Autonomous and Mobile Robotics
Midterm Class Test, 2020/2021

Problem 1

Are the following claims *true* or *false*? Answer and provide an explanation.

(a) A robot subject to a Pfaffian constraint of the form $\boldsymbol{A}^T\dot{\boldsymbol{q}} = \boldsymbol{0}$, with constant $\boldsymbol{A}$, is always nonholonomic.

(b) A robot whose configuration is described by 2 generalized coordinates and subject to a scalar Pfaffian constraint is never nonholonomic.

(c) The configuration space of a spatial manipulator with 3 revolute joints is $SO(3)$.

(d) A unicycle can follow arbitrary Cartesian paths, whereas a car-like robot cannot.

(e) In a kinematically redundant robot, position+orientation of the end-effector are a flat output.

Problem 2

Consider a unicycle moving in a planar workspace where a Cartesian inertial frame is assigned.

(a) Using the transformation in chained form, design (1) a feedback control law that drives the robot to the x axis, with orientation parallel to the y axis (the final value of x is not assigned) (2) a feedback control law that drives the robot to the y axis, with orientation parallel to the x axis (the final value of y is not assigned).

(b) Express each control law in the original coordinates, and discuss which measurements are needed for its implementation. Draw a block scheme of each control system.

Problem 3

Consider a mobile manipulator consisting of a differential-drive platform carrying a 2R planar arm, with link lengths ℓ_1 and ℓ_2. The base of the manipulator is located on the sagittal axis, at a distance b from the midpoint between the two wheels. The manipulator is equipped with ideal servo loops at the joint level, so that its control inputs can be assumed to be the joint velocities. The available sensors are (1) wheel encoders for the differential-drive platform (2) joint tachometers for the manipulator arm (3) a vision system that measures the position of the end-effector.

Design a localization system for estimating in real time the configuration of the mobile manipulator. Provide equations (be sure to define all symbols) and a block scheme. In particular, discuss clearly how each sensor measurement is used in your scheme.

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