COM S 476/576 Project 3: Finding Paths Using PRM and RRT

Due Apr 6 at 11:59pm

In this project, we will practice using RRT (Section 5.5) and PRM (Section 5.6) to solve planning problems.

The C-space and C-space obstacles Consider the C-space $\mathcal{C} = [-3, 3] \times [-1, 1]$ and C-space obstacles shown in Figure 1. The C-space obstacles are defined by two half circles centered at $(0, -1)$ and $(0, 1)$, respectively, both having radius $1 - dt$, where $dt = 0.02$. (I suggest making dt a parameter in your code. We will consider a similar configuration but with a different value of dt in the next project.) Anything within the two half circles are considered obstacle regions.

The initial configuration is $q_I = (-2, -0.5)$ and the goal configuration is $q_G = (2, -0.5)$.

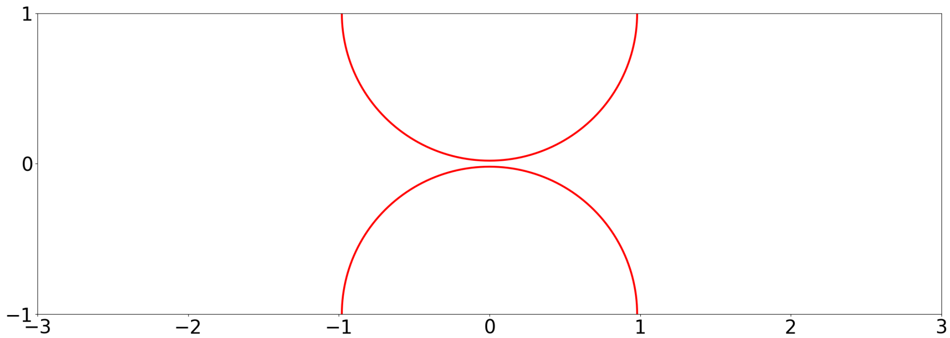

Figure 1: The C-space and C-space obstacles.

Task 1 (Exploring the C-space using RRT) [10 points for 476, 6 points for 576]: Neglect the goal configuration. Use the Euclidean distance as the distance metric. Explore the C-space using RRT and plot the resulting tree in the C-space for the following cases. The result should be similar to Figure 2.

(a) Neglect the obstacle and assume that $\mathcal{C}_{free} = \mathcal{C}$.

(b) Take into account the obstacles. Use a step size of 0.1 for collision checking.

Task 2 (Solve the planning problem using RRT) [10 points for 476, 6 points for 576]: Use the single-tree search outlined in Section 5.5.3. You should check periodically if the tree can be connected to q_G. This can be easily done by setting $\alpha(i)$ as q_G with a certain probability p. For example, the book recommends $p = 0.01$. You should have this as a parameter in your code. Once q_G is successfully added to the tree, quit the loop and compute the path from q_I to q_G. Plot both the resulting tree and path. The result should be similar to Figure 3, which uses $p = 0.1$.

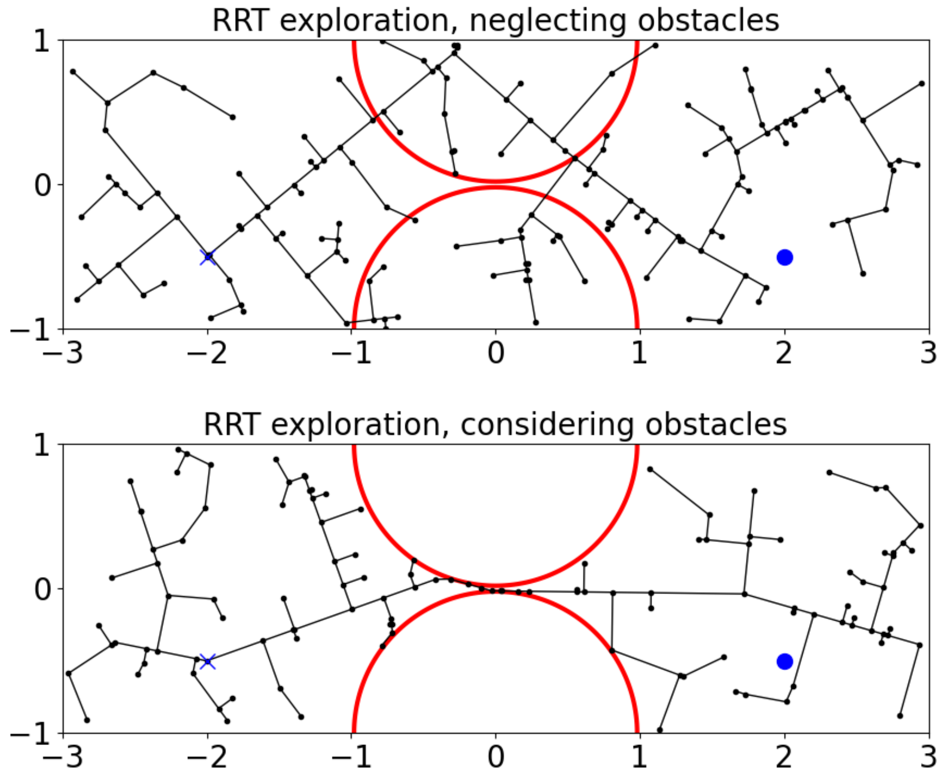

Figure 2: The result of RRT exploration. The black lines are the edges in the tree. The blue cross and the blue dots are the initial and goal configuations, respectively. (top) Task 1(a), and (bottom) Task 1(b).

Task 3 [required for 576, bonus for 476] (Solve the planning problem using PRM) [8 points for 576, 5 bonus points for 476]: This last part of the assignment is required for those taking COM S 576 only. 5 bonus points will be given to those taking COM S 476 who correctly completes the task.

Use the algorithm described in Figure 5.25 in the textbook. As for the number of nodes N, try a different value until you can solve the problem. When connecting to the nodes in the neighborhood, use Nearest K and set $K = 15$. Figure 4 shows a solution using $N = 1000$, including the roadmap and the path.

Submission: Please submit a single zip file on Canvas containing the followings

- your code (with comments, explaining clearly what each function/class is doing),
- the plots from each of 3 tasks, similar to Figure 2-4, and
- a text file explaining clearly how to compile and run your code.

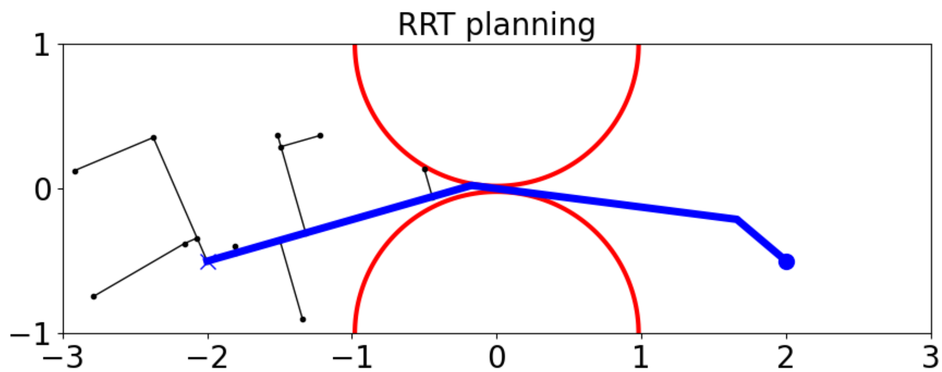

Figure 3: The result of RRT planning with $p = 0.1$ as described in Task 2, showing the tree and the path from q_I to q_G.

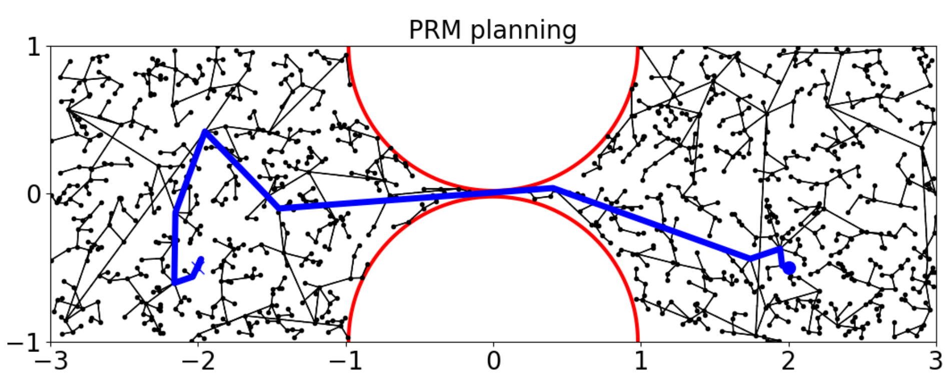

Figure 4: The roadmap and the path from q_I to q_G using PRM with $N = 1000$.