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Department of
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ELG7113/MCG5470: Machine Learning for Adaptive and Intelligent Control Systems
Assignment 2

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Due date posted in Virtual Campus

Policy

The solutions of the attached problems must submitted to Virtual Campus as a single file by using the dedicated Assignment. The file must include your name and the assignment number, and ideally it should be a pdf, for example `LastName_FirstName_hw1.pdf`.

It is acceptable to upload handwritten solutions, but please be sure that your writing is readable. Whenever required, code and outputs have to be attached.

Problem 1

Consider a system with transfer function $G(s) = G_1(s)G_2(s)$, where $G_1(s) = \frac{b}{s+a}$ and $G_2(s) = \frac{c}{s+d}$. The true values of parameters are $a = 1$, $b = 1$, $c = 2$, $d = 1/2$. Consider a and b to be known, and c and d to be unknown.

1. (**20pt**) Use the Minimum Degree Pole Placement (MDPP) algorithm to design a continuous time linear controller, for which the design specifications state that the closed-loop poles should correspond to the characteristic polynomial $A_m(s) = s^2 + 2s + 1$. Obtain the Diophantine equation and solve for the control parameters.

2. (**20pt**) Design a minimal order continuous time indirect self-tuning regulator. Clearly indicate the measurement mode. To avoid differentiation, use the filter $H_f(s) = \frac{1}{A_m(s)}$.

3. (**20pt**) Simulate the system driven by the reference signal

$$u_c(t) = \begin{cases} 1 & \sin\frac{2\pi t}{40} \geq 0 \\ 0 & \sin\frac{2\pi t}{40} < 0 \end{cases} \tag{1}$$

and plot (1) the control action u and (2) the output y along with the reference u_c for $0 \leq t \leq 100$. Also plot the estimators $\hat{c}$ and $\hat{d}$ along with the true values.

Problem 2

The system in problem 1 is sampled with period $T = 2$.

1. (**5pt bonus**) Obtain the analytical expression for the pulse transfer function $H(q)$ in terms of T and the continuous process parameters. Show that by assigning the parameters, the pulse transfer function is

$$H(q) = \frac{1.59831q + 0.587984}{q^2 - 0.503215q + 0.0497871} \tag{2}$$

2. (**20pt**) Use the Minimum Degree Pole Placement (MDPP) algorithm to design a discrete time linear controller with the same polynomial $A_m(s)$ as in Problem 1. Consider the design procedure in which all process zeros are canceled (check that this is possible).

3. (**20pt**) Design a minimal order discrete time indirect self-tuning regulator. Estimate all parameters in the pulse transfer function.

4. (**20pt**) Simulate the system driven by the same reference signal as in Problem 1. Plot (1) the control action u and (2) the output y along with the reference u_c for $0 \leq t \leq 100$. Also plot the estimators along with the true values.

5. (**20pt**) Modify the controller by adding an integral action to compensate for the step disturbance

$$v(t) = \begin{cases} 0.25 & t \geq 35 \\ 0 & t < 35 \end{cases} \tag{3}$$

6. (**10pt**) Plot the uncompensated and the compensated output errors $y - u_c$ for $0 \leq t \leq 100$.

Problem 3

Consider the same system as in Problem 2.

1. (**20pt**) Design a minimal order discrete time direct self-tuning regulator. Re-parametrize the system to express the discrete time dynamics in terms of control parameters, and use the minimum phase design procedure.

2. (**20pt**) Simulate the system driven by the same reference signal as in Problem 1. Plot (1) the control action u and (2) the output y along with the reference u_c for $0 \leq t \leq 100$. Also plot the estimators along with the true values.