thws Technische Hochschule Würzburg-Schweinfurt

Faculty of Computer Science and Business Information Systems
5172080: Fundamentals of Mobile Robotics

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Tutorial 3

Topic: Probabilistic Sensor Models

Solutions will be discussed in class Monday 12:10-13:10, Week 46 of the calendar year.

Q 1 – Distance-Only Sensor

In this exercise, you try to locate your friend using her cell phone signals. Suppose that in the map of Würzburg, the University of Applied Sciences is located at $m_0 = (10, 8)^T$, and your friend's home is situated at $m_1 = (6, 3)^T$. You have access to the data received by two cell towers, which are located at the positions $x_0 = (12, 4)^T$ and $x_1 = (5, 7)^T$, respectively. The distance between your friend's cell phone and the towers can be computed from the intensities of your friend's cell phone signals. These distance measurements are disturbed by independent zero-mean Gaussian noise with variances $\sigma_0^2 = 1$ for tower 0 and $\sigma_1^2 = 1.5$ for tower 1. You receive the distance measurements $d_0 = 3.9$ and $d_1 = 4.5$ from the two towers.

1.a

Is your friend more likely to be at home $p(m_1 \mid d_0, d_1)$ or at the university $p(m_0 \mid d_0, d_1)$? Explain your calculations.

1.b

Now, suppose you have prior knowledge about your friend's habits which suggests that your friend currently is at home with probability $P(\text{at home}) = 0.7$, at the university with $P(\text{at university}) = 0.3$, and at any other place with $P(\text{other}) = 0$. Use this prior knowledge to exactly calculate the posteriors of a).

Q 2 – Sensor Model

Assume you have a robot equipped with a sensor capable of measuring the distance and bearing to landmarks. The sensor furthermore provides you with the identity of the observed landmarks.

A sensor measurement $z = (z_r, z_\theta)^T$ is composed of the measured distance z_r and the measured bearing z_θ to the landmark l. Both the range and the bearing measurements are subject to Gaussian noise $\mathcal{N}(z_{\text{exp},r}, \sigma_r^2)$ and $\mathcal{N}(z_{\text{exp},\theta}, \sigma_\theta^2)$ with variances σ_r^2, and σ_θ^2, respectively. The range and the bearing measurements are independent of each other.
A sensor model

$$p(z \mid x, l)$$

models the probability of a measurement z of landmark at position $l = (l_x, l_y)^T$ observed by the robot from pose $x = (x_x, x_y, x_\theta)^T$.

Design a sensor model $p(z \mid x, l)$ for this type of sensor departing from expected distance and bearing measurements $z_{\text{exp},r}$ and $z_{\text{exp},\theta}$. Furthermore, explain your sensor model.