Autonomous and Mobile Robotics
Midterm Class Test, 2017/2018

Problem 1

Consider the following kinematic model

$$\begin{aligned}\dot{q}_1 &= q_2 u_1 + q_3 u_2 \\ \dot{q}_2 &= -q_1 u_1 \\ \dot{q}_3 &= -q_1 u_2\end{aligned}$$

1. Study the controllability of the system.
2. Write the differential constraint underlying the model, and indicate whether it is holonomic or nonholonomic based on the previous controllability study.
3. Give a geometric description of the local and global mobility of the system in configuration space.

Problem 2

Consider a unicycle robot whose driving and steering velocities are subject to the following bounds:

$$|v| \leq 1 \text{ m/s} \qquad |\omega| \leq 1 \text{ rad/sec}$$

1. Plan a geometric path that brings the robot from the origin of the configuration space to point $(1, 1, \pi/2)$ [m,m,rad].
2. Describe in detail the steps of a computational procedure for associating a feasible timing law to the planned path.

Problem 3

Consider a differential-drive robot whose control inputs are the left and right wheel angular accelerations, respectively a_L and a_R. The robot is equipped with *(i)* an accelerometer which measures (by integration) the linear and angular velocity of the robot, and *(ii)* a sensor which measures the relative bearing between the robot and a single landmark whose position is unknown. For simplicity, assume that all measurements are updated every T_s seconds, where T_s is the sampling interval of the robot control loop.

1. Write the kinematic model of the system (with a_L and a_R as control inputs).
2. Derive a discrete-time model of the system that can be used for odometric localization under the assumption that a_L and a_R are known.
3. Build an EKF for estimating simultaneously the configuration of the robot and the position of the landmark. Be sure to provide all the filter equations and a block scheme showing all the signals involved in the process.

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