Introduction to Robotics

Assignment #5

Due: 15.06.2021, 23.59

Task 5.1 (8 points) Configuration Space – Programming Task:

Given is the planar 2-DOF manipulator as seen in Figure 1.

- The base is mounted at position $(500, 500)$ of the reference coordinate system.
- The manipulator is defined as
  - link length: $l_1 = l_2 = 200$
  - joint range: $\rho_1, \rho_2 \in [0, 2\pi)$
- The reachable workspace has a radius of 400
- The workspace holds two circular obstacles
- Obstacle o_1
  - origin: $(270, 620)$
  - radius: 50
- Obstacle o_2
  - origin: $(250, 200)$
  - radius: 200

5.1.1 (6 points): Use the mechanims of configuration space to shrink the manipulator to a single point. Assume the manipulator to have no physical links and the TCP to be a circle with radius 2. Plot the configuration space with the two C-obstacles and the point-sized manipulator. Discretize the configuration space to a precision of at least $1°$.

5.1.2 (2 points): Plot the start area (circle with radius 10 around $s = (900, 500)$) and the two goal areas (circles with radius 10 around $g_1 = (580, 150)$ and $g_2 = (230, 470)$) in the workspace and in the configuration space. Draw a path from s to g_1 and from s to g_2.

Task 5.2 (7 points) Configuration Space with Links – Programming Task:

Extend your program to include the geometrical properties of the links. Assume the links to be mounted at the very edge in the center and to have a width of 10. Draw a path from s to g_1 and from s to g_2.

Task 5.3 (5 points) Arbitrary C-Obstacles – Programming Task:

Extend the program to support arbitrary polygon obstacles. Assume two new obstacles

- Obstacle o_3: a rectangle with the following corner points
  - $(650, 450)$, $(650, 200)$, $(800, 200)$, $(800, 450)$
- Obstacle o_4: a polygon with the following corner points
  - $(600, 800)$, $(550, 900)$, $(750, 900)$, $(700, 800)$, $(650, 750)$, $(600, 800)$

Plot the configuration space with C-obstacles $o_1 - o_4$. Draw a path from s to g_1 and from s to g_2.

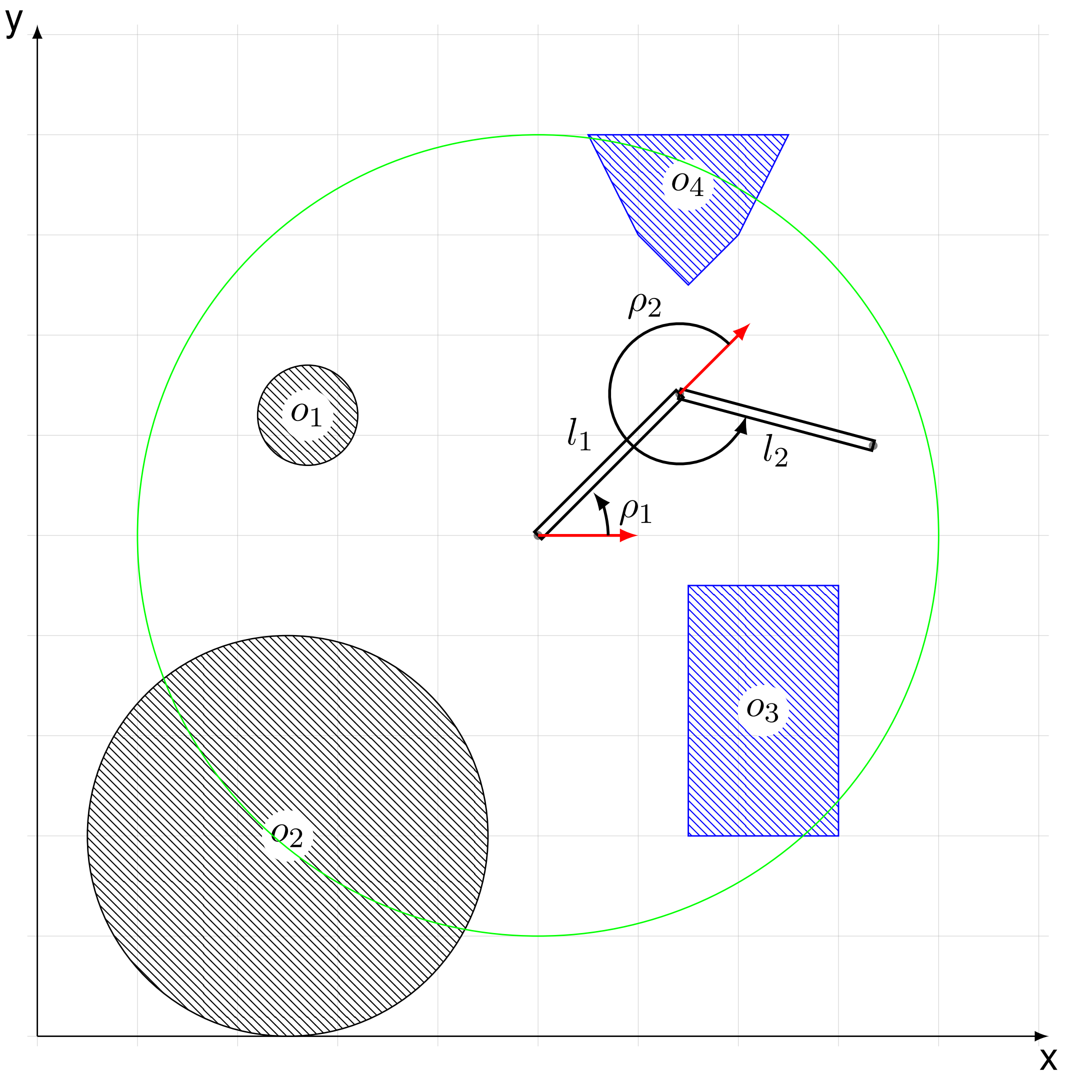

Figure 1: 2-DOF planar manipulator in workspace with obstacles. Grid distance is 100

Pay attention to the depicted direction of ρ_1 and ρ_2

The red arrows represent the zero position of the joints, the black arrows point in the positive rotation direction

Present the resulting plots as a `PDF` and pack your executable code (with all required libraries) as a `ZIP` file.

Hints:

When using python you might find useful:

Shapely library allows for polygons, circles (buffered points), affine transformations and intersections of objects `https://pypi.python.org/pypi/Shapely`

numpy is a powerful scientific library with fast array transformations and math functions `http://www.numpy.org/`

math math library grants access to sine, cosine, degree and radians `https://docs.python.org/2/library/math.html`

PIL(low) is the python imaging library which can export arrays to images `https://pypi.python.org/pypi/Pillow/2.2.1`

mulitprocessing allows to speed up your code by using multiple processes `https://docs.python.org/3/library/multiprocessing.html`