**AEEM 5117/6117: Intelligent Robotics**

**Course Project #2**

**4. b) Design and implement a traditional control system (kinematics control) for the robots to accomplish the task in the sense that the total travel distances of the two robots is minimum.**

**Solution**:

Given the width and depth of opening equal to 2 and 1 correspondingly and the length of the rod is 5 (2.5x of width of the opening). Let *(x1, y1)* denotes robot 1 position, *(x2, y2)* denotes robot2 position and θ denotes the angle of rod in the coordinate system which is shown in figure 1. The problem is to find the shortest path of moving robots from their initial position to outside of the room (*y1 > 1* and *y2 > 1*).



Due to the constraints of rod, walls, opening, the robots could only carry the rod out of the room through the opening without hitting the wall and keep a fixed distance between them.

Consider that robots could rotate the rod, **the total travel distance of two robots should be sum of move distances and rotate distances**. And the whole path could be dived to **three parts: inside room, in opening and outside room**.

* Part 1: Inside room, there is no obstacles the robots could move without restriction. So, the shortest path is the straight line between initial position and target position (*y == 0* and *-1 < x < 1*) for each robot. Straightly moving will travel shorter distance than rotating during this part.
* Part 2: In the opening, both robots are constrained by the opening, so the best way is move both robots in straight line until one of them reach the final target position (*y == 1*), it will travel more distance with rotating the rod than moving them straightly during this part. And then move another robot into the opening with least travel distance.
* Part 3: Once anther robot in the opening (*y == 0, -1 < x < 1*), to achieve the shortest travel distance, rotating could be performed as it can move one robot with fixing another.

Since the whole space is symmetry about y axis, we could consider the problems with initial position on one side of the room and apply the same strategy to the problems with initial positions on the other side.

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| **Part1**   1. Θ > α      1. Θ < α | 1. Moving R1 to position (-1,0) the total travel distance is 2. Need to rotate the rod until its angle equals to α, which is the minimal angle for move Robot 1 to the target position (y==1) without any other rotation. The position of robot 1 after rotation is (x1’, y1’), The total traveled distance will be |
| **Part 2**   1. Move R1 to target position (y==1)   2 possible paths     1. Move robot 2 into the opening (-1, 0)   2 possible paths | There are two options for move R1 to the target position (y==1)  Option1:  Option2:  **Consider the angle of rod: α <= θ <= , with Option 1, the total travel distance is shorter than with option 2.**    Move R2 into the opening (-1, 0)  The total travel distance is  Option1:  Option2:  **Consider the angle of rod: α <= θ <= , with Option 1, the total travel distance is shorter when θ > 0.8; but when α < θ < 0.8, the total travel distance is shorter with option 2;** |
| **Part 3**   1. Move R2 out of room   3 possible paths    Illustrate for distance calculation for option 3     1. General case | There are three options for move R2 to the target position (y==1)  Option1:  Option2: move directly for x, then rotate R2 to the target position (-1,0).    Where  **option 2 vs option 1**    Option3: rotate R1 with firstly, then move directly and rotate R2 to the target position (-1,0). So, the total move distance is  **option 2 vs option 3**    **Consider the 0.4636 <= θ <= 1.57, with option 2, the total travel distance will be shortest when θ <= 0.75, but with option 1, the total travel distance will be shortest when θ > 0.75.**  More generally, when **θ <= 0.75**, if there is space () to rotate robot2 with fixing robot1, the total travel distance for rotating robot 2 will be shorter than directly moving both robots. |

**Special case discussion for Part 1**

If the initial position of rod is on the left of the room with negative value of angle, which is shown in below figure. The are two possible paths for moving one of the robots to the target position (*y == 1*) for the part 1. Which option is better for traveling the shorter distance?



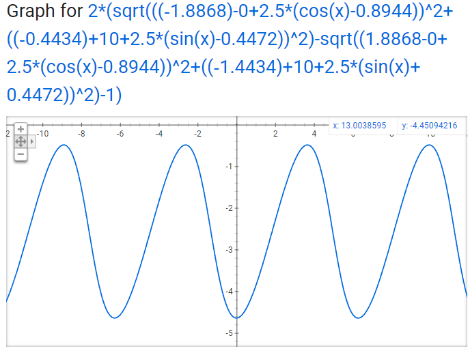
Consider the center of the rod at initial position (*x, y*) and the angle of rod is *θ, -α <= θ < 0*. (as *θ >= 0*, option 1 is obvious better). Try to move the rod in the room until one of the robots reaches the target position (*y==1*).

For option 1, the total distance includes rotating rod until *θ==α*, then move center of rod to (-1.8868, -0.4434) with one robot reach the target position (*y==1*).

For option 2, the total distance includes rotating rod until *θ==-α*, then move center of rod to (1.8868, -0.4434) and finally move one robot to target position (*y==1*).

If the initial position is given, we could know which option leads to the shorter travel distance.

For example, given (*x,y*) = (0,-10), D1 < D2



Give a fixed *y == -10*, the relationship of D1 and D2 relies on angle of rod and *x*.

And D1 < D2 when *x* is about smaller than certain value.

