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A LINEAR CONSTANT GAIN CONTROLLER BASED ON INTEGRATED GUIDANCE AND CONTROL FOR THE RE-ENTRY PHASE OF A MANNED SPACE MISSION

Abstract

The re-entry phase is a critical phase of a human space mission in which the vehicle experiences very harsh environment. The control system should take the vehicle along a path such that the vehicle neither burns out nor breaks apart. The control system should also make sure that the crew members are not exposed to forces greater than 3g. Additionally, accurate landing of the vehicle at the designated location should also be ensured. These stringent requirements make the re-entry control systems unique among the aerospace control systems.

The conventional systems for manned re-entry vehicles use a two loop mechanism with an outer guidance loop and an inner control loop. The outer loop accounts for the translational motion using a point mass motion model without consideration of the attitude dynamics, while the inner loop tracks the reference attitude generated by the outer loop. To bring about the required attitude motion, it uses control effectors in the form of aerodynamic control surfaces or reaction control system (RCS) thrusters.

The feasibility of an Integrated Guidance and Control (IGC) system for a manned re-entry vehicle is established in this paper. A closed loop constant gain controller using LQR technique based on IGC system is presented. Vehicle parameters and aerodynamic model of the Space Shuttle is used for simulations. The resulting trajectory is found to be more optimal than the open loop trajectory generated using the traditional translational dynamics. The models are validated by carrying out trajectory optimization for the full three dimensional motion model and comparing the results with published results. However, the IGC problem is solved for a two dimensional motion model, where it is assumed that the vehicle moves in a single plane throughout the re-entry phase.

This paper is organized in five sections. The first section provides the introduction to the problem and the various models used in the simulations. The second section describes and formulates the problem in the optimal control framework and briefly discusses the solution methodology. The results of trajectory optimization using the conventional technique are given in section 3. Section 4 describes the solution of the problem using IGC methodology. The fifth and final section provides the conclusions.