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POWERED DESCENT TRAJECTORY DESIGN AND GUIDANCE STRATEGY OF CHANDRAYAAN-3 LUNAR LANDER MISSION

Abstract

Trajectory design for the descent from the perigee of an elliptical orbit around moon till touchdown, of Indian Lunar Lander Mission Chandrayaan-3, is brought out in this paper. Descent trajectory is configured as comprising of eight phases and controlled by controlling the thrust of a cluster of four engines as well as orientation of the lander. The main attributes of the guidance algorithm used for generating the steering commands is to ensure thrust and attitude continuity between phases. Major deceleration happens from 30km to 7.4km altitude with the objective of reaching the target height with a specified velocity, engine thrust and orientation with respect to vertical . The conditions are then suitable for absolute sensor operation since they will be nadir looking . A second order polynomial guidance is designed for this phase. The second phase is for a duration of 10 seconds where the engine thrust and orientation achieved during the previous phase is maintained so as to obtain altitude update at the end. The third phase is the Fine Braking phase wherein, with height update, a cubic polynomial guidance is used to reach the target of 800m above the designated landing site with zero velocity. Target acceleration of the cubic polynomial guidance is strategically selected to have a vertical orientation and also the fact that since two engines have to be shut off, the other two will not have jump in their thrusts during further operations. The fourth phase is hovering at 800m height for 12 seconds using a position velocity controller guidance. During this operation height and velocity sensors are operated to give an update at the end. Thereby the fifth phase begins with a cubic polynomial guidance to vertically descent to 150m followed by the sixth phase which is hovering again for 22 seconds. Hazard Camera is operated to generate hazard free target. Next phase uses cubic polynomial guidance to re-target to 10m height of the hazard free location with vertical velocity as -1m/s. Cubic polynomial guidance during vertical descent and re-targeting is set to have target orientation as vertical by the choice of target acceleration. Last phase of descent is to maintain vertical velocity and have touchdown which uses a velocity controller as guidance. Touchdown sensing triggers engine switch off. Strategy of designing the time of flight for polynomial guidance through ground tuning is also brought out.