Development and Implementation of an Improved A*/FTG Hybrid Algorithm on a Differential Drive Mobile Robot Chassis

Lin, Ethan (School: New Hyde Park Memorial High School)

Path planning, or determining an optimal and collision-free route from a start point to a goal, is one of the most challenging problems in autonomous mobile robotics. Classical A* is a foundational global path planner; however, it prioritizes optimality over safety and is collision-prone in dynamic environments due to a lack of sensor feedback. Follow-the-Gap (FTG) is a local path planner; however, it is not globally optimal due to a lack of static-map awareness. This research introduces a novel IA*-FTG hybrid algorithm, integrating improved versions of A* and FTG to enable mobile robots to safely navigate dynamic environments. Classical A* was enhanced by adding obstacle inflation and incorporating a penalty factor based on obstacle proximity, increasing safety and robustness. FTG was improved by implementing a novel, multi-objective optimization function considering clearance, goal alignment, static map awareness, and motion consistency in gap scoring to improve optimality and safety. The novel hybrid algorithm was implemented on a custom differential-drive mobile robot. Using a Raspberry Pi 4B running ROS 2 for navigation and a Teensy 4.0 for low-level control, the mobile robot can plan optimal paths while detecting and avoiding obstacles in real time with a low-cost 2D LiDAR module. The novel IA*-FTG hybrid algorithm was evaluated against classical A* as a benchmark across 15 physical tests, achieving a 100% path completion rate with 0 collisions, significantly improving safety and robustness while maintaining path optimality. This novel hybrid algorithm has a significant impact due to its versatility, with applications across a wide range of mobile robots operating in dynamic environments, such as wheeled platforms, humanoids, quadrupeds, and drones.

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