Autonomous and Mobile Robotics
Final Class Test, 2014/2015

Problem 1

Consider a differential-drive robot with velocity inputs ω_R, ω_L (respectively, angular speed of the right and the left wheel).

1. Write the kinematic model of the system in the above inputs.
2. Prove that this kinematic model is controllable.
3. Draw a sketch of a Lie Bracket maneuver.

Problem 2

Consider a circular robot with unicycle kinematics moving in a known environment containing circular obstacles. Denote by $\boldsymbol{q} = (\boldsymbol{p}, \theta)$ the robot configuration, with $\boldsymbol{p} = (x, y)$, and by v, ω its velocity inputs. The robot must reach a certain destination $\boldsymbol{p}_{\text{goal}}$ (final orientation is not assigned). Build a navigation system that integrates the following components:

1. A robot-independent module that uses the environment geometry and the assigned goal to build an artificial force field $\boldsymbol{f}(\boldsymbol{p})$.
2. A module that transforms the artificial command $\boldsymbol{f}(\boldsymbol{p})$ into actual velocity inputs v, ω.
3. A module that computes the robot state needed by the first two.

Discuss in detail the possible options and the motivation behind your choices. Provide a block scheme of your system with a clear indication of the inputs and the outputs of each block. Points that deserve special attention are: (1) which is the main difficulty in building the transformation module? (2) with your navigation system, is the robot guaranteed to converge to the destination, and under which assumptions?

Problem 3

Consider a differential-drive robot equipped with a sensor that can measure relative range and bearing between itself and certain landmarks distributed in the environment. The number of landmarks is L but their position is unknown. For simplicity, assume that (1) the sensor is located above the midpoint of the wheel axis (2) the sensor can detect and identify all landmarks, irrespective of their position. Build a localization system for estimating simultaneously the configuration of the robot and the position of the landmarks. How should the system be modified if the sensor cannot reconstruct the identity of the landmarks?

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