ECE 463/663 - Homework #10

Kalman Filters, LQG/LTR Control. Due Monday, April 27th

Kalman Filters

Cart and Pendulum (HW #5): Use a previously deisgn control law for the cart and pendulum system. Add noise to the system as

$$s\begin{bmatrix} x \\ \theta \\ \dot{x} \\ \dot{\theta} \end{bmatrix} = \begin{bmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & -6.533 & 0 & 0 \\ 0 & 16.333 & 0 & 0 \end{bmatrix} \begin{bmatrix} x \\ \theta \\ \dot{x} \\ \dot{\theta} \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 0.333 \\ -0.333 \end{bmatrix} (F + n_u)$$

$$y = x + n_y$$

where there is Gaussian noise at the input and output

$n_u \sim N(0, 0.02^2)$ *mean zero, standard deviation 0.02*

$n_y \sim N(0, 0.01^2)$ *mean zero, standard deviation 0.01*

1) Use a servo-compensator to force the DC gain to one (i.e. use the servo compensator from homework set #9).

Plot the step response

- Without noise (same as homework set #9)
- With noise

2) Design a full-order observer using pole-placement to place the observer poles at {-3, -4, -5, -6}

- Simulate the response of the cart with noise added at the input and output.
- Plot the states of the plant and the observer with noise,.

3) Design a Kalman filter (i.e. a full-order observer with a specific Q and R)

- Simulate the response of the cart with noise added at the input and output.
- Plot the states of the plant and the observer with noise,.

LQG / LTR

4) Design a control law so that the cart and pendulum behaves like the following reference model:

$$y_m = \left(\frac{1}{s^2 + 1.4s + 1} \right) R$$

4a) Give a block diagram for your controller

4b) Give the resulting control law

4c) Plot the step response of the model and the linearlized plant for yor control law.