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MOTION PLANNING FOR LUNAR SURFACE PERSON TRACKING ROBOT VIA FLATNESS-BASED SAFE-MPC WITH VIRTUAL DISTURBANCES

Abstract

Due to the abundant resources of the Lunar, the progress of human exploration of it has gradually accelerated, so the realization of manned lunar landing is inevitable in the future development. As this goal approaches, the astronauts will encounter challenges in a growing quantity of Lunar surface missions including lunar surface exploration, collection of lunar soil, and so on. Meanwhile, the difficulty of carrying out the missions for astronauts would be significantly increased by the unknown, extreme environment on the lunar surface. The development of sophisticated assistive robots, capable of tracking and supporting astronauts to reduce their workload, has emerged as a significant research focus. However, current challenges with person tracking robots include maintaining reliable and effective tracking in complex disturbance environments, reducing resource consumption, and ensuring motion safety.

In this paper, we focus on the integration of motion planning and tracking control of robot. Considering a motion planning problem can be seen as a two set-points transition problem, while the differentially flat system property has shown strong performance in addressing this type of challenge and the tracking mission requires the robot to operate within a safe region, we present a Flatness-Based Safe-Model Predictive Control (Safe-MPC) with Virtual Disturbances combining the advantages of MPC and differentially flat systems to guide the robot along a smooth, real-time B-Spline curve trajectory while satisfying practical constraints and ensuring safety. By solving the optimization problem in the flat space, we obtain a reference trajectory that moves the robot from its current point to the target point, and calculate a safe-tube size according to the mission scenario. Then we introduce virtual disturbance into the differentially flat system to implement the calculated safe-tube, and use Safe-MPC to track the reference path. The simulation results in lunar scenario demonstrate that the robot can stay in the safe area while tracking the target.