Robotic Autonomous Trolley Collection with Progressive Perception and Nonlinear Model Predictive Control

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Abstract

Autonomous mobile manipulation robots that can collect trolleys are widely used to liberate human resources and fight epidemics. Most prior robotic trolley collection solutions only detect trolleys with 2D poses or are merely based on specific marks and lack the formal design of planning algorithms. In this paper, we present a novel mobile manipulation system with applications in luggage trolley collection. The proposed system integrates a compact hardware design and a progressive perception and planning framework, enabling the system to efficiently and robustly collect trolleys in dynamic and complex environments. For the perception, we first develop a 3D trolley detection method that combines object detection and keypoint estimation. Then, a docking process in a short distance is achieved with an accurate point cloud plane detection method and a novel manipulator design. On the planning side, we formulate the robot's real-time motion planning under a nonlinear model predictive control framework with control barrier functions to improve obstacle avoidance capabilities while maintaining the target in the sensors' field of view in close distances. We demonstrate our design and framework by deploying the system on actual trolley collection tasks, and their effectiveness and robustness are experimentally validated.

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