

## Sheet 8

Topic: EKF-Localization, Bearing only SLAM

Submission deadline: Tue 1.7.2008, 11:00 a.m. (before class)

### Exercise 1: Landmark-Based EKF Localization

Consider a robot in a static environment with the two distinct landmarks “No-Smoking Sign” and “Clock” as depicted in Figure 1. Execute one iteration of the EKF localization algorithm to estimate the robot’s pose after a movement and the observation of the two landmarks.



Figure 1: A robot rotation round its center and two landmarks.

The robot starts at time 0 at position  $(x, y, \theta) = (0, 0, 0)$  with a pose uncertainty given by  $\Sigma = ((1, 0, 0), (0, 1, 0), (0, 0, 0.1))$ . For  $\delta_t = 1s$ , it rotates with angular speed  $\omega = 0.785$  ( $45^\circ$ ). Let the velocity-based motion model be defined by  $\alpha_1 = \alpha_3 = 0.1$  and  $\alpha_2 = \alpha_4 = 0.01$ . After the rotation, landmark 0 (“No-Smoking Sign”) is observed as  $z_0 = (10.23, 0.61$  ( $35^\circ$ )) and landmark 1 (“Clock”) as  $z_1 = (29.81, -0.96$  ( $-55^\circ$ )), whereby the vectors denote (range,bearing) measurements. We know that the landmark 0 (“No-Smoking Sign”) is located at  $(0, 10)$  and landmark 1 (“Clock”) is located at  $(30, 0)$ . We assume that the landmarks are easy to distinguish so that a perfect feature correspondences is given. The measurement uncertainty shall be given by  $(\sigma_r = 0.5, \sigma_\phi = 0.1)$ .

- (a) Perform one iteration of the filter and give the resulting pose estimate  $\mu_1$  as well as the pose uncertainty matrix  $\Sigma_1$ .

- (b) Compare the old and new pose estimates as well as the uncertainty ellipses in a rough sketch. How did the pose estimates change and why?
- (c) Would it be possible to use the standard version of the Kalman filter? How would you expect the results to change?

For the solution of this exercise you may find the freely available program “Octave” (<http://www.gnu.org/software/octave/>) helpful.

### **Exercise 2: Bearing only SLAM**

*Bearing only SLAM* refers to the SLAM problem when the sensors can only measure the bearing of a landmark but not its range. One problem in bearing only SLAM with EKFs concerns the initialization of landmark location estimates, even if the correspondences are known. Discuss why, and devise a technique for initializing the landmark location estimates (means and covariances) that can be applied in bearing only SLAM.