FRTN15 Predictive Control - Exercise Session 5
Model Reference Adaptive Systems

1. In this problem we consider a linear process with the transfer function $kG(s)$, where $G(s)$ is known and k is an unknown parameter. Find a feed-forward controller that gives a system with the transfer function $G_m(s) = k_0G(s)$ where k_0 is a given constant. Use the controller structure

$$u = \theta u_c$$

where u is the control signal and u_c the command signal. Use the MIT rule to update the parameter θ, and draw a block diagram of the resulting adaptive system.

2. The adjustment law used in Question 1 is an integral controller, that is, the parameter is the output of an integrator. There are, however, other possibilities for choosing the adaptation mechanism. For instance, it can be expected that faster adaptation can be achieved by using a proportional and integral adjustment law. Such a PI law can be written as:

$$\theta(t) = -\gamma_1 u_c(t)e(t) - \gamma_2 \int^t u_c(\tau)e(\tau)\, d\tau \tag{1}$$

Since a system with the transfer function

$$H(s) = \gamma_1 + \gamma_2/s$$

is output strictly passive for positive γ_1 and γ_2, it follows from the passivity theorem that Equation 1 gives a stable adjustment law if GG_c is positive real.

Using the same problem formulation as in Question 1, with:

$$G(s) = \frac{1}{s}$$

determine the differential form of the parameter update law in Equation 1, and discuss how γ_1 and γ_2 influence the convergence rate.

3. Consider a system described by the model

$$\frac{dy}{dt} = -ay + bu \tag{2}$$

where u is the control variable and y the measured output. Assume that it is desired to obtain a closed-loop system described by

$$\frac{dy_m}{dt} = -a_m y_m + b_m u_c$$

Let the controller be given by

$$u(t) = \theta_1 u_c(t) - \theta_2 y(t) \tag{3}$$

Design a MRAS based on the MIT rule. Explain any approximations made and comment on any prior knowledge about the plant that may be required.