Project-5 Proposal

Title

ROS-based Path Planning for Turtlebot Robot using Informed Rapidly Exploring Random Trees (Informed RRT*)

Team Members

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Introduction

The motion planning problem is divided into two broad categories, action-based planning and sample-based planning. The terms used throughout the section are defined below:

1. **Definitions**

   a. **Action-Based Planning**
   The motion planning problem where the map is divided into cells and then the optimal path is found between the start node and goal node by defining a set of actions for the node.

   b. **Sample-Based Planning**
   The motion planning problem where instead of dividing the grid into cells, the optimal path between the start node and goal node is found by sampling points at random [2][3].

   c. **RRT Algorithm**
   A rapidly exploring random tree (RRT) is an algorithm designed to efficiently search non-convex, high dimensional spaces by randomly building a space-filling tree. The tree is constructed incrementally from the

samples drawn randomly from the search space and is inherently biased to grow towards large unsearched areas of the problem [2].

d. **RRT* Algorithm**
RRT* is an optimized version of RRT. When the number of nodes approaches infinity, the RRT* algorithm will deliver the shortest possible path to the goal. It extends the RRTs to finding an optimal solution from the start node to every other node [2].

e. **Informed RRT* Algorithm**
An algorithm that is a variant of RRT* algorithm. It finds an optimal path from the start node to the goal node and retains the same probabilistic guarantees on completeness and optimality as RRT* while improving the convergence rate and solution quality [6].

2. Background

Intelligent mobile robot is a robot system that perceives information about its environment through sensors, determines the state and generates the necessary action to traverse from current position to the goal in order to accomplish a given task [1]. The necessity of using an efficient motion planning algorithm on the mobile robot is to ensure that the robot moves from the start point to the goal point in an optimal way and in optimal time. The motion planning problem is commonly solved by discretizing the state space with a grid for action-based planning or through random sampling for sample-based planning [2][3]. The problem with action-based planning is that as the problem size increases, the time required to find an optimal solution increases exponentially.

Sampling-based Planning algorithms, e.g. RRT and RRT* have been extensively used for path planning of mobile robots in recent years [2][3]. Sampling-based Planning algorithms provide quick solutions for complex and high dimensional problems using randomized sampling in search space [4][5]. Rapidly-exploring Random Trees (RRT) is a sampling-based planning algorithm that gives the optimal path quickly but fails to give an optimal solution. The variants of RRT algorithm like RRT* algorithm ensures to be asymptotically optimal, with the probability of finding an optimal solution approaching unity as the number of iterations reach infinity [7]. Although RRT* [8] extend the RRTs to finding the optimal solution, however, they find the optimal path from the initial state to every other state. This tends to be inefficient in scenarios where single query nature exists. On the other hand, Informed RRT* algorithm, a variant of RRT* algorithm, finds an optimal path from the start node to the goal node and retains the same probabilistic guarantees on completeness and optimality as RRT* while improving the convergence rate and solution quality [6].

3. Literature Review

In [6], Gammell et al. demonstrated the simulation results of testing the Informed RRT* algorithm and the RRT* algorithm in an unknown environment. Informed RRT* algorithm, a variant of RRT* algorithm, finds an optimal path from the start node to the goal node and retains the same probabilistic guarantees on completeness and optimality as RRT* while improving the convergence rate and solution quality. In [10], Kuwata et al. demonstrated their variant of the RRT algorithm, that is a real-time motion planning algorithm. In [9], Zhang et al. presented their variant of the RRT algorithm where RRT is combined with simultaneous localization and mapping (SLAM). In [1], Chang-an et al. presented the simulation results of testing their variant of the RRT algorithm and the traditional RRT algorithm in an unknown environment. Their variant of the RRT algorithm performed better than the traditional RRT algorithm. In [4], Seif et al. demonstrated a new path planning algorithm that is applicable to dynamic environments. In [3], Karaman et al. presented the overview of various sample-based algorithms used in motion planning.

Goal

We will be working on **Option 1.**
In this paper, the Informed RRT* algorithm will be used on **ROS Turtlebot2** to navigate in a configuration space consisting of static obstacles. Turtlebot2 belongs to the class of differential drive mobile robots whose movement is based on the relative rate of rotation of its two independently driven wheels placed on either side of the robot [9]. The path generated by the Informed RRT* algorithm will be compared with the path generated by the RRT* algorithm on the basis of the optimal time and optimal path from the start node to the goal node. This will help us verify that Informed RRT* outperforms RRT* in rate of convergence, final solution cost, and ability to find difficult passages while demonstrating less dependence on the state dimension and range of the planning problem.

Method

1. **Path Planning Method**
   The path planning algorithm we are going to use is **Informed RRT*** [6]. The algorithm is a variant of the RRT* algorithm. Unlike RRT*, Informed RRT* finds an optimal path between the start node and goal node and not between the start node and every other node.

2. **Title of Paper**
   The paper that we are going to work on is titled “Informed RRT*: Optimal Sampling-based Path Planning Focused via Direct Sampling of an Admissible Ellipsoidal Heuristic” [6].

3. **Software Packages and Programming Languages**
   The first step of the project would be implementing the algorithm using Python language. After the algorithm is implemented, we will use ROS Turtlebot2 to validate the algorithm by comparing the path generated by the algorithm to the path generated by the RRT* algorithm on the basis of the optimal time and optimal path from the start node to the goal node. The following are the software packages and programming languages we will be using for completing the project:
   a. ROS
   b. ROS Turtlebot2 package
   c. Gazebo Simulator
   d. Matplotlib
   e. Python

Timetable

Date	Task / Subtasks
11 April	Task: Overview of Sample-based Planning Algorithms Subtasks: 1. Complete the overview of the sample-based planning algorithms, i.e RRT, RRT* and Informed RRT*.

	2. Read and write the pseudo code of the Informed RRT* algorithm. 3. Complete the Introduction Section of the paper.
17 April	Task: Implement Informed RRT* and RRT* algorithms on ROS Turtlebot 2 software Subtasks: 1. Implement Informed RRT* and RRT* algorithm in Python for the holonomic robot case. 2. Next, implement the Informed RRT* algorithm for the Turtlebot robot, which is a Differential Drive Robot. 3. After implementing the algorithm, integrate the algorithm with ROS Turtlebot 2. 4. Complete the Method Section of the paper.
24 April	Task: Visualise and Compare the Path generated by Informed RRT* and RRT* algorithms using Gazebo Simulator and matplotlib package Subtasks: 1. Compare and visualise the path generated from start node and goal node in a configuration space consisting of static obstacles. 2. Plot the results using the matplotlib package for comparison. 3. Complete the Results Section of the paper.
7 May	Task: Submit the final version of the paper.

References

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