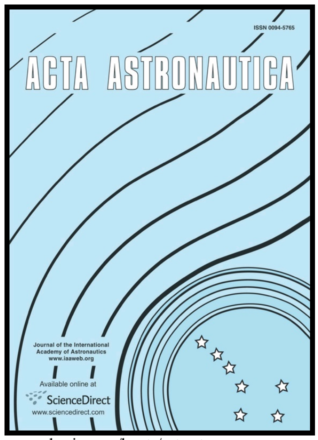

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Robust Adaptive Backstepping Control for Reentry Reusable Launch Vehicles

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Abstract: During the reentry process of reusable launch vehicles (RLVs), the large range of flight envelope will not only result in high nonlinearities, strong coupling and fast time-varying characteristics of the attitude dynamics, but also result in great uncertainties in the atmospheric density, aerodynamic coefficients and environmental disturbances, etc. In order to attenuate the effects of these problems on the control performance of the reentry process, a robust adaptive backstepping control (RABC) strategy is proposed for RLV in this paper. This strategy consists of two-loop controllers designed via backstepping method. Both the outer and the inner loop adopt a robust adaptive controller, which can deal with the disturbances and uncertainties by the variable-structure term with the estimation of their bounds. The outer loop can track the desired attitude by the design of virtual control-the desired angular velocity, while the inner one can track the desired angular velocity by the design of control torque. Theoretical analysis indicates that the closed-loop system under the proposed control strategy is globally asymptotically stable. Even if the boundaries of the disturbances and uncertainties are unknown, the attitude can track the desired value accurately. Simulation results of a certain RLV demonstrate the effectiveness of the control strategy.

Keywords: Reusable launch vehicle; flight control; robust adaptive control; backstepping control

1 Introduction

In the development process of reusable launch vehicles (RLVs), the high-precision flight control plays an important role to ensure the RLV to be safer, more affordable, and more reliable [1,2]. However, the dynamics