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Time Optimal Control Mode Switching between Detumbling and Pointing in the Early Orbit Phase

Authors : W. M. Ng, O. B. Iskender, L. Simonini, J. M. Gonzalez

Abstract : A multitude of factors, including mechanical imperfections of the deployment system and separation instance of satellites from launchers, oftentimes results in highly uncontrolled initial tumbling motion immediately after deployment. In particular, small satellites which are characteristically launched as a piggyback to a large rocket, are generally allocated a large time window to complete detumbling within the early orbit phase. Because of the saturation risk of the actuators, current algorithms are conservative to avoid draining excessive power in the detumbling phase. This work aims to enable time-optimal switching of control modes during the early phase, reducing the time required to transit from launch to sun-pointing mode for power budget conscious satellites. This assumes the usage of B-dot controller for detumbling and PD controller for pointing. Nonlinear Euler's rotation equations are used to represent the attitude dynamics of satellites and Commercial-off-the-shelf (COTS) reaction wheels and magnetorquers are used to perform the manoeuver. Simulation results will be based on a spacecraft attitude simulator and the use case will be for multiple orbits of launch deployment general to Low Earth Orbit (LEO) satellites.

Keywords : attitude control, detumbling, small satellites, spacecraft autonomy, time optimal control
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