ECE-CT590Computing and Control, Spring 19-20
Kalman Filter Tracking

Objective:

The objective of this project is two fold:

1) To compare the static ranging data from an ultrasonic transducer processed byO
    a. averaging and
    b. alpha Kalman filter
2) To simulate a Kalman Filter based alpha-beta target tracking system using ultrasonic data to measure the position of a moving target. The motion is simulated.

Background:

- Your team should have statistics and calibration curve data for an ultrasonic sensor from
- Notes are provided to estimate the variance of the state noise – this was also discussed in class

Alpha filter vs Averaging

Pick the ultrasonic transducer in the middle range of variance – it must have variaince

1- Using your version of " fixtures from the 2nd floor window" and yardsticks gather multiple measurements from the transducer at various location – you can use the data you obtained earlier
    - At least 10 measurement for each point -but more is better – do not move once located
    - Make sure to record "ground truth" as exactly as possible. You don't need to be on the inch marks exactly the state variance is +/- ¼ inch so you ground truth should vary by that range. Mix up being right on or between +1/4 and -1/4 of inch marks
    - Do at least 20 locations, separated nominally by 1 inch but the more the better
    - MAKE SURE TO USE THE SAME TRANSDUCER AS BEFORE

Processing the data

Measurement of a single static point

- For each data set use the averaging process described in the notes

1 MEASUREMENT $\hat{x}_1 = y_1 - \bar{n}$ $\quad \sigma_{\tilde{x}}^2 = \sigma_N^2$

K MEASUREMENTS $\hat{x} = \frac{1}{k}\sum_{i=1}^{k} \hat{x}_i$ $\quad \sigma_{\tilde{x}}^2 = \frac{1}{k}\sigma_N^2$

- Implement an alpha filter to process each individual set of data. Remember this was the model of the flagpole blowing in the wind. Let T = 1 (see notes) and computer alpha using Kalata's paper.
- Plot (stems) and make a table for each position (1) ground truth, (2) average value with +/- 3 sigma shown in k measurements (2) Kalman filter estimate use

all data and $\sigma_{\hat{x}}^2 = \alpha \sigma_N^2$ this plot represents static measurements no dynamics.

- Use formulas for above variances based on prior statistics of transducer variance
- Recall the relationship between standard deviation sigma and variance

Simulation of Moving Target

- This is the model of the transducer moving at a constant velocity, i.e., train on tracks). For instance we moving 1 inch per second. So T = 1 and we say each measurement occurred at 1 sec. You can adjust T up or down. Compute out how fast this is in miles-per-hour and pick some reasonable number.
- Process the data with an alpha-beta Kalman filter – you need to computer alpha and beta from the noise and state variances using Kalata's paper (do not use the same alpha as the alpha filter). Remember this is a matrix equation and K(k) and P(k|k) are fixed values,
- Make sure units are correct
- You should have 10 measurements for each of the position points, break them up into sets of 10 so you have 10 different sets of data each representing measurements of the transducer moving along its length
- Process each set and plot vs time. Show the actual point and connect with a curve (as Matlab does the fitting). Note we expect the velocity to be "constant" but there will be startup artifacts so you can get around this by looking at Kalata;s paper track initialization.
- Plot time vs ground truth for your data set
- For each point does the Kalman filter provide a better estimate than just the averages you found for the singe point. Show _/-3 sigma for the position error from Kalman filter
- Show also in table.
- Do a phase plant plot for the ground truth and overlay the error ellipse at each point. Next plot the x, v pairs from each run of the Kalman filter. They should be inside the error ellipse.

  Remember phase plot is horizontal axis position, vertical axis velocity