An Efficient and Time-Optimal Trajectory Generation Approach for Waypoints under Kinematic Constraints and Error Bounds

Abstract:

This paper presents an approach to generate the time-optimal trajectory for a robot manipulator under certain kinematic constraints such as joint position, velocity, acceleration, and jerk limits. This problem of generating a trajectory that takes the minimum time to pass through specified waypoints is formulated as a nonlinear constraint optimization problem. Unlike prior approaches that model the motion of consecutive waypoints as a Cubic Spline, we model this motion with a seven-segment acceleration profile, as this trajectory results in a shorter overall motion time while staying within the bounds of the robot manipulator's constraints. The optimization bottleneck lies in the complexity that increases exponentially with the number of waypoints. To make the optimization scale well with the number of waypoints, we propose an approach that has linear complexity. This approach first divides all waypoints to consecutive batches, each with an overlap of two waypoints. The overlapping waypoints then act as a bridge to concatenate the optimization results of two consecutive batches. The whole trajectory is effectively optimized by successively optimizing every batch. We conduct experiments on practical scenarios and trajectories generated by motion planners to evaluate the effectiveness of our proposed approach over existing state-of-the-art approaches.