ECE8843 Assignment 3 : Robot Path Planning

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I. Problem Statement

Robbyna is a robot located in a known 2D environment. Having as input data the start and goal location of the robot, as well as its dimensions, find a path of waypoints (x, y) to reach a given goal position.

The initial map is shown below:

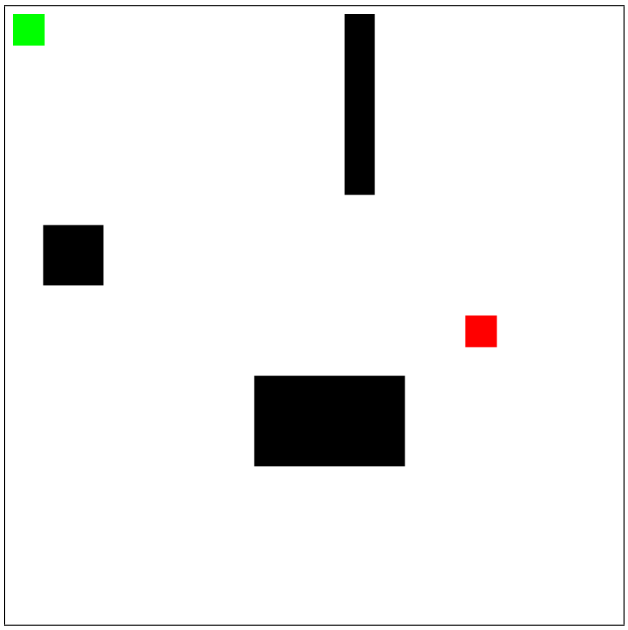

Fig. 1. Original map

A. Initial Conditions

- *Start Location:* $(0, 0)$
- *Goal Location:* $(15, 10)$
- *Robot Dimensions:* $(1, 1)$

and the obstacles are located as shown in Table I

TABLE I
ORIGINAL OBSTACLES METRICS

Obstacle	*Original Location*	*Original Size*
0	$(8, 12)$	$(5, 3)$
1	$(1, 7)$	$(2, 2)$
2	$(11, 0)$	$(1, 6)$

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B. Assumptions and definitions

Since the problem statement does not pose any constraint on the robot's movement, I am assuming that the agent is capable of omnidirectional movement.

We define each grid as having possibly one one out of 3 states:

- *Free:* None of the area occupied by the grid is occupied by an obstacle
- *Obstacle:* Some or all of the area occupied by the grid is part of an obstacle
- *Inflated:* Space that cannot be reached by the robot and that is in the neighborhood of an obstacle

II. Obstacle Growing

We implemented a simple function that grows the existing obstacles. The function evaluates each grid on the 2D world. If the grid is an *obstacle*, then it will inflate the obstacle by setting the *free* neighbors to an *inflated* state.

The map with grown obstacles is shown in Fig.2. The new dimensions of the obstacles are shown in Table II. In general the obstacles were inflated approx. 1 grid at each side (with the exception of obstacles at the border of the map)

TABLE II
GROWN OBSTACLES METRICS

Obstacle	*Location*	*Size*
0	$(7, 11)$	$(7, 5)$
1	$(0, 6)$	$(4, 4)$
2	$(10, 0)$	$(3, 7)$

III. Probabilistic Random Map

After growing the obstacles we generated a roadmap to represent our environment. Our method of choice was Probabilistic Roadmaps. We generated a roadmap with 350 random nodes, which produced a very dense map. The edges in the map were generated by joining nodes with a distance between them of less than 2.0 grid units. We chose a small value to avoid having to test for collision along the edges.

The roadmap obtained can be seen in Fig.3. Blue circles represent the nodes and the magenta lines are the edges. The green and red rectangles represent the start and goal location.

IV. Path Search

The PRM generated in the previous section is nothing more than an undirected graph composed of nodes and edges. To find the path between the start and goal location, first we located the two nodes closest to the start and goal location

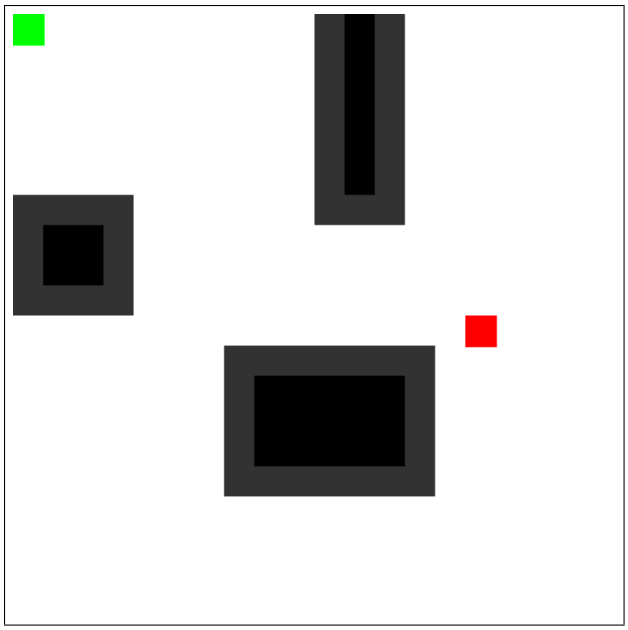

Fig. 2. Map with grown obstacles

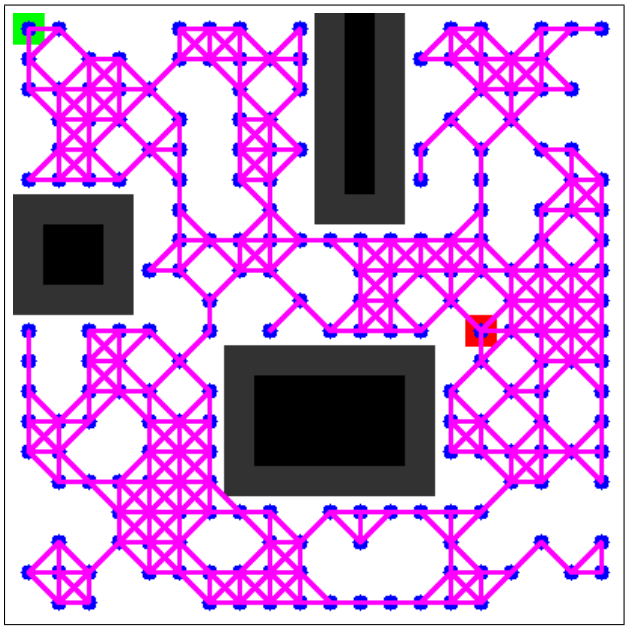

Fig. 3. Roadmap with 350 nodes

and then performed a breadth-first search between these nodes. Once found a path between these two, we just attached the original start and end locations to the extremes of this path. Since our PRM is very dense, the joining of these locations did not require collision checking.

Our breadth-first procedure assumed that all connected nodes had the same distance with respect to their parent node. This is not exactly true, since some children nodes where directly at the left, right, up or down directions of their parent, whereas other were at diagonal direction, hence their distances were not the same. However, since these are small we decided not to assign them different costs in order to preserve simplicity.

The path found is the green polyline depicted in Fig.4. The waypoints that compound the path are shown in Table III

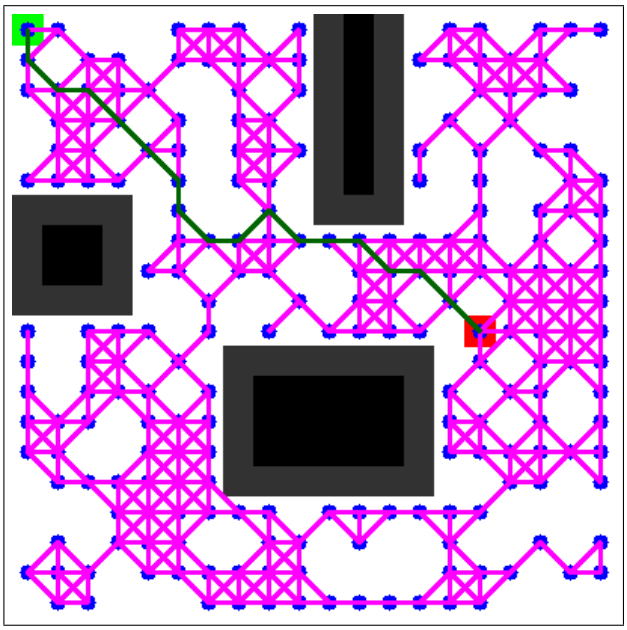

Fig. 4. Path found highlighted in green

TABLE III
WAYPOINTS

Waypoint	*Location*
0	$(0, 0)$
1	$(0, 1)$
2	$(1, 2)$
3	$(2, 2)$
4	$(3, 3)$
5	$(4, 4)$
6	$(5, 5)$
7	$(5, 6)$
8	$(6, 7)$
9	$(7, 7)$
10	$(8, 6)$
11	$(9, 7)$
12	$(10, 7)$
13	$(11, 7)$
14	$(12, 8)$
15	$(13, 8)$
16	$(14, 9)$
17	$(15, 10)$
18	$(15, 10)$