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Integrated Path Tracking Control for Collision Avoidance of Autonomous Mobile Robot with Unknown Disturbance

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Abstract:

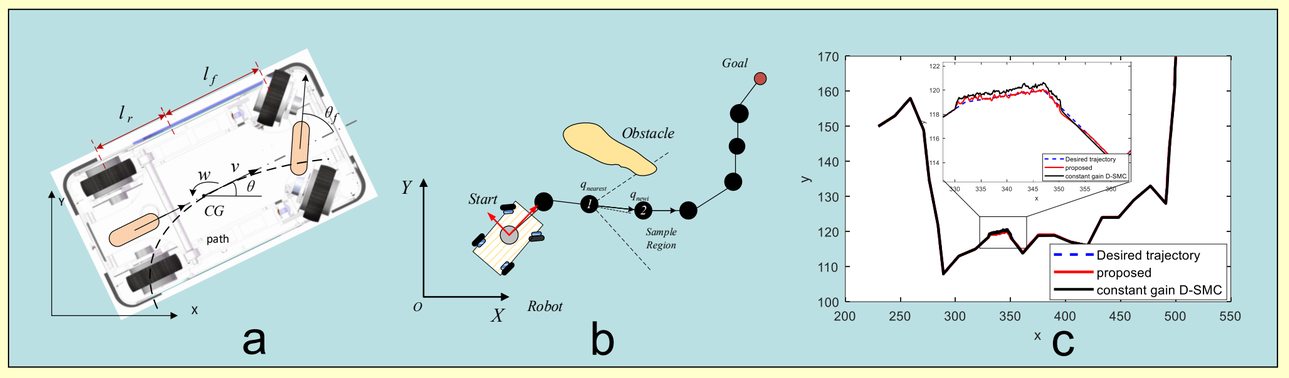
Autonomous mobile robot (AMR) has been appealed for intelligent manufacturing and automation applications due to their commendable performance. In the presence of external disturbances and modeling parametric perturbations in industrial applications, it is difficult for the considered AMR to accurately tracking on a desired trajectory while avoiding collisions. In order to solve this challenge, this paper proposes an integrated path tracking control based on an improved adaptive decoupled sliding mode controller (ADSMC). Firstly, the path planning is optimized by using the goal biased rapidly-exploring random tree path planning scheme that considers angle constraints and variable step length. Secondly, an improved decoupled sliding mode controller is designed to follow this path. Adaptive gains are scheduled online by exploring barrier functions, which maintains the tracking integrated in a small neighborhood of origin in unknown environments. The convergence and stability of the AMR system are guaranteed theoretically. Finally, through several experiments, the effectiveness of the scheme proposed in this paper is verified.

Contributions:

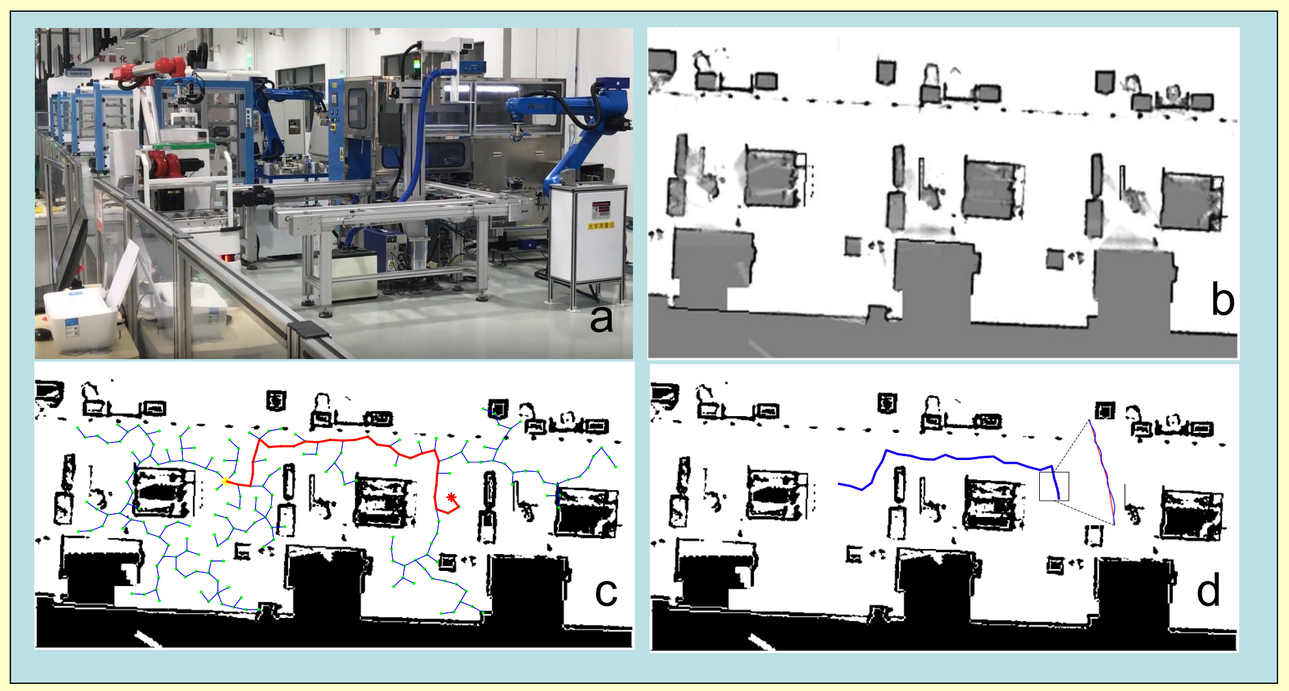
1) By optimizing the RRT method, the angle constraints and dynamic step are considered to ensure the smoothness of the path, so that the planning path can conform to the mobile robot model and avoid collisions. In addition, the RRT random point expansion of goal-biased is also considered, which reduces the number of unnecessary nodes and improves the planning efficiency.

2) Three decoupled sliding mode surfaces are designed to track the three degrees of freedom for the AMR respectively, so that the robot can accurately track the planning path.

3) An ADSMC scheme based on barrier functions is presented to overcome the disturbance in the unknown disturbed environment, which is independent of the disturbance boundaries. Barrier functions based gain guarantees the control signal follows the absolute value of the disturbances, which keeps the slide variable in the predefined neighborhood.



Figure(a) : AMR kinematic model; Figure(b): Path planning with collision avoidance strategy; Figure(c): Tracking performance of proposed ADSMC controller



Figure(a) and (b): AMR application scenarios and maps;
Figure(c) and (d): Path planning and tracking performance

Summary:

In this paper, an integrated path planning and control method is used to solve the tracking problem under unknown disturbance environment. The path planning is optimized by using the RRT trajectory planning scheme that considers angle constraints and goal-biased. And an improved ADSMC is designed is applied to follow this path. Adaptive gains are considered by exploring barrier functions, which maintains the tracking error in a small neighborhood of origin. To verify the effectiveness of this strategy, this paper conducts simulation experiments on a four-wheel AMR system. Planning and tracking results show that the tracking accuracy and robustness of the AMR system have been improved. Therefore, the proposed ADSMC method is beneficial for stabilizing the path tracking. Future work may include available modes or switching control schemes.