CS8803: STR, Spring 2015. Lab 2: Kalman Filtering

This assignment may only be completed alone (no groups)

Due: Wednesday, March 11, beginning of class

Assignment

The goal of this lab is to experience implementing a simple Kalman Filter. The lab must be done in MATLAB with the helicopter simulation code provided with the assignment.

The helicopter has a nonlinear motion model with added Gaussian noise. The LQR controller provided with the assignment attempts to hover the helicopter in a stationary position. We have linearized the dynamics around this stationary point and provided the A, B, C matrices of this linearization:

$$\begin{aligned} x_{t+1} &= Ax_t + Bu_t + \epsilon \\ \epsilon &\sim \mathcal{N}(0, Q) \\ y_t &= Cx_t + \xi \\ \xi &\sim \mathcal{N}(0, R) \end{aligned}$$

This linearization and the LQR gain matrix provided both fail when the helicopter strays too far from the stationary point. The LQR controller operates on the estimate of x, μ_{x_t}, to generate the controls at each timestep. Currently, this estimate is taken just from the observation, with no knowledge of uncertainty or prior states. Implement a Kalman Filter as discussed in class to provide a better estimate of the position and improve the performance of the controller.

Experiments and what to turn in

You should run the following experiments and show the results in your report

- Set both error terms (sigmaX, sigmaY in the code) to zero, run the simulation and observe the successful hovering of the helicopter
- Increase each error (separately) until it fails to hover. **Describe why is it failing and show the NED (North East Down) graph for each case.**
- Reset each error to the default values and implement a Kalman Filter. Tune your parameters so that it can successfully hover. **Show all 3 graphs for this.**
- Increase each error until it fails and ponder the shortcomings of this system.

You should submit a short report (about 3-4 pages) describing your approach, results, and implementation. Please include all the graphs requested above, labeled.

Extra credit

EKF, UKF Implement a non-linear Kalman Filter for this system
Relinearize Relinearize at each timestep and get better results with higher error terms