Assignment no. 4

due: Monday, March 11th, 2024

Ex 4.4 due: Sunday, March 10th, 2024

The exercises in this assignment refer to the setting of a disc (or two) moving among (not necessarily convex) polygonal obstacles in the plane, where the workspace is bounded within an axis-parallel rectangle.

Let p be a free placement of the (center of the) disc robot, namely a placement where the disc does not intersect the obstacles. We assume that the robot is an open set and the polygonal obstacles are closed sets. We define the *upward* (respectively *downward*) *vertical clearance* of a free placement p of the disc as the maximal distance it can be moved vertically upward (respectively, downward) before hitting an obstacle, and denote it by $u(p)$ (respectively, $d(p)$). The *vertical clearance* of such a free placement, $v(p)$, is defined as follows $v(p) = \min(u(p), d(p))$. The vertical clearance of a free path γ is defined to be $v(\gamma) = \min_{p \in \gamma} v(p)$.

Install and use DiscoPygal as described in the course's website. No need to install a new version if you already installed the updated version for Assignment no. 3. The PRM solver can be found in the DiscoPygal package under `discopygal\solvers\prm\prm.py`, as well as in the course's website.

For the programming assignments, please submit a single tar/zip file, named `q{num}_{id1}_{id2}.zip`. For example, for the second question: `q2_123456789_987654321.zip`. That zip file should have **only one** *.py file, containing the entire code of your solver. Additional files, like README, scenes, etc., are fine. Also please make sure that loading that single python file into the solver_viewer tool works correctly.

Check the course website for additional information regarding the submission of the programming exercises.

Exercise 4.1 (p2), 30 points Motion planning for a single disc robot with high vertical clearance.

Modify the PRM implementation for a single disc such that it will compute paths with high vertical clearance. Describe your solution in detail and report on experimental results with at least three different scenes of increasing complexity.

Exercise 4.2 (p2), 40 points Motion planning for two unit disc robots, optimizing for total length.

Devise and implement a planner that aims to minimize the total distance traveled by the two robots, namely the objective is to minimize the sum of the lengths of the two paths for the robots. You can start with the given PRM (which supports multi disc robots, but you can assume that there are only two) and modify and improve it with respect to this objective function. Alternatively, you can implement a different solution altogether. Design three scenes on which you will demonstrate the quality of your solution. Describe your solution in detail, describe the scenes that you designed and explain why they were chosen, and report on experimental results.

Notice that there are additional exercises on the other side of the page.

Exercise 4.3, 30 points Two unit disc robots are moving in the plane. One robot moves along the polygonal path $\pi_1 = u_0, u_1, \ldots, u_m$, namely, the robot starts with its center at the point u_0, moves along the line segment u_0u_1 and so on until it reaches u_m. The other robot moves along the polygonal path $\pi_2 = v_0, \ldots, v_n$. The robots are not allowed to move backward along their respective paths. In this exercise there are **no obstacles** in the workspace and the robots just need to avoid collision with one another. We are given a parameter $\Delta > 0$ and we need to determine whether there is a coordinated motion of the robots along their respective paths, such that at all times they are at least Δ away from one another. Design an efficient algorithm to decide whether such a motion exists. A possible way to describe a coordinated motion is to indicate for every position of the first robot along π_1, what is the position (which can be a point or a sub-path) of the other robot along π_2.

Exercise 4.4, due: March 10th(!), 2024 Choose a topic for your final personal project. It should include an experimental section. Write a short text, between 5 to 15 lines, about the problem you plan to address, and upload it to the Moodle page at the assigned spot. Wait for approval of the project by the course's team before you start working on it.