CSE 571: Probabilistic Robotics
Assignment #2
October 10, 2007
Due: Tuesday, October 30

Problem:

1. Let X and Y denote two random variables that are jointly Gaussian:

$$\begin{aligned} p(x,y) &= \mathcal{N}(\mu^*, \Sigma) \\ &= \det(2\pi\Sigma)^{-\frac{1}{2}} \exp\left\{-\frac{1}{2}\left((x,y)^T - \mu^*\right)^T \Sigma^{-1} \left((x,y)^T - \mu^*\right)\right\} , \end{aligned}$$

where $\mu^* = (\mu_x^*, \mu_y^*)^T$ and $\Sigma = \begin{pmatrix} \sigma_x^2 & \sigma_{xy}^2 \\ \sigma_{xy}^2 & \sigma_y^2 \end{pmatrix}$ are the mean and covariance, respectively. Show that conditioning on Y results in a Gaussian over X:

$$\begin{aligned} p(x \mid y) &= \mathcal{N}(\mu, \sigma^2) \\ &= \left(2\pi\sigma^2\right)^{-\frac{1}{2}} \exp\left\{-\frac{1}{2}\frac{(x-\mu)^2}{\sigma^2}\right\} \end{aligned}$$

with $\mu = \mu_x^* + \frac{\sigma_{xy}^2}{\sigma_y^2}(y - \mu_y^*)$ and $\sigma^2 = \sigma_x^2 - \frac{\sigma_{xy}^4}{\sigma_y^2}$.

2. Implement landmark based robot localization using an EKF and a particle filter. For the matlab code package and a more detailed description of the project click on the project link on the course web site.

   Once your filters are implemented, please investigate some properties of them. How do they behave

   - as the sensor or motion noise go toward zero?
   - as the number of particles decrease?
   - if the filter noise parameters underestimate or overestimate the true noise parameters?

   In order to get quantitative results, you should generate plots that show the different evaluation criteria on the x-axis, and the corresponding filter error on the y-axis. For instance, you can plot number of samples versus average localization error, where error is measured by the distance between the real robot position and the mean estimate of the particles.