ROBOTICS (01/07/2017)

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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) Describe what is C-Space and how it is used for graph-based trajectory planning

Exercise 2 (Theory/Numerical Exercise)
With reference to the synchronous drive kinematics, answer the followings:
a) Describe a robot with an omnidirectional robot kinematics
b) The synchronous drive kinematics is holonomic, what does this mean?
c) Describe what are direct and inverse kinematics (in general) and what they are used for
d) Assuming a synchronous drive robot starts in $[x_s, y_s, \theta_s] = [0,0,0]$ compute the inverse kinematics, i.e., the setpoints for <u>linear and angular velocities</u>, to let the robot reach the goal position $[x_g, y_g, \theta_g] = [\sqrt{3}, 1, \pi/2\,]$. Assume the maximum linear speed is 1m/s and angular speed 1rad/s.

Exercise 3 (Theory)
Let's consider the Simultaneous Localization and Mapping problem; answer the following questions:
a) How Simultaneous Localization and Mapping (SLAM) differs from Localization?
b) How Simultaneous Localization and Mapping (SLAM) differs from Mapping?
c) Describe what is the difference between online and offline SLAM
d) Describe how scan matching works, and describe its limits
e) Provide the derivation of the recursive Bayes Filter for online SLAM

Exercise 4 (ROS and Gazebo)
Describe briefly (a) what are ROS and (b) Gazebo, (c) what it is their relationship and (d) how they can be used together.

Exercise 5 (Other)
Describe (a) how an electric DC motor works, (b) what gears coupled with a DC motor are used for, (c) what rotatory encoders coupled with DC motors are used for.