Generating Path Combining RRT* with Dubin's CSC Path Under Curvature Constraint Condition

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INTRODUCTION AND OBJECTIVE

In the world of robotics, path planning plays a vital role in enabling motion. Robots or vehicles can generally be classified into two types: holonomic and non-holonomic. Holonomic path planning does not involve many issues since it has fewer motion constraints, making it relatively easier to design paths. In contrast, non-holonomic path planning introduces more challenges because the constraints increase significantly, considering both vehicle dynamics and kinematics. When non-holonomic constraints increase, the planned path must satisfy curvature, velocity, acceleration, and steering limits, not just geometric feasibility. Keeping this in mind, in this paper we propose an approach that combines Dubin's paths (CSC), RRT*, and a smoothing technique to generate paths for a non-holonomic vehicle in an obstacle-rich environment, while ensuring that the path curvature remains bounded.

METHOD OF ANALYSIS

We used a non-holonomic vehicle with a fixed minimum turning radius operating in an obstacle-rich environment. Assuming a grid size of 1000 units ×1000 units considering only a single obstacle for initial studies and assuming the initial and final locations are far apart. First, we implemented the Dubin's CSC path to connect the start and target locations directly, ensuring an optimal and feasible route in the absence of obstacles. However, when obstacles lie in between, we employed RRT* all around the obstacle to generate feasible detours around them. After bypassing the obstacles, the RRT* path reconnects with the original Dubin's path (CSC). In this way, a set of waypoints is generated, which are then smoothed while considering the minimum turning radius of the vehicle, ensuring that the path curvature remains within the allowable range of operation.

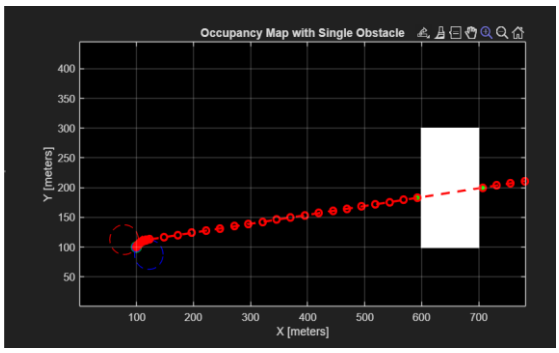

Figure 1: CSC Dubin's path is created between initial and final position generating waypoints

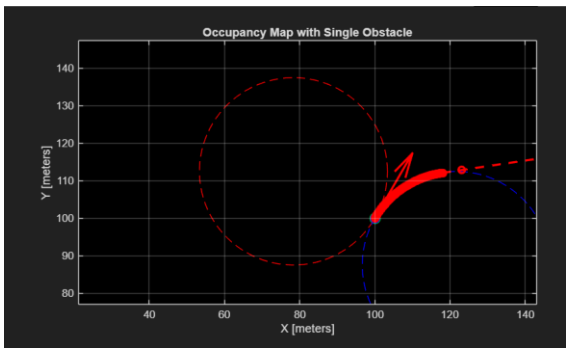

Figure2: CSC Dubin's path with pi/3 heading angle with Minimum turning radius of 20 units at initial position

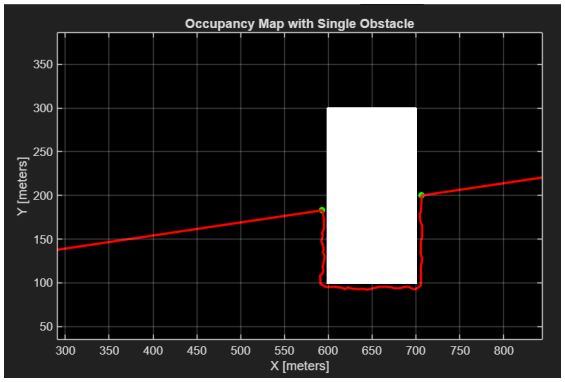

Figure 3: Final Raw path created without Smoothening combining CSC dubins and RRT*

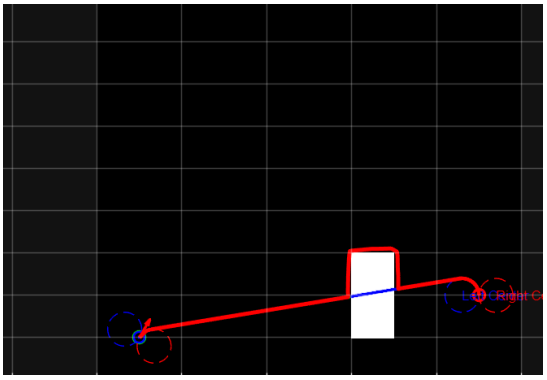

Figure 4: Final Raw path created without Smoothening combining CSC dubins and RRT*

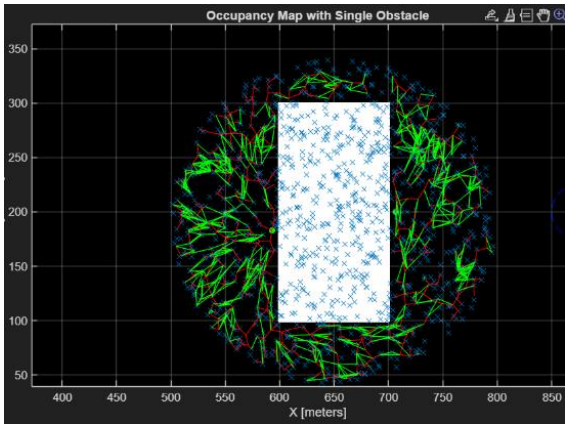

Figure 5:Green line shows the Rewiring between RRT* and red thin lines in circle of connections between parent nodes with blue x as sampling points.

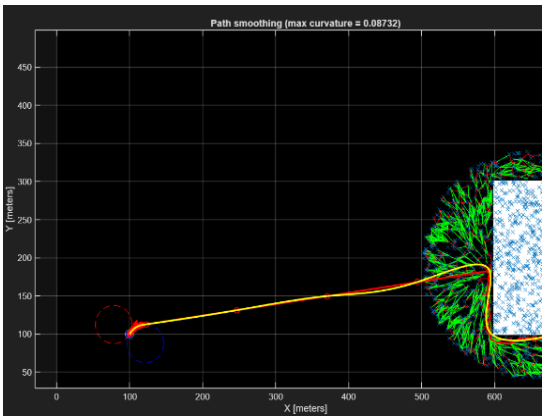

Figure 6:s Red Line shows the Actual path generated which is smoothed using B-Spline shown by yellow line.

HIGHLIGHTS OF IMPORTANT POINTS

A Dubin's–RRT* algorithm was implemented/Simulated using MATLAB to address non-holonomic path planning for car-like vehicles. The method Gives a shortest path between initial and final position using dubin's CSC path as shown in fig. 1& 2 and then RRT* is applied across the complete obstacle shown in fig. 3, 4, 5. A B-spline smoothing module was applied to enforce C^2-continuity and reduce sharp turns shown by yellow path as shown in fig. 6 which have maximum curvature of 0.08732 which is not expected. Curvature Boundedness is still to be processed and will be shown implemented in full length paper with experimental Analysis of theoretical works.

REFERNCE

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II. Lugo-Cárdenas, G. Flores, S. Salazar, and R. Lozano "Dubin's path generation for a fixed wing UAV " in Proc. 2014 Int. Conf. Unmanned Aircraft Systems (ICUAS),Orlando, FL, USA, May 27- 30, 2014, pp. 819–824.

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