Module E: Motion Planning

Part 1. Introduction to Motion Planning

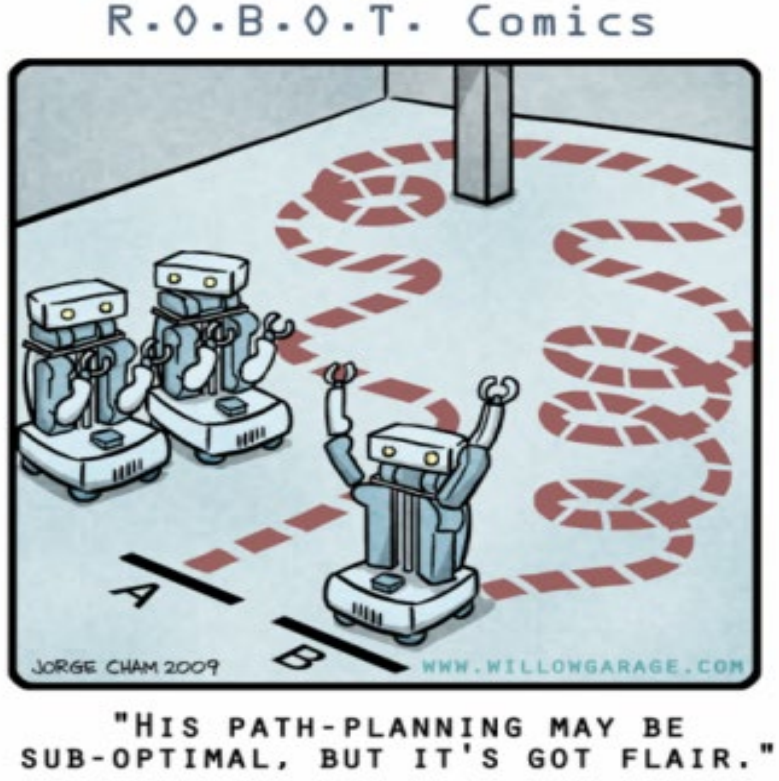
Part 2: Dijkstra and A* algorithm

Part 3. RRT and RRT*

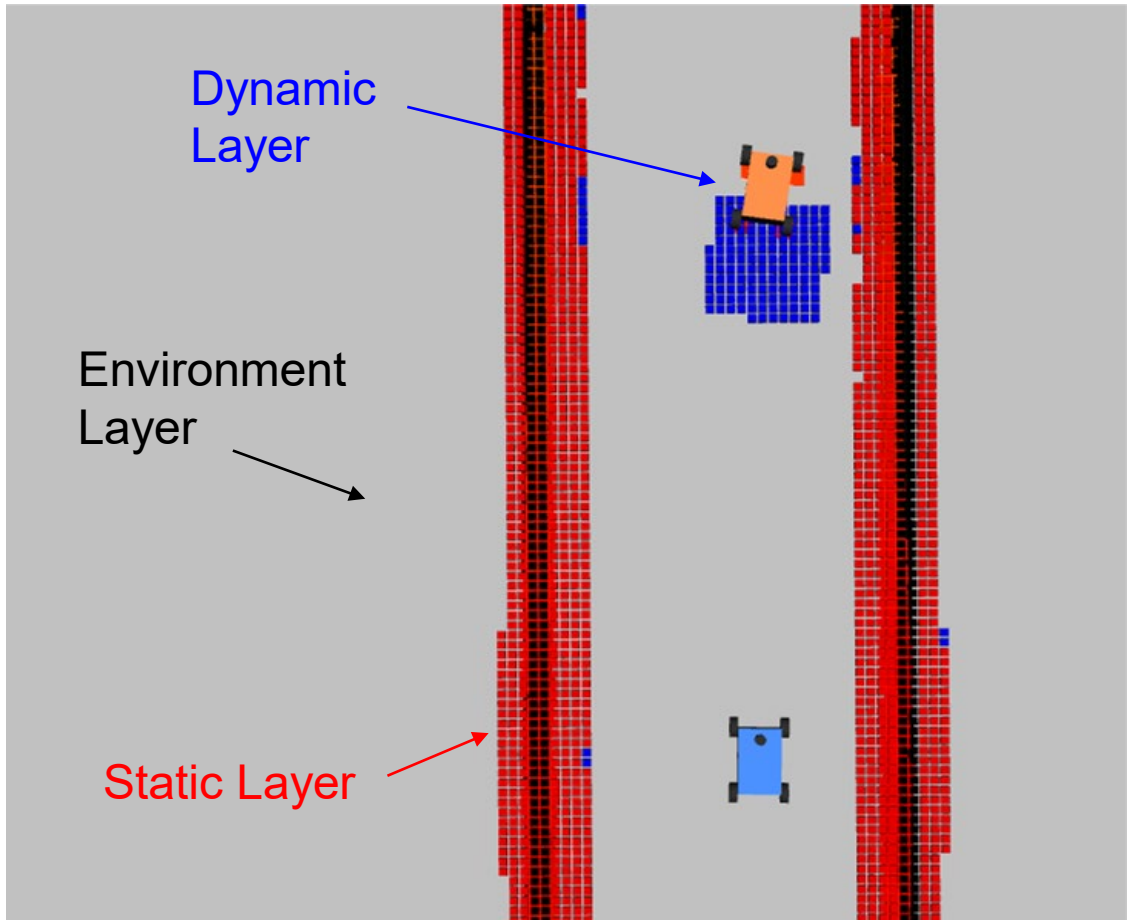
References:

https://f1tenth.org and UPenn ESE 680 Slides

http://www.willowgarage.com/pages/research/motion-planning



The Motion Planning Problem

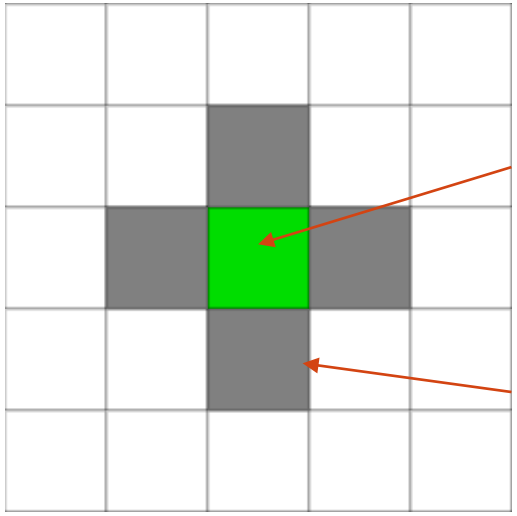


From Upenn ESE 680 Slides

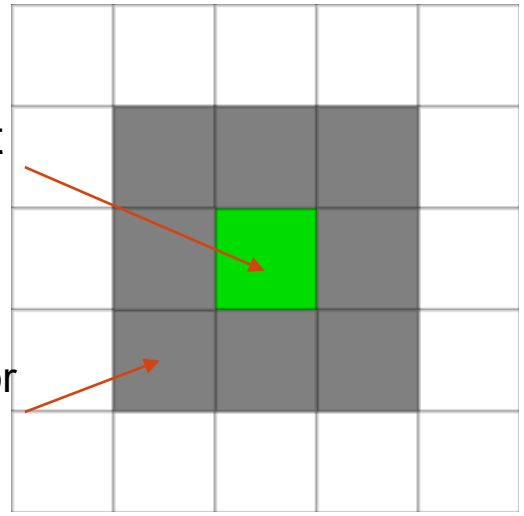
- Path planning:
  - Find a path to go from a starting point to a destination and avoid obstacles;
  - May need to set a goal dynamically in race if multiple cars are on the race track;
  - If possible, minimize the cost of the path
  - Can be divided into local or global path planning
- Performance metrics:
  - Completeness: the algo terminates in finite time; returns a solution when one exists and failure otherwise;
  - Optimality: returns the minimum cost solution when a solution exists.
  - Complexity: time and memory space

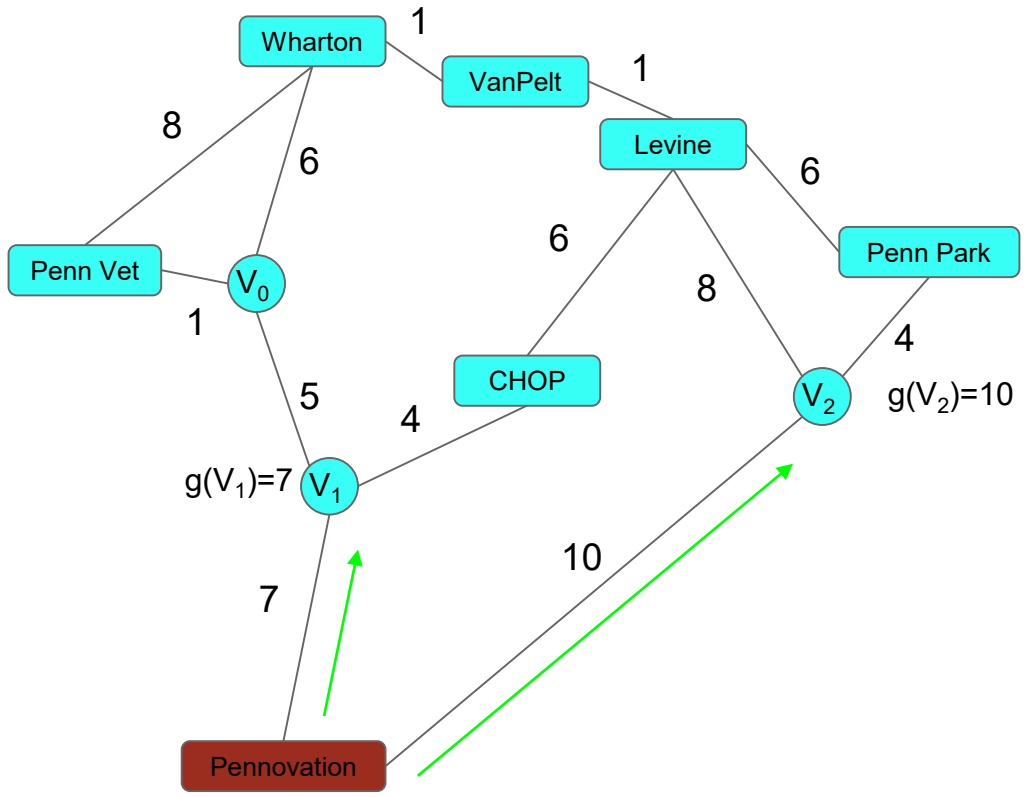
Occupancy Grid or Graph

4-Connected



8-Connected





- Blind Search algorithm:
  - Breadth First Search (BFS)
  - Depth First Search (DFS)
- Informed Search algorithm:
  - Heuristic Search: Dijkstra, D*, A*;
  - Sampling based search: PRM, RRT, RRT*

A* Search Algorithms

0	1	2	3	4	5	6	GOAL
8	9	10	11	12	13	14	15
16	17	18	19	20	21	22	23
24	25	26	27	28	29	30	31
32	33	34	35	36	37	38	39
START	41	42	43	44	45	46	47

Upenn ESE680 RRT project description

- The cost of a node v:

  f(v) = g(v) + h(v)

  h(v) is a heuristic that underestimates to cost to reach the goal from v

  g(v) is the sum cost of operation from start to v

A* algorithm is proven to be complete.

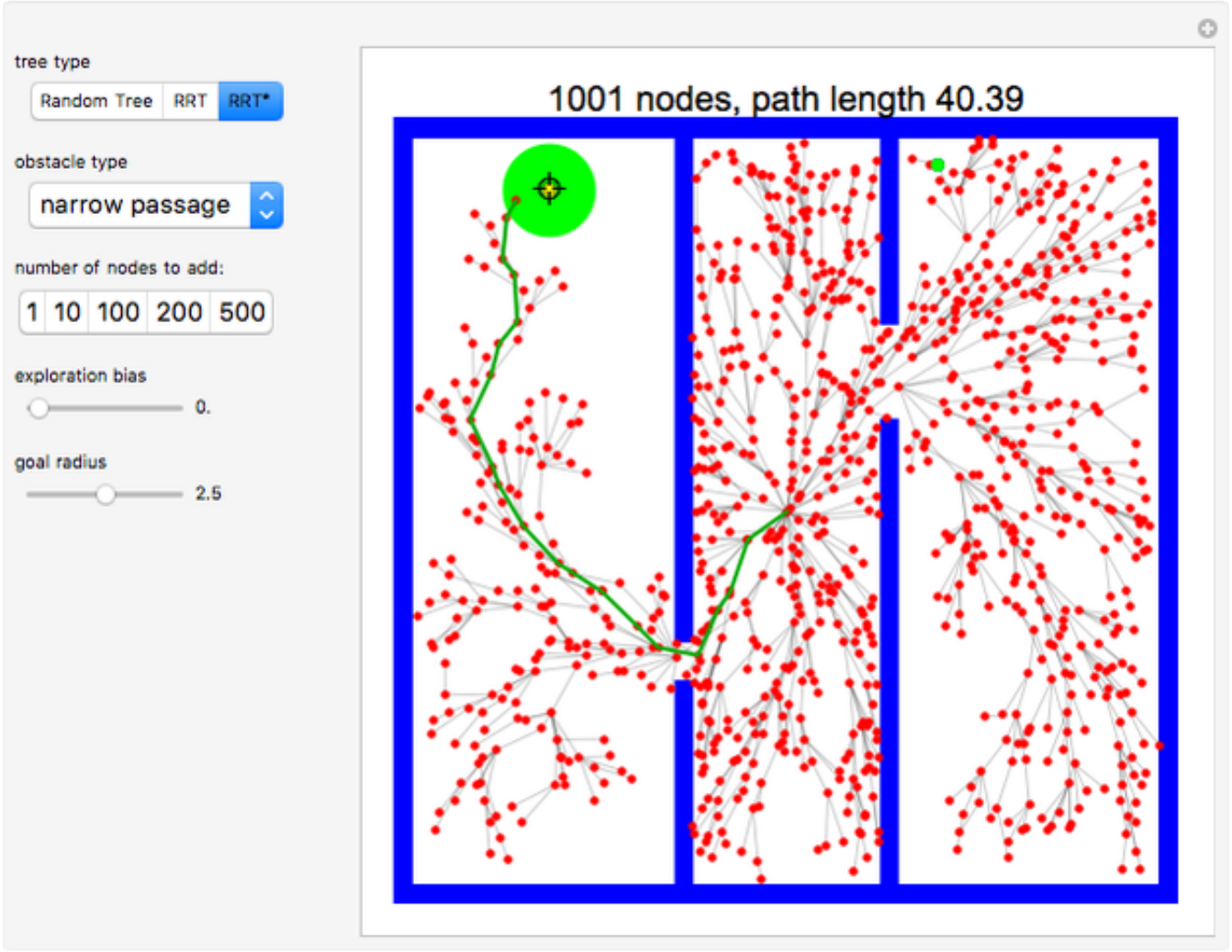
- Reference: lots of YouTube videos, e.g.: https://www.youtube.com/watch?v=-L-WgKMFuhE

Random Graph, RRT and RRT*

- Aaron Becker of Houston University: RRT, RRT* & Random Trees: https://demonstrations.wolfram.com/RapidlyExploringRandomTreeRRTAndRRT/

- Multi-robot RRT: https://github.com/hasauino/rrt_exploration

- Python Robotics Library by Dr. Atsushi Sakai of UC Berkeley https://github.com/AtsushiSakai/PythonRobotics#path-planning



- https://www.youtube.com/watch?v=Ob3BIJkQJEw