Proposal ELEC 844

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***Abstract*— This work addresses the moving-goal problem in motion planning for a robot with Ackermann steering. The proposed approach adapts the Rapidly-exploring Random Tree (RRT) algorithm to generate kinematically feasible motions and continuously replan as the goal changes position. Its performance will be compared with a standard RRT. Experiments involve a moving goal following a circular trajectory among obstacles and evaluate computation time and success rate under varying goal speeds, replanning time budgets, and step sizes. The objective is to determine whether the added computational cost of kinematic feasibility yields improved overall performance.**

I. INTRODUCTION

Motion planning is the field responsible for developing methods that enable a robot to generate a path within a map to reach a predetermined goal [1]. It allows a robot to navigate environments filled with obstacles, where moving directly toward the goal in a straight line is not possible. Instead, the robot must plan and follow a collision-free path that safely avoids these obstacles [2].

One of the ongoing challenges in motion planning is dealing with a moving goal. This issue is actively studied, as highlighted in various sources [3], [4], [5]. The complexity arises because the robot must continuously replan its path in real time while the goal's position changes over time [5]. If the replanning process takes too long due to computational limitations, the generated path may become invalid or lead the robot to an outdated goal position.

In this proposal, I aim to evaluate the performance of a motion planner in addressing the moving-goal problem for a robot with Ackermann steering in an obstacle-laden map.

II. RELATED WORKS

In [4], the issue of a moving goal for mobile robots is addressed using a variation of the D* algorithm. The results indicate slightly better performance in certain aspects compared to other approaches for this application. However, this method does not consider the robot's kinematic constraints, which means that while a path to the goal may exist, the robot might not be physically capable of following it. Additionally, it does not include comparisons with sampling-based planners.

In [6], the authors propose an online planning approach for a robot with Ackermann steering that considers its kinematic constraints. Their method, called the Fast Bi-directional Kinematic RRT, enables real-time planning and demonstrates improved efficiency in dense environments compared to SST and TP-space RRT. However, their experiments were conducted only for static goals.

Finally, in [5], the authors address the moving-goal problem by framing it as a pursuit-evasion scenario. They solve it using the EST algorithm and incorporate time information into the tree, comparing its performance with RRT and RRT*. The results reveal that EST achieved better performance; however, the experiments were conducted with point-like robots rather than those with kinematic constraints.

III. PROPOSED METHODOLOGY

The proposed methodology utilizes RRT algorithm to generate edges that represent feasible motions based on the Ackermann steering kinematic model, as defined in Equation 1 [6]. Since the goal is dynamic, the planner must continuously replan in real time [3]. To achieve this, the robot first constructs an initial tree and follows the first node of the resulting path. While navigating that segment, it simultaneously replans using the position of the next node from the previous tree and the current position of the moving goal.

$$\begin{bmatrix} \dot{x} \\ \dot{y} \\ \dot{\theta} \\ \dot{\phi} \end{bmatrix} = \begin{bmatrix} \cos\theta & 0 \\ \sin\theta & 0 \\ \frac{1}{\ell}\tan\phi & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix} \tag{1}$$

Some challenges may arise from this approach. First, the planner has a limited amount of computation time. If the planning process takes too long, the goal may have already moved, making the original path outdated. Therefore, if a valid path is not found within the allotted time, the system must replan from scratch, considering the updated goal position.

The second challenge involves generating edges that represent feasible motions. A solution to this problem is presented in [7], where a steering function is used to connect nodes. Building on this idea, the current work employs the RRT algorithm as the foundation for sampling points in the configuration space. After each sample, the planner identifies the nearest existing node and uses a trajectory generator to connect it to the sampled point. If the resulting trajectory length is shorter than the defined step size, a complete connection is made; otherwise, the trajectory is extended only up to the step limit, and a new node is created at that position [7].

IV. COMPARISON EXPERIMENTS AND HYPOTHESIS

This work will compare the RRT with kinematically feasible edges generated using the steering function described in

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[7] against a standard RRT. The hypothesis is that the standard RRT will plan faster because it requires less computation, but may generate lower-quality or even infeasible paths for the robot. The objective is to assess whether the speed advantage justifies the loss in path quality for a moving-goal scenario, or whether the additional computational effort required to account for kinematic constraints results in better overall performance.

The evaluation will consider two main metrics: computation time, as used in [3], and success rate, as defined in [5]. The experiments will be conducted in a scenario where the moving goal follows a circular trajectory among pre-positioned obstacles. Furthermore, the analysis will include a sensitivity study of key parameters, considering cases where the goal moves faster, slower, or at the same speed as the robot, as well as different time budgets for replanning and varying planner step sizes.

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