Motion Planning (RBE550)
Programming Assignment 4: RRT and RRT* Algorithm Implementation

Assignment By:
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Question asked in Assignment:

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?

Answer:

Rapidly-Exploring Random Trees (RRT) and RRT* are both probabilistic motion planning algorithms used to generate paths for robots or other autonomous systems in complex environments. The main difference between the two lies in their approach to building the tree (connection between the new sampled node and its neighbors) and the optimality of the solution.

RRT builds a tree by randomly selecting a point in the space and extending the tree towards that point. It keeps repeating this process until it reaches the goal region. The solution generated by RRT is not guaranteed to be optimal, but it is probabilistically complete, meaning that it will eventually find a solution if one exists.

On the other hand, RRT* improves on RRT by adding a rewiring step that optimizes the tree structure. RRT* first builds a tree like RRT, but then it rewires the tree by considering neighboring nodes and potentially re-parenting them if it leads to a better path to the goal. The rewiring process can be time-consuming but results in a more optimized tree structure and a better path to the goal. The solution generated by RRT* is probabilistically optimal, meaning that it will find the best solution with a high probability.

In terms of efficiency, RRT* is generally slower than RRT due to the additional rewiring step. However, the improved optimality of the solution can make up for the extra time required. If the environment is complex and the robot has to navigate around many obstacles, RRT* is likely to provide a better solution than RRT.

Question asked in Assignment:
Compare RRT with the results obtained with PRM in the previous assignment. What are the advantages and disadvantages?

Answer:
There are several advantages and disadvantages if compared between RRT and PRM:

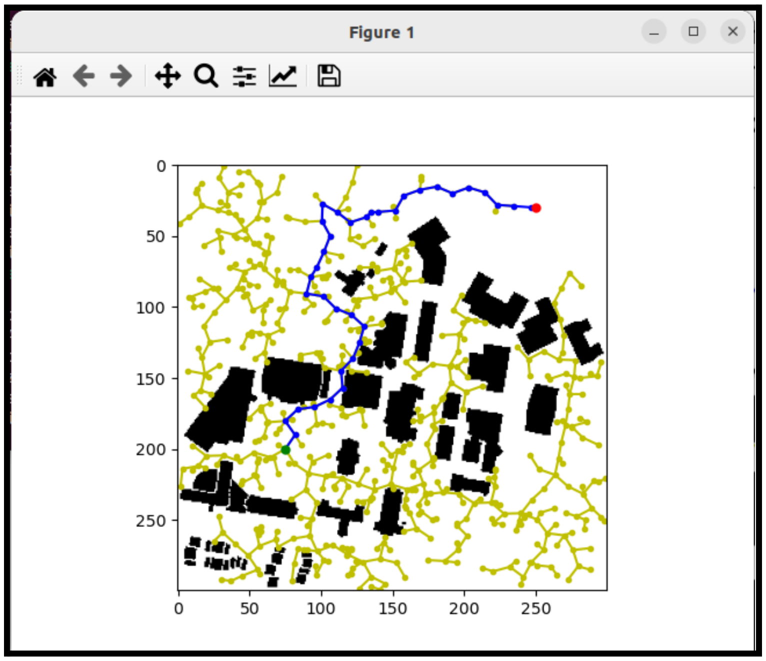
1. If we continue to T = infinity, we can find a solution if there is one or return that there is no path, as RRT is probabilistically complete.Due to different factors like the K-nearest neighbor search radius or the resolution of uniform sampling, PRM is not always accurate and may yield no path discovered.
2. In contrast to PRM method, which may not always guarantee this, each node in RRT tree is always connected to the start node.
3. Whereas PRM is a graph-based algorithm, RRT is a tree-based approach. To discover nodes in the C-free space, PRM will sample the complete C-space (free space). Always looking for nodes that can be linked to the tree, RRT.
4. Several criteria, independent of the objective location, are used for PRM sampling.RRT searches the C-space with a goal bias that directs the exploration in the direction of the target node.

Algorithm Results and Explanation:

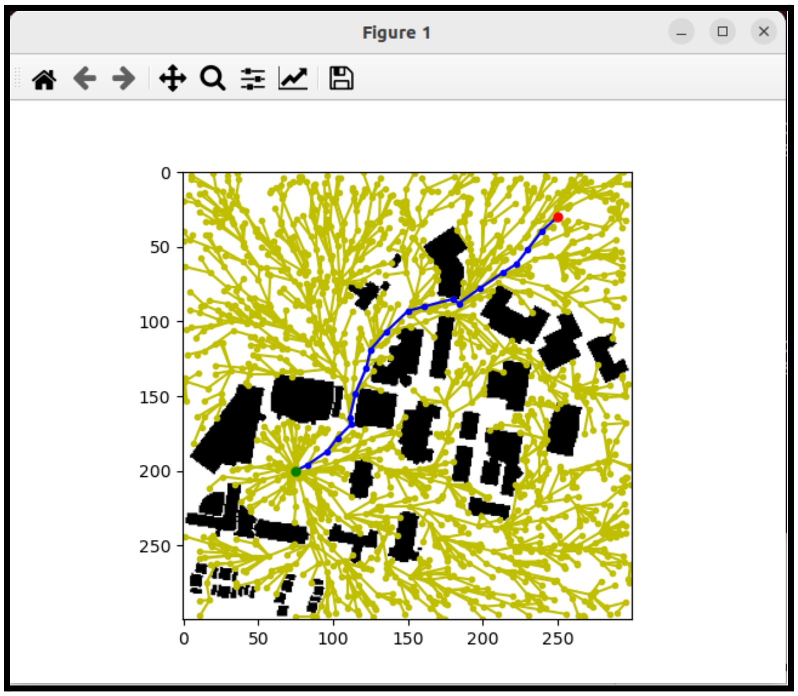
RRT and RRT* Algorithm:

Both these algorithms produce different results. RRT* gives more optimal solution compared to RRT but may take more time because of computational additions.

RRT Implementation Result:



RRT* Implementation Result:



RRT* initially adds the node to the tree by linking it to the neighbor with the lowest cost, which results in these different trees. The program then rewires nearby nodes to connect them to the present node if doing so would lower their cost. This rewiring process assists in lowering the tree's nodes to less expensive neighbors. This guarantees that the intended path will be optimum.

RRT can use two different goal search strategies: one in which the tree stops looking for nodes once it locates the goal node, and the other in which it maintains updating the cost of the goal node if a shorter path to the goal is discovered. If we implement RRT using the first approach, this distinguishes our algorithm from RRT*, which employs the second implementation method.

References:

1. https://theclassytim.medium.com/robotic-path-planning-rrt-and-rrt-212319121378
2. https://www.youtube.com/watch?v=QR3U1dgc5RE