COMP3702/COMP7702 Artificial Intelligence (Semester 2, 2020)

Assignment 2: Continuous motion planning in Canadarm

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**Question 1** (Complete your full answer to Question 1 on the remainder page 1)

The configuration space (C-space) is the set of all possible robot configurations. A robot has limitations on the states that it can occupy, thus not being able to visit the entire state space of an environment. The restrictions on the robot are due to limitations on its degrees of freedom. A configuration of the robot can be represented as a list of each segment’s length and the angles at each joint.

I am using probabilistic roadmap (PRM) to solve the given problem of finding of moving the robot arm between its original and goal state.

**Question 2** (Complete your full answer to Question 2 on pages 2 and 3, and keep page 3 blank if you do not need it)

**sampling strategy**

Uses workspace information to narrow passages in C-space,

Firstly, breaks task into a sequence of partition spaces, number of partition spaces equals to number of grapple points, uses bridge configs to connect up two adjacent partition spaces, makes each partition space has both initial config and goal config, then solves the partition spaces in order.

Secondly, for each partition space, repeatedly sample a certain number(100 initially) of collision-free robot configurations with a random sampling strategy, then adds these configurations to a list G.

**Checking if a configuration is valid or not**

While taking the samples, checks each robot configuration(posture of arm) whether it is collided with obstacles or itself using method *test\_obstacle\_collision()* and *test\_self\_collision()* respectively, if a collision is detected, then discard this robot configuration, otherwise add it to list G.

**Connection strategy**

Using Lazy Approach strategy, for the robot configurations in list G, add edges(neighbors) to all pairs of vertices located within a certain distance of each other(no collision check), the distance here is an average value of Manhattan distances of all points(joints of arms) between two robot configurations. Each robot configuration has approximately 10 neighbors when the distance is initially set to 0.25.

**Checking if a line segment in C-space is valid or not**

Finds a path(a sequence of robot configurations) by calling *find\_graph\_path()*, for each pair of adjacent robot configurations in path, discretises the line segment between them into primitive segments(robot configurations), for each primitive segment, checks if it is collide or not, if a collision is detected, then discard neighbour connections for this pair of adjacent robot configurations, repeat finding a path, otherwise a valid path is found.

**Question 3** (Complete your full answer to Question 3 on page 4)

The method used to solve the problem is complete, meaning that the arm will be able to find a path to its goal state if one exists. Our robot in essence uses a BFS search, it means our program will find the optimal solution, however it is not time efficient. This means our program would solve a problem spec with a single grapple point efficiently, but for a situation requires lots of samples such as the arm needs to grab the grapple points a few times to reach the final position, our robot would fail due to time limit.

A negative aspect to the sampling strategy used is in the case of a very restricted environment, with many obstacles and small gaps between obstacles. The random sampling strategy used does not selectively sample closer to obstacles and inside passageways, and as such, could have its efficiency greatly increased in these scenarios if modified to do so. By sampling randomly in conjunction with the heuristics used however, the probability that the goal state is found quickly is very high in the case that the environment does not have many small passageways. The sampling strategy also makes it difficult for the arm to connect to a grapple point, in the scenario where the grapple point ‘collision’ area is extremely small (and/or just has an extremely low tolerance value), due to the spread of the random sampling.