1 Introduction

Autonomous vehicles have become common industrial tools for material transport through workshops and eCommerce warehouses, and container transport through large ports. In such applications, the vehicles require collision-free and safe motion trajectories at every time instant. Nowadays, the computation of such trajectories is mostly simplified by strongly conditioning the environments in which the vehicles operate: they are forced to move over dedicated tracks, are separated from humans, and their velocities are limited. However, these restrictions also reduce the performance, and therefore the potential of using autonomous vehicles, to a great extent. As a consequence, there is a growing interest in more flexible motion planning techniques, which poses challenges in vehicle localization, safety and in particular, in trajectory generation.

This abstract presents a novel approach to efficiently generate motion trajectories through vast, uncertain environments containing moving obstacles. It combines a high level grid-based path planner with a low level local trajectory optimizer. The high level planner uses a grid-based method to find a rough trajectory through the environment. The low level motion planner finds a local trajectory in the neighborhood of the vehicle by solving an optimization problem with a receding horizon, dealing with uncertainties in the environment. The proposed approach is validated by extensive numerical simulations.

2 Methodology

The proposed method first represents the stationary part of the environment in a tree, containing the obstacle occupancies. Afterwards, the high level path planner uses this tree to find a rough global path through the environment, consisting of a sequence of waypoints. The low level planner acts within a local frame around the vehicle and takes into account both the stationary and moving obstacles. It uses the section of the global path that is inside the frame to make an initial guess for the motion trajectory to a local goal. This local goal is determined from the waypoints of the global path. The low level planner uses a spline parameterization for the local trajectory, formulates the trajectory generation problem as an optimal control problem and solves it with a receding horizon [1]. When the vehicle is close to the local goal, the global path is updated, a new local frame is obtained and a new trajectory is computed. New local frames are obtained until the final goal lies within the frame, allowing the local planner to compute a trajectory to the endpoint.

3 Simulations

Figure 1 shows the simulation of a holonomic vehicle moving through a vast warehouse. In addition to a number of stationary obstacles, the warehouse also contains two moving obstacles (hatched in Figure 1) that invert their movement direction when hitting a wall. The global path, computed by the high level planner, is given by the red dashed line. The solid line is a connection of the spline trajectories over all frames, computed by the low level planner. Each local frame is plotted by a dotted rectangle, together with the initial vehicle position inside the frame, its trajectory through the frame and its goal position within the frame, using one color per frame. Figure 1 clearly shows that the local spline trajectories traverse the warehouse in a more optimal way than the grid path, since they are more flexible. Furthermore, it is clear the goal position differs from the end position of the grid path. This is because the grid path can only connect grid points, while the spline trajectory can reach any feasible position. The apparent detour in the center of the environment is due to an inversion of the movement direction of the left moving obstacle, after hitting the wall.

Figure 1: Holonomic vehicle moving through a vast warehouse

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