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ATTITUDE TRACKING AND STABILIZATION FOR SOFT LANDING OF A LUNAR MODULE

Abstract

Most studies reported in literature deal with the soft landing of a lunar module as a point mass problem; however, when confronted with the rigid body dynamics of the lunar landing module, invariably studies have not reported several technical knowhow that are to be solved viz. (i) Capacity and suitable configuration of Reaction Control System (RCS), (ii) amount of fuel loading, (iii) guidance schemes of command tracking and (iv) finally, lunar module stability aspects during landing. It is clear that the understanding of the lunar module for a soft landing mission scenario in entirety has not been reported wholly.

In this paper, a configuration of the Lunar module with 440 N of 5 main thrusters and 11 N of 9 fine control attitude thrusters is considered for this study. Six degrees of freedom nonlinear equation has been used with realistic conditions of the problem such as actuator dynamics, control, bounds, RCS constraints. The resultant three control equations have nine RCS jet control variables which have been combined suitably and simplified into three RCS jet firing directions. The objective of the algorithm has been to track the guidance law commanded trajectory and have to stabilize the undesired moment of main thruster firing using the nine attitude control thrusters.

Using a dynamic formulation, the required body rates for the lander to track the guidance goals and stability conditions is calculated in the outer loop of the design. The required moments for achieving the goals demanded by outer loop are calculated in the inner loop of the design. The Pulse-Width-Pulse-Frequency Modulator (PWPFM) design has been implemented to achieve the desired moments with practical limitation of the RCS firing time, maximum moment generation, RCS firing delay etc., included.

Concluding remarks: The control algorithm using dynamic inversion technique is implemented to track the demanded guidance trajectory and for stabilizing the undesired moment caused due to C.G. offset of main thrusters. The goals have been converted to the required body rates from which the needed moment along each axis has been computed. The control moment is calculated in a matrix sense so that the effects of cross coupling of moments are also taken into account. Pulse-Width-Pulse-Frequency technique has been implemented for its pseudo-linear operation capability. Also, RCS mounting configurations, fuel consumption analysis, C.G. offset margin analysis have been analyzed and results reported.