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MOTION PLANNING
ASSIGNMENT – 02

Standard Search Algorithm Implementation

A) For PRM, what are the advantages and disadvantages of the four sampling methods in comparison to each other?

Sampling	Advantage	Disadvantage
Uniform	• Low complexity • Ensures connectivity of the samples	• Computationally inefficient • Large number of nodes
Random	• Low complexity	• Doesn't always ensure connectivity
Gaussian	• Less nodes • Better connectivity • Efficient in finding path around obstacle	• Doesn't always ensure path • Depends on threshold set to explore nearest neighbor
Bridge	• Better connectivity in narrow spaces • Less nodes to explore	• Doesn't always ensure path • Depends on threshold set to explore nearest neighbor

B) For RRT, what is the main difference between RRT and RRT*? What change does it make in terms of the efficiency of the algorithms and optimality of the search result?

RRT	RRT*
• Due to randomness in seed generation, the path could be a zigzag. • For small number of nodes, the path doesn't differ from the one from RRT*. • Computationally faster than RRT* since RRT doesn't revisit the nodes and repeatedly check for obstacle avoidance.	• Tries to smothen the tree branches in each step, thus zigzag disappears. Thus resulting in shortest path. • Only when the number of the nodes approaches infinity does the RRT* generate shorter path than RRT. • records the distance each vertex has traveled relative to its parent vertex (cost of the vertex). After the closest node is found in the graph, a neighborhood of vertices in a fixed radius from the new node are examined. If a node with a cheaper cost than the proximal node is found, the cheaper node replaces the proximal node. • After a vertex has been connected to the cheapest neighbor, the neighbors are again examined. Neighbors are checked if being rewired to the newly added vertex will make their cost decrease. If the cost does indeed decrease, the neighbor is rewired to the newly added vertex. This feature makes the path more smooth.

C) Comparing between PRM and RRT, what are the advantages and disadvantages?

	Advantage	Disadvantage
PRM	• Probabilistically complete • Memory efficient	• Trees not always connected • Focus more on building graphs in state space and not on generating the path
RRT	• Fast convergence • Simple Computation • Exploration towards unexplored regions of C-space	• Path is random • Path not always optimal • Needs a lot of nodes to find optimal path

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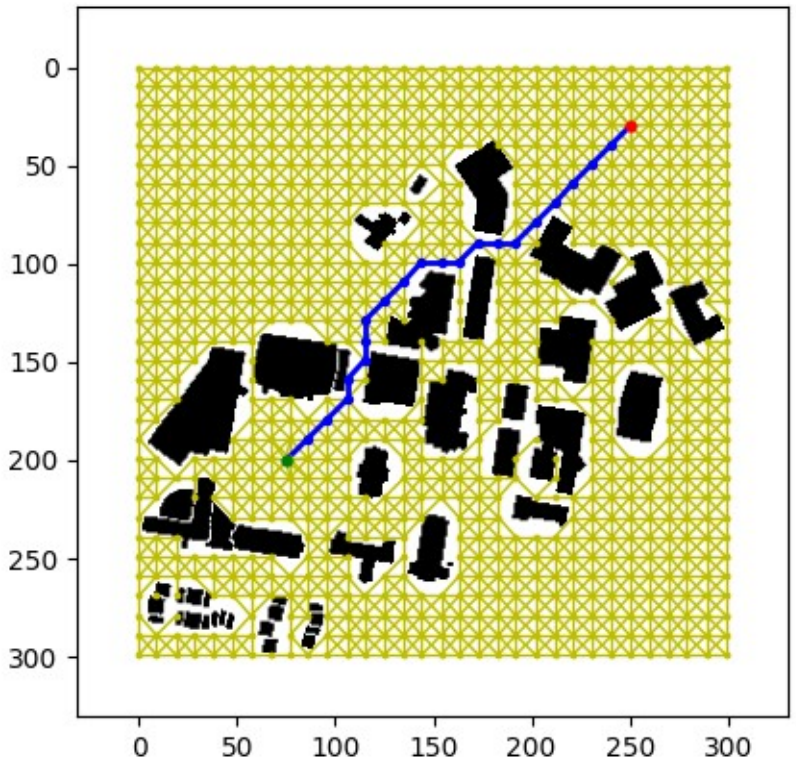
ALGORITHM RESULTS:

PRM:

UNIFORM SAMPLING:

Uniform Samples were taken across the map and each of these samples are checked for collision. If they lie in free space, they are added to the samples list. The path is then found using Djikstra Algorithm using the points in free space.

```
(cv) gs@gs:~/Desktop/WPI/Motion-Planning/Assignments/A
The constructed graph has 838 nodes and 2735 edges
The path length is 263.92
```

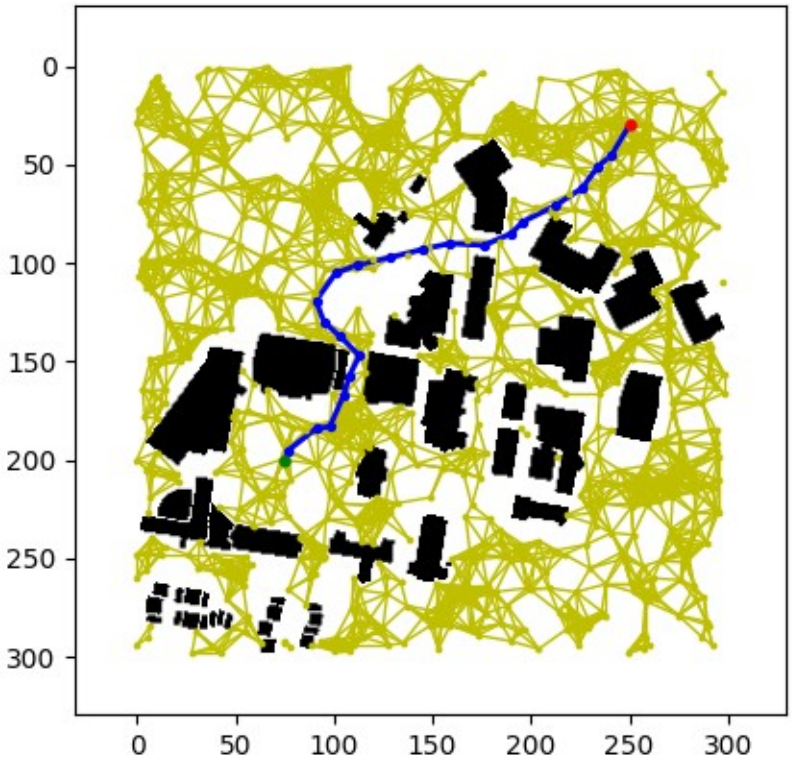


RANDOM SAMPLING:

Each of the node is randomly generated across the map and each of these samples are checked for collision. If they lie in free space, they are added to the samples list. The path is then found using Djikstra Algorithm using the points in free space.

The nodes are generated randomly every time the function is called, thus the path generated differs everytime. It is also possible that the function may not generate a path.

```
The constructed graph has 832 nodes and 3784 edges
The path length is 298.60
```

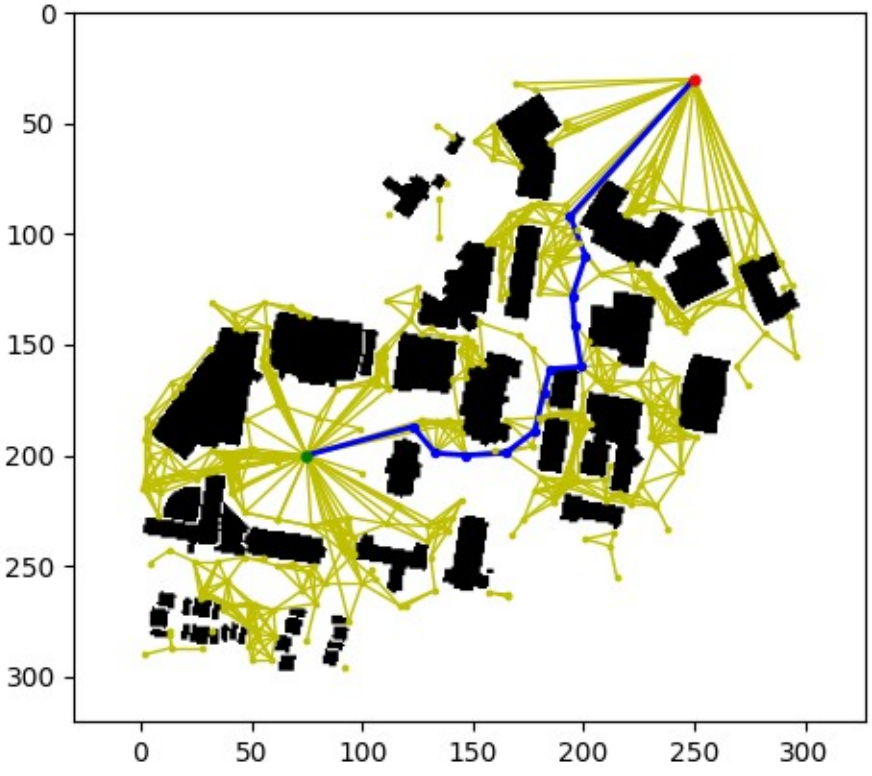


GAUSSIAN SAMPLING:

In this method a point is chosen randomly. Another point is chosen by normal distribution with mean first point. If one point is in obstacle and other point is in free space then the point in free space must be close to obstacle. By this way all the points near obstacle were found.

As the number of points drastically decrease the K-nearest neighbor's radius is increased to ensure better connectivity. The graph shown below has its nodes mostly concentrated near obstacles because of this reason.

```
The constructed graph has 300 nodes and 819 edges
The path length is 310.82
```

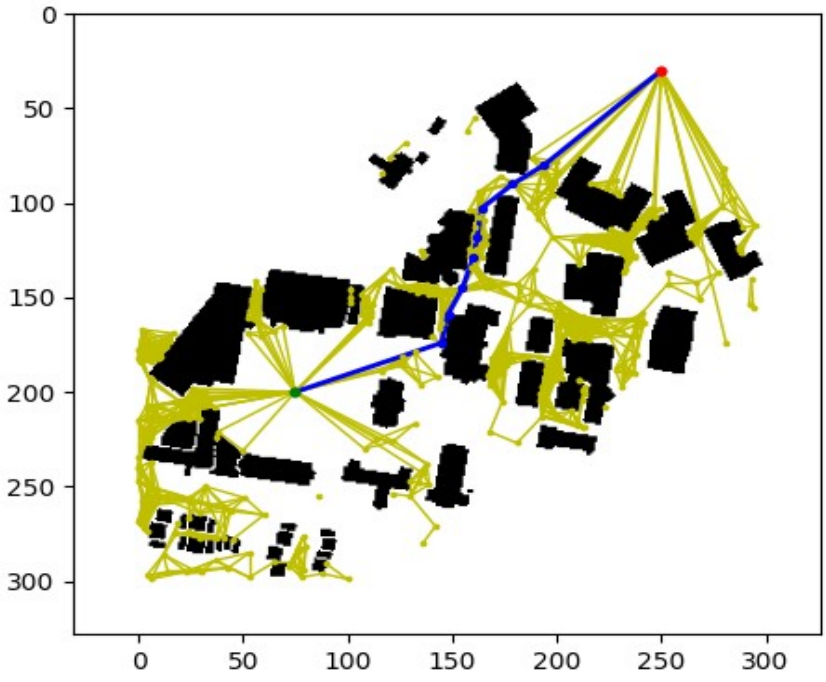


BRIDGE SAMPLING:

The bridge test is a hybrid technique that aims at better coverage of the free space. The idea is to take two random samples, where the distance between the samples is chosen according to a Gaussian distribution. Only if both samples lie in obstacle and the point in the middle of them lies in free space, the free sample is added to the list.

The sampled points are between the two obstacles. This ensures better connectivity of two clusters of the networks.

```
The constructed graph has 384 nodes and 1948 edges
The path length is 261.65
```



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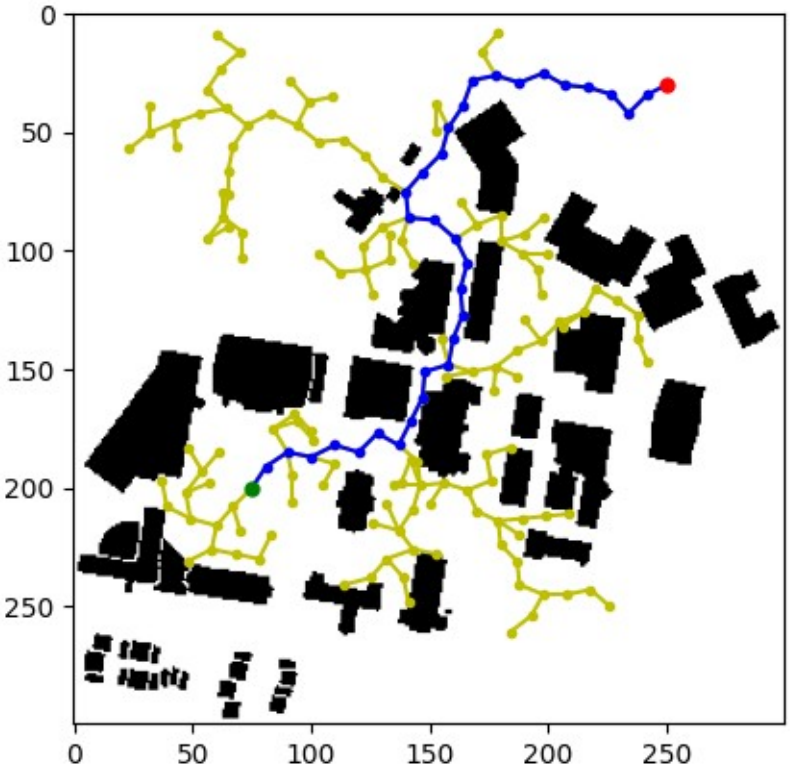
RAPIDLY EXPLORING RANDOM TREE (RRT):

RRT is a sampling based algorithm which explores the empty area and fills the empty areas with nodes. A start points is taken and a max distance of the sample is defined. If the distance between the start point and its nearest node is larger than max distance, the tree will be created pointing the direction of the line segment of the two points. If distance is lesser than the max distance, the node is checked for collision. If there is no collision between nodes the node then is appended to the vertices list.

As mentioned above the tree is allowed to expand and explore the free space. When one of the node is close to goal region, the node is then simply connected to it. Backtracking is done to get path from start to goal. For a given number of points, the path is not ensured, but as number of samples increases the chance of getting path also increases.

```
It took 165 nodes to find the current path
The path length is 360.94
```



RRT*:

RRT* is a variant of RRT where we impose an additional condition such that before connecting the new node with the nearest node we evaluate the cost to connect from the neighboring nodes, if the cost is minimum we will connect it to the least cost node.

```
It took 1372 nodes to find the current path
The path length is 260.08
```