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RATE ESTIMATION AND DAMPING OF A HIGHLY ASYMMETRICAL TUMBLING SPACECRAFT USING MAGNETOMETER DATA

Abstract

Low-Earth Orbit (LEO) satellites find its application for Resource management, Radar imaging, Cartographic, Oceanographic and other scientific applications. With increase in number of missions, there is need for autonomous operations on-board especially during attitude loss to ensure power safety and attitude re-orientation. The autonomy and mission requirements make it essential to have a gyro-less algorithm for spacecraft rate estimation and provision to autonomously damp the rates with thrusters whenever spacecraft enters safe mode. This algorithm is also useful when gyros are off as well as during gyro malfunction/gyro saturation. Post safe mode, the first step is to ensure power safe and thermal safe conditions for the spacecraft. In case of high rates it has to be damped by thrusters and brought to a threshold so that sun acquisition is possible with sun-sensors. This Paper details an extension of work by the same authors for Magnetometer based rate estimation (MRE) and MRE based rate damping (MRD) applied to highly asymmetrical spacecrafts. MRE algorithm estimates spacecraft angular rates, while MRD damps the spacecraft rates using thrusters. MRE is an Extended Kalman Filter based algorithm to estimate spacecraft angular rates from sequential readings of magnetometer data alone. Based on these estimated rates thruster selection is done autonomously and thruster ON time is computed for firing the thrusters in MRD. Here inertia asymmetry plays a major role that can lead to instability with thruster firing. A novel method is adopted wherein thruster firing is done at zero cross-over of any of the estimated rates to reduce the cross coupling effect. On zero cross-over detection of any one axis, thruster selection and polarity for firing is done based on the maximum rate of the other two axes. Thruster firing duration is computed from the acceleration of the zero cross-over axis. Thus the major component of the momentum vector that lies in a plane at zero cross-over detection is damped using this method. There are in built protection logics to take care of wrong firing, firing duration more than intended etc. MRE and MRD are validated for large range of initial rates by detailed digital simulations and various levels of ground testing. The performance is found to be satisfactory.