Probabilistic Robotics
BAIPR6, Fall 2009
Exercise: Motion and Sensor Model

Assigned: Week 40, Due: Week 41
Friday October 9th, 17:00

Arnoud Visser

September 30, 2009

Question 1

We have a robot equipped with wheel encoders and on-board software that combines the measurements from the multiple encoders in a tuple of time-discrete odometry measurements $(\delta_{\texttt{rot1}}\delta_{\texttt{trans}}\delta_{\texttt{rot2}})^T$.

(a) Let the robot start at pose $(xy\theta)^T = (0m, 0m, 0^o)^T$ and obtain the following subsequent odometry measurements: $(\delta^1_{\texttt{rot1}}\delta^1_{\texttt{trans}}\delta^1_{\texttt{rot2}})^T = (10^o, 3m, 10^0)^T$ and $(\delta^2_{\texttt{rot1}}\delta^2_{\texttt{trans}}\delta^2_{\texttt{rot2}})^T = (-20^o, 10m, -10^0)^T$.

Please assume perfect measurements and calculate the exact poses $(x^1y^1\theta^1)^T$ and $(x^2y^2\theta^2)^T$ with equation (5.40) from the book.

(b) How would your pose estimate look for first movement $(\delta^1_{\texttt{rot1}}\delta^1_{\texttt{trans}}\delta^1_{\texttt{rot2}})^T = (10^o, 3m, 10^0)^T$ under the following simple uniform error model? Please draw the extremes of the pose estimates into into a a diagram.

$$\begin{aligned}\hat{\delta}_{\texttt{rot1}} &= \delta_{\texttt{rot1}} \pm \epsilon_{\texttt{rot1}} \\ \hat{\delta}_{\texttt{trans}} &= \delta_{\texttt{trans}} \pm \epsilon_{\texttt{trans}} \\ \hat{\delta}_{\texttt{rot2}} &= \delta_{\texttt{rot2}} \pm \epsilon_{\texttt{rot2}}\end{aligned}$$

with $(\epsilon_{\texttt{rot1}}\epsilon_{\texttt{trans}}\epsilon_{\texttt{rot2}})^T = (5^o, 0.5m, 10^0)^T$.

(c) Apply the same error model again on the n extreme poses of the previous question. This would result in $n \times n$ poses. Please draw the $\frac{n \times n}{2}$ positions of the extremes of this motion estimate (i.e. without final orientation) after the second movement.

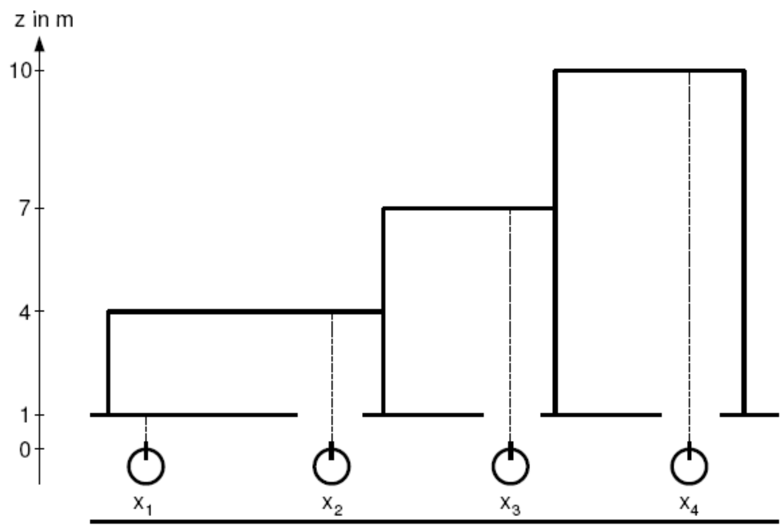

Figure 1: Accurate map of a corridor with three rooms

Question 2

A robot is moving along the middle of a corridor with a given accurate map, as depicted in figure 1.

At some of the given locations x_i the robot takes a measurement of the distance z_k, using a 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 $80m$. The measured distances are $z_1 = 1.0m$, $z_2 = 2.0m$, $z_3 = 5.4m$, $z_4 = 8.6m$, $z_5 = 9.4m$. The correspondence 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 uniform 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 an d x_3 is in general three times as likely as doing so at x_1 and x_4. Use this prior information to recalculate the probabilities of (a).

(c) Because people are present in the corridor, a faulty measurement of $z = 1m$ can occur in 50% of the cases, no matter the actual distance. How does this change the results of (a) and (b).

Hand-In

When you have completed the assignment, you will mail one file: `yourname_answer_MotionSensorModel.pdf`.

Acknowledgements

This assignment is equivalent with an assignment from the Albert-Ludwigs-Universität Freiburg, and is originally written by Wolfram Burgard, Jürgen Sturm and Boris Lau. The second question was used in the previous course in one of the exams.