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LANDMARK ACQUISITION AND TRACKING USING VARIABLE SPEED CONTROL MOMENT GYROS

Abstract

In this paper, the performance of a cluster of Variable Speed Control Moment Gyros (VSCMGs) for landmark acquisition and tracking is analyzed. VCMGs are considered superior to classical Control Moment Gyros (CMGs) for avoiding the geometric singularity problem owing to the extra degree of freedom available from the CMG wheel. CMGs are generally used in agile satellites. These satellites maximize the data obtained per orbit by performing large in-track and cross-track attitude manoeuvres. In addition, they carry out spot-to-spot imaging of targets of interest on earth. Such imaging sequence demands high torque and faster settling times. The performance of VSCMGs have not been evaluated and analyzed till now for a multiple landmark acquisition and tracking problem.

In this paper, first the mission requirements are defined and the target locations of interest are chosen. Then, based on the satellite ground trace and the geometry of the targets with respect to the on-orbit location of the spacecraft, the attitude commands are computed. This includes the in-track and cross-track angle commands for acquisition of the target and inertial rates to track the target after acquisition. A cascaded-saturation controller with appropriate inner and outer limits is used for attitude control. This generates torque commands for a near time-optimal manoeuvre in the acquisition phase and works as a linear PID controller in tracking phase. The study considers a 4-VSCMG cluster in roof type configuration. Roof-type cluster was chosen against the popular pyramid cluster due to the asymmetric momentum requirement for the spacecraft.

The performance of VSCMGs for completing the acquisition and tracking of these multiple targets was studied based on numerical simulations. The maximum rate limit of the spacecraft, maximum gimbal rate limit for individual CMGs, maximum torque output per CMG and maximum gimbal motor torque available were applied as constraints. The error between the demanded and generated torque, pointing error, tracking error and total angular momentum demand and power consumption were computed. The gimbal motor and CMG wheel motor torque demand were computed and the power consumption of these two motors calculated. The same target distribution with the cascaded-saturation controller was used for comparing the performance of classical CMGs with that of the VSCMGs. The study will bring out whether the VSCMGs with their extra degree of freedom are superior to the classical CMGs in completing a realistic attitude manoeuvre with various design constraints.