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ATTITUDE CONTROL OF A FAST-RETARGETING AGILE NANOSATELLITE USING NEURAL NETWORK BASED STEERING FOR VARIABLE SPEED CONTROL MOMENT GYROSCOPES

Abstract

This research proposes the singularity free attitude control and steering strategy for fast nanosatellite retargeting maneuver. The research considers an Earth imaging 3U CubeSat with deployable solar panel, equipped with cluster of Variable Speed Control Moment Gyroscopes (VSCMG) in pyramid configuration and a star sensor for precise targeting within uncertainty of 0.1 deg. Highly precise star sensors are inadequate at high angular velocities and cannot be used in fast slew maneuvers. Control Moment Gyroscope (CMG) an attitude control device commonly used in large spacecraft as primary attitude control actuator, generates torques utilizing gyroscopic couple by tilting spin axis of high angular momentum wheels. Despite having significantly large torque compared to Reaction Wheels, they pose the problem of singularity. Substantial efforts had been made to overcome the singularity problem associated with CMGs. Variable Speed Control Moment Gyroscope (VSCMG) having an extra degree of freedom than CMG, can avoid singularities by changing flywheel speed to escape singular states. Singularity Robust Inverse (SRI) being most common singularity avoidance and escaping technique is computationally complex and requires precise knowledge of orientation. In this paper we introduce combination of Neural Network-based fast and inverse free steering logic for cluster of VSCMG in pyramid configuration during large slew maneuver followed by SRI steering for precise attitude tracking. The performance of Neural Network-based steering, SRI steering and combination of both is evaluated via numerical simulations using Monte-Carlo analysis. Neural Network-based steering agent is found to be computationally less expensive and showed significant improvement in settling time over SRI steering, moreover it is capable of escaping singularities and avoid singular states in large slew maneuvers however less precise than SRI steering. Results are demonstrated and verified on ground using specifically designed and developed VSCMG Hardware in Loop Simulation testbed.