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OVERCOMING REAL-TIME BARRIERS IN ROCKET LANDING: A HYBRID LCVX-DNN FRAMEWORK WITH DYNAMIC CONSTRAINTS

Abstract

Fuel-optimal powered landing of reusable rockets under multiple constraints presents significant computational challenges, particularly due to the real-time limitations of traditional convex optimization methods that permit free terminal time. To address these issues, we propose a real-time lossless convex optimization (LCvx) guidance algorithm enhanced by a deep neural network (DNN) predictor. Initially, we develop an accurate dynamic model for the powered landing phase and integrate an integral-based Gauss pseudospectral method within the LCvx framework to discretize the trajectory, converting the continuous problem into a solvable discrete form. Convexification techniques are employed to manage non-convex constraints, such as maximum thrust ramp rate and tilt angle, which are subsequently transformed into a second-order cone programming (SOCP) problem for resolution. The DNN is trained offline using a dataset of optimal state-control pairs and predicts control commands in real-time based on the current state. These commands are then input into the flight system's differential equations to compute subsequent states, forming a closed-loop system that meets stringent real-time performance requirements. This approach markedly enhances computational efficiency and guidance autonomy while maintaining precise trajectory control, thereby providing robust support for high-precision autonomous landings of reusable rockets.