30th IAA SYMPOSIUM ON SMALL SATELLITE MISSIONS (B4)
Interactive Presentations - 30th IAA SYMPOSIUM ON SMALL SATELLITE MISSIONS (IP)

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PRACTICAL IMPLEMENTATION OF SLIDING MODE CONTROL LAW FOR PERFORMING DETUMBLING OF NANO SATELLITE FROM HIGHER INJECTION RATES

Abstract

Nano satellites as the name suggests are small in size, relatively much cheaper than conventional satellites, requires small space and easier to assemble. With currents trends Nanosatellite has drawn much attention as they can be made from COTS components and are ready to launch for science mission which requires immediate attention. However, being small in size, they suffer large injection rates from launch vehicles which needs to be stabilized for power generation, science operation and communication purpose. Nanosatellites are mostly equipped small reaction wheels for performing three axis attitude control and magnetic torquers for initial Detumbling. If the Detumbling mode convergence time is large, it can result in power issues as attitude is not favorable for power generation. Also, if the detumbling convergence is declared much before then wheels may get saturated as system angular velocity can be beyond. In this Research, a sliding mode control is proposed to perform the Detumbling of Nano satellites from high injection rates. Results shows designed sliding mode control law for detumbling of Nanosatellite has significant advantage of convergence time over conventional $\dot{B}$ control law. It also avoids computation of $\dot{B}$ using magnetometer data which is in general very noisy and delays convergence time. Also, in $\dot{B}$ control law convergence is declared using thresholds which can be corrupted due to large magnetometer noise and can trigger false convergence. In proposed algorithm, convergence trigger is based on angular velocity measured using IMU which poses significant advantage over conventional trigger. Sliding mode control suffers from chattering over sliding manifold which is avoided by using saturation function thereby linearizing the system response over sliding manifold. This research also focuses on practical implementation on hardware and design modifications which are required to take care of various non-linearities, saturation, hardware responses and noises present in system. Stability of the algorithm was demonstrated using large scale Monte Carlo simulation and bounds on convergence time is derived based on statistical methods. Proposed algorithm was implemented in the flight computer and its efficiency was demonstrated in ISRO's hardware in loop simulation (HILS) facility.