MECH 550
Project 2
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1. A succinct statement of the problem that you solved.
Problem 1: Check whether a point(random location) is inside the given obstacles.
Problem 2: Check whether a circle(random location and size) is inside or intersect with the given obstacles.
Problem 3: Check whether a square(random location, size and rotation angle) is inside or intersect with the given obstacles.

2. A short description of the robots (their geometry) and their configuration spaces.
Problem 1: The point robot. A point has two parameters, its x-axis coordinate(x) and y-axis coordinate(y). x and y defines its location in the workspace. Its configuration space is the same as the workspace. Figure 1 shows the configuration space for a point robot, which is exactly the workspace.

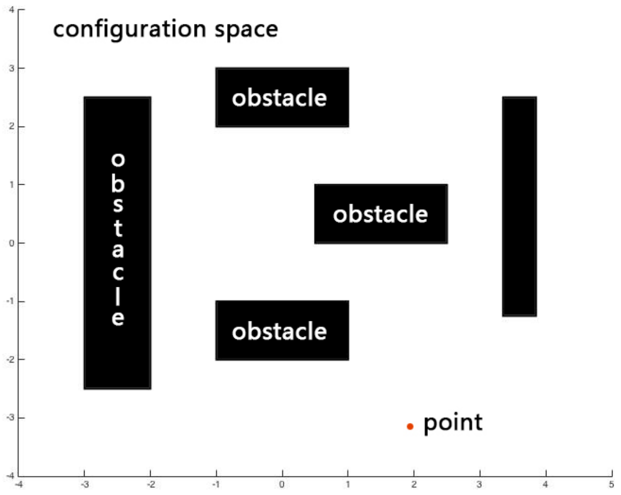


Figure 1 Configuration space for a point robot

Problem 2: The circle robot. A circle has three parameters, the x-axis(x) and y-axis(y) coordinates of its center and the radius. x and y defines its location in the workspace and radius defines its size. Since the radius does not change, the configuration of the robot has two DOFs. Figure 2 shows the configuration space for a circle robot.

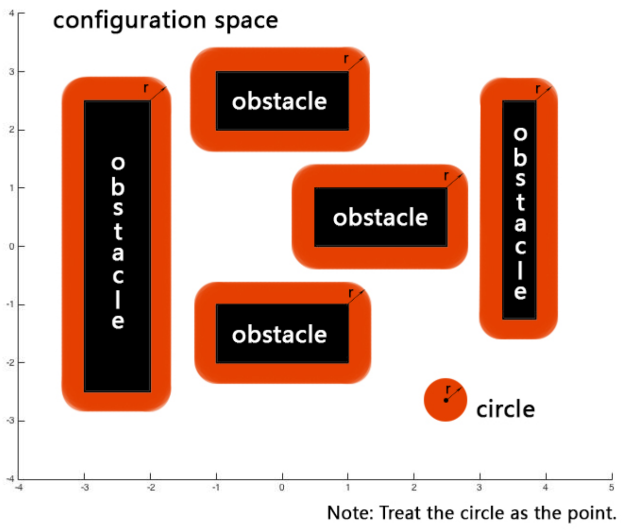
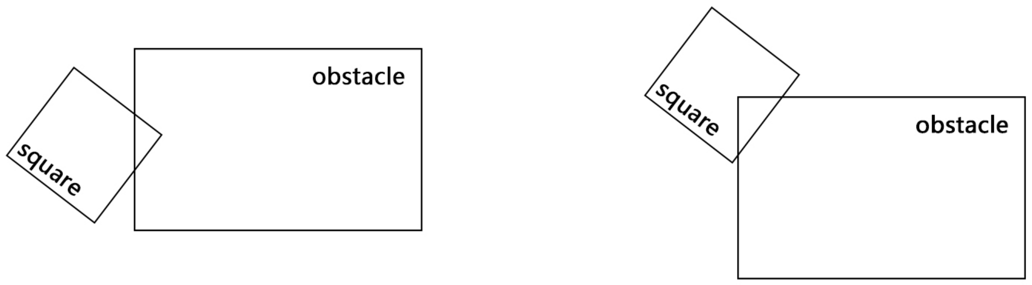


Figure 2 Configuration space for a circle robot

Problem 3: The square robot. A square has four parameters, the x-axis(x) and y-axis(y) coordinates of its center, the length of its edge SideLength and the rotation angle θ with respect to its center. x and y defines its location in the workspace, SideLength defines its size and θ defines its rotation state. Configuration space for a square robot is a 3 dimension spaces, since it has 3 DOFs (x, y, θ).

3. 1) A summary of your experiences in implementing the different collision checkers.
Collision checker 1 and 2 are relatively simple. We carefully implemented and tested checker 1 for the possibility of later use. Checker 3 is the most difficult one. We came up with two algorithms to implement checker 3.

Algorithm 1: Check whether any edge of square intersects with edges of obstacles.
Algorithm 2: Judge whether any corner of the square is in obstacles; or any obstacle's corner is inside the square.
Case 1: Judge whether any corner of the square is in obstacles.
In this case, apply the point checker of the four corner of obstacles to simplify our algorithm.
Case 2: Judge whether any corner of the obstacles is in the square.
In this case, since the square is rotated by θ, i.e. the edge is not parallel to the axises, we cannot directly use point checker. Instead, we rotated both obstacles and square (pivot is the center of square) by – θ. Then we use. Figure 3 illustrates case 1 and 2.



case 1: One or more corner points of the square are in collision with the obstacles.

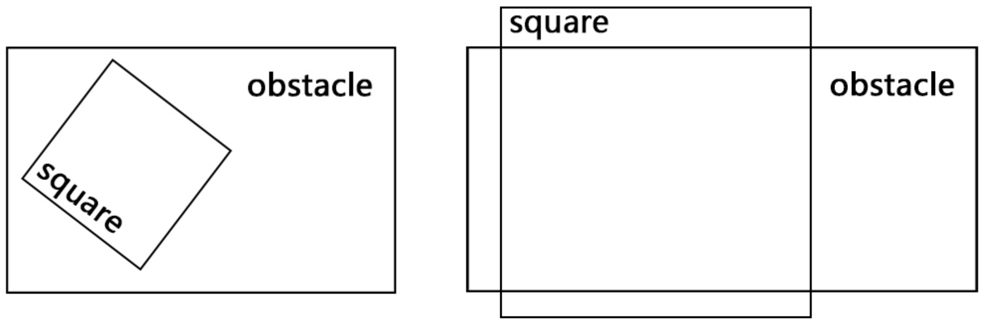
Case 2: One or more corner points of the obstacles are in collision with the square.

Figure 3 Two cases in algorithm 2.

Later we decide to implement algorithm 2. Since implementing algorithm 1 will encounter the annoying line segment situation. And the point checker helps in algorithm 2, which make it easier to implement. Implementing the algorithm took us some time. However, everything worked out eventually.

Unfortunately, later we found that neither of the two algorithms are perfect. They all have missing cases. Missing case of algorithm 1: When the whole square is inside the obstacles, or the obstacle is inside the square. This algorithm does not work.

Missing case of algorithm 2: When square and obstacles are intersected but not have corners in the others. Figure 4 shows the missing case of algorithm 1 and algorithm 2.



Missing Case of Algorithm 1

Missing Case 1 of Algorithm 2

Figure 4 Missing cases for algorithm 1 and algorithm 2

2) Were there any cases that were particularly easy/difficult?
Yes, Problem 3 is much more difficult than the other two and it is harder than what we have thought. The square robot has four parameters to define its shape, location and rotation in the space. And this problem is more complicated because we need to consider different cases, to solve each case we need to consider both rotation and translation of the square, while doing other two, considering translation of the robot is just enough. As the rotation in the work place is based on the origin of the work place, so when we to try to deal with the rotation angel θ, we have to transform the coordinates of every point of robots and obstacles. While doing this we meet many corner cases. And finally, it takes us seven hours to finish the codes and pass the test but we still have one case not included in.

3) Did you run into any numerical precision issues or other similar complications?
No.

4) Does your implementation accurately classify the given test sets?
Yes.

5) How did you debug your implementation?
We output the parameters of the mistake robots (point, circle and square), and visualized the wrong cases given obstacles and them in the MATLAB to see and try to explain why these robots were not fit with the codes. If we could not see obvious problems in the output graphics or codes, then we wrote debug codes to see which case appeared to went wrong. If it still did not work, we output every parameter of the object and obstacles, which we used functions to calculate, to see whether they were wrong.

6) Does your code accurately classify all of the optional test sets?
Yes. The optional test sets actually is the missing case for algorithm 1. However, our algorithm can classify these points correctly.

4. 1) Rate the difficulty of each exercise on a scale of 1–10 (1 being trivial, 10 being impossible).
Problem 1: 4
Problem 2: 4
Problem 3: 7

2) Give an estimate of how many hours you spent on each exercise, and detail what was the hardest part of the assignment.
Problem 1: 3 hours
Problem 2: half an hour
Problem 3: 7 hours
The hardest part of the assignment:
Sichao Zhang's answer:
The hardest part of the assignment is to solve problem 3. We considered two cases(case1 and 2) to cover all the possible situations to solve this problem at first time. However, there turned out a lot of mistakes when we finished the codes. Then we realized that the rotation in the work place was with respect to the origin point of the work place but not the center of the square. So it took us some time to do the calculation and then we wrote a rotation function that enabled a random point in work place can rotate around a given point in a given angle. However, we we had one case(case 3) that was not included in the codes although our collision checker passed the test.

Peiguang Wang's answer:
The hardest part of the assignment is the debugging part. To get a more direct feeling of the wrong cases, we write a MATLAB program to visualize the obstacles and object. Thanks to that visualization program, we find mistakes in our rotation formula. Also, when a visualization does not help us debugging, we tracked every variables and tested them. Debugging needs a long time as well as patience.