# **Motion Planning Standard search algorithm implementation**

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

Uniform sampling:
Advantages of uniform sampling is that it spans the whole sample space. But in a way this is also the disadvantage of uniform sampling, Since it needs to iterate/check over a large number of samples. Also Uniform Sampling has least dispersion. Because we are taking random samples of C-space and repeating the process till all the sample values are collision free. Essentially this means we end up with highly dense sample space with samples placed closed to each other than in any other sampling technique.

Random Samples:
Advantage over uniform is that it has less number of samples as the probability of choosing the same point may occur and we disregard that point. The disadvantage of random sampling is that

Gaussian Samples:
The advantage is that we sample only near obstacles. If we have big obstacles that are nearby each other then we will get a lot of samples. But if we don't have many obstacles then we might not get enough samples altogether. Also gaussian samples may be too close to obstacles as per the standard deviation taken by us. Hence trial and error method is to be performed for choosing appropriate standard deviation.

Bridge Samples:
The advantage of bridge sample over gaussian is that it samples near obstacles but it tries to avoid closeness to obstacles by taking the midpoint of two nodes. This comes very handy in case of narrow paths. However if the narrow path has sharp edges this sampling too fails.

2)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 and RRT* both expands based on choosing a random direction. But in RRT we check for a new node in the direction of a random point and take a step in that direction and we append that node if there is no collision. Where as in RRT* We also check for neighbors when a new node is found and we try to update the cost of these neighboring nodes through a new node, if a lower cost path is found. Next time when this neighboring node becomes a new node then we already have the best path to reach that node. Hence this reduces the computation.

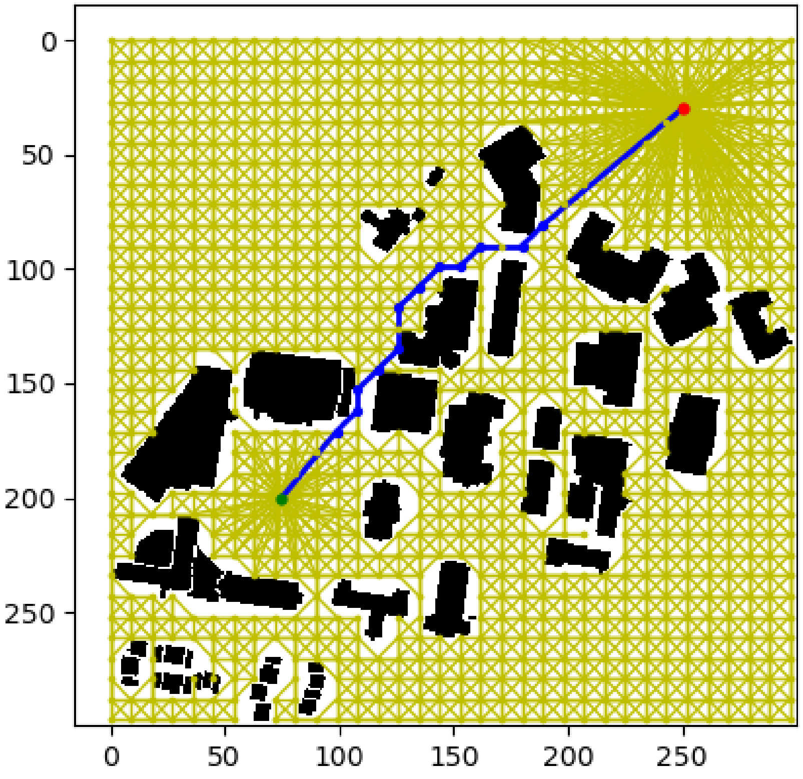
3)Comparing between PRM and RRT, what are the advantages and disadvantages?

RRT itself finds the shortest path whereas PRM just builds a road map. RRT algorithm is advantageous to find possible paths from a given point.But when a new location was given, an entirely new graph had to be generated. Repeatedly generating a new graph to find a single path is not very efficient.This is the disadvantage of RRT. This can be overcome by using PRM. In PRM instead of generating a fresh graph with each desired path we build a roadmap that covers the sample space properly and we then perform path finding algorithms such as dijkstras to find the shortest path.

## Results

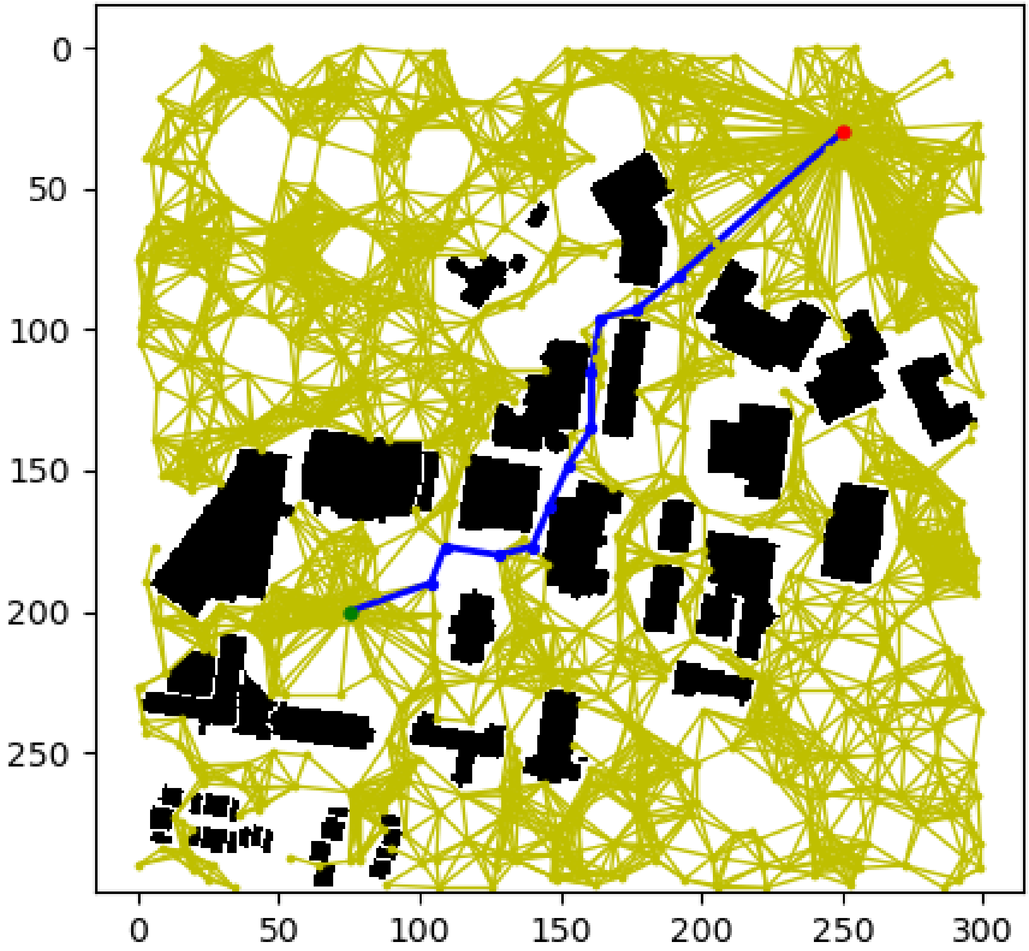
1) **Uniform Sampling:**

   Here it can be observed that the goal and start area are crowded with points. This is because we have selected K-d tree radius in the orders of 70 for goal and start. We sample by taking a step each time.  We want our samples to be equally spaced in image. Therefore we first calculate sqrt(n_pts) since our image is a 2D image, take this as step_len.  Then divide #rows and #cols with step_len which gives us the individual step legnths of rows and cols



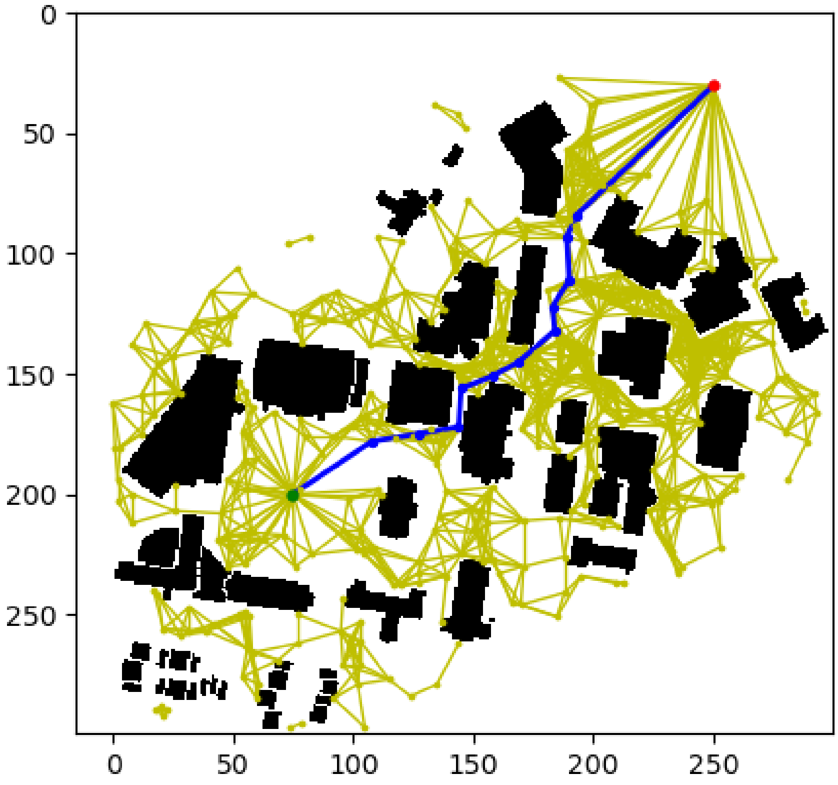
**2) Random Sample:**

______Here we just choose random points as samples. We use random.randint function of numpy python to generate random samples in range(#rows,#cols). We then check for collision criteria and add the new found samples if it passes.



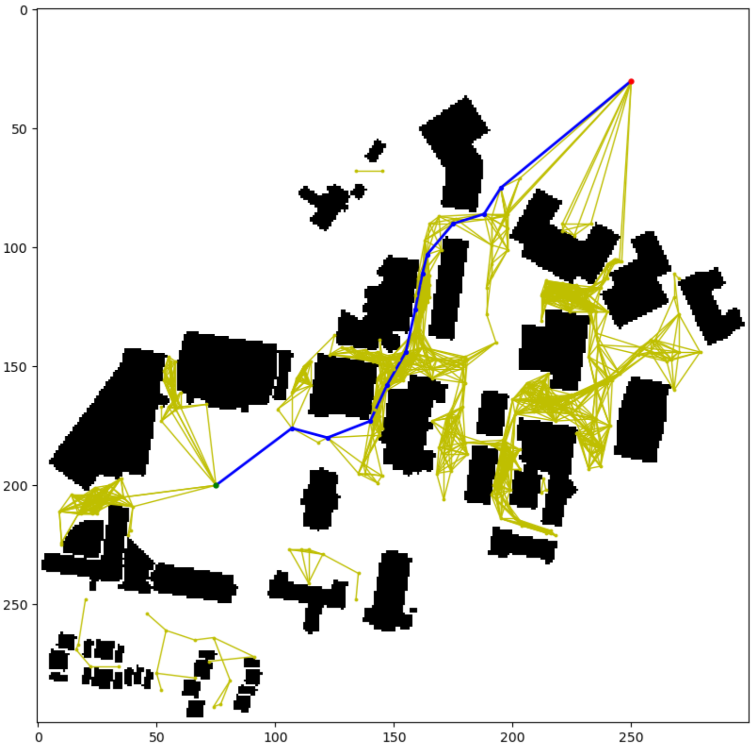
3) **<u>Gaussian Sample:</u>**

First generate random samples of length n_pts then select a point from this set and take a gaussian sample of this point.Check if both the points are either in free space or in collision. If so then drop the points.If not then append the free space sample to our samples queue. Here again we can see that goal and start are joined to too many samples this is because the K-d tree radius for goal and start are of order 70s. We can also see that samples are concentrated around the obstacles. This is due to the fact that we are only updating samples when a collision is found. But we also got less number of samples when compared to random or uniform.



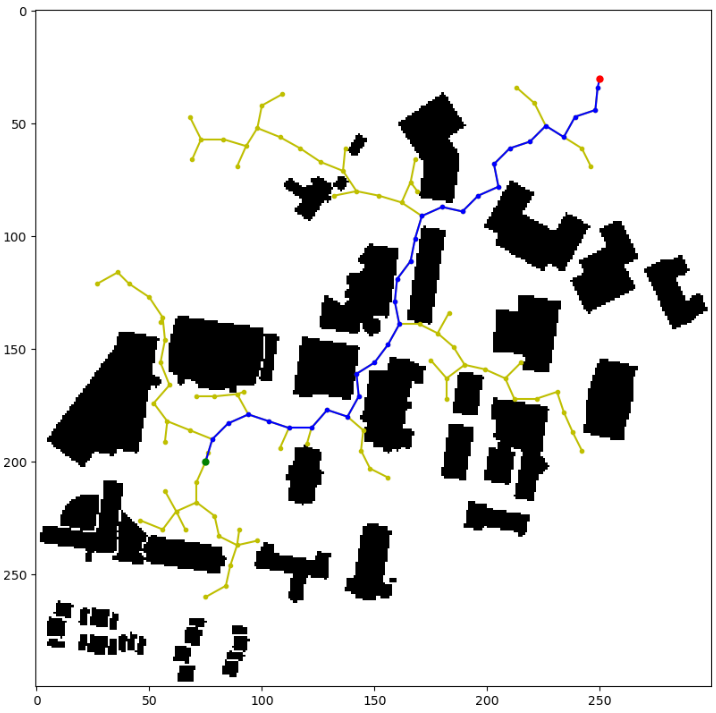
4) **Bridge Sample:**

This is more like gaussian sampling except that the updation condition is different. Here our criteria is both of the point and its gaussian pt are in collision then consider the midpoint of the line between point and the gaussian pt. Check if this mid point is in collision if not then add it to samples.Hence bridge sampling takes a lot of points near the obstacles. Now, we can see that more points are concentrated near obstacles hence it is difficult for us to connect start and goal with low K-d tree radius hence we choose this in the order of 70s in order to make connections from start and goal.This generates even less samples than gaussian because we are only taking midpoints of the collisions which spans only the narrow passages. There is a high chance of low connectivity in bridge sampling when taken K-d tree radius in range of 10s we couldn't obtain a path.



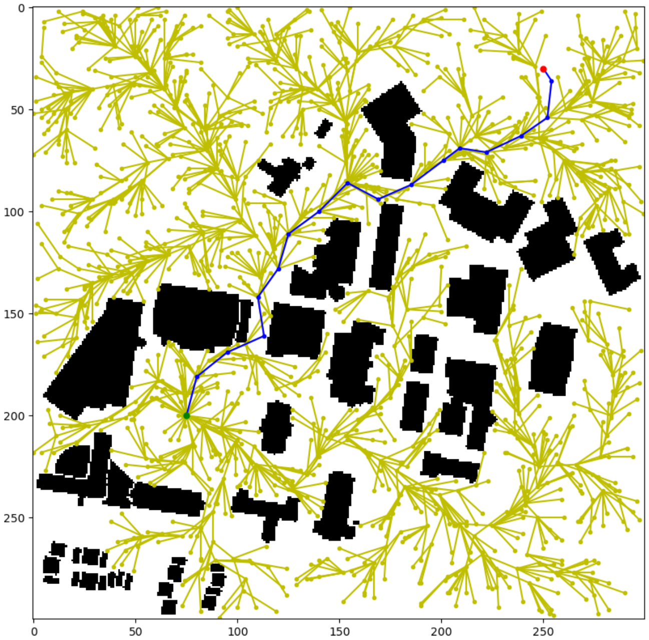
### 5) **RRT:**

RRT we check for a new node in the direction of a random point and take a step in that direction and we append that node if there is no collision. We can observe that RRT has less number of nodes when compared to other



6)**<u>RRT*:</u>**

Here we are also exploring neighbors when a new node is discovered. Hence we are making more connections here when compared to RRT. Even though these connections are computationally expensive we finally will get the shortest path as we are rewiring neighbors each time a new node is discovered.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