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CLOSE-LOOP REAL-TIME GUIDANCE AND CONTROL OF REUSABLE ROCKET LANDING BASED ON CUSTOMIZED CONVEX OPTIMIZATION

Abstract

Compared with the traditional disposable space launchers, the reusable orbital launch vehicles (ROLV) can reduce launch costs and will play an important role in future commercial spaceflight. One of the key technologies of ROLV is the recycling guidance and control of the rocket. Because the first-stage recycling phase of rocket is usually within the range of dense atmosphere, the uncertain dynamic environment brings great challenges to the control and guidance algorithm. To meet these creative challenges, a close-loop real-time online guidance algorithm with high robustness is investigated in this work. Recently, the research of convex optimization in the field of aerospace engineering control has greatly promoted the innovation of guidance and control technology. Guaranteed by the efficient numerical algorithms, polynomial complexity and global optimum with a deterministic convergence criteria, the convex program is very promising for real-time onboard computations. However, most practical guidance and control problems are non-convex and can not be solved directly using convex optimization. Convexification technologies such as lossless convexification and successive convexificatio can rapidly obtain the convergent solutions without affecting the optimality, feasibility or the convergence of the original problems. Although the convex optimization problems can be solved effectively to global optimality, the general convex optimization solver can not meet the requirements of real-time onboard computing. Considering a particular problem, the core convex optimization framework is generally immutable and only some boundary conditions are varying in the repeatedly solving process. Thus, the customed interior point method (IPM) solvers can take full advantage of the specific problem structure to significantly reduce the number of mathematical operations and computational branches used by the solver's executable. In this study, we will explore the utilization of customized convex optimization for recycling guidance and control of the reusable rocket. The expected contributions of this work are as follows. First, we will transform the recycling guidance and control problem of the first-stage rocket into a convex optimization framework based on the existing convexification technologies. Then, we will customize the convex optimization problem using the IPM solvers. In addition, based on the customized convex optimization problem, we will build a close-loop numerical simulation platform to test the robustness of the algorithm in the simulated real disturbance environment. Moreover, we will further investigate the hardware-in-the-loop simulation on the embedded systems to test the actual computing efficiency of the algorithm in embedded hardware and verify whether the algorithm meets the requirements of real-time online computing.