Albert-Ludwigs-Universität Freiburg
Institut für Informatik
Lecture: Introduction to Mobile Robotics
Summer term 2008

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# Sheet 1

Topic: Drives, Odometry, Bayes

Submission deadline: Tue 6.5.2008, 11:00 a.m. (before class)

**General Notice**

To be admitted to the final exam, every student has to

- attend at least 7 of the seminars in person,
- submit solutions for at least 7 of the exercises, and
- present at least one of the solutions in class.

The exercises should be done in groups of one or two students. Bonus points for the final exam can be collected according to the following rule: Every student

- gets 2 bonus points for each solution presented by herself / himself
- and can collect at most 10 bonus points.

The bonus points will only be granted, if

- you attend at least 9 of the seminars in person, and
- your group submits solutions for at least 9 of the exercises.

Programming assignments have to be submitted electronically (for details see the homepage: `ais.informatik.uni-freiburg.de/teaching/ss08/robotics/`). Written assignments have to be handed in paper form at the class on Tuesday.

**Exercise 1:**

A robot equipped with a differential drive starts a the position $x = 0$, $y = 0$ and with heading $\alpha = \frac{\pi}{2}$ ($\frac{\pi}{2}$ is the direction of the $y$-axis). It has to move to the position $x = 300cm$, $y = 0$, $\alpha = \frac{\pi}{2}$. The movement of the vehicle is described by steering commands ($v_l$ = speed of left wheel, $v_r$ = speed of right wheel, $t$ = driving time).

(a) What is the minimal number of steering commands $(v_l, v_r, t)$ needed to guide the vehicle to the desired target location?

(b) What is the length of the shortest trajectory under this constraint?

(c) Which sequence of steering commands guides the robot on the shortest trajectory to the desired location if an arbitrary number of steering commands can be used?

(d) What is the length of this trajectory?

Note: the length of a trajectory refers to the scalar traveled distance along the trajectory.

**Exercise 2:**

**Introduction** The JAVA program `mobrob` is the basic software framework used in this course. The source code can be obtained from the class website[1]. The program can be compiled and run using the Sun JDK 1.5[2]. At this point, no additional libraries are required. Eclipse[3] is a free and convenient development environment we recommend you to use.

**Task: DifferentialDrive** Complete the method *getNewPose* in the *DifferentialDrive* class. Thus, calculate the robot pose $(x, y, \theta)$ given the old pose, the steering command $(v_l, v_r, t)$ and the distance between both wheels $l$. (A list of sample commands is given in the *DifferentialDrive* class.) Copy the programm output into a text file.

Submit your source code as well as the output file via the class website. Please consider in-code comments, self-explanatory names for variables and methods and well-organized source code in general. Make sure that your code compiles without warnings.

**Exercise 3:**

(a) Prove the conditionalized version of the general product rule:

$$P(A, B \mid E) = P(A \mid B, E) \cdot P(B \mid E)$$

(b) Prove the conditionalized version of Bayes' rule:

$$P(A \mid B, C) = \frac{P(B \mid A, C) \cdot P(A \mid C)}{P(B \mid C)}$$

[1] http://ais.informatik.uni-freiburg.de/teaching/ss08/robotics/
[2] http://java.sun.com
[3] http://www.eclipse.org

**Exercise 4:**

A student receives a positive outcome on a first-stage test for a serious but rare disease. The test reports false positives with a probability of 0.04. For simplicity, we assume that there are no false negatives. Can you assess the probability of the student actually suffering from the disease? (Hint: distinguish carefully between the proposition that the test diagnoses the disease and the proposition that the student is ill). What is your estimate, given that 1 out of 250 in the population suffers from this disease?

**Exercise 5: (optional)**

$M$ is the matrix of the joint probability distribution $p(x, y)$:

$$M = \begin{pmatrix} p(x_1, y_1) & \cdots & p(x_1, y_m) \\ \vdots & \ddots & \vdots \\ p(x_n, y_1) & \cdots & p(x_n, y_m) \end{pmatrix}$$

Prove that if the rank of the matrix is 1, then $x$ and $y$ are independent!