Final project
Tracking of a maneuvering vehicle

The objectives of this assignment are to encourage you to think creatively and critically to extract a useful signal from noisy experimental data, find best estimation method of a dynamical process and make forecast of its future development.

This assignment is to be done in groups of 3-4 students, and only one document is submitted for the group. You may also freely talk with students in other groups, but the final documents that you submit must be done only by your group.

Formulation

1. What to do if your vehicle does a strong maneuver?

2. There are GPS measurements of coordinate x and y for your availability of a vehicle motion.
   files/folder/Final projects/Project 5/data/ trajectory_data.mat
   The file contains variables z corresponding to the GPS measurements of two vehicles

   The format of z in matlab:
   First row – measurements of the coordinate x
   Second row – measurements of the coordinate y

   The format of txt data
   Element in the first column - measurements of the coordinate x
   Element in the second column - measurements of the coordinate y

3. How you can track the motion reliably in these conditions?
   First construct a linear Kalman filter

   State vector $X_i = \begin{vmatrix} x_i \\ V_i^x \\ y_i \\ V_i^y \end{vmatrix}$

   (a) Let's assume that the true trajectory X_i is described by a motion with normally distributed unbiased random acceleration a_i with variance $\sigma_a^2 = 0.01^2$ for both a_i^x, a_i^y.

$$x_i = x_{i-1} + V_{i-1}^x T + \frac{a_{i-1}^x T^2}{2}$$

$$V_i^x = V_{i-1}^x + a_{i-1}^x T$$

$$y_i = y_{i-1} + V_{i-1}^y T + \frac{a_{i-1}^y T^2}{2}$$

$$V_i^y = V_{i-1}^y + a_{i-1}^y T$$

$$T = 1$$

   (b) From a prior information you know that the variance of measurement noise is $\sigma_\eta = 10^2$ for both $\sigma_{\eta_x}, \sigma_{\eta_y}$

(c) Initial filtered estimate of state vector $X_{0,0}$

$$X_0 = \begin{vmatrix} 0 \\ 0 \\ 0 \\ 0 \end{vmatrix}$$

Initial filtration error covariance matrix $P_{0,0}$

$$P_{0,0} = \begin{vmatrix} 10^5 & 0 & 0 & 0 \\ 0 & 10^5 & 0 & 0 \\ 0 & 0 & 10^5 & 0 \\ 0 & 0 & 0 & 10^5 \end{vmatrix}$$

4. Plot the estimation results (Prediction and Filtration) independently for X and Y. We see that the maneuver is not greatly detected.

5. How we can improve this?
   Let's analyze the filter residual

   $$v_i = z_i - HX_{i,i-1}$$

   Residual v_i indicates the strong mismatch between measurements and predictions. Thus, at these moments we should increase the prediction error covariance matrix $P_{i,i}$

   For instance of absolute value of v_i is greater than the $3.5\sigma_\eta$ both for X and Y then you should indicate that $P_{i,i}$ is again huge

   $$P_{i,i} = \begin{vmatrix} 10^5 & 0 & 0 & 0 \\ 0 & 10^5 & 0 & 0 \\ 0 & 0 & 10^5 & 0 \\ 0 & 0 & 0 & 10^5 \end{vmatrix}$$

Friday, October 25

1. Present your results with charts in 15 minutes.
   The presentation should include the problem formulation, why it is important, nice figures, grounds why the chosen method is the best method (visual analysis, quantitative criteria, simplicity of implementation, and any other arguments). Which regularities are found. Discuss what are the risks of obtained estimations and conclusions about the process. Make general conclusions about the efficiency of method.

2. Submit the final version of your project to canvas.