RRT algorithm explained

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April 13, 2024

Introduction

Motion Planning

- Motion planning involves finding feasible paths for robots to navigate from their initial positions to their goal positions while avoiding obstacles.
- RRT is a motion planning algorithm designed to solve problems efficiently.

Basic Concepts

- RRT builds a tree structure consisting of vertices (nodes) and edges in the configuration space of the robot.
- The configuration space represents all possible states the robot can occupy.
- The algorithm aims to efficiently explore this space to find a path from the initial configuration to the goal configuration, avoiding obstacles along the way.

Algorithm overview(steps)

- The four mai steps are: initialization, expansion, connection, and optimization.
- Initialization involves starting with a tree containing only the initial configuration.
- Expansion iteratively grows the tree towards unexplored areas by randomly sampling points and extending the tree towards them.
- Connection involves finding the nearest node in the tree to the sampled point and adding it to the tree if it leads to a collision-free path.
- Optimization refers to refining the tree structure to improve solution quality, if necessary.

Algorithm improvments

Expansion strategies

These strategies aim to balance exploration of unexplored areas with exploitation of known areas. Strategies include uniform sampling, biased sampling towards unexplored areas, and goal-directed sampling, where sampling is biased towards the goal configuration.

Optimization techniques

These techniques include shortening paths, smoothing trajectories, and minimizing path curvature. Optimization is performed after the basic tree construction to refine the path found by the algorithm.

Application

- Robotics (autonomous vehicles, manipulators, drones),
- Game development (NPC movement, obstacle avoidance)
- Bioinformatics (protein folding, molecular motion planning)
- Virtual simulation, animation

Advantages and Limitations

Advantages

Advantages include its efficiency in exploring high-dimensional configuration spaces, scalability to complex environments, and flexibility to incorporate various optimization strategies.

Limitations

Limitations include the lack of optimality guarantees, sensitivity to sampling strategies and parameters, and the potential need for post-processing to obtain smoother paths.