EECS 598 Motion Planning Project Proposal

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1 Abstract

Robots are frequently required to operate and plan in changing environments and with incomplete information. This proposal describes using a recently introduced sample based motion planning algorithm called Fast Marching Trees or FMT* and adapting it for dynamic planning. The algorithm as a single query planner in a static environment is shown to converge to an optimal solution faster than RRT* as stated in the paper [1]. The goal in this proposal is to use FMT* to initially plan an algorithm and upon encountering an obstacle, bias the node selection of subsequent re-planning attempts. This study will compare the performance of FMT* re-planning using prior information from a previous solution with an RRT* variant proposed in [2].

2 Introduction and Background

Dynamic sampling based motion planners have been a major area of interest as most environments in which robots are expected to operate in are not static. Additionally, if incomplete information about the environment is used to plan and new information is learned when executing a trajectory, it is desirable to reuse as much information from the current plan as possible. [3] provides an extensive list of dynamic sampling based planning algorithms (SBP) and organizes them into two main paradaigms: those based on PRMs and those based RRT and RRT*.

One of the first sampling based motion planning algorithms that could be used for re-planning was ERRT [4]. It introduced the idea of using a waypoint cache to bias samples between successive planning phases taking advantage of the fact that once an obstacle was encountered, the re-planned path could be calculated quicker by knowing a previous path to the goal. This algorithm did require regrowing the tree. DRRT [5] addresses this and tries to reuse the tree grown in the initial planning phase by invalidating nodes and branches in the tree when encountering an obstacle and then trying to reach the robot location with the pruned tree with the root of the tree changed to the goal configuration. MP-RRT [6] combines the sampling bias introduced by ERRT and the re-usage of parts of the tree from DRRT. All three algorithms are based on RRT which provides no guarantee about path optimality.

In the RRT* space, there are many algorithms that have attempted to use its variants for dynamic path planning as well. Similar to DRRT, RRT^x [7] starts the root of the tree from the goal configuration and actively rewires the tree as new obstacles are discovered. While the algorithm performed well in simulation, in some cases an inverse dynamics model cannot always be calculated and so this proposal focuses on a solution with forward planning. Finally, there has been one study on online RRT* and online FMT* proposed by Chandler and Goodrich [8], but it focuses more on online rewiring of the tree for adapting to dynamically changing goal configurations.

Building upon the waypoint caching idea in ERRT, the proposal in this work describes using the FMT* algorithm with a biased sampling of the nodes on the initial path in future re-planning phases. While, no rewiring is performed in the tree, the expectation is that biasing the sampling of the nodes when re-planning will still provide a significant improvement in computation time when compared to naively re-planning from a new start location.

3 Proposed Work

The main dynamic FMT* algorithm being proposed can be summarized as as follows:

1. Run FMT* to obtain an initial solution path
2. Follow the path until an obstacle is encountered
3. Store nodes in a waypoint cache that meet the following criteria:
    - node is not in collision
    - node cost to goal is less than cost of current robots location to goal
4. Run FMT* again with sampling from both uniform space and waypoint cache

The above algorithm will be compared with an FMT* algorithm which naively re-plans in the whole space each time an obstacle is encountered and the dynamic RRT* as proposed in [2]. In that paper, when encountering an obstacle, the authors assume that the best way to re-plan is to select as a sub goal the next available node on the initial solution path that is collision free after the obstacle. All nodes in the tree that are in the obstacle are invalidated and the tree is rewired and grown with new samples until the sub goal on the original solution path is reached.

The algorithms discussed will be implemented in either OpenRave or OMPL.

4 Proposed Experiments and Expected Outcomes

To analyze the suggested algorithm, the following three classes of simulations are proposed:

- FMT* and re-planning using no biasing
- FMT* with node biasing from the initial solution
- Dynamic RRT* as proposed in [2]

The environment in which the simulations will be run is inspired by the test environment used in the FMT* paper. The start and goal configuration will lie in a high dimensional environment (dimension ≥ 5). For inducing the re-planning, dynamically appearing obstacles (hyperrectangles) will be added in the environment along the path of each algorithm. For evaluation, the same generated environment will be used to run simulations for all three algorithms. However, since the re-planning stage will create different paths for each planner, it will be programmed such that the path calculated by each planner will run into a fixed number of obstacles to evaluate re-planning time across all three algorithms.

5 Weekly Schedule

Week 1 (March 11-17): Implement Dynamic FMT* and Dynamic RRT* Algorithm

Week 2 (March 18-24): Implement Dynamic FMT* and Dynamic RRT* Algorithm

Week 3 (March 25-31): Create environment for running simulations

Week 4 (April 1-7): Run simulations of both Dynamic RRT* and Dynamic FMT*

Week 5 (April 8-14): Finish collecting data and prepare report

References

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