ECE-420: Discrete-Time Control Systems
Homework 5

Due: Friday October 17 in class

For these problems you will need to download the code from the class website. You should put your results for these problems in a word file and write me a short memo summarizing your results.

1) Run the program **plant_identification_driver.m** and try to understand what is going on. Try a variety of forgetting factors, including $\lambda = 0.05$, $\lambda = 0.95$, and then a value of the forgetting factor that you think balances convergence to the correct parameter values in a reasonable time without too much overshoot. Include all three plots in your homework (do not include plots of the system output). Note that the Simulink model only models the plant, not the estimate of the parameter within the plant. This is included here so you can add your RLS algorithm in Project C.

2) Using your choice of forgetting factor, rerun your systems using a step input, a sinusoidal input, and an input that pulses on and off (you just have to uncomment some of the code). Turn in all of your graphs and indicate if the system is working (do not include plots of the system output). If it is not working, why not?

3) Change the plant so that instead of sudden changes over time, there is a gradual change in a parameter,

$$y(n) = -0.5\cos(\pi nTs)y(n-1) - 0.1y(n-2) + 0.5u(n-1) + \cos(2\pi nTs)u(n-2)$$

You should only have to uncomment code to do this, but you will have to change the Simulink file to make the Simulink model match the Matlab model. Comment out the old code and add your new code, since you will used them both in the Project. Modify the plot command so the true sinusoidal variation in b_2 and a_1 is plotted along with the RLS estimate. The input should be a random signal. Modify the forgetting factor to get as good a result as you can. Turn in both plots, and be sure your Matlab and Simulink plots of the output match.

4) Modify the time interval so Ts = 0.01 and try problem 3 again. Modify the forgetting factor until you get good results, and then turn in your graphs (two of them, one for the output and one for the parameter estimates). Why does this work better?

5) Consider the continuous-time state variable model with a delay longer than one sample interval,

$$\dot{x}(t) = Ax(t) + Bu(t - T - \tau) \quad 0 < \tau < T$$
$$y(t) = Cx(t) + Du(t)$$

Show that the discrete-time state variable model for this system can be written as

$$\begin{bmatrix} x(n+1) \\ u(n-1) \\ u(n) \end{bmatrix} = \begin{bmatrix} G & H_1 & H_0 \\ 0 & 0 & I \\ 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} x(n) \\ u(n-2) \\ u(n-1) \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ I \end{bmatrix} u(n) \quad y(n) = \begin{bmatrix} C & 0 & 0 \end{bmatrix} \begin{bmatrix} x(n) \\ u(n-1) \\ u(n-2) \end{bmatrix} + Du(n)$$

Hint: Draw a sketch of u(nT) for various times, u((n-1)T), u(nT), u(n+1)T), etc. like we did in class.