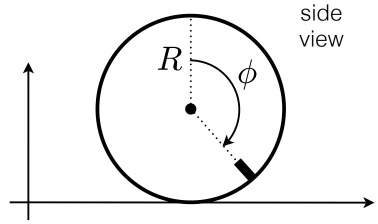
Autonomous and Mobile Robotics
Midterm Class Test, 2016/2017

Problem 1

Consider a unicycle moving on a plane and augment its configuration vector $\boldsymbol{q}$ by including the wheel angle ϕ.



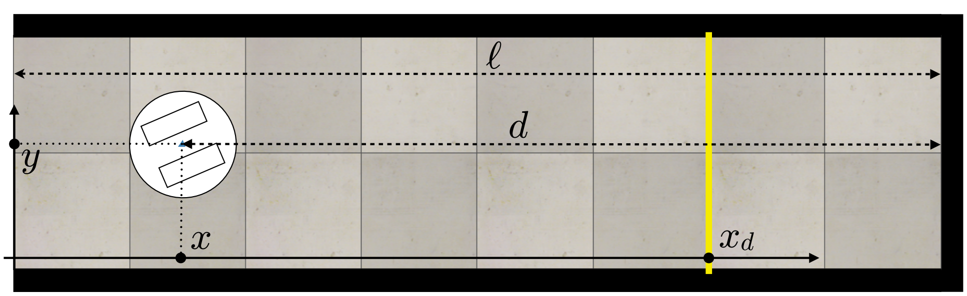
1. Define the augmented configuration space and its dimension.
2. Write the augmented kinematic model of the robot in the appropriate velocity inputs.
3. Show that the augmented kinematic model is controllable.
4. Describe a sequential maneuver for moving the robot between two augmented configurations $\boldsymbol{q}_s$ and $\boldsymbol{q}_g$.

Problem 2

Consider a (2,3) chained form system. Plan a feasible geometric path that connects the origin of the configuration space to point $(1, 1, 1)$. Be sure to provide the parametric expression of all the configuration variables.

Problem 3

A unicycle robot moves in a corridor whose end is closed by a wall. The length of the corridor is ℓ. Note the world frame.



1. Design a feedback control law for driving the robot coordinate x to a desired value x_d. The y coordinate is not of interest; however, the robot should not collide with the lateral walls.
2. Assume that the robot is equipped with a compass that measures its orientation θ and a range finder that measures the distance d to the end wall. For simplicity, assume that the range finder is located at the center of the robot. Design a localization system for estimating in real time the state variables needed by your controller. Provide equations (be sure to define all symbols) and a block scheme.

[210 min; *turn page for some hints...*]

Hints (depending on your chosen solution approach, these may be useful or not)

Problem 1

2. *As an alternative to the classical procedure, one may also write the required kinematic model by direct augmentation of the classical unicycle model.*

4. *The sequential maneuver may be found by adding one step to the basic maneuver for reconfiguring a rolling coin.*

Problem 2

The flat outputs of a (2,3) chained form are the first and the third coordinate (z_1 and z_3).

Problem 3

1. *Identify the output variable to be controlled and try input-output linearization. You can use the remaining input to keep the robot parallel to the corridor...*