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COMPARISON OF NON-LINEAR HEURISTIC CONTROL AND LINEAR TIME-VARYING OPTIMAL CONTROL DESIGN FOR 3-AXES ATTITUDE CONTROL OF A MICROSATELLITE

Abstract

The attitude determination and control (ADCS) subsystem of a commercial microsatellite needs to be well equipped with good sensors and actuators for precise pointing and knowledge capabilities. This design employs a set of 4 reaction wheels and 3 magnetotorquers to get a complete 3-axes active control of attitude and angular rates.

The characteristics of the satellite body, reaction wheels, magnetotorquers as well as the various environmental disturbance torques cause the dynamics of the system to be non-linear as well as time varying. As a result, the well-established analytical methods for linear control are difficult to employ for stability and performance without certain assumptions. A choice needs to be made between simplifying the dynamics of the system to obtain analytical results or use heuristic methods and ensure all mission scenarios are tested for stability and acceptable performance.

In this study, we intend to employ both these methods, and compare the results for a set of mission scenarios. The study aims to understand the pros and cons of each of these methods and the situations under which each of them makes better design sense.

In the first method, the dynamics of the system is modelled with all the possible non-linearities and characteristics using minimal simplifying assumptions. The resulting model is non-linear and time varying and needs accurate modelling of the orbital environment to give proper results. The control algorithm for such a model is then approximated as a PD controller with choice to modify the gains within certain values. The choice of the gains is heuristic, and the result is simulated within the model to select the best possible performance. The stability cannot be guaranteed, but can be ensured by running all possible mission scenarios via a Monte Carlo type testing.

In the second method, the dynamical equations are linearized under certain set of assumptions. The equations are still time-varying since the magnetic field of the earth changes continuously in orbit and magnetotorquer performance is directly dependent on it. Once linearized, a time varying optimal controller with a closed loop feedback is designed. Stability and performance of this controller is guaranteed within the assumptions taken.

As a final steps, control gains from both these methods are compared under similar mission scenarios and both performance and stability is determined and compared within these scenarios. This comparison enables us to choose the best control algorithm for this ADCS subsystem and its underlying characteristics.