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IMPROVED MAGNETIC ATTITUDE CONTROL

Abstract

Magnetic rods along with magnetometers are usually used as part of spacecraft magnetic attitude control for low earth orbits, for their energy efficiency, reliability, simplicity and lightweight. However, the magnetic rods' drawbacks include poor accuracy, instantaneous under actuation and constrained output torque in the plane that orthogonal to the magnetic field. Magnetometer measurements, also, are prone to several types of errors and are degraded by the time varying magnetic field generated by the currents in the spacecraft electronics and magnetic rods. In order to mitigate this effect on the measurements, physical separation between the magnetometer and the other spacecraft components is usually attempted. Furthermore, magnetic rods duty periods are set alternately with magnetometer measurements' periods, which adds to the under actuation problem. Higher order magnetic field models are used to calibrate magnetometers online. However, recently, the North Pole movement rate has increased more than the predicted rate, heading from Canada to Siberia. Therefore, in the meantime, the accuracy of these models are questionable; and may lead to inaccuracy for navigation purposes. As a result, the world magnetic model is now planned to be updated early in 2019 instead of the secluded update in 2020.

The proposed concept is to eliminate the need to turn off the magnetic rods, in some cycles, in order to increase the rods operation time. This is achieved by using the estimated magnetic field in these cycles instead of the measured one. The magnetic field estimation here is an attitude dependent problem. Therefore, another attitude sensor is required. This estimation utilizes the existing spacecraft angular velocity feedback to probe the geomagnetic field, which is considered as a pseudo magnetic field measurement. Then these measurements are refined inside an adapted multiplicative extended Kalman filter, with a particular proposed simple magnetic field propagation model for this problem. Monte Carlo simulation shows that maneuver times can be reduced by up to 60%, and the actuator's power can be reduced by up to 50%. Six parameters are used to check the accuracy of the estimated magnetic field. The results show a good matching. Furthermore, a real data form CASSIOPE mission is used to verify the proposed magnetic field estimation. The results show a close performance to what is already rendered by the Monte Carlo runs.