EECS4421: Lab 6

Thu Mar 24, 2013
Due: End of class on Wed Apr 5, 2017

1. Implement an extended Kalman filter (EKF) where the plant model is linear and the measurement model is non-linear. Use your EKF to solve the following localization problem:

Suppose that you have an omnidirectional (slide 9 from Day 22 lecture) robot moving in an environment with two point landmarks m_1 and m_2 and a known goal location g. The coordinates of the landmarks are $m_1 = [5\ 0]^T$ and $m_2 = [10\ 0]^T$. The coordinates of the goal are $g = [15\ \ -2]^T$. At each time step, the robot can move one unit towards the goal (in a straight line from its estimated current position towards the goal); this is the control input u_t. Assume that the control input is accurate (has zero mean error) but has covariance Q:

$$Q = \begin{bmatrix} 0.25^2 & 0 \\ 0 & 0.25^2 \end{bmatrix}$$

The plant model for the robot is:

$$x_t = \begin{bmatrix} x \\ y \end{bmatrix}_{t-1} + u_t + \varepsilon$$

where $\begin{bmatrix} x \\ y \end{bmatrix}_{t-1}$ is the estimated location of the robot at time $t-1$ and ε is a zero mean Gaussian random variable with covariance Q. Because the plant model is linear, you can use the regular Kalman filter equations for the prediction phase of the filter (lines 3–4 on slide 5 from the Day 20 lecture).

Assume that the robot is equipped with a sensor that can measure the distance to each landmark simultaneously and unambiguously (i.e., the robot can measure the distance from its true location to both landmarks and it knows which landmark produces which distance measurement). Assume that the distance measurement is accurate (has zero mean error) but has variance equal to 0.25^2. In other words, each measurement is

$$z_t = \begin{bmatrix} d_1 \\ d_2 \end{bmatrix} + \delta$$

where d_1 is the distance to landmark 1, d_2 is the distance to landmark 2, and δ is the zero mean Gaussian measurement noise with covariance

$$R = \begin{bmatrix} 0.25^2 & 0 \\ 0 & 0.25^2 \end{bmatrix}$$

(a) What is the matrix H_t obtained after linearizing the measurement model? Give the full equation for each element of H_t.

(b) Implement the EKF for the robot and show the localization results using the EKF at each time step $t = 0, 1, 2, ..., 25$. Your plots should show the estimated location of the robot (using the EKF) and the true location of the robot. Show the results for two different estimates of the starting location x_0:

$$x_0 = \begin{bmatrix} 0 \\ 9 \end{bmatrix}$$

and

$$x_0 = \begin{bmatrix} 0 \\ -5 \end{bmatrix}$$

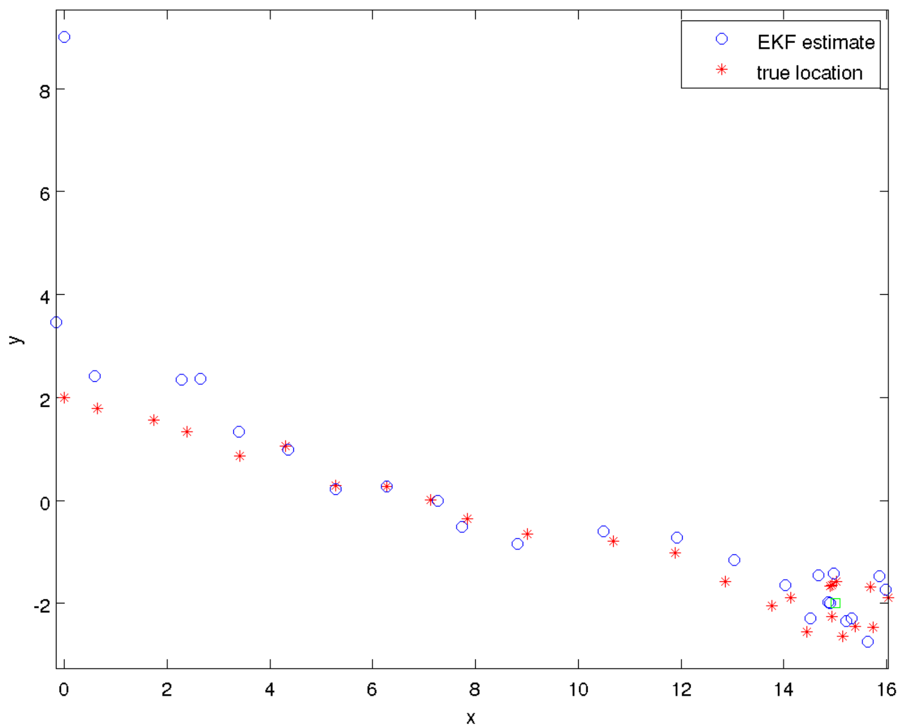
For the estimated state covariance use

$$\Sigma_0 = \begin{bmatrix} 4 & 0 \\ 0 & 4 \end{bmatrix}$$

The true starting position of the robot is always

$$x_{\text{true}} = \begin{bmatrix} 0 \\ 2 \end{bmatrix}$$

My results using $x_0 = [0\ 9]^T$ are shown below:



(c) The results using $x_0 = [0\ -5]^T$ should be quite different. Explain why the two different starting points produce such different results.

Submit written solutions for questions (a) and (c); you may submit these electronically with your Matlab files if you wish. Submit Matlab scripts (your implementation of the EKF and the scripts needed to produce your two plots) for question (b).

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submit 4421 L6 your-matlab-files
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