MECH 7710 Homework Assignment #4
Nonlinear Estimation

Due Tuesday 5/2 at Presentations

1. Develop a model for a pendulum with inertia $J_p = 2.5\frac{Nm}{rad/s\text{^}2}$ (at pin), mass $m = 1.6\ kg$, and length $L = 1\ m$. The pin introduces damping in the system that should be modeled as $\tau_b = b\dot{\theta}^3$ where $b = 1.25\frac{Nm}{rad/s}$. The input to the system is a torque at the pin given by $\tau = 12Nm$. Assume system is acted on by a horizontal disturbance force at the end of the pendulum ($f(t) = 5 + \eta$ where $\eta \sim N(0,2)$). The measurement of the angle of the pendulum is corrupted by zero mean Gaussian white noise with variance of 1 degree.
    a. Develop a simulation of the system
    b. Develop an extended Kalman filter to estimate the position and velocity (and any additional needed parameters) of the pendulum given measurement as described
    c. Develop an unscented Kalman filter to estimate the position and velocity (and any additional needed parameters) of the pendulum given measurement as described
    d. Use Monte Carlo simulations to compare the performance of the EKF and UKF. Be sure to compare expected covariance to sampled covariance from Monte Carlo simulations

1. Repeat problem #4 on HW#2. Convince yourself that the Least Squares solution you developed is the same as the solution given from arx.m. (What are the ARX inputs to recover the least squares solution you developed in HW#2?)
    a) Now crank up the sensor noise to σ=1.0. Try using higher order ARX fits? Can you identify the model?
    b) What about with another model form? Which model form worked best? How good is the fit (provide plots for proof) What was the order of the fit?