CMPE-633 : Topics in Robotics and Control
Problem Set # 2

Fall 2010

Due Date : Nov 8th, 2010 (Nov 10th with 25% late penalty).
Total Points : 100.

Problem 1. A^* Algorithm. (25 Points)

1. Generate a discrete configuration space that resembles a rectangular grid of finite dimensions. Each square in the grid has 8-connectivity with its neighbors. The robot occupies one square at a time.

2. Mark the boundary of the grid as an obstacle wall. Also, throw some randomly places obstacles in the space. For an example, see Figure 2.2 in LaValle.

3. Implement the A^* algorithm for path planning on this discrete configuration space. Assume that the cost of moving the robot to its adjacent position is 1. The hueristic distance in the algorithm is taken as the Euclidean distance between two grid points.

Use MATLAB or C to implement this algorithm. Use appropriate graphics to show the execution of the algorithm for arbitrary choices of start and goal squares.

Problem 2. Star Algorithm (25 Points)

1. Generate a polygonal 2D robot having at least 4 vertices. (For higher number of vertices, make sure that your robot is convex).

2. Generate arbitrary convex polygons as obstacles in a planar configuration space.

3. Implement the star algorithm (in MATLAB or C) to convert this workspace into a configuration space.

Problem 3. Roadmap Construction and A^* (20 Points)

1. Take an example output of your code from Problem 2 and enclose in a rectangular box (if you have not already).

2. Using pencil and paper, perform the vertical decomposition of Example 6.1 (LaValle) to generate a roadmap for this configuration space.

3. Encode this roadmap as a discrete configuration space using graph theory. (e.g. write down the adjacency matrix)

4. Suggest, how would you implement the A^* algorithm on this discrete algorithm?

5. Finally, put everything together and discuss how would you do path planning for the robot, combining all of the machinery you have developed.

Bonus (10 points) Implement this problem in MATLAB or C code.

Problem 4. Rigid Body Configuration Spaces (20 Points)

Consider a 2D robot as depicted in the Figure below. It has two revolute and one prismatic joints.

1. Sketch the configuration space of this robot. Determine degrees of freedom and an appropriate coordinate system.

2. Clearly indicate the topology of this configuration space.

3. Map the obstacle shown in the workspace to the configuration space.

4. Briefly discuss the issues in implementing navigation functions, visibility graphs, Voronoi roadmaps, Bug algorithms on this configuration space.

Bonus (10 points) Implement this problem in MATLAB or C code.

Problem 5. Configuration Spaces. (10 Points)

Give the configuration space and DOF of the following mechanisms.

1. A door handle connected to a door.

2. Two point robots in 2D trying to maintain wireless connectivity with each other.

3. A train on tracks with 10 compartments and 16 wheels on each compartment.

4. A fighter aircraft being fueled in the air by a large transport aircraft.

5. A tractor pulling a trolley.