Albert-Ludwigs-Universität Freiburg
Lecture: Introduction to Mobile Robotics
Summer term 2010

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Sheet 11

Topic: EKF, Rao-Blackwellization, Path Planning

Submission deadline: July 13, 2010

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Exercise 1: EKF

In the lecture the state prediction step of the EKF-framework was presented using the *velocity motion model* as follows:

$$\begin{aligned}\bar{\mu}_t &= g(\mu_{t-1}, u_t)\\ \bar{\Sigma}_t &= G_t \Sigma_{t-1} G_t^T + B_t Q_t B_t^T,\end{aligned}$$

where G_t is the Jacobian of the state transition function g and Q_t is the covariance matrix of the noise in *control space*. The transformation from the noise in *control space* to *state space* is performed by linear approximation using the Jacobian B_t given by the derivative of the state transition function g with respect to the control parameters (see slide 13 of the EKF Localization slides).

In this exercise you'll have to specify the following state prediction components of the EKF-framework for the *odometry motion model*.

1. State transition function $\bar{\mu}_t = g(\mu_{t-1}, u_t)$ and its Jacobian G_t.
2. Given the covariance matrix Q_t of the noise in *control space*

$$Q_t = \begin{pmatrix} \alpha_1|\delta_{\text{rot}_1}| + \alpha_2\delta_{\text{trans}} & 0 & 0 \\ 0 & \alpha_3\delta_{\text{trans}} + \alpha_4(|\delta_{\text{rot}_1}| + |\delta_{\text{rot}_2}|) & 0 \\ 0 & 0 & \alpha_1|\delta_{\text{rot}_2}| + \alpha_2\delta_{\text{trans}} \end{pmatrix},$$

   specify the Jacobian B_t needed by the linear approximation that transforms the noise from *control space* to *state space* (remember that $\alpha_1, \ldots, \alpha_4$ are constant parameters specific to the robot).

Exercise 2: Rao-Blackwellization

Explain the idea of Rao-Blackwellization in general. How is the principle utilized for landmark-based SLAM, how for grid-based SLAM and where does the performance gain come from in both cases?

Exercise 3: Mobile Robot Path Planning

Assume a robot using the 5d-A* technique for path planning.

1. Construct a situation in a static environment without unknown obstacles in which the robot does not find a path close to the optimal solution.
2. Construct a situation in a dynamic environment with unknown obstacles in which the robot does not find a path close to the optimal solution.

Explain (in brief!), why the solutions are far away from being optimal.