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USING AERODYNAMIC TORQUES TO AID DETUMBLING INTO AN AEROSTABLE STATE

Abstract

Aerodynamic torques normally become the dominating disturbance effect to the attitude of satellites flying in orbits below 400km. Similarly to gravity gradient torques, aerodynamic torques can be used for passive stabilization. The torques provide a restoring effect when the attitude of the satellite deviates from its equilibrium position to achieve a course pointing accuracy. Therefore, potentially aerodynamic toques can be used or to help to reduce the use of active attitude control for stabilization.

Spacecraft always perform a detumbling manoeuvre to stabilize themselves after deployment from a launch vechicle. The B-dot method, using magnetorquers to provide torques opposite to the rotation rate of magnetic field in the body frame, has become widely implemented to detumble spacecraft in low Earth orbits because it is simple and reliable. However, when implemented on a satellite with aerostable properties, it can needlessly consume an additional energy to fight against the natural dynamics of the system.

The use of aerodynamic torques to aid the detumbling of the spacecraft is considered. A sliding mode control algorithm is developed to schedule the magnetorquer gain of a modified B-dot detumbling method in order to stabilize the satellite in reference to the ram direction. The method is simulated to evaluate the control method in a 6-DOF attitude propagator developed at the University of Manchester. The 6-DOF attitude propagator implements the aerodynamic effects including the Sentman gas-surface interaction model, horizontal wind model and rarefied gas particle density model in order to produce a high fidelity aerodynamic torque model in low Earth orbits.

A case study is then presented of a planned University of Manchester CubeSat demonstrating that it can be detumbled and stabilized in yaw and pitch axes with respect of the flow direction with an average accuracy of 1.5 degrees. The method saves about 12% actuating energy comparing to the standard B-dot detumbling method, however takes 19% more time to be stabilized. Furthermore, the uncertainties and limitations of this control method are also discussed. Finally, other potential applications of the control method are described.