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ONBOARD REAL TIME THRUST ESTIMATION FOR CHANDRAYAAN-3: A NOVEL APPROACH USING ACCELEROMETER DATA AMIDST RCS CORRUPTION

Abstract

India achieved a historic milestone as the fourth nation to execute a precise and soft landing on lunar surface. Chandrayaan-3, comprises of dual module launch configuration consisting of a propulsion module and a lander module. The propulsion module propelled lander module from an earth parking orbit (180 [km] x 36000 [km]) to a lunar parking orbit (150 [km] x 150 [km]). Upon reaching the lunar parking orbit propulsion module was jettisoned from lander module. Lander module then executed two deorbit burn to reduce perigee altitude to 30 [km] for powered descent initiation. Accurate estimation of engine thrust (within accuracy of 20 N) during these deorbit burns was crucial for planning the optimal powered descent start latitude. Lander uses four cluster of engines to perform deceleration from orbital velocity to near zero velocity. Attitude control of lander was achieved through on-pulsing of reaction control system (RCS) which is mounted along same direction as the main engines. During deorbit burns main engines are fired at various throttling levels to characterize its performance before initiating powered descent. These engines apart from producing forces also produces disturbing momentum due to various uncertainties such as cg, thrust alignment, thrust mis match. Reaction control system ensures that attitude is tracking required guidance command amidst disturbing moments from engines. Since both main engines and RCS produces forces in same direction, accelerometer data gets corrupted with RCS on-pulses. Other measurements such as pressure and temperature are available at coarser interval and is insufficient for actual engine thrust determination. Also, system has various delays such as command delay from onboard computer to RCS valves, accelerometer data acquisition and uncertainties such as RCS rise time, fall time, peak thrust. Under these uncertainties, model based thrust estimation has shortfalls and its prediction accuracies are much higher than requirement. To overcome these uncertainties, a novel method is proposed where over a given guidance cycle, accelerometer data is stored in circular buffer for all measurement cycle and minimum norm solution is chosen for estimating thrust. This solution eliminates the RCS component as any RCS pulsing will increase overall acceleration norm. Further to this, total acceleration is divided to individual engine component based on on-orbit disturbance and engine location. This algorithm has been implemented and tested at various test beds, demonstrating promising results. Flight performance of the proposed algorithm has been verified showcasing its effectiveness in estimating thrust amidst RCS interference.