CSE4421: Assignment 4

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Posted: Sat 19 Mar, 2011
Due: Tue Apr 05, 2011

1. (a) Suppose you have two noisy measurements of the distance between a robot and an object; the measurements and their estimated variances are:

$$\begin{aligned} x_1 &= 6 \qquad & \sigma_1^2 &= 2 \\ x_2 &= 9 \qquad & \sigma_2^2 &= 1 \end{aligned}$$

Do you think that the true distance to the object is closer to 6 or closer to 9? Explain why.

1. (b) Compute the optimal estimates of the distance and its variance for the values in part (a) assuming that the noise in the measurements is zero-mean, independent, and Gaussian distributed.

1. (c) Suppose you have two noisy measurements of a location relative to the robot; the measurements and their covariances are:

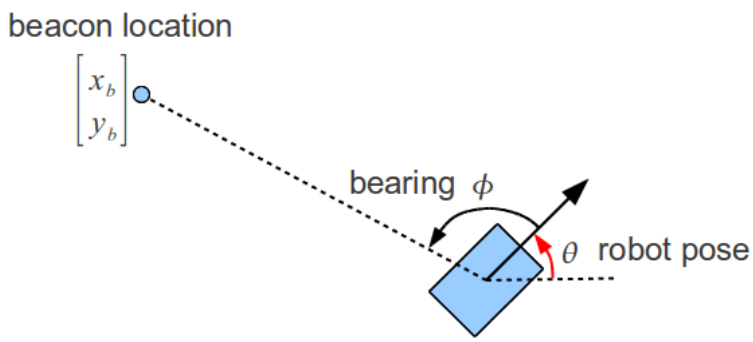
$$x_1 = \begin{bmatrix} 5.1962 \\ 3 \end{bmatrix} \qquad \Sigma_1^2 = \begin{bmatrix} 1.75 & 0.433 \\ 0.433 & 1.25 \end{bmatrix}$$

$$x_2 = \begin{bmatrix} 7.7942 \\ 4.5 \end{bmatrix} \qquad \Sigma_1^2 = \begin{bmatrix} 1.25 & -0.433 \\ -0.433 & 1.75 \end{bmatrix}$$

Do you think that the true location is closer to x_1 or closer to x_2? Explain why.

1. (d) Compute the optimal estimates of the location and its covariance matrix for the values in part (c) assuming that the noise in the measurements is zero-mean, independent, and Gaussian distributed. The appropriate equations are given by Equation 4.5 in Section 4.9 of the textbook.

2. In class, we developed a measurement model assuming that a mobile robot could measure the distance to a beacon fixed to known location in the world (Slide 4, Day 22). Suppose that in addition to measuring the distance, the robot is also able to measure the bearing to the beacon. The bearing is defined as the angle measured from the robot's heading direction and the line segment between the robot's position and the beacon location (see figure).



(a) Assuming that there is only only one beacon, provide a measurement model where both the distance and bearing are measured by the robot.

(b) During the measurement update (or correction) phase of a Kalman-like filter algorithm, the difference between the actual measurement and the expected measurement is calculated as

$$r_{k+1} = z_{k+1} - \hat{z}_{k+1}$$

where z_{k+1} is the actual measurement of the distance and bearing, and $\hat{z}_{k+1}$ is the vector of predicted distance and bearing computed using the measurement model. Do you see any problems computing r_{k+1} given your measurement model?

3. Based your understanding of the extended Kalman filter and the assigned reading from Day 24, what do you think are the major advantages of the unscented Kalman filter compared to the extended Kalman filter when applying such a filter to a real problem? A list of advantages is sufficient for your answer.