Online Planner based on Modified RRT and Trajectory Optimization

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ABSTRACT

This paper addresses the development of an online trajectory-planner for multi-rotors. The planner is capable of generating trajectories in partially unknown environments with moving obstacles. The developed algorithms are capable of quickly avoid unexpected obstacles, both static and moving. The trajectory planner is based on a modified RRT and a trajectory-optimization algorithm. The cost function used is a combination of trajectory time and energy/fuel consumption, in order to allow the generation of optimal trajectories in terms of mission costs. Several simulations are performed and the real-time avoidance capability of the proposed solution is validated.

To this end, an algorithm capable of planning aggressive trajectories in partially unknown environments with moving obstacles has been developed. The algorithms are able to quickly react to new detected obstacles (including moving obstacles), and to safely avoid them by quickly adjusting the trajectory without the need to stop the UAV. Concerning trajectory planning, it is also desirable to compute optimal trajectories. Optimality is defined in terms of mission costs (a combination between mission time and fuel/energy consumption). The algorithm has anytime capabilities, meaning that it is possible to quickly generate a suboptimal trajectory and then optimize it for a given period of time. An optimal trajectory is computed if enough computation time is available. To enable path planning in real time, a simplified dynamic model for multi-rotors was used.

Both the RRT and the trajectory optimization algorithms were combined into a real-time trajectory planner. An additional implemented feature is the capability of quickly stopping the multi-rotor when a close collision time is predicted. Several simulations using a simplified environment are performed that validate the capability of the algorithm to generate collision free trajectories in partially unknown environments. It was also proven the capability of avoiding moving obstacles, which trajectories are predicted assuming a constant obstacle speed. The algorithms were also used to plan the trajectories of two agents using a distributed approach. The agents were capable of coordinating among them collision free trajectories. Finally, it was shown that a vehicle with realistic dynamics is capable of following aggressive trajectories generated by the proposed planner. Physics simulations were performed using Gazebo to show the possibility of using these algorithms for aggressive multi-rotor maneuvering.