Department of Engineering Cybernetics

TTK4215 Adaptive Control
Assignment 6

Problem 1

Problem 4.10 c,d from Ioannou & Sun. See Figure 1.

Hint Problem 4.10 a,b,d was part of Assignment 5. You are supposed to repeat d, but now with the estimator designed by incorporating the extra information provided in c).

Problem 2

Problem 4.11 from Ioannou & Sun. See Figure 2.

4.10 Consider the mass-spring-damper system shown in Figure 4.12.

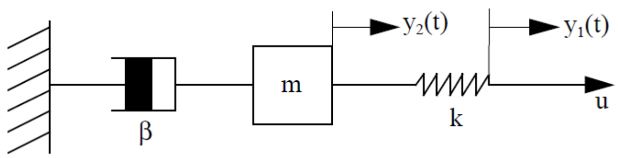

Figure 4.12 The mass-spring-damper system for Problem 4.10.

(a) Verify that the equations of motion are given by

$$\begin{aligned} k(y_1 - y_2) &= u \\ k(y_1 - y_2) &= m\ddot{y}_2 + \beta\dot{y}_2 \end{aligned}$$

(b) If y_1, y_2, u can be measured at each time t, design an on-line parameter estimator to estimate the constants k, m and β.

(c) We have the a priori knowledge that $0 \leq \beta \leq 1$, $k \geq 0.1$ and $m \geq 10$. Modify your estimator in (b) to take advantage of this a priori knowledge.

(d) Simulate your algorithm in (b) and (c) when $\beta = 0.2$ kg/sec, $m = 15$ kg, $k = 2$ kg/sec^2 and $u = 5\sin 2t + 10.5$ kg $\cdot$ m/sec^2.

Figure 1: Problem 1

4.11 Consider the block diagram of a steer-by-wire system of an automobile shown in Figure 4.13.

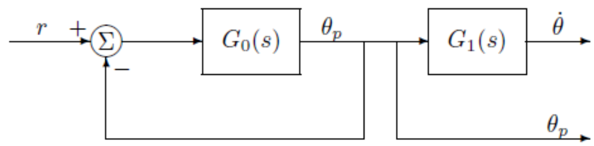

Figure 4.13 Block diagram of a steer-by-wire system for Problem 4.11.

where r is the steering command in degrees, θ_p is the pinion angle in degrees and $\dot{\theta}$ is the yaw rate in degree/sec. The transfer functions $G_0(s), G_1(s)$ are of the form

$$G_0(s) = \frac{k_0\omega_0^2}{s^2 + 2\xi_0\omega_0 s + \omega_0^2(1 - k_0)}$$

$$G_1(s) = \frac{k_1\omega_1^2}{s^2 + 2\xi_1\omega_1 s + \omega_1^2}$$

where $k_0, \omega_0, \xi_0, k_1, \omega_1, \xi_1$ are functions of the speed of the vehicle. Assuming that $r, \theta_p, \dot{\theta}$ can be measured at each time t, do the following:

(a) Design an on-line parameter estimator to estimate $k_i, \omega_i, \xi_i, i = 0, 1$ using the measurement of $\theta_p, \dot{\theta}, r$.

(b) Consider the values of the parameters shown in Table 4.6 at different speeds:

Table 4.6 Parameter values for the SBW system

Speed V	k_0	ω_0	ξ_0	k_1	ω_1	ξ_1
30 mph	0.81	19.75	0.31	0.064	14.0	0.365
60 mph	0.77	19.0	0.27	0.09	13.5	0.505

Assume that between speeds the parameters vary linearly. Use these values to simulate and test your algorithm in (a) when

(i) $r = 10\sin 0.2t + 8$ degrees and $V = 20$ mph.

(ii) $r = 5$ degrees and the vehicle speeds up from $V = 30$ mph to $V = 60$ mph in 40 second with constant acceleration and remains at 60 mph for 10 second.

Figure 2: Problem 2