0.5$. Show the responses for different $\hat{J}(0)$ and $\hat{B}(0)$ with the goal of tracking a smoothened step input. You can pick any amplitude you prefer. The adaptation gains γ_1 and γ_2 can be arbitrary.

Problem 3

Simulate an adaptive state-feedback controller for the following system

$$\dot{x} = Ax + B\Lambda u$$
$$\dot{x} = A_m x_m + B_m r$$

where A and B are known, and Λ is unknown, given by

$$A = \begin{bmatrix} 1 & 0 & 2 \\ 3 & 4 & 1 \\ 7 & 2 & 1 \end{bmatrix} \qquad B = \begin{bmatrix} 1 & 2 \\ 0 & 1 \\ 1 & -1 \end{bmatrix} \qquad \Lambda = \begin{bmatrix} 0.5 & 0 \\ 0 & 0.5 \end{bmatrix}$$

and different r, (i) $r = [5, 5]^T$, (ii) $r = [5\sin(\omega t), 5\sin(\omega t)]^T$. You can pick any Hurwitz A_m and B_m that satisfies the matching conditions specified in class.

Problem 4:

Consider the plant given in Figure 1 below, a DC Motor, with τ as the control input and x as the position output. All parameters are unknown.

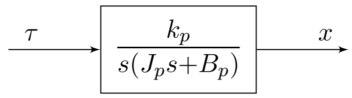

Figure 1: DC motor for problem 1

(a) Design an adaptive PID controller so that $x \to x_d$, where x_d is a desired position signal.

- You can assume that k_p, J_p are positive.
- You can assume that $\dot{x}$ is measurable.

(b) Design an adaptive phase-lead compensator so that $x \to x_d$, where x_d is a desired position signal.

- You can assume that k_p, J_p are positive.
- You can assume that $\dot{x}$ is measurable.

In both cases (a) and (b) above, show that such a τ exists (ie. algebraic part has a solution). Also show that the closed-loop adaptive system has bounded solutions, and that asymptotic tracking can be achieved. Clearly state any other assumptions you need to make.