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ROCKET LANDING GUIDANCE USING MODEL PREDICTIVE STATIC PROGRAMMING

Abstract

With the successful reuse of SpaceX's Falcon-9 and other commercial rockets, reusable rocket has gained significant attention worldwide in recent years and will continue acting as a focus of the space industry. One of the key technologies to achieve reuse is precise landing guidancewhich required to guide the rocket return and land at the predetermined point with the minimum fuel consumption. The general strategy is to perform onboard real-time trajectory planning and feed the rocket with the most recently updated control commands. Due to its rapid and deterministic convergence properties most researchers adopt convex optimization as the planning method and plenty of studies focus on it. Compared with Mars landing owing to the fact that aerodynamic is not negligible and more physical limits of vehicle make the problem contain more nonlinearities and non-convex control constraints, plenty of complex convexification works have to be implemented. In this paper, another computationally efficient method called model predictive static programing (MPSP) is adopted to solve the rocket landing problem. Theoretically, the MPSP has simpler principle and more convenient to implement that the nonlinear dynamic can directly be applied. In implement, the aerodynamic and propulsion are also considered as the control force. As a result, the optimal problem is formulated with the rocket's angle of attack, thrust magnitude and thrust direction angles as control inputs. Due to the terminal time is not determined altitude is used as the independent variable of dynamic equation. At the same time, in order to handle the strict control constraintsthe analytical solution in the original MPSP method is replaced to solved by Internal point method which viewed as convex programing problem. The effectiveness of the proposed method and comparison with convex optimization based method is demonstrated by numerical experiments. The result shows that the proposed method owns higher calculation efficiency at the expense of little more fuel compared with convex based method.