An AI-based Approach for Path Planning of Robotic Wheelchairs in Obstacle-Dense Environments with Quality and Reliability Constraints

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Abstract:
Autonomous robotic wheelchairs have become a primary mobility tool for people with limited mobility. The fundamental challenges in mobile robot navigation include three pivotal aspects: the robot's localization, map construction, and path planning. A main focus of this paper is path planning with improved quality and reliability constraints taken into account. Given a location of the wheelchair and a navigation environment map, path planning aims to determine an optimal route from the origin to the destination. However, simply determining the shortest/cheapest route in terms of time or cost is often insufficient, as user safety, comfort during the trip, and the ability of the wheelchair to successfully complete its mission must also be ensured. This challenge becomes more complex when navigation occurs in urban areas with many unpredicted obstacles. Therefore, effective path planning must simultaneously consider multiple constraints rather than focusing solely on distance, cost, or travel time. Solving this multi-constrained problem requires an integrated approach that balances these different aspects of navigation. To this end, we develop a new AI-based practical PRM-type path-planning algorithm designed for obstacle-dense environments while satisfying quality and reliability constraints. To achieve this goal, we formulate and solve a mixed integer mathematical programming model for AI-based device optimization. Quality constraints in this model ensure the trip's smoothness and user's comfort. Reliability constraints ensure the ability of the wheelchair to function in complex environments with a low probability of failure. The proposed approach is evaluated on real and simulated maps and demonstrated its applicability and effectiveness.

Keywords:
Robotic wheelchair, obstacle-dense environment, AI-based path-finding algorithm, quality constraints, reliability constraints.