Project-5 Proposal

Title

ROS-based Path Planning for Turtlebot Robot(Non-holonomic) using Informed Rapidly-exploring Random Trees (Informed RRT*).

Team Members

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Introduction

1. **Definitions**

    a. **Action-Based Planning**
    The motion planning problem where the grid 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[3].

    c. **RRT* Algorithm**
    An algorithm that extends the RRTs[2] to finding an optimal solution from the start node to every other node[4].

    d. **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[1].

2. Background

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.The problem with action-based planning is that as the problem size increases, the time required to find an optimal solution increases exponentially. On the other hand, 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[2]. Although RRT*[4] 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.

3. Literature Review

We will be using Informed RRT* algorithm[1], an algorithm which finds the optimal path from the start node to the goal node. It retains the same probabilistic guarantees on completeness and optimality as RRT* while improving the convergence rate and solution quality. 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.

Goal

1. We will be doing **Option 1,** that is, we will implement the Informed RRT* algorithm(Sampling based method) on ROS Turtlebot software package.

2. First, we will implement the algorithm in Python and use Matplotlib to check for the path generated and the nodes explored by the algorithm, as we did in Project 3 Phase 2 and Phase 3. Next, we will implement the Informed RRT* algorithm for non-holonomic robots using the differential drive constraints of the Turtlebot. Next, we will use the implemented algorithm on ROS Turtlebot simulation and compare the path generated by the Informed RRT* algorithm with the path generated by the RRT* algorithm.

Method

1. **Path Planning Method**

   The path planning algorithm we are going to use is **Informed RRT***[1]. 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”[1].

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 Turtlebot to validate the algorithm by comparing the path generated by the algorithm to the path generated by the RRT* algorithm. The following are the software packages and programming languages we will be using for completing the project:
   a. ROS
   b. ROS Turtlebot package
   c. Matplotlib
   d. Python

Timetable

Date	Task
10 April	1. Complete the overview of the Informed RRT* algorithm and read the paper mentioned in the references section[1]. 2. Complete the Introduction Section of the paper.
17 April	1. Implement Informed RRT* and

	RRT* algorithm in Python for the holonomic robot. 2. Next, implement Informed RRT* for the Turtlebot robot(Non-holonomic robot). 3. After implementing the algorithm, integrate the algorithm with ROS Turtlebot. 4. Complete the Method Section of the paper.
24 April	1. Compare the path generated from start node and goal node through RRT* and Informed RRT*. 2. Visualize and plot results for comparison. 3. Complete the Results Section of the paper.
7 May	1. Submit the final version of the paper.

References

[1] Gammell, J., Srinivasa, S., & Barfoot, T. (2014). Informed RRT*: Optimal Sampling-based Path Planning Focused via Direct Sampling of an Admissible Ellipsoidal Heuristic. *IEEE/RSJ International Conference on Intelligent Robots and Systems.*

[2] Noreen, I., Khan, A., & Habib, Z. (2016). A Comparison of RRT, RRT* and RRT*-Smart Path Planning Algorithms. *IJCSNS International Journal of Computer Science and Network Security, 16(10),* 20-27*.*

[3] Karaman, S., & Frazzoli, E. (2011). Sampling-based algorithms for optimal motion planning. *IJRR, 30(7)*, 846–894.

[4] Karaman, S., Walter, M., Perez, A., Frazzoli, E., & Teller, S. (2011). Anytime motion planning using the RRT*. *ICRA, 1478–1483*.