Motion Planning Assignment 2

Submitted by: Purna Patel

WPI ID: 150062312

Probabilistic Road Map:

Uniform Sampling:

- Samples are distributed evenly throughout the C-space.
- Advantages:
  - Faster than gaussian sampling and bridge sampling.
  - Points are distributed evenly throughout the space and so it covers every part of the C-space.
  - No need to tune the parameters.
- Disadvantages:
  - Fail to capture narrow gaps and paths.

Random Sampling:

- Samples are distributed randomly across the C-space.
- Advantages:
  - Faster than all other sampling methods.
  - No need to tune the parameters.
- Disadvantages:
  - Points may not be distributed evenly across the C-space so it may not cover every part of the C-space.
  - Fail to capture narrow gaps.

Gaussian Sampling:

- Uses gaussian distribution to sample the space and the sampling condition guides the distribution towards the edge of the obstacles.
- Advantages:
  - Captures the edges of the obstacles.
  - Better in capturing narrow gaps than uniform and random sampling.
  - Samples are distributed around the obstacles.
- Disadvantages:
  - Slower than Uniform and Random sampling.
  - Samples are distributed in clusters among the C-space and so it fails to capture other region where there are less obstacles.
  - Parameters like scale of gaussian distribution, max distance for the nearest neighbours etc. needed to be tuned for consistent performance.

Bridge Sampling:

- This algorithm guides the sample distribution towards the gaps between the obstacles.
- Advantages:
  - Consistently captures the narrow gaps.
- Disadvantages:
  - Slowest of all other sampling methods.
  - Samples are distributed in clusters among gaps and corners and so it does not capture other parts of the C-space.
  - If not tuned well, frequently fails to find a path.
  - Parameters like scale of gaussian distribution, max distance for the nearest neighbours etc. needed to be tuned for good performance.

Rapidly exploring Random Tree:

RRT:

- RRT is a single query roadmap which computes only one roadmap for each new query.
- This optimizes the computation time compared to the multi-query methods.
- Advantages:
  - Computationally very light compared to RRT*.
  - Finds a path very quickly.
  - Due to goal bias, the search is guided towards the goal and so the nodes explored in other direction are less.
  - Less tuning parameters.
- Disadvantages:
  - The path found is not optimal.

RRT*:

- RRT* is also a single roadmap like RRT but the difference is it do not stop the search after goal is found.
- Instead, it keeps on rewiring the nodes as new nodes are found and thus it keeps on optimizing the path.
- Advantages:
  - Path found is optimal.
  - Due to rewiring, the path found is smooth compared to other roadmaps.
  - Do not terminate after the goal is found and so it keeps on looking for better path.
- Disadvantages:
  - Computationally very heavy.
  - Needs tuning of parameters for good and consistent performance.
  - Very slow compared to normal RRT.

Comparison between PRM and RRT:

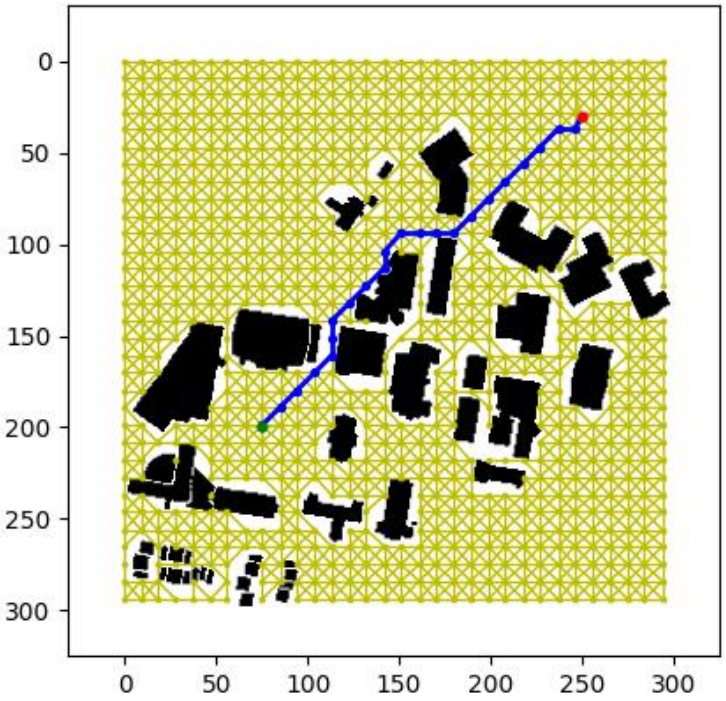
PRM	RRT
Multi-query roadmap method	Single-query roadmap method
Different steps for exploring and searching	Explores and search simultaneously
Do not work for dynamic environment	Can work for dynamic environment

Algorithm Results and explanation:

PRM:

Uniform Sampling:

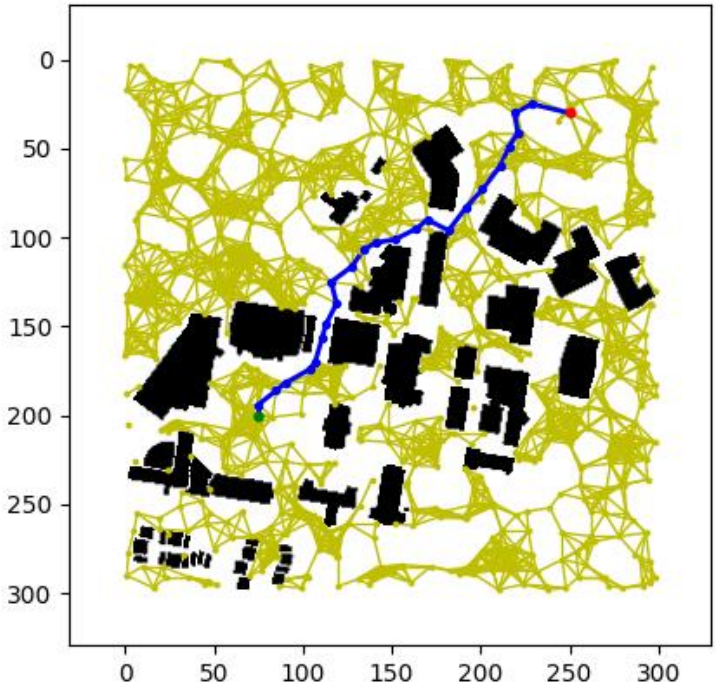
- Following was the result found using Uniform sampling based PRM.



- As seen in the graph, the samples are distributed evenly among the C-space.
- There are very less samples distributed in the narrow gaps and so it is possible that it might miss the optimum path.

Random Sampling:

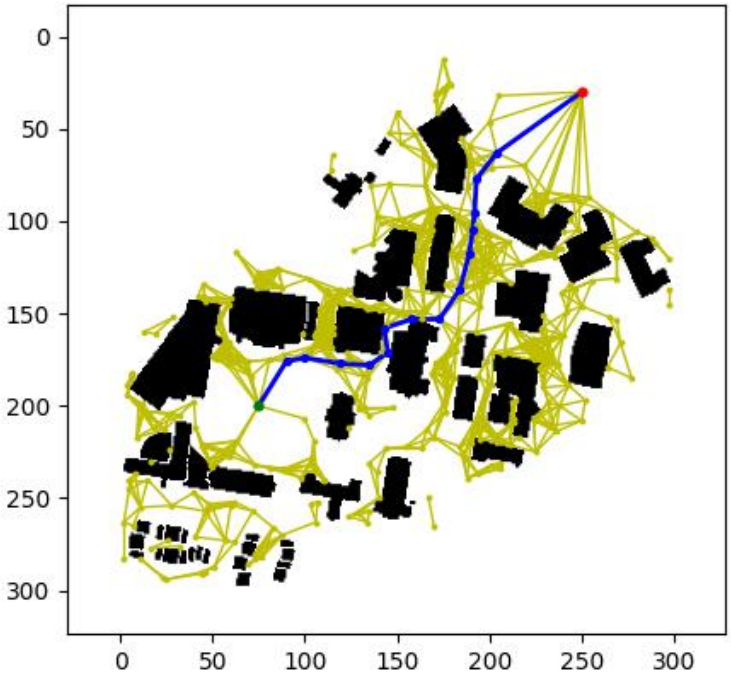
- Following was the result found using Random sampling based PRM.



- As seen in the graph, the samples are distributed randomly among the C-space.
- There are very less samples distributed in the narrow gaps and so it is possible that it might miss the optimum path.

Gaussian Sampling:

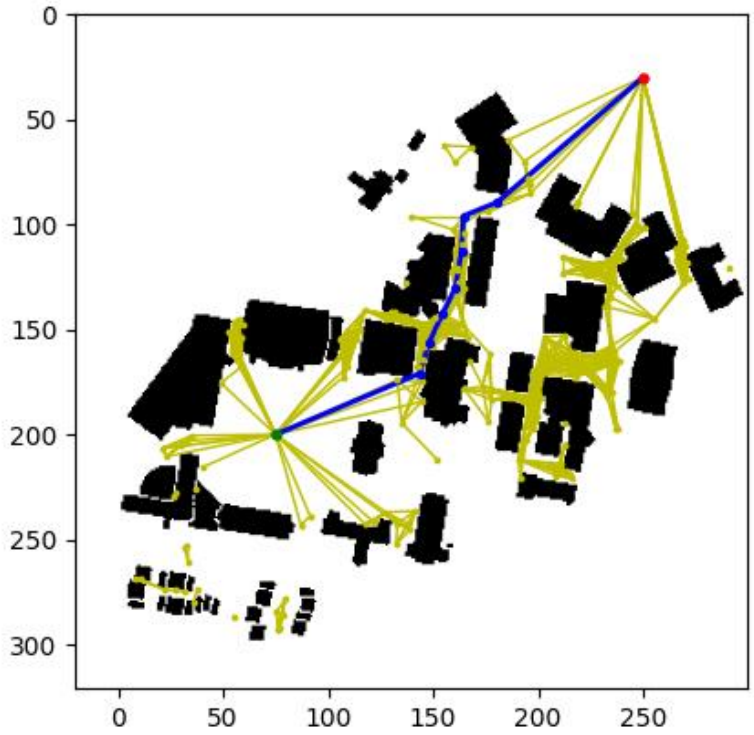
- Following was the result found using Gaussian sampling based PRM.



- As seen in the graph, the samples are distributed along the edges of the obstacles.
- As the density of samples along empty region is less, in order to find path, the number of neighbours assigned to the start and goal position is set to 50.
- This sampling performs better in capturing the narrow gaps.

Bridge Sampling:

- Following was the result found using Gaussian sampling based PRM.

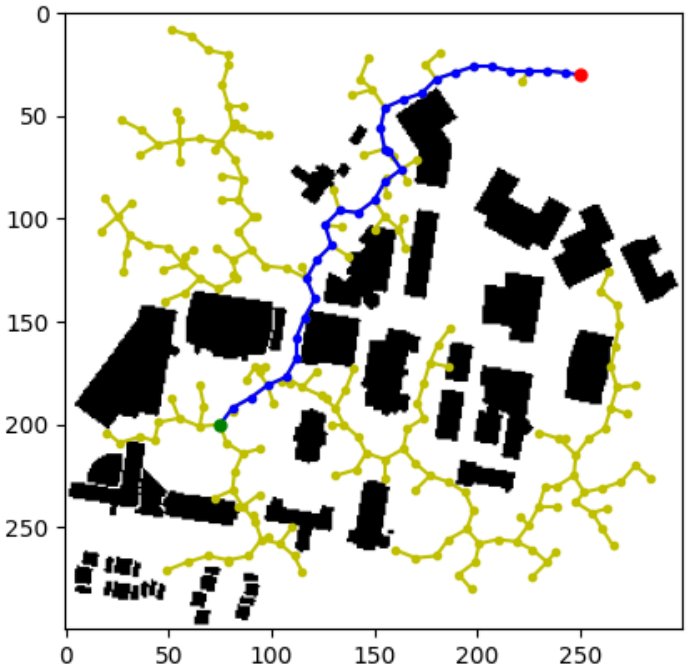


- As seen from the graph, the samples are clustered along the gaps.
- This sampling method performs best in capturing the narrow gaps.
- But other region is not sampled and hence it often fails to generate a path.
- To overcome this drawback, number of neighbours to start and goal are increased.

RRT variants:

RRT:

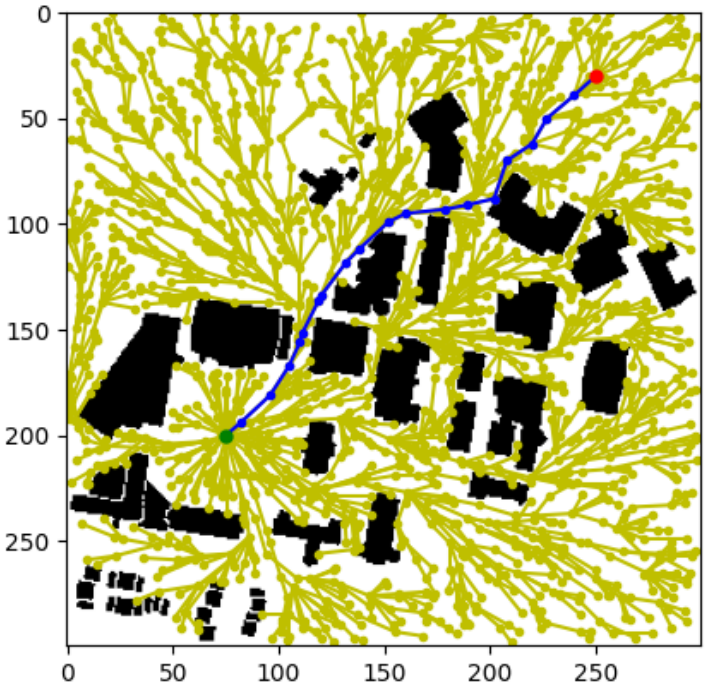
- Following was the result found using simple RRT algorithm.



- It is seen in the graph that very less samples are explored.
- This makes RRT least computationally heavy.
- But the path obtained is not optimal.

RRT*:

- Following was the result found using RRT* algorithm.



- RRT* was successfully able to find the optimal solution.
- Rewiring step helps find the optimal solution.
- But this makes the algorithm very computationally heavy.