

ROBOTICS (26/09/2016)

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The exam will be graded IFF the following recommendations have been taken into account:

- Write clearly so that the teacher can easily understand your answers
- Write your name, surname, and student id on each sheet you deliver for evaluation
- For each exercise/question report clearly the number and sub-number (if present)
- You are not allowed to use any programmable device (e.g., smartphone, calculator, etc.)
- You can use pen or pencil, paper will be provided, you cannot use notes or books

Exercise 1 (Algorithm)

Let's consider how trajectory planning works, in particular:

- a) Describe what is trajectory planning
- b) Describe how graph-based search planning works
- c) Describe the A* algorithm for graph-based search
- d) How can motion primitives improve on basic graph-based planning?

Exercise 2 (Theory/Numerical Exercise)

With reference to a differential drive robot having a wheel base width of 50cm, answer the followings:

- a) Describe what are direct and inverse kinematics and what they are used for
- b) Provide the direct kinematics formulas for a differential drive robot
- c) Assuming the robot starts in $[x_s, y_s, \theta_s] = [0,0,0]$ compute the inverse kinematics, i.e., the wheel speed setpoints, to let the robot reach the goal position $[x_g, y_g, \theta_g] = [\sqrt{3}, 1, \pi/2]$. Assume the maximum speed for each wheel is 1m/s.

Exercise 3 (Theory)

A robot is filled up with sensors, some of them are proprioceptive others are exteroceptive:

- a) What is the difference between proprioceptive and exteroceptive sensors?
- b) Provide one example of sensor for each category
- c) What are encoders used for?
- d) Are encoders proprioceptive or exteroceptive sensors?
- e) Describe the difference between linear and rotary encoders
- f) Describe the difference between incremental and absolute encoders
- g) How does the quadrature technique work?
- h) How do absolute rotary encoders work?

Exercise 4 (ROS and Gazebo)

Describe briefly (a) what are ROS and (b) Gazebo, (c) what is their relationship and (d) how they can be used together.

Exercise 5 (Other)

Describe (a) what is scan matching, (b) how it works, and (c) what it is used for.