Albert-Ludwigs-Universität Freiburg
Lecture: Introduction to Mobile Robotics
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Institut für Informatik

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Sheet 4

Topics: Probabilistic Motion and Sensor Models

Submission deadline: Fri 18.05.2007, 11:00 a.m. (before class)

Exercise 1:

Let a robot be equipped with wheel encoders and on-board software that transforms the physical measuring data into time-discrete odometry measurements $\langle \hat{\delta}_{rot_1}, \hat{\delta}_{trans}, \hat{\delta}_{rot_2} \rangle$.

(a) Derive equations for the calculation of the end-pose $\langle x', y', \theta' \rangle$ after a performed motion $\langle \delta_{rot_1}, \delta_{trans}, \delta_{rot_2} \rangle$ from a start-pose $\langle x, y, \theta \rangle$.

(b) Let the robot start at pose $\langle x, y, \theta \rangle = \langle 0m, 0m, 0^\circ \rangle$ and obtain the following subsequent odometry measurements:

$$\begin{aligned} \hat{\delta}^1_{rot_1} &= 10^\circ \\ \hat{\delta}^1_{trans} &= 3m \\ \hat{\delta}^1_{rot_2} &= 10^\circ \end{aligned}$$

$$\begin{aligned} \hat{\delta}^2_{rot_1} &= -20^\circ \\ \hat{\delta}^2_{trans} &= 10m \\ \hat{\delta}^2_{rot_2} &= -10^\circ \end{aligned}$$

Please assume perfect measurements and calculate the exact pose of the robot.

(c) How would your pose estimate for the first movement look like under the following simple error model? Please draw the movements and pose estimates into one diagram.

$$\begin{aligned} \hat{\delta}_{rot_1} &= \delta_{rot_1} \pm \varepsilon_{rot_1}, & \varepsilon_{rot_1} &= 5^\circ \\ \hat{\delta}_{trans} &= \delta_{trans} \pm \varepsilon_{trans}, & \varepsilon_{trans} &= 0.5m \\ \hat{\delta}_{rot_2} &= \delta_{rot_2} \pm \varepsilon_{rot_2}, & \varepsilon_{rot_2} &= 10^\circ \end{aligned}$$

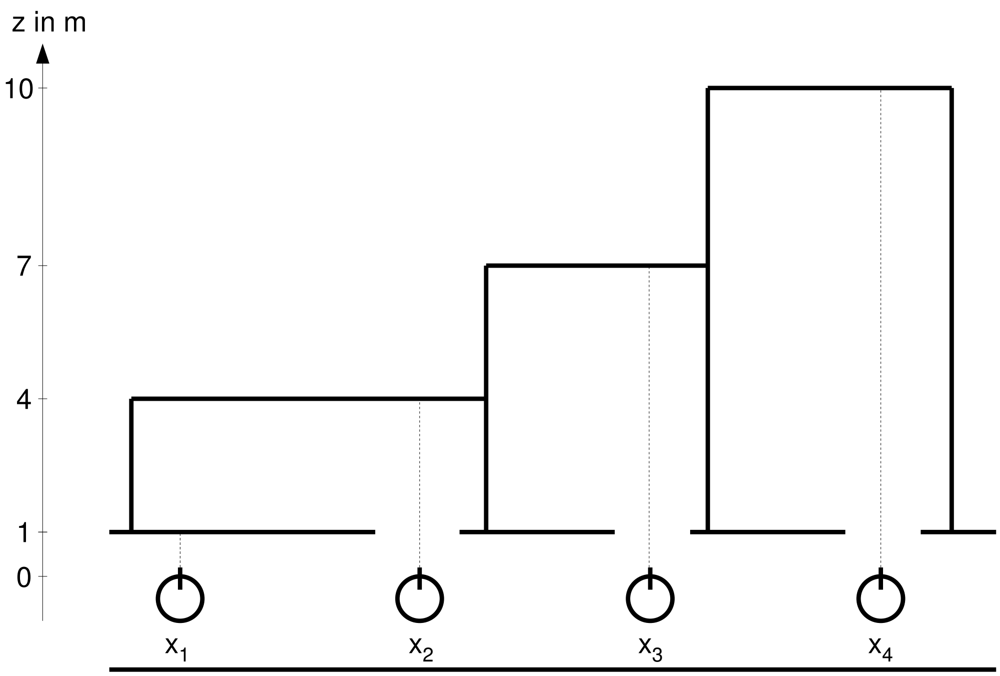

Figure 1: Map

Exercise 2:

A robot moves along the middle of a corridor with a given accurate map, as depicted in the figure. At some of the given locations x_i it takes measurements z_k of the distance to one side, using one laser beam. Every measurement is corrupted only with additive Gaussian noise $\mathcal{N}(\mu, \sigma)$ with $\mu = 0m$ and $\sigma = 1m$. The scanner range is assumed to be unlimited. The measured distances are $z_1 = 1m$, $z_2 = 2m$, $z_3 = 5.4m$, $z_4 = 8.6m$, $z_5 = 9m$. The mapping between z_k and x_i is unknown.

(a) For each measurement, determine the most likely robot pose by calculating the probabilities for each position given the measurement using Bayes' rule. Assume an equally distributed *prior*. The *evidence* term (denominator) can be neglected, but the probabilities should be scaled such that $\sum_{i=1}^{4} P(x_i|z) = 1$.

(b) The robot believes that taking measurements at the positions x_2 and x_3 is in general four times as likely as doing so at x_1 and x_4. Use this prior information to recalculate the probabilities of (a).

(c) Suppose the laser scanner is not as ideal as above, and reports a faulty measurement of $z = 1m$ in 50% of all cases, no matter the actual distance. How does this change the results of (a) and (b)?