3D Path Planning: Pruning with Constraint Satisfaction (7a)

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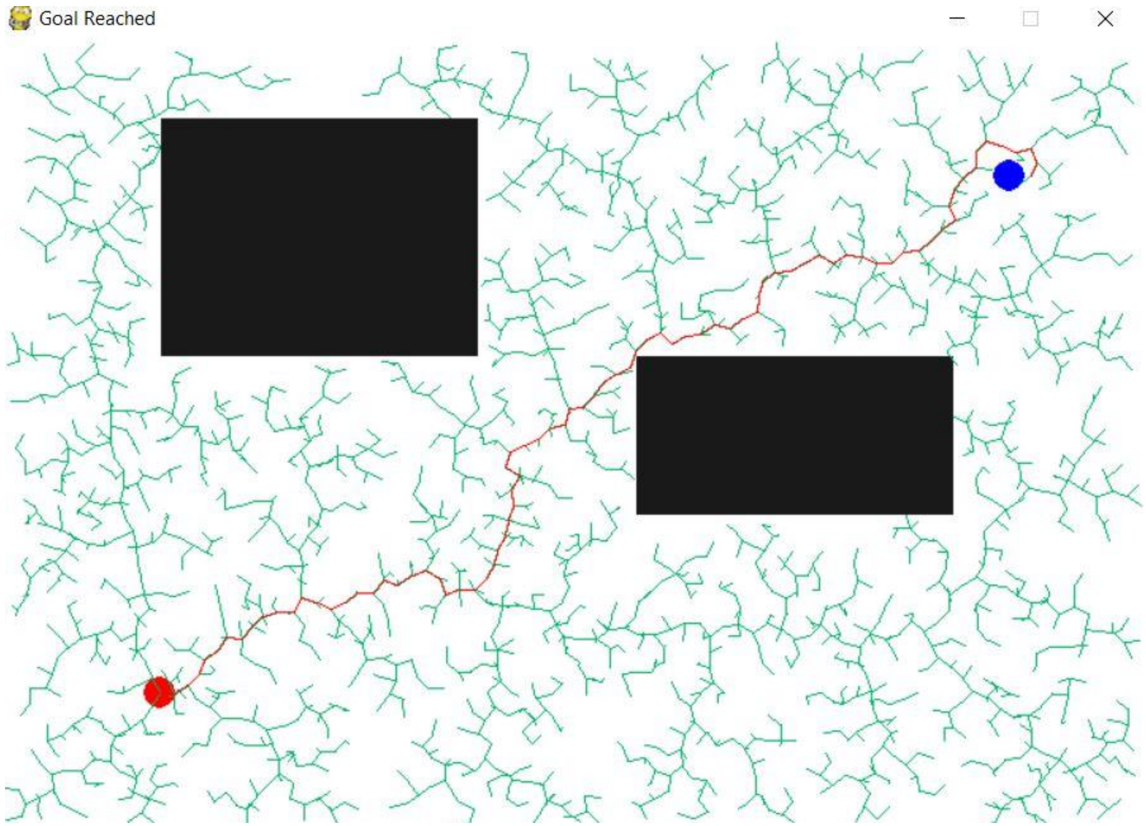
Introduction

- 3D path planning is required in various applications such as drones and self-automated robots, self-driving cars, games etc.

- Find a trajectory from the initial configuration to the goal configuration, subject to rules of motion and any other constraints, such as collision avoidance and various non-holonomic constraints.

Rapidly-exploring Random Trees (RRT)



- Search a space by randomly building a space-filling tree.
- The tree is constructed by randomly selecting samples and biased to grow in large unsearched areas.

Limitations

- **Time consuming**
- Results in non-optimal paths
- Jagged Path
- Need of efficient nearest neighbour technique

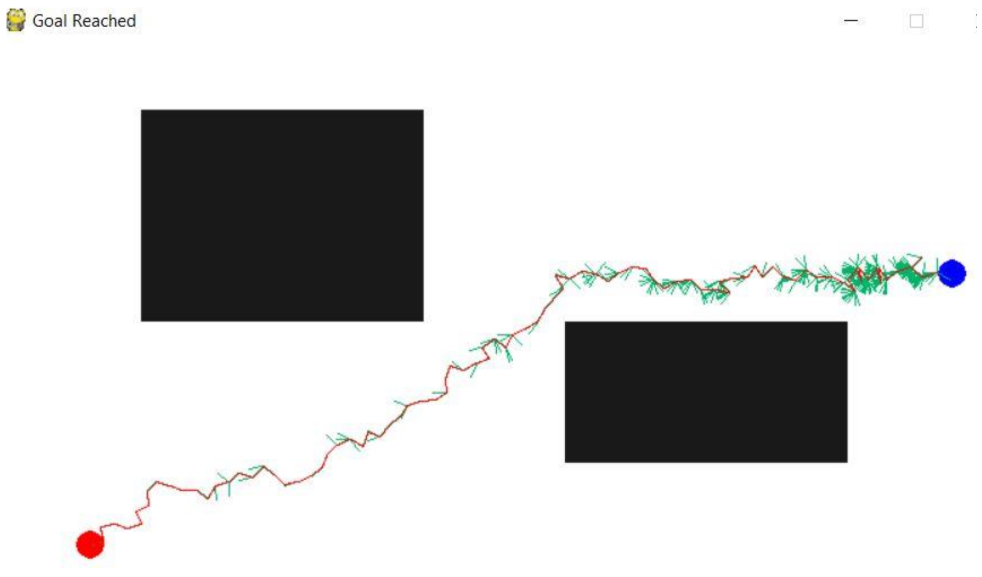
RRT-A*

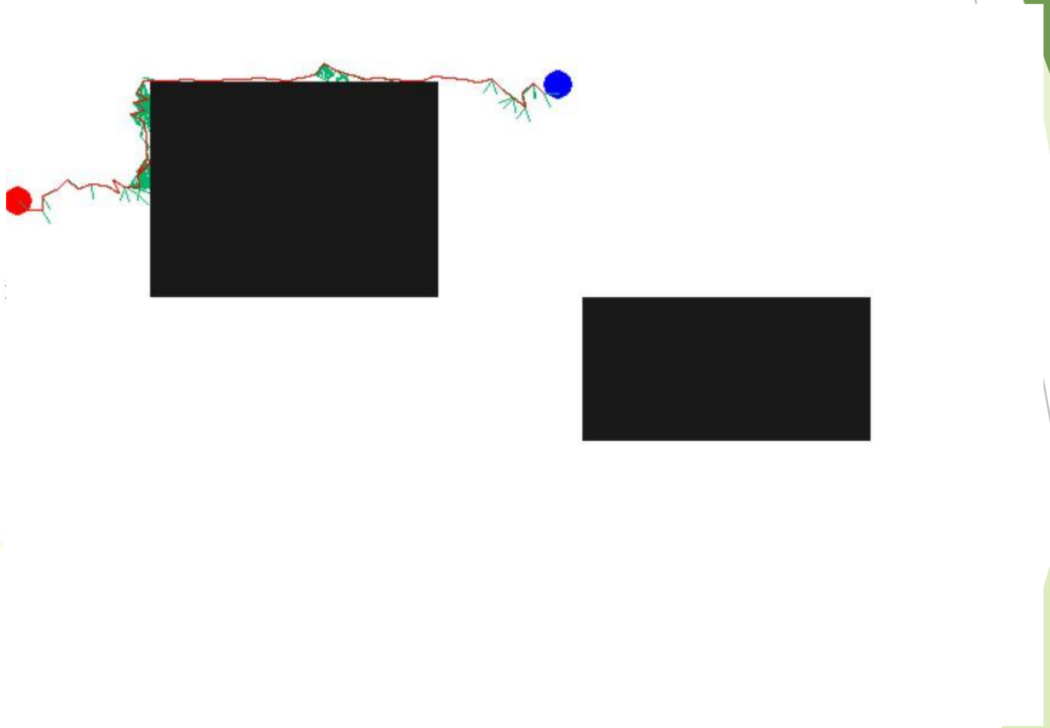
- A* algorithm is a graph traversal algorithm, i.e. it gives a path between 2 nodes.

- A* uses heuristics to guide its search which makes it better than Dijkstra's algorithm.

- The cost function of A* is used to determine selection of nodes in the RRT algorithm.

RRT-A*

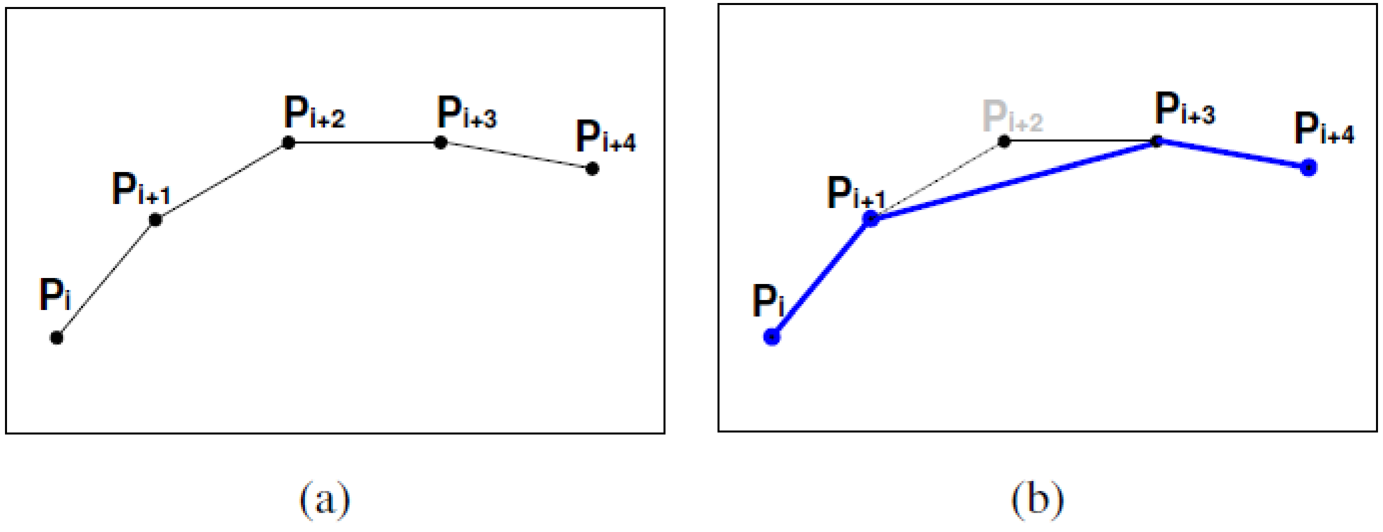




Limitations

- **Results in non-optimal paths**
- Jagged Path
- Need of efficient nearest neighbour technique

Node Pruning

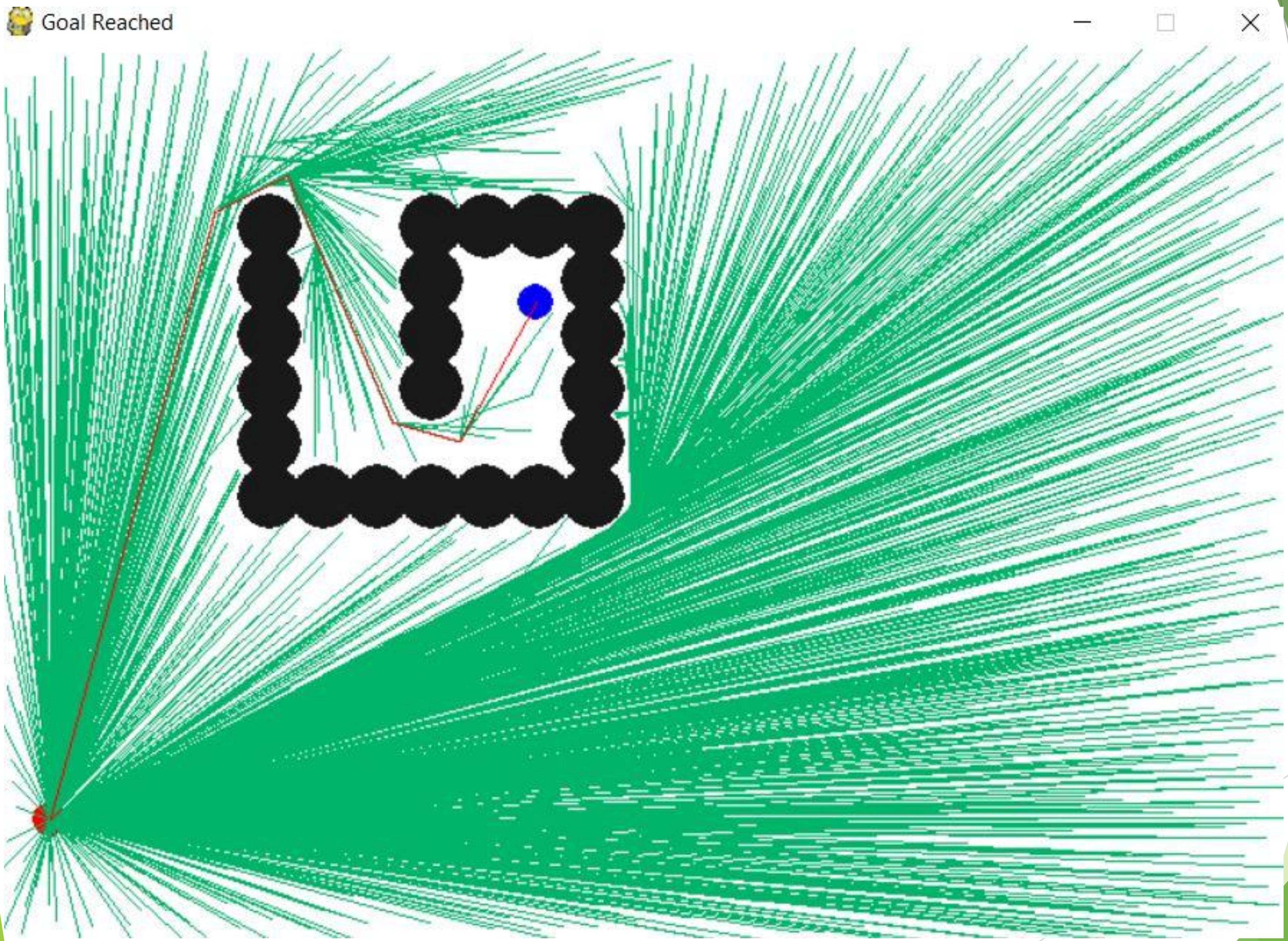


Limitations

- **Results in sub-optimal paths**
- Jagged Path
- Need of efficient nearest neighbour technique

RRT*

- Extension of RRT algorithm which converges towards optimum solution
- It connects the new vertex, X_new, to the vertex that incurs the minimum accumulated cost up until X_new.
- RRT* may also extends the new vertex to the vertices in X_near in order to “rewire” the vertices that can be accessed through X_new with smaller cost.

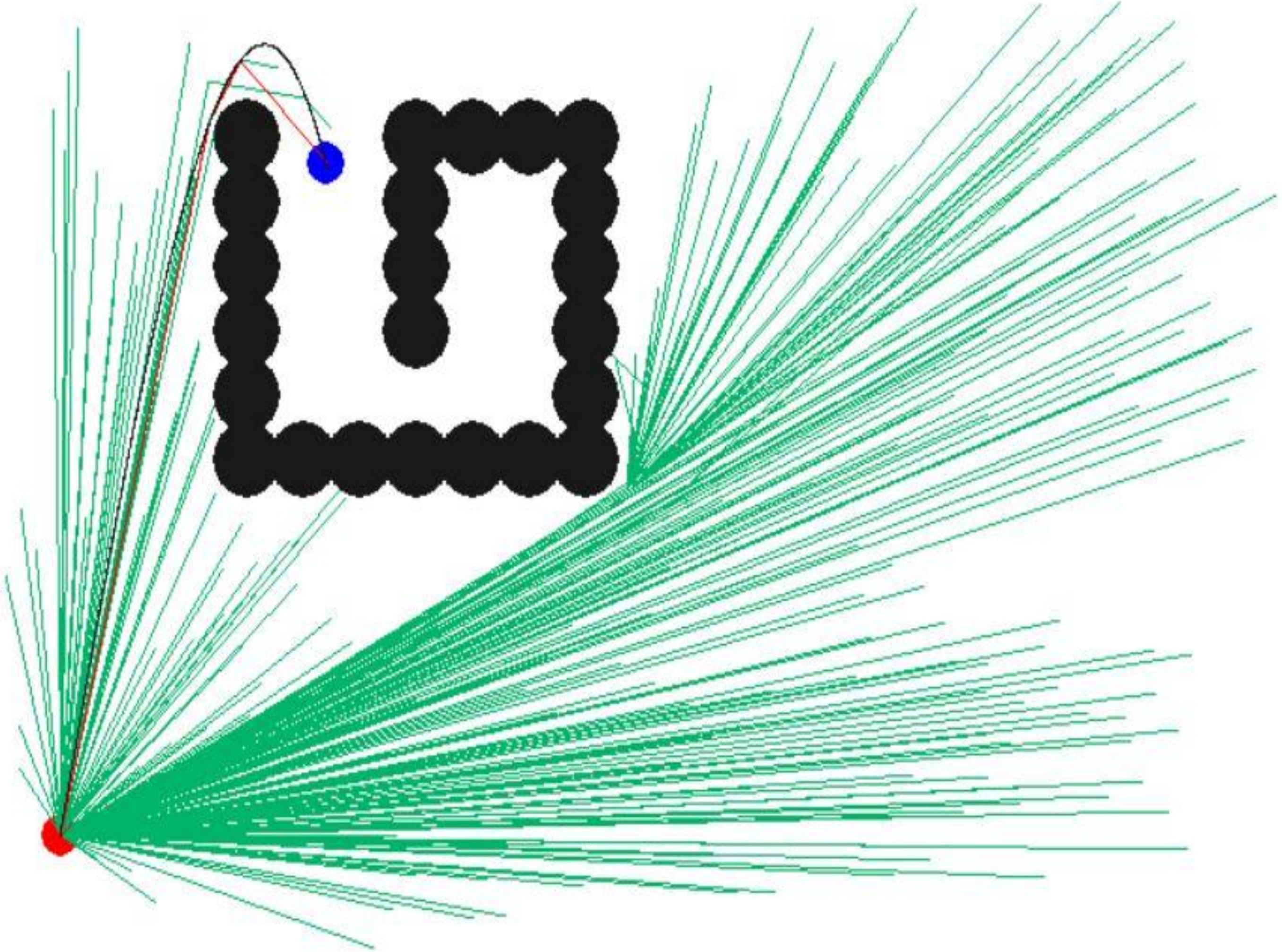

Goal Reached

Limitations

- **Jagged Path**
- Need of efficient nearest neighbour technique

Spline Fitting in RRT*

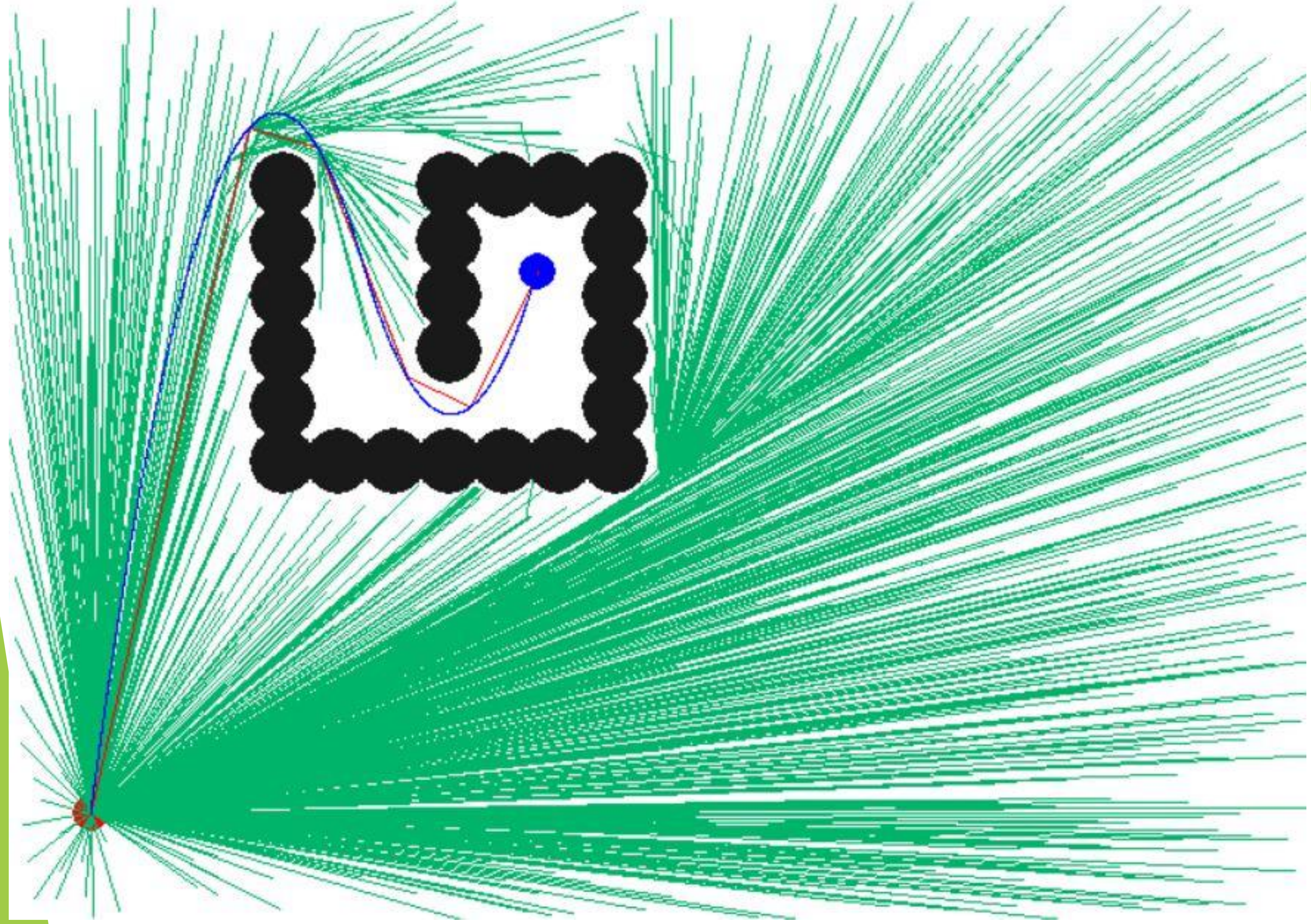
- RRT* produces jagged paths
- Impossible for drones, cars etc. to follow.
- Paths are smoothened using splines.



Limitations

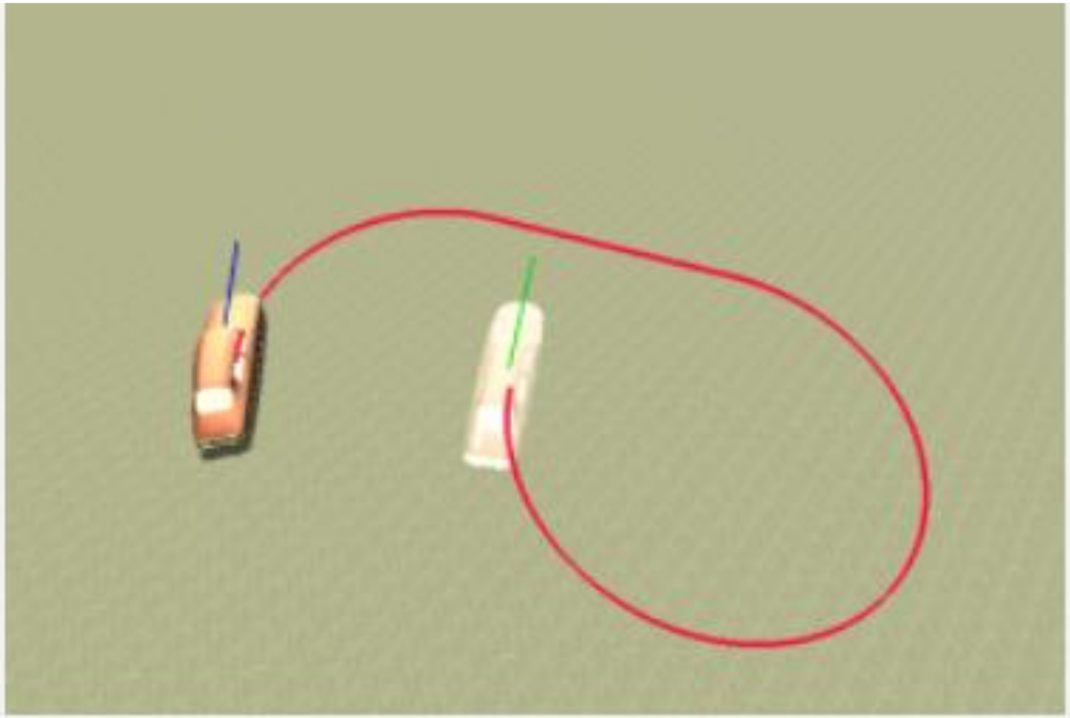
- **Need of efficient nearest neighbour technique**

Two Phase sampling with RRT*



- If a collision free path satisfying various constraints exists between frontier of the tree and the goal point, then a direct connection is made.

Dubins Path Planning

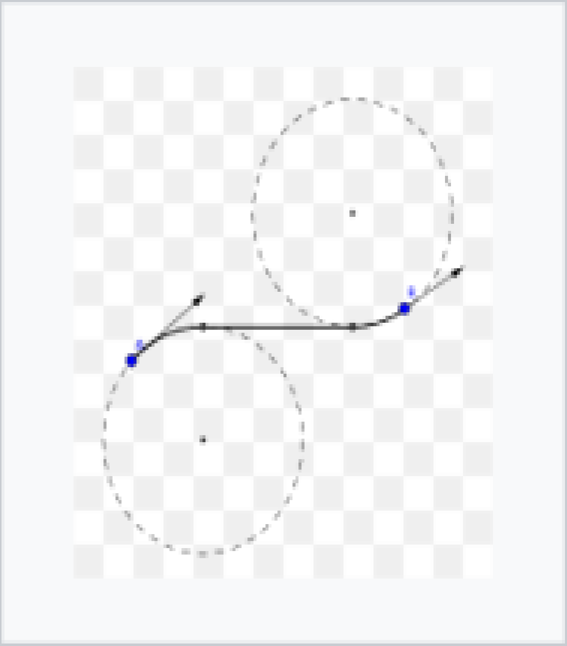


The Dubin's Car only moves forward, never backwards, even if reversal leads to a shorter path.

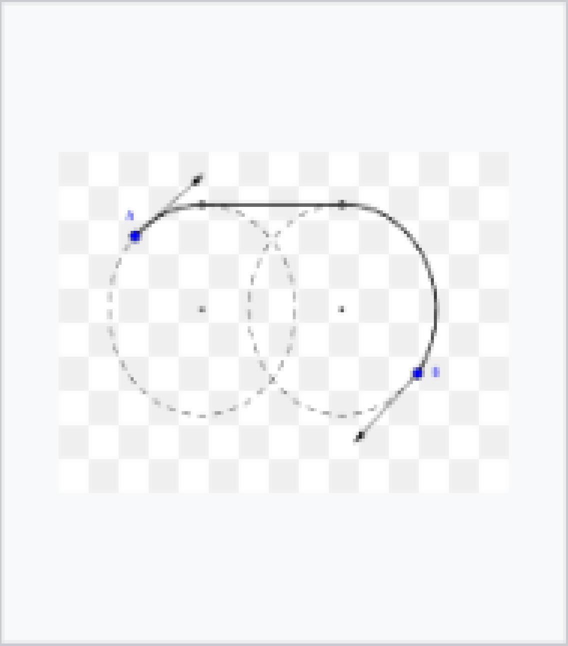
- Dubins car can only move forward, and it always moves at a unit velocity.
- Shortest curve between two points with a constraint on the curvature of the path and with prescribed initial and terminal tangents to the path.

Dubins Path Planning

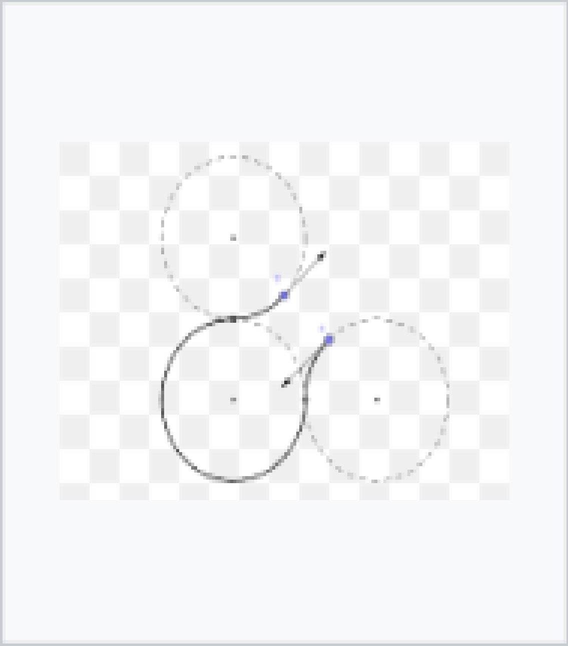
- 6 combinations of controls that describe ALL the shortest paths, and they are: RSR, LSL,RSL, LSR, RLR, and LRL.



An RSL Dubins path



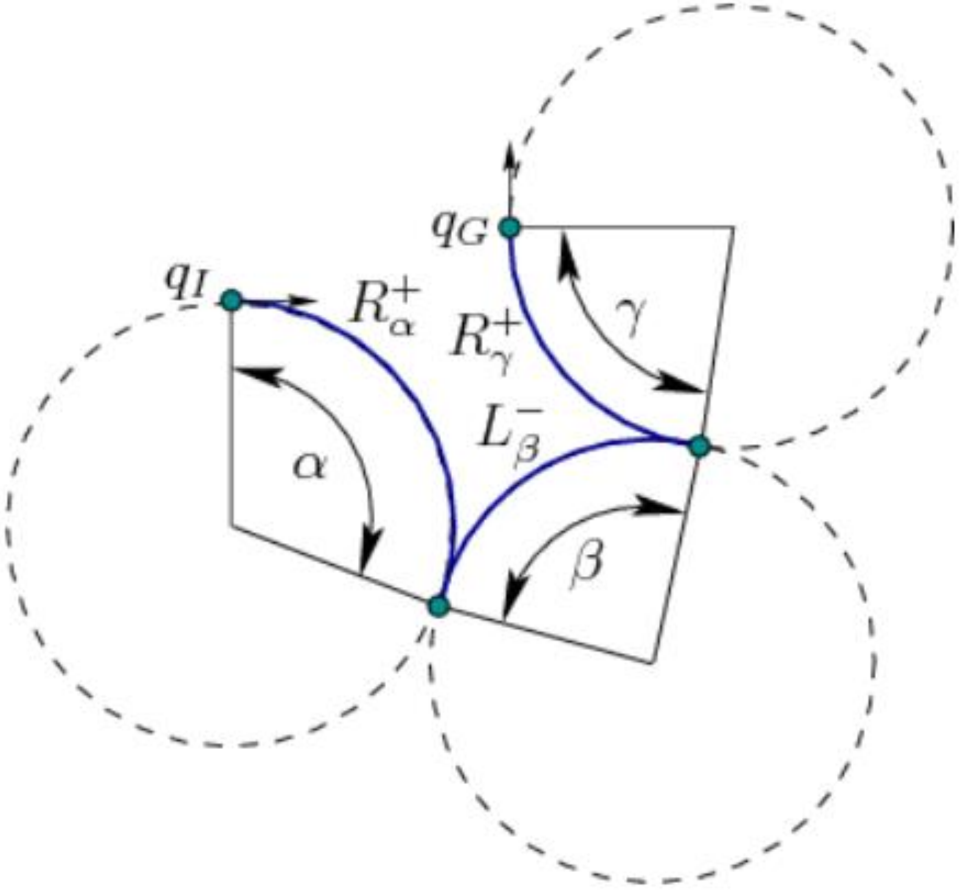
An RSR Dubins path



An LRL Dubins path

Reeds-Shepp Path Planning

- Similar to Dubins path with an additional movement control of moving back



Redds-Shepp

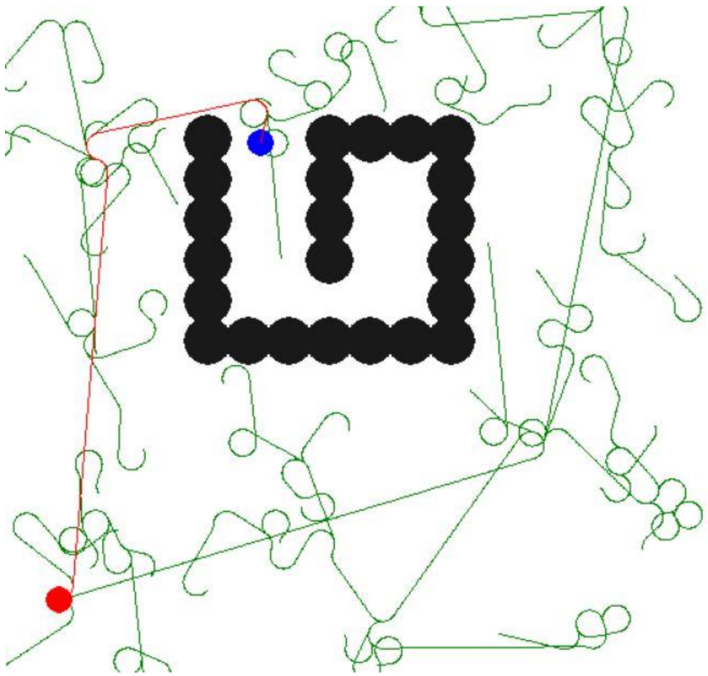
- There are 48 different combinations of these controls that describe ALL the shortest paths.

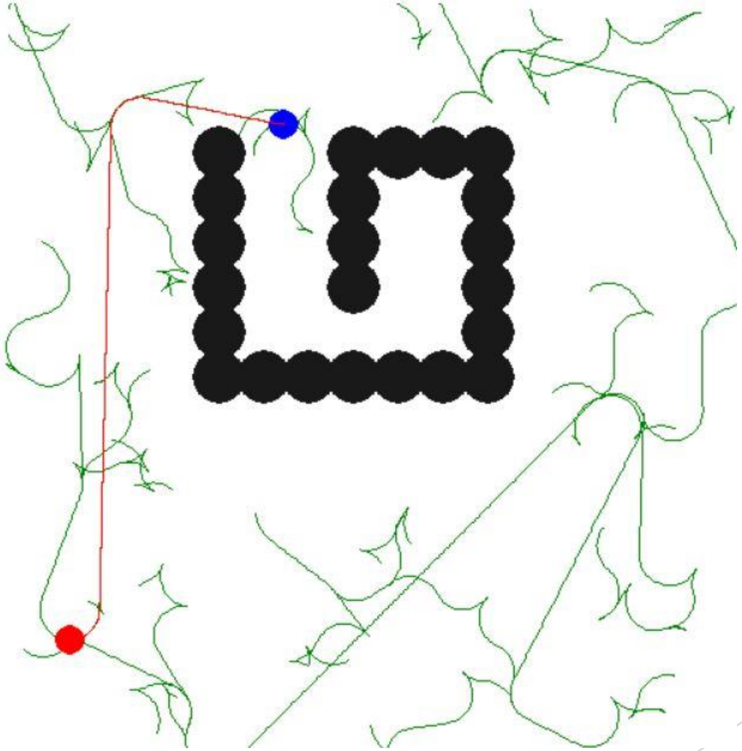
Symbol	Gear: u_1	Steering: u_2
S^+	1	0
S^-	-1	0
L^+	1	1
L^-	-1	1
R^+	1	-1
R^-	-1	-1

Figure 15.8: The six motion primitives from which all optimal curves for the Reeds-Shepp car can be constructed.

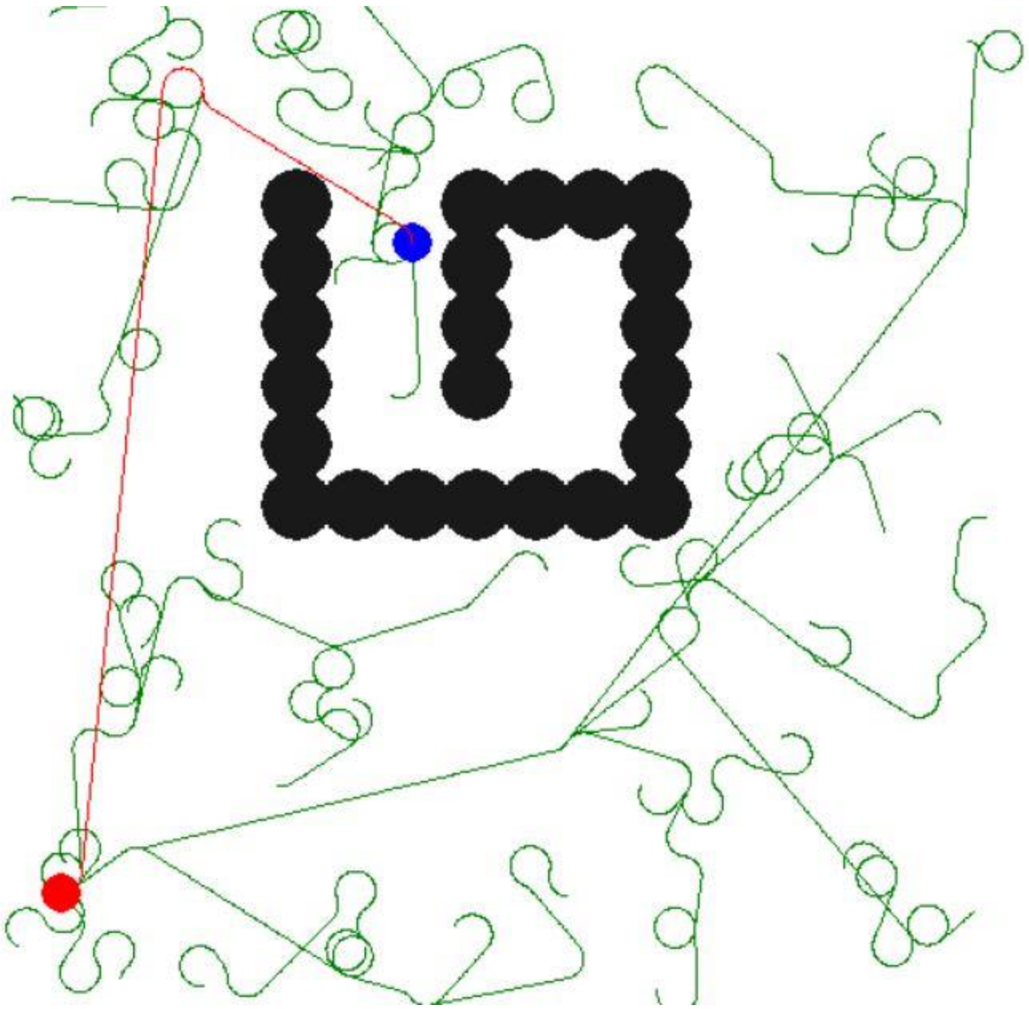
RRT* Dubins & RRT* Reeds-Shepp

- Combine Dubins(or Reeds-Shepp) with RRT* to get the desired results, i.e, a path satisfying all non-holonomic constraints.

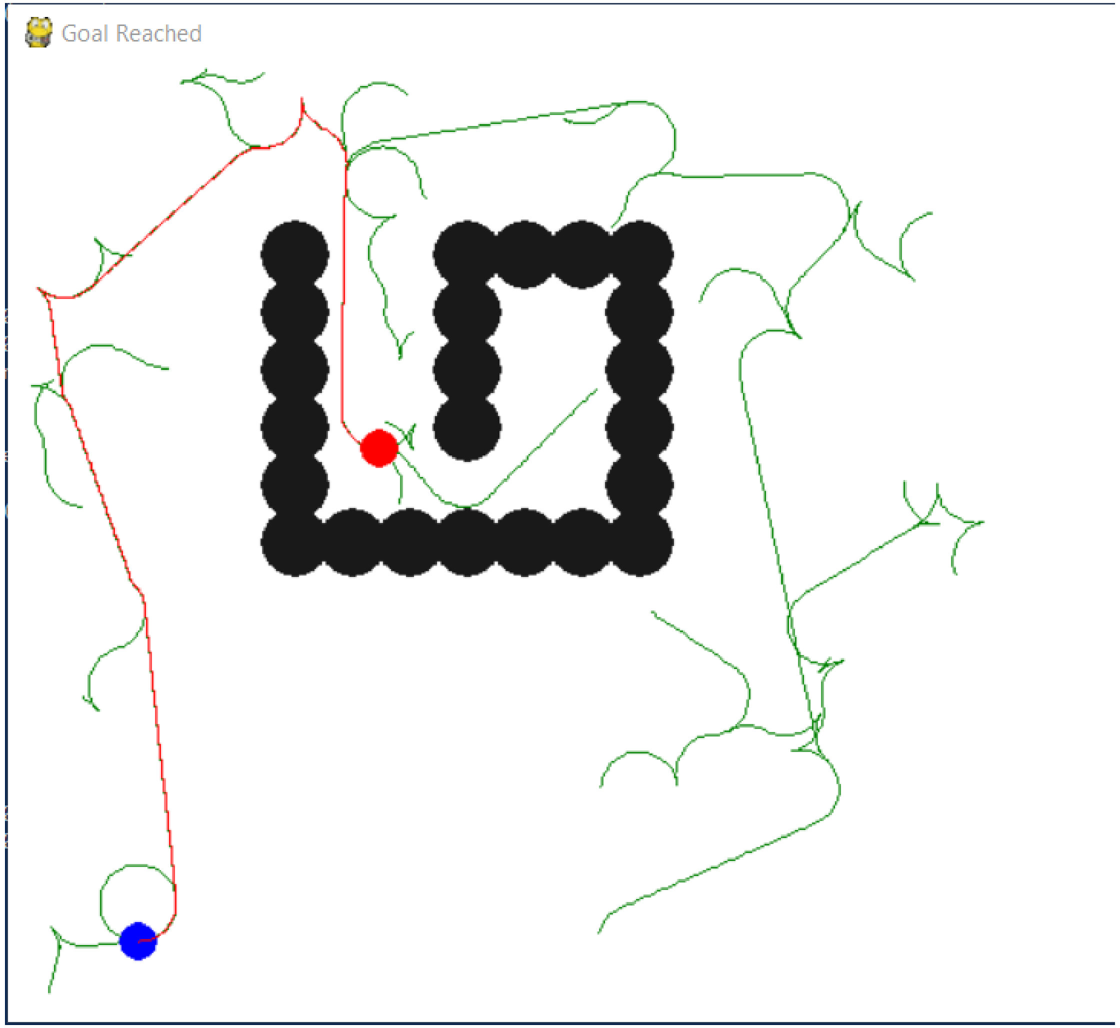




RRT* Dubins



RRT* Reeds-Shepp



Thank You

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