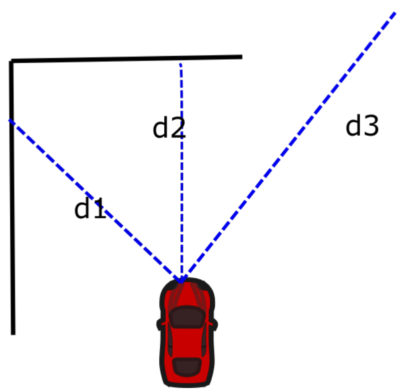
Autonomous exploration in structured environments

Using the instructions/ assumptions given below, write a program (Python /C++ / language of choice) to simulate a robot exploring a structured environment without any map

Part-1: 2-D Lidar

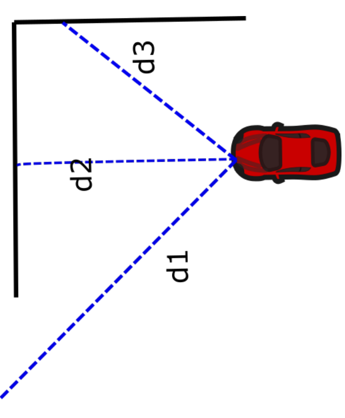
The robot of interest, is assumed to be fitted with a 2D Lidar sensor. Lidar measures the distance to an object by emitting a laser beam and measuring the time taken to receive the reflected beam. Simulate a 2D lidar sensor with parameters (N, d, ϕ). The sensor will emit N beams spanning a field-of-view Ø degrees. The angular separation between any 2 beams will be ϕ/N degrees. Each beam can measure a maximum distance of d

In the example below, a robot is placed 5 units from a pair of orthogonal walls Assumed sensor parameters are: ϕ=60, N=3, d=10



Measured beam distances are: d_1 = 5/cos60, d_2 = 5, d_3 = 10

Now the robot is rotated 90 degrees counter-clockwise



Measured beam distances are: d_1 = 10, d_2 = 5, d_3 = 5/cos60

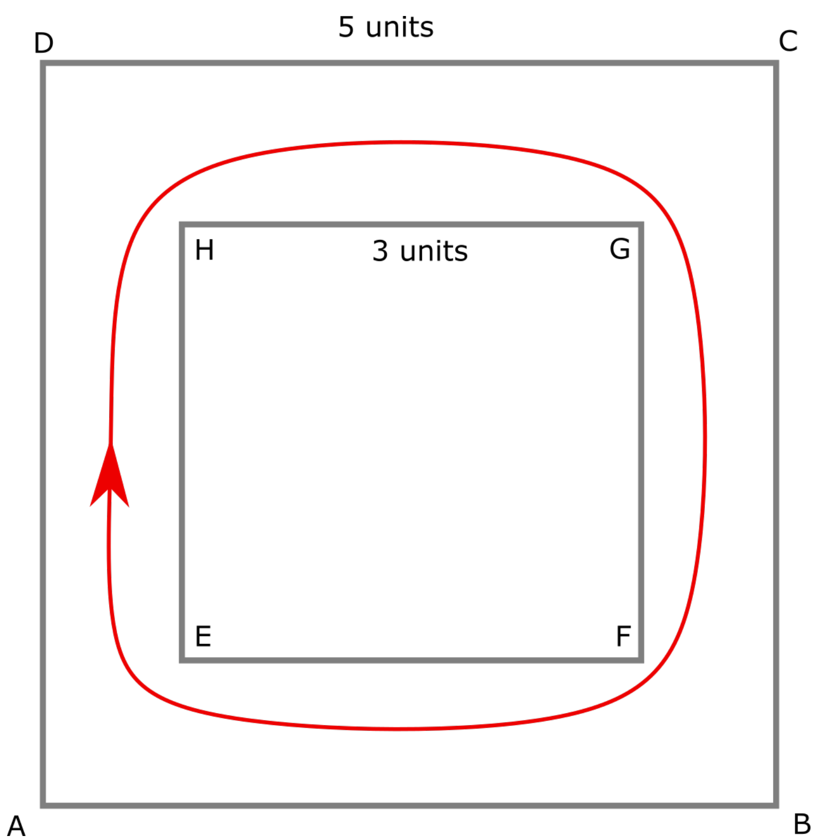
Part 2: Simulate robot motion

Let be (x, y, θ) the robot pose. If v, w is the velocity control applied, the following kinematic model can be used to evolve the robot pose:

$$x[t+dt] = x[t] + v \times \cos\theta[t]dt$$
$$y[t+dt] = y[t] + v \times \sin\theta[t]dt$$
$$\theta[t+dt] = \theta[t] + \omega dt$$

Part 3: Set-up structured environment

The Lidar can be assumed to operate in an indoor environment comprising only of walls. Each wall is denoted as a line segment. An example environment is given below. This comprises of an annular region between 2 square rooms. Outer square side is 5 units and inner square side is 3 units



In this example the set of walls is given by the line segments: {AB, BC, CD, DA, EF, FG, GH, HE}. The coordinates of these line segments can be assumed to be known apriori for the purposes of simulation.

Part 4: Exploration

An example exploratory path is shown for the environment chosen. Feel free to reuse this environment or create your own. Place the robot at an arbitrary starting position. The following steps are to be followed

1. Every 0.1 seconds, simulate the 2D lidar measurement given the current robot position and

orientation. Remember the lidar measurements are local to the robot frame while robot's position and orientation are relative to the global environment that you have assumed
2. Choose ω such that the robot follows the direction of least obstacle. Velocity v can be a small, constant value for duration of the exploration
3. Simulate the robot motion and update the robot's pose
4. Stop exploration after T iterations

Sensor parameters: (N, d, ϕ) can be taken to be (7, 5 units, 90 degrees) initially. In effect, the angular separation will be 15 degrees. For sophisticated environments, this may need to be fine-tuned appropriately

Part 5: Visualization

1. Provide a video of the robot exploring the chosen environment (similar to videos in the examples folder). The robot can be assumed to be point-mass
2. Provide the profile plot of ω for the chosen during the course of the exploration

Submission Guidelines

1. A Github repository has been setup https://github.com/naveenmoto/exploration.git
2. Your given email address has been granted permission to this repo. Please email naveen@artpark.in in case this needs to change
3. Add a folder (folder name is <first name_lastname>) with your files and check it in
4. Please follow honor code - code signatures and commit history shall be checked