SC 627 Assignment 2 -

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Introduction

In this assignment, the following tasks have to be performed -

1) Problem 1: Plan a path using **artificial potential field** in the given world file for any start and end point.
2) Problem 2: Make a roadmap using **Voronoi diagram** in the given world and find the shortest path between start and end point.
3) Problem 3: Make a roadmap using **vertical cell decomposition (trapezoidal decomposition)** and find the shortest path between start and end point in the world.

Artificial potential field

The basic idea is to create a potential field which is a superposition of an attractive potential (conic or quadratic) towards the goal location and a repulsive potential due to the presence of obstacles in the environment. The negative gradient of this potential will give the velocity (speed and direction) in which the bot needs to move to avoid obstacles and reach the goal location.

Conic attractive potential - $U(q) = \zeta\, d(q, q_{goal})$ so $\nabla U(q) = \frac{\zeta}{d(q,q_{goal})}(q - q_{goal})$

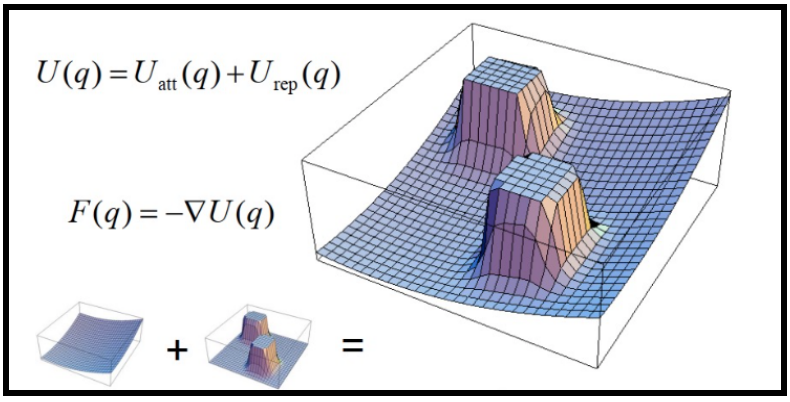
Quadratic attractive potential - $U(q) = \frac{1}{2}\zeta\, d^2(q, q_{goal})$ so $\nabla U(q) = \zeta(q - q_{goal})$

Repulsive potential -

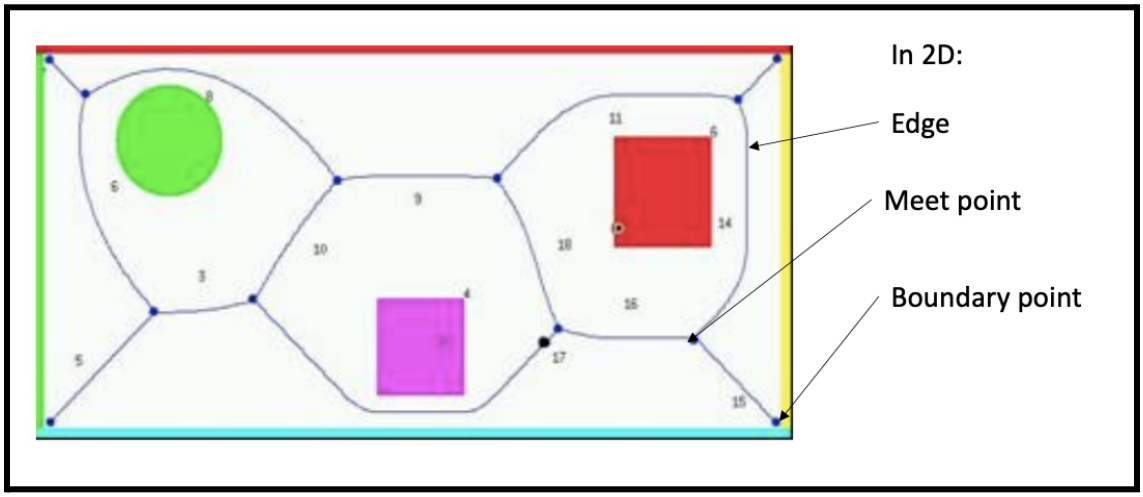
$U(q) = \frac{1}{2}\eta(\frac{1}{D(q)^2} - \frac{1}{Q^*})^2$ if $D(q) \leq Q^*$ and $U(q) = 0$ if $D(q) > Q^*$

So $\nabla U(q) = \eta(\frac{1}{Q^*} - \frac{1}{D(q)})\frac{1}{D(q)^2}\nabla D(q)$ if $D(q) \leq Q^*$

On superposition we get $U(q) = U_{attractive}(q) + U_{repulsive}(q)$. Using appropriate values of ζ and η will help achieve the desired motion

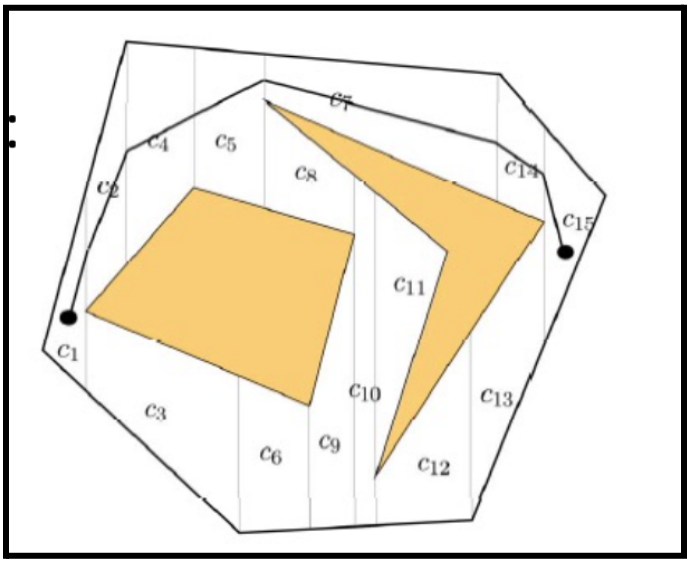


Voronoi diagram



In this method, a generalized Voronoi diagram is constructed by drawing lines which are equidistant from the obstacles as shown in the above figure. The intersection points of the various lines will form the nodes of the graph/roadmap and the lines will form the edges of the roadmap. Once the roadmap is created, graph search algorithms like Djikstra can be used to find a path from the start location to the goal location.

Vertical cell decomposition / Trapezoidal decomposition



In this method, the environment is divided into trapezoidal cells depending on the vertices of the obstacles and the boundary. Then the centroids of the cells and their edges can be treated as nodes of a graph/roadmap and an appropriate path from start to end can be obtained using graph search algorithms like Djikstra.

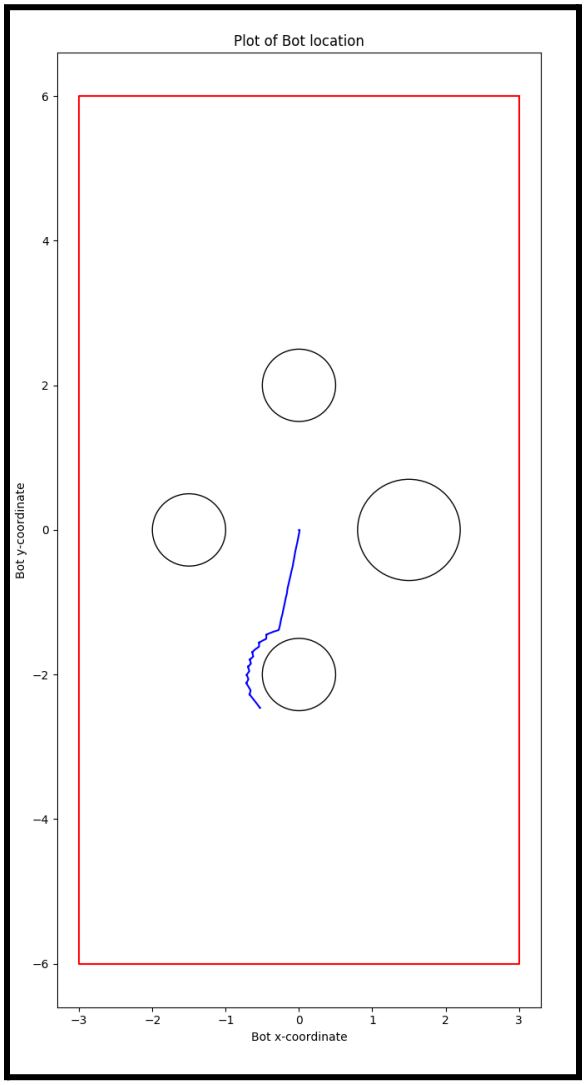
Simulation results

Given below are the links to videos showing the working of the various algorithms under various circumstances

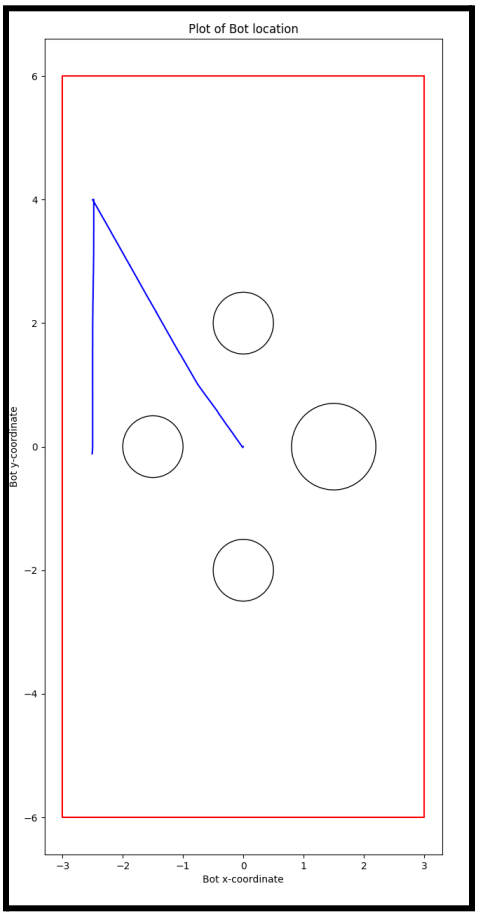
1) Artificial potential field - In this method, the bot moves from (0,0) to (-0.5,-2.5)
2) Voronoi diagram - In this method the bot moves from (0,0) to (-2.5,0)
3) Trapezoidal decomposition - In this method, the bot moves from (0,0) to (-3.5,-0.5)

Plots of paths taken in the above vid-

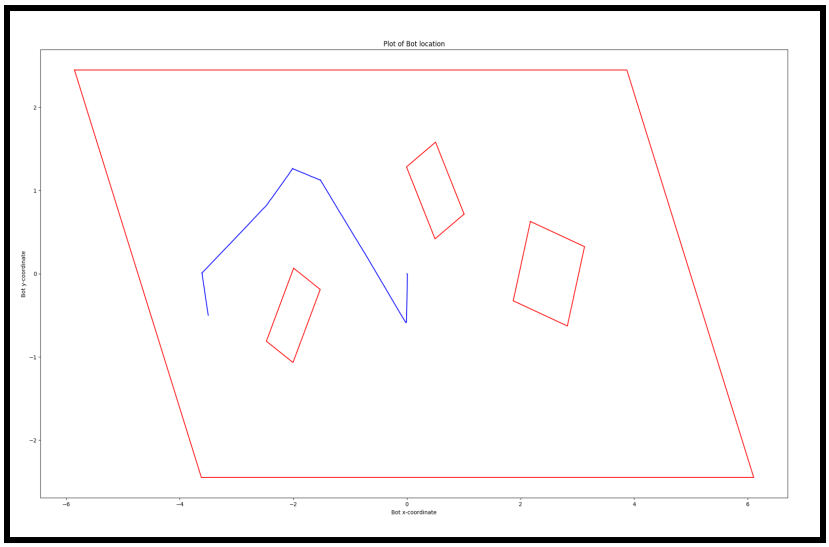
1) Artificial potential field



2) Voronoi diagram

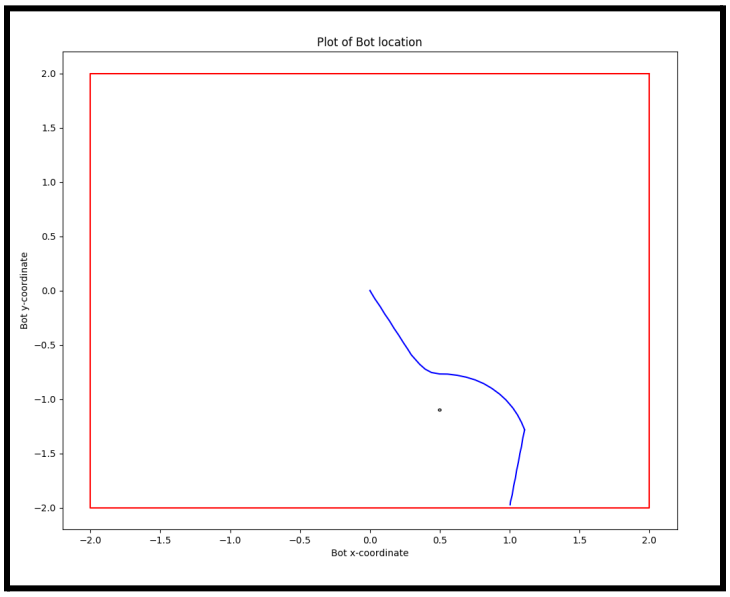


3) Trapezoidal decomposition

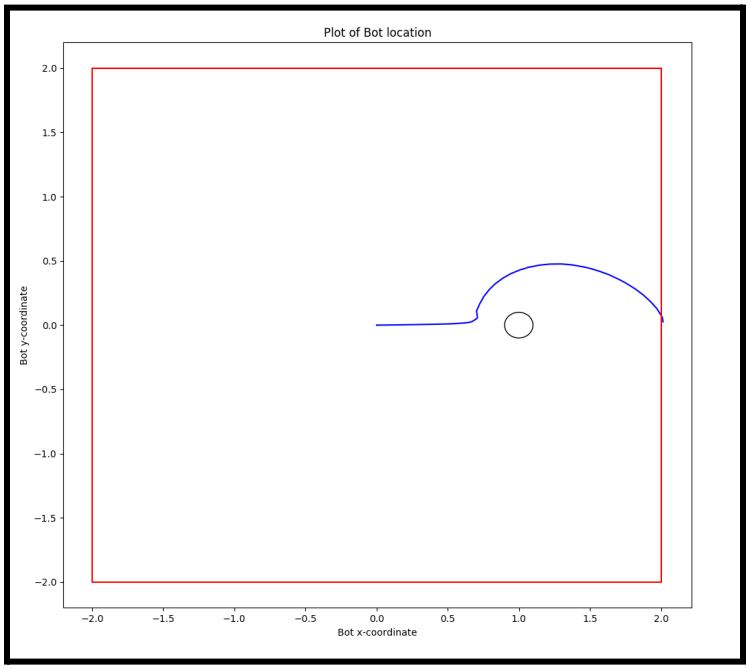


Demonstration results

Artifical potential field



Start location - **(0,0)**
Goal location - **(1,-2)**
Obstacle at **(0.5,-1.1)**



Start location - **(0,0)**
Goal location - **(2,0)**
Obstacle at **(1,0)**