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A NOVEL APPROACH FOR AUTONOMOUS SPACECRAFT RECOVERY TO SUN POINTING ORIENTATION

Abstract

ISRO spacecrafts in Low-Earth Orbit (LEO) has applications ranging from Oceanography, Resource management, Radar imaging Cartography etc. With increase in number of missions, there is a limitation on ground stations availability for health monitoring and spacecraft recovery. This necessitates that during any anomaly leading to safe mode, autonomously all the loads in the control loop, including sensors and actuators to be switched off autonomously, and the spacecraft needs to orient to thermal safe and power safe geometry while using minimum resources possible, with the sensors/actuators that were not in loop previously. A novel scheme is developed to autonomously acquire the sun using magnetometer, sun sensors and thruster which traditionally is done utilizing IMU (when ON/available) and Sun sensor. This scheme can also be used in case of non-availability of Gyros . Rate Estimation using Magnetometer data (REMD) is a Kalman filter based algorithm that estimate spacecraft angular rates from sequential readings of magnetometer data alone and is an effective solution for estimating spacecraft angular rates in situations when rate sensors are unavailable or sensors show degraded performance. A control law based on sun vector derived for sun sensors and rate information from REMD is devised, which modulates thrusters using PWPFM (Pulse Width Pulse Frequency Modulation) applying required torque for acquiring and maintaining Sun pointing. On-board computed control torque is mapped to the equivalent torque with on/off actuation by thrusters. It is computed during each control cycle and used as input for the REMD state propagation to refine rate estimate. A new measurements methodology is formulated that employs central differencing of the first derivative of fourth order. This results in measurement noise reduction by 25% that primarily dictates the estimation accuracy. This algorithm performs better than pseudo rates derived from the attitude channel. This novel algorithm is intended to be used in future Low Earth Orbit satellites. The developed algorithm is robust to practical scenario of magnetometer measurement bias caused by spacecraft residual magnetism or temperature variation. This has been further corroborated with Monte Carlo Simulations and actual magnetometer data collected during spacecraft integrated tests.