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FAULT TOLERANT ATTITUDE CONTROL FOR SPACECRAFT WITH LORENZ AND MAGNETIC TORQUES

Abstract

Fault tolerant control has attracted increased interest for spacecraft attitude system when the actuator faults occur and abundant research results have been obtained in the past few decades. However, the previous techniques mainly focus on the spacecraft with traditional actuators such as thruster, reaction wheel or control moment gyros. Recently, a new electromagnetic actuation, Lorenz torque, has been applied in some small satellite. The Lorenz torque is produced by three pairs of moving coulomb shells in the geomagnetic field. Similar to the magnetic torque, the underactuated problem will still be induced, which limit its application. In order to avoid the underactuated problem, it has been proposed to combine the Lorenz and Magnetic torques to achieve the attitude control. This paper will discuss the fault tolerant attitude control problem with hybrid Lorenz and Magnetic torques. Specially, for the spacecraft actuated by three coulomb shell pairs (CSP) and three magnetic torquers (MT), how to achieve the attitude control when the actuator failure occurs in some shell pairs or torquers.

In order to achieve the target, an attitude control technique for a small Low Earth Orbit (LEO) satellite should be discussed firstly in presence of torque disturbance and uncertainties including gravity gradient, aerodynamic moment and inertia uncertainties. The following step will discuss the torque distribution methods in the cases of different actuator combination when there are failure occurs in some actuators. Specifically, three cases will be discussed mainly, i.e. one CSP and three MTs, two CSPs and two MTs and three CSPs and one MT. Finally, it will discuss how to solve the charges of the CSPs and the magnetic dipole moment of the MTs for each case. The effectiveness of the techniques in this paper will be proved by the control theory and simulation. In this method, the fully actuated attitude control can still be achieved even some of the MTs and CSPs are unhealthy compared with [1]. Moreover, the attitude control system will have strong robustness to some uncertainties.

Reference:

[1]. Xu, H., Ye, Y. (2017). Fully actuated spacecraft attitude control via the hybrid magnetocoulombic and magnetic torques. Journal of Guidance Control Dynamics(12), 3353-3360.