ECE 463/663 - Homework #11

LQR Observers. Due Monday, April 24th

Please submit as a hard copy, email to jacob.glower@ndsu.edu, or submit on BlackBoard

Kalman Filters

Cart and Pendulum (HW #4): The dynamics for a cart and pendulum system with sensor and input noise is as follows

$$s\begin{bmatrix} x \\ \theta \\ \dot{x} \\ \dot{\theta} \end{bmatrix} = \begin{bmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & -29.4 & 0 & 0 \\ 0 & 26.133 & 0 & 0 \end{bmatrix}\begin{bmatrix} x \\ \theta \\ \dot{x} \\ \dot{\theta} \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \\ -0.667 \end{bmatrix}(F+\eta_u)$$

$$y_1 = x + n_x$$

$$y_2 = \theta + n_\theta$$

where there is Gaussian noise at the input and output

$n_u \sim N(0, 0.2^2)$ *mean zero, standard deviation 0.2*

$n_x \sim N(0, 0.05^2)$ *mean zero, standard deviation 0.1*

$n_\theta \sim N(0, 0.01^2)$ *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 #10.

Plot the step response

- Without noise (same as homework set #10)
- 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,.