Homework 5

16-311: Introduction to Robotics

2018

Contents

1 Learning Objectives

1. Review definitions of motion planning.

2. Develop intuition of configuration space.

3. Gain experience with path planners.

2   Motion Planning Definitions

1. What does it mean for a planning algorithm to be complete?

2. What is the difference between workspace and configuration space?

3. In the image below, is a or b closer to X by the L1 metric?
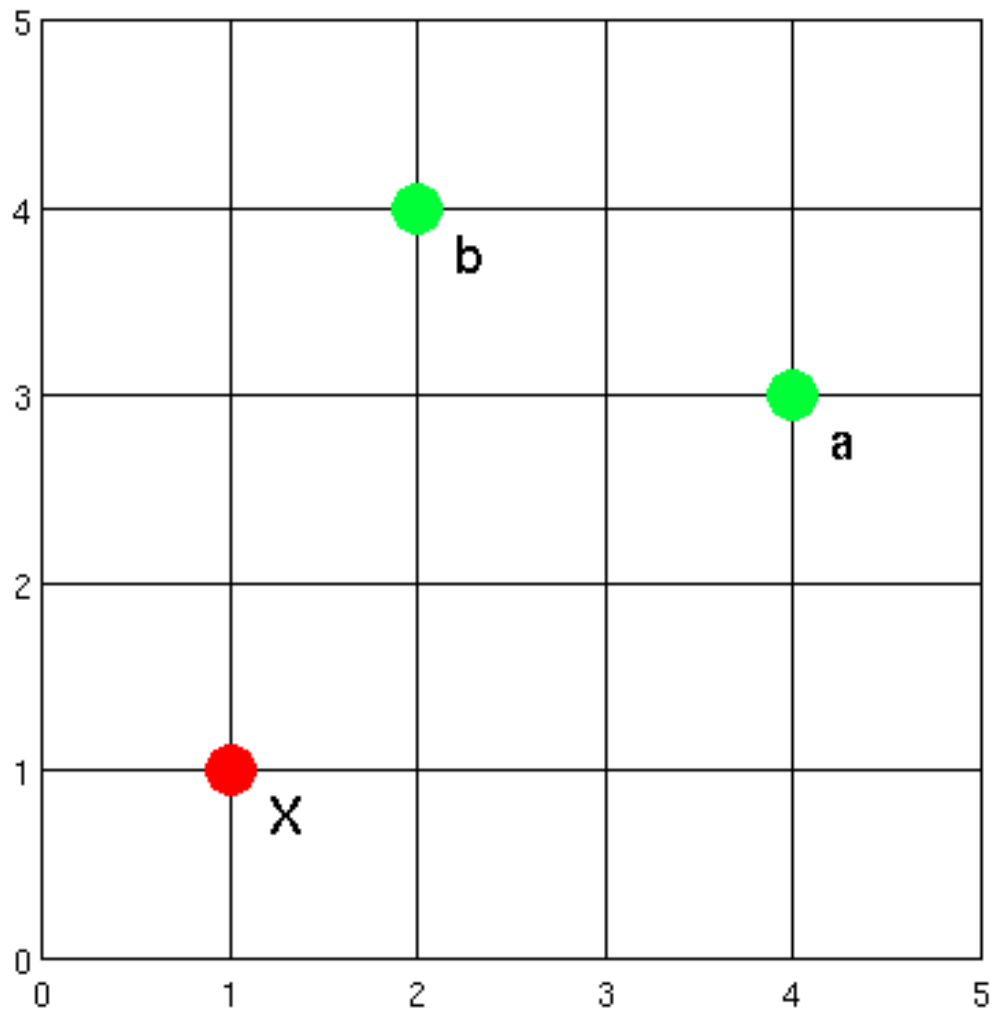
4. Is a or b closer to X by the L2 metric?

Figure 1: Starting X and two possible goals, a and b.

3 Configuration Space Practice

For the sample environment in the figure below, draw the resulting path from the wavefront planner (in the continuous domain, ie. not with pixels) for the mobile robot using the L1 metric. Remember to take into account the configuration space of the robot and assume that the walls are obstacles as well.

Create multiple copies of the figure, and submit the following:

1. One copy showing the configuration space.

2. One copy showing the wavefronts.

3. One copy showing the resulting path(s).

The figures can build on each other (i.e. the copy with the wavefronts can be the copy with the configuration space with wavefronts on top of it, etc.). You can do this in a program like MS Paint or hand draw the pictures and include pictures on your pdf.
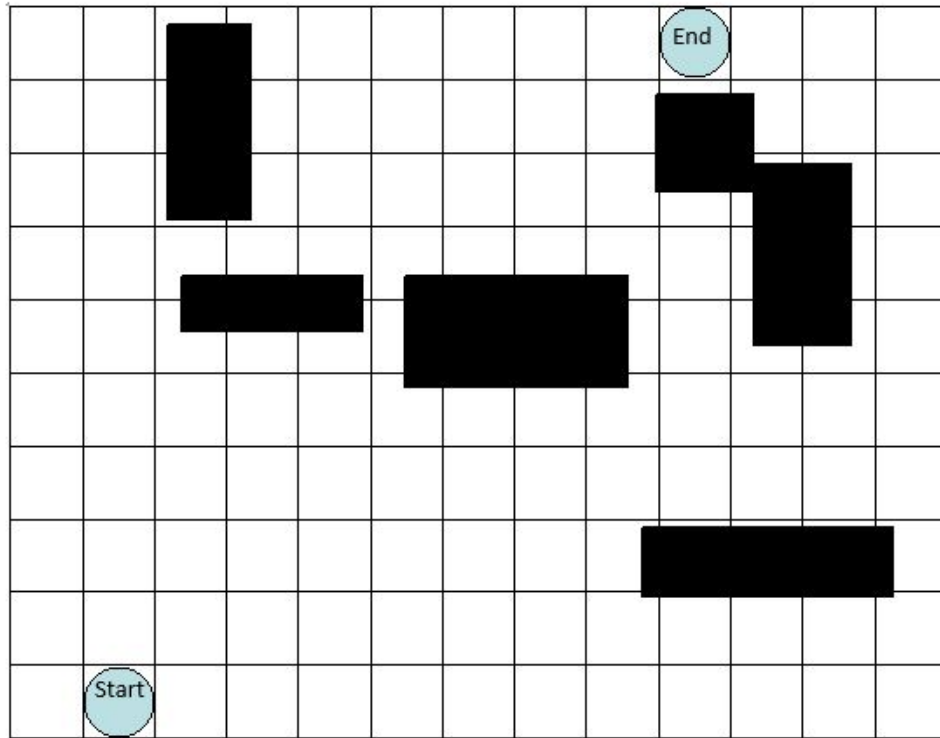

Figure 2: Workspace with obstacles.

4 Bug Algorithms

For the configuration space in the previous question, draw the path from the start to the goal using either the Bug 1 or Bug 2 algorithm and indicate which one you used.

5 Configuration Space Intuition

The goal of this section is to improve reasoning on movement through a configuration space.

The image below shows an example two-link robot arm (red). This robot can only pivot its joints, the first joint is fixed in x and y. The circle at the bottom of the robot represents the first link. Here, horizontal to the right is 0 degrees. The second link is represented by the circle in the middle of the arm. For this link, 0 degrees is when this link is colinear with the first link. Assume no joint limits.

On the image on the right, draw the shortest path from start to goal. On the image to the left, draw three intermediate configurations uniformly distributed throughout the path.
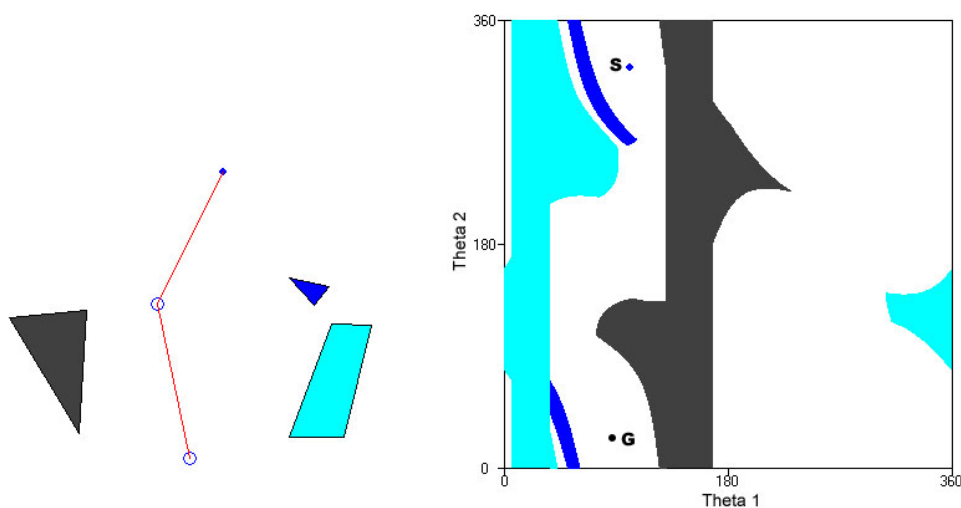

Figure 3: Left: Robot arm with real-world obstacles. This arm is in the starting (S) configuration. Right: Configuration space for arm robot.

6 Visibility Graph

Here, we will create a visibility graph for a sample workspace with polygonal obstacles. This methodology will be helpful for the path-planning lab.

Create the visibility graph for the following environment. You may hand-draw this, use an image editor or create a program to accomplish this task.
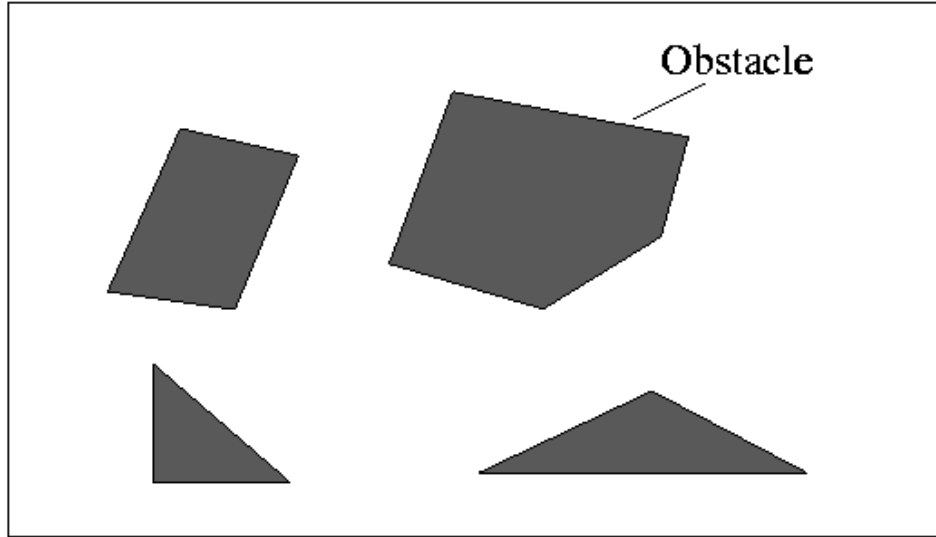

Figure 4: Sample Environment 1.

7 Voronoi Diagram

Using the same environment image, draw a Voronoi diagram using either the Manhattan distance (L1) or the Euclidean distance metric (L2). For the Manhattan metric, use a diamond. For the Euclidean metric, you can envision and circle that expands and contracts; when two or more points on the circle touch an obstacle, the center is on the Voronoi diagram.

You can draw this image by hand, use an image editor or write a program that accomplishes this task.
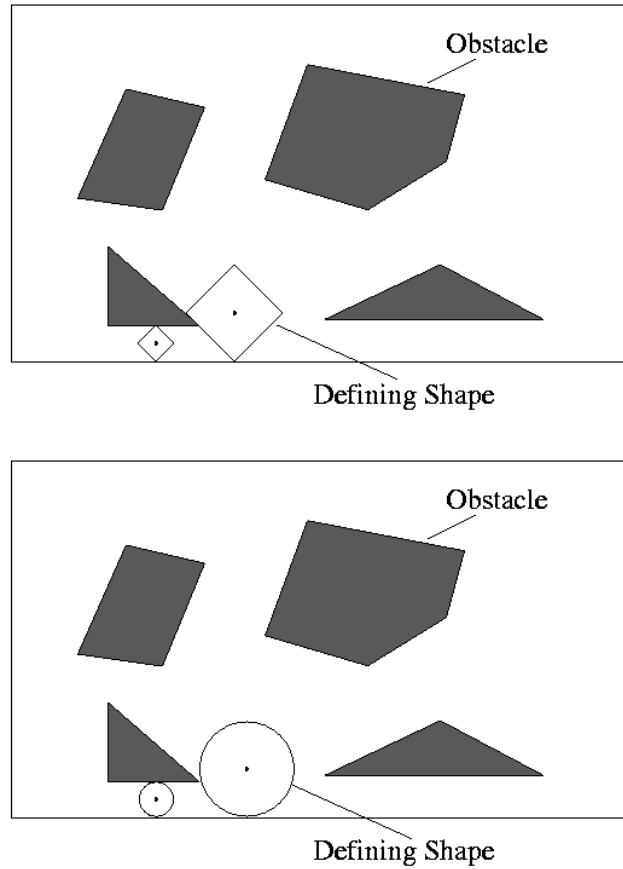
Figure 5: Top: Sample Environment 1 with square. Bottom: Sample Environment 1 with cicle.

8 What To Submit

Submissions are due on Autolab by the date specified in the Syllabus.

1. Create a .pdf file with the written answers to ALL THE SECTIONS named hw5.pdf.

2. Ensure all required images are here (three images for configuration space, one for the bug algorithm, one for the arm configuration space, one for visibility graph, and one for voronoi diagram).