Path planning algorithm for **cluttered environments** using **computational geometry** approaches

Mid Term Review

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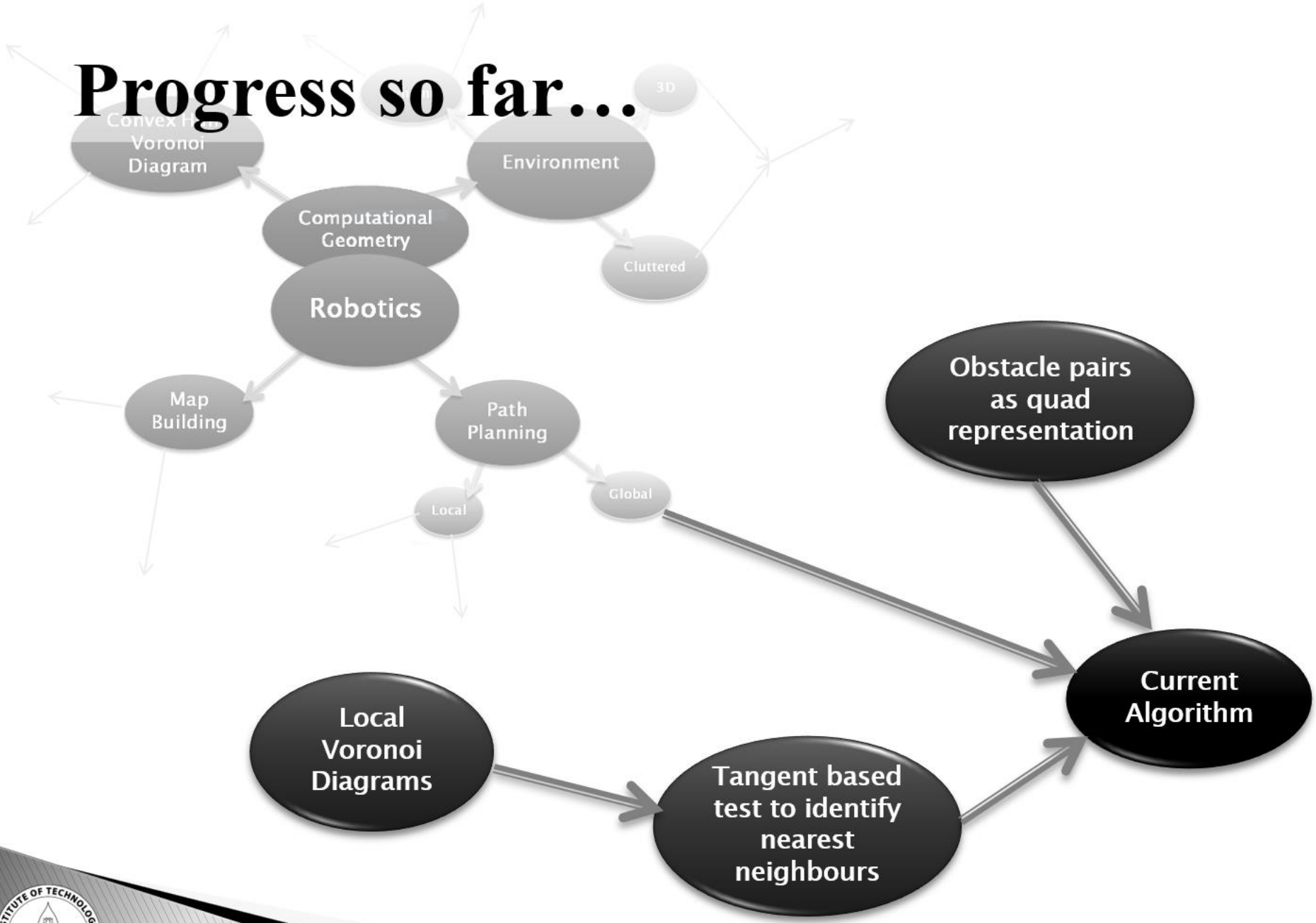
Problem Statement

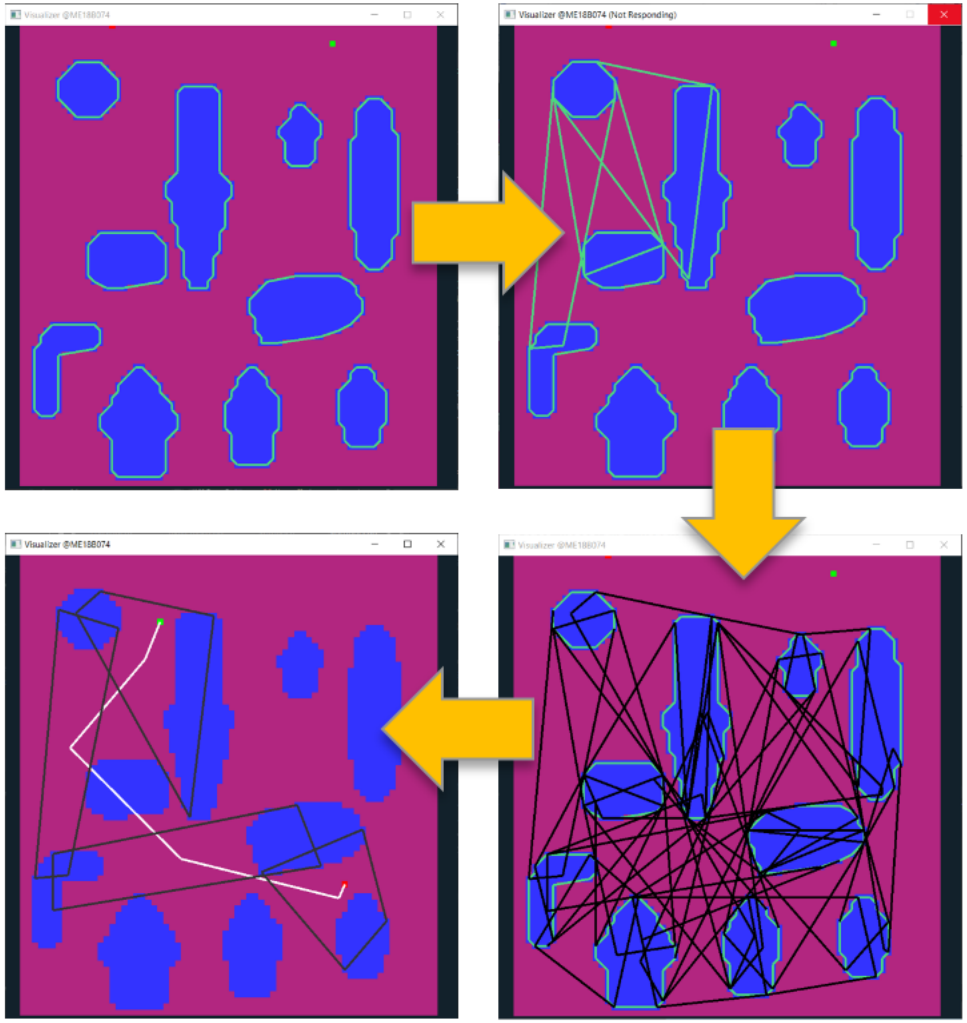
- The project work aims at creating a new algorithm in Path Planning using Computational Geometry approaches
- This work involves designing a new data structure to represent nodes and obstacles, and building graphs to handle obstacles in the cluttered environment more efficiently.
- The aim is to exploit the concepts of Computational Geometry to handle the geometry of obstacles more effectively, and at the same time use elliptical approximations to address the problem of higher Complexity of Geometry based algorithms.

Progress so far…



Algorithm

Locating obstacles and storing as polygons / ellipses



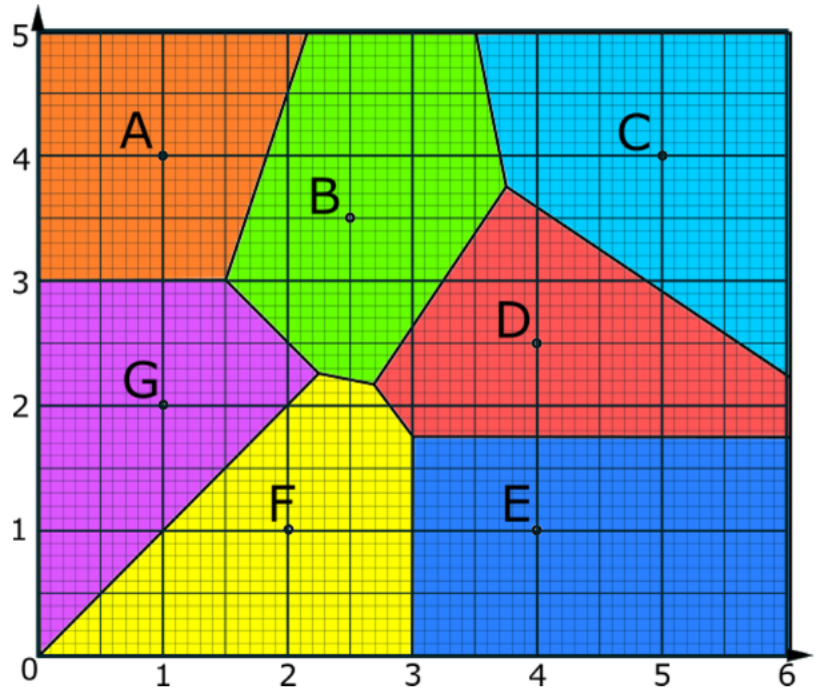
Finding neighbour pairs

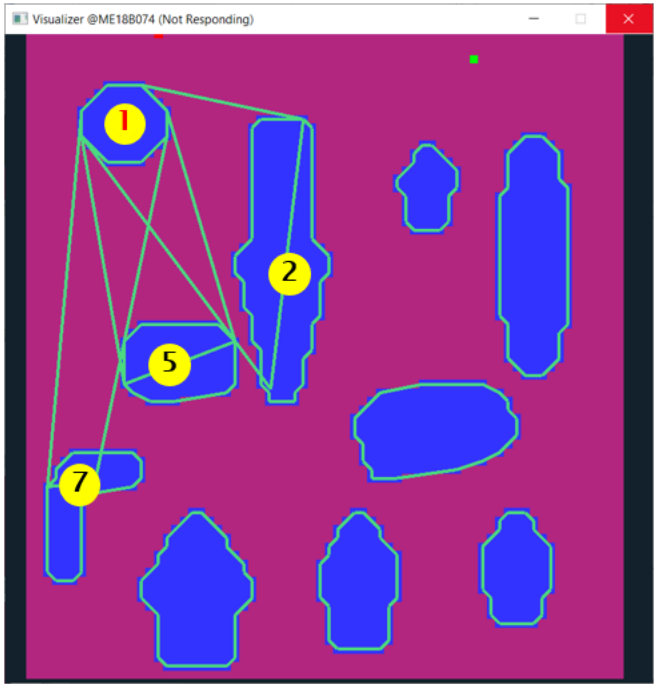
Path search in this quad map

Graph building with quads as nodes

Nearest Neighbours

- Do two given polygons share a voronoi edge?
- Which polygons in a given map shares voronoi edge?





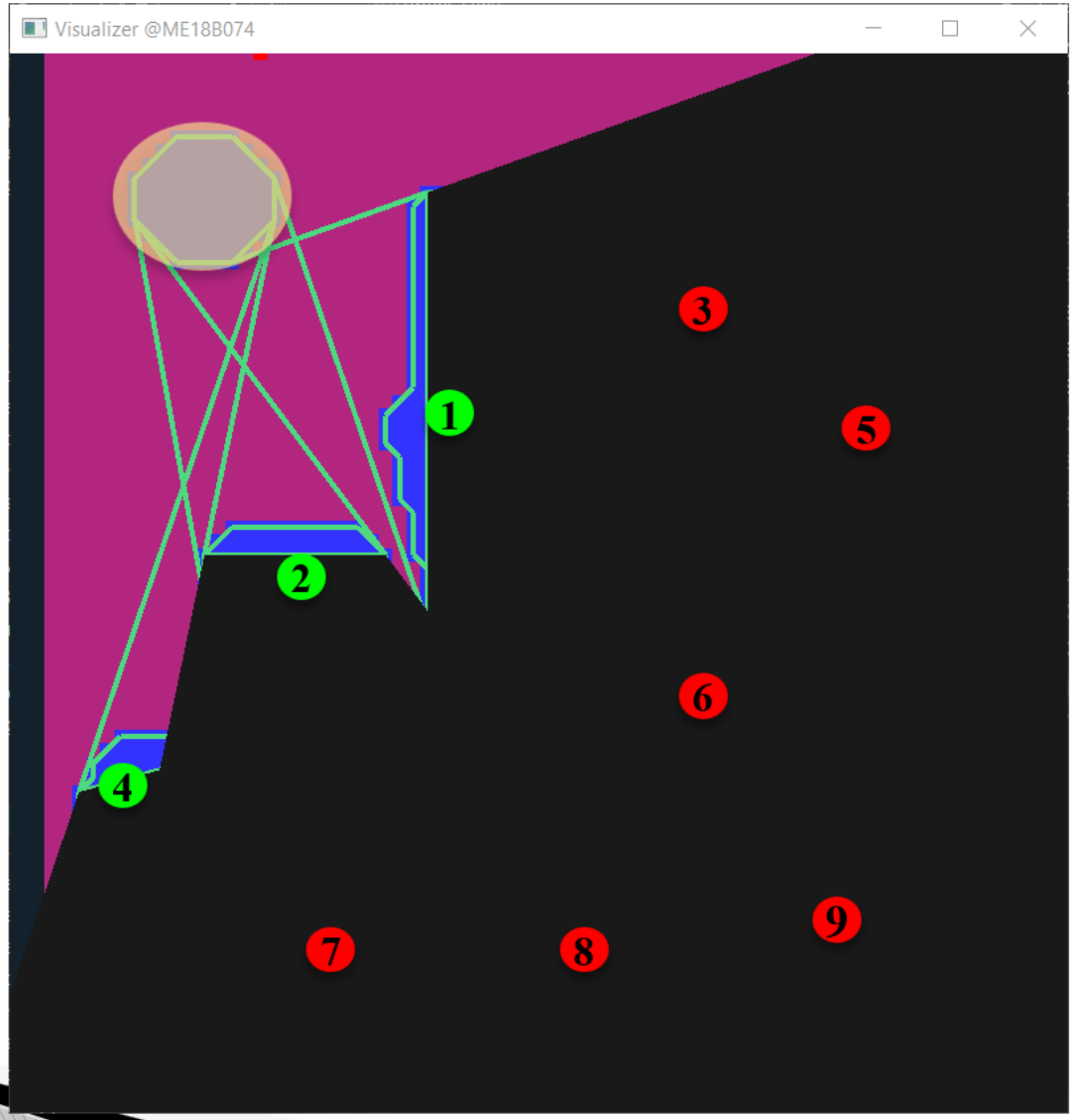
If a robotic agent is moving around obstacle 1; its path around that location will be influenced only and only by obstacles 2, 5 and 7

https://www.transum.org/Maths/Activity/Graph/VoronoiDiagram.asp

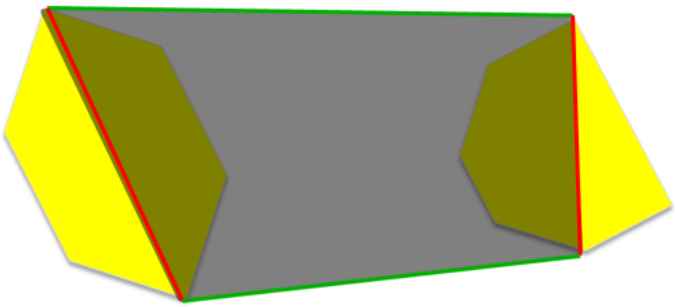
Checks to Identify Nearest Neighbours

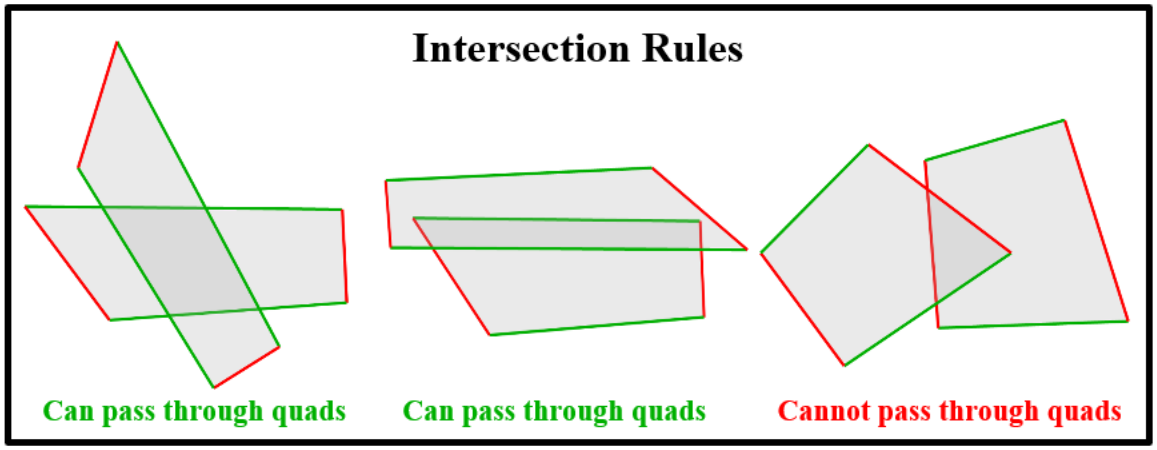
Check-list

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9



Quad Data Structure





Rules:

- Robot can enter/exit this quad from any point on green line.
- It can never cross /enter/exit from red line
- Local path inside this quad is determined by the geometry of these 2 polygons

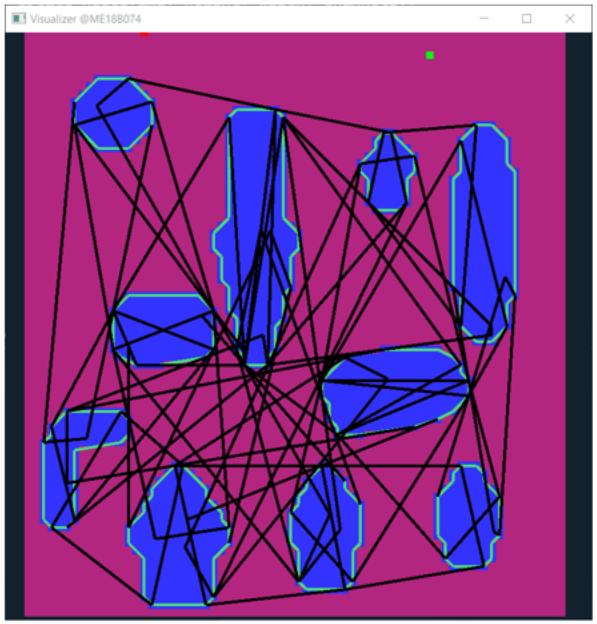
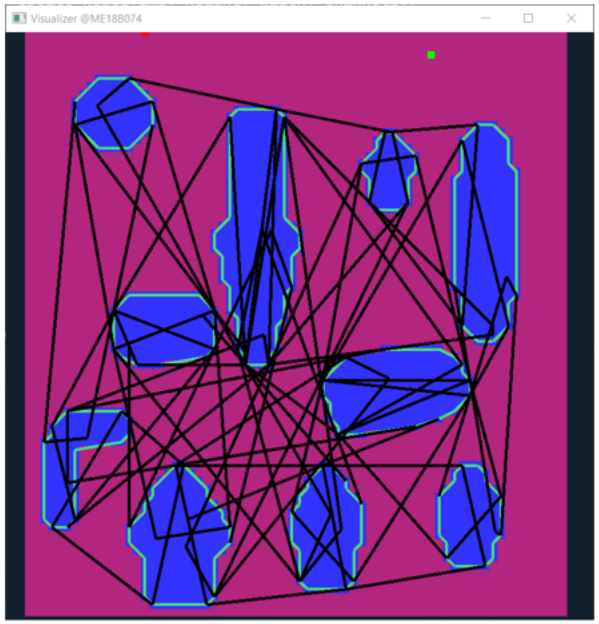


Fig : Representing obstacle maps as a collection of quads

Path Search

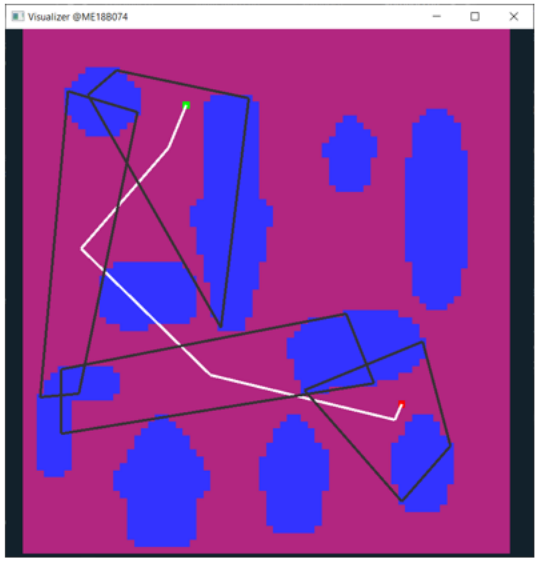
- The obstacle map is then represented as a collection of these constrained quads.
- Path is first searched with these quads as nodes.
- Later local paths inside these quads can be computed keeping geometry of corresponding obstacle pair in consideration.



Results


Visualizer @ME18B074


Visualizer @ME18B074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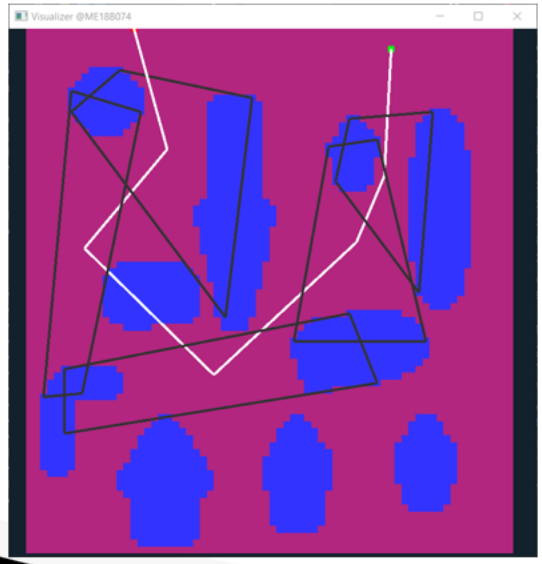
Visualizer @ME18B074


Visualizer @ME18B074

Results

- A bare minimum and functional algorithm is ready which considers obstacles as polygons (no approximations) and not ellipses.
- The current version of the coded algorithm is not optimized to its full potential, and thus it doesn't guarantee significant accuracy.
- But it acts as a proof of concept and validates the proper functioning of nearest-neighbours and quad data-structure part of the algorithm.
- The quad-ranking strategy needs to be thought of to eliminate unnecessary back-and-forth turns in the planned paths.
- There are certain quads, which get covered up by 2-3 other quads as a group. This redundancy needs to be resolved to further speed up traversals.

To be done…


Computational Geometry
Robotics
Map Building
Path Planning
Obstacle pairs as quad representation
Approximating obstacles as ellipses
Current Algorithm
Local Vornoi Diagrams
Tangent based test to identify nearest neighbours
Quad ranking and heuristics
Extending to 3D environment

Timeline

- **Jan 2023** – Finish till Elliptical approximation
- **Feb 2023** – Fine tune 2D algorithm and optimize it to full potential.
- **March 2023** – Extending it to 3D environments
- **April 2023** – Further fine-tuning and converting to ready-to-use format/package