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ATTITUDE GUIDANCE AND CONTROL FOR RAPID DEORBIT OF SPACE DEBRIS BY AERODYNAMIC DRAG

Abstract

Problems of orbital debris tend to be more and more serious in accordance with increase of the amount of space debris. To solve such crucial problems, much attention is paid to active debris removal (ADR) missions. This study focuses on small satellites which realizes capture and removal of large debris while considering cost effectiveness. Small satellites have a lot of advantages that they can be developed rapidly with a low-cost. On the other hand, they have also disadvantages typified by strict limitation of fuel consumption. ADR missions using thrusters from high-altitude to reentry consume a lot of fuel. In such missions, volume of propulsion system in satellites become large and it is difficult for small satellites to adopt such a large-scale propulsion system. Typically, satellites in Low Earth Orbit (LEO) consider atmospheric drag as a primary disturbance force. The dependence of drag forces on a satellite's flow-wise projected area drives coupling between attitude and orbit states [1]. By tracking advantage of this coupling effect, aerodynamic disturbance is gained and debris can be rapidly descended. In this study, new attitude guidance and control which actively use aerodynamic force for fuel-constrained ADR small satellites is proposed to rapid deorbit of space debris. First, this study introduces the reference attitude defined by an equilibrium (balance) point in attitude dynamics acted by aerodynamic and gravitational torques. The desired attitude is set to maximize two contradicting objectives: maximizing projection area to generate large aerodynamic force while minimizing disturbance torque that can be managed by low wheel spin rates and accelerations. Then, the proposed steering law can manage the angular momentum and wheel spin rates by magnetic torquers (MTQs). Since this approach uses only RWs and MTQs in this phase, this technique can reduce total fuel consumption and deal with long mission duration in this aerodynamic descending phase. Finally, the effectiveness of the proposed new attitude guidance and control is demonstrated through numerical simulations.

[1] A. Harris, C. D. Petersen, and H. Schaub, AIAA/AAS Space Flight Mechanics Meeting, Kissimmee, Florida, January 8–12, 2018.