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NON-LINEAR CONTROL STRATEGIES FOR ATTITUDE MANEUVERS OF A LEO CUBESAT BASED ON MODIFIED RODRIGUES PARAMETERS

Abstract

CubeSats, represent a low-cost tool for the study, interpretation and design of satellite modules and their associated factors. With the arrival of CubeSats in the aerospace industry, there has been an increase in the development and execution of satellite missions bringing with it the problematic characteristics of each satellite subsystem. Particularly for the attitude determination and control subsystem (ADCS), the problems of the system lie in the high degree of non-linearity of the satellite dynamic model and the disturbances of the orbital environment. The kinetics contains second-order algebraic non-linearities; on the other hand, depending on the attitude coordinates, the kinematics may contain algebraic and/or trigonometric non-linearities that lead to geometric singularities or indeterminacies. The disturbances affect the rotational motion of the satellite. These problems present in the dynamic model (kinetics and kinematics) influence the development of the controllers, since they complicate the implementation of the control laws, limit the operating range of the satellite and require techniques for the rejection of disturbances.

This research deals with the development attitude control techniques for a CubeSat that approaches the non-linearities of the satellite dynamic model and rejects disturbances of the orbital environment in order to perform pointing maneuvers. In this scenario, the attitude control system is able to perform: solar pointing, nadir tracking and active ground tracking.

Through the use of the V methodology, the mission design processes, the requirements for the subsystem, the design and implementation of the orbital, satellite dynamics and the controllers are addressed, and finally, the evaluation of the controllers and verification of the accomplishment of the requirements.

The satellite trajectory is obtained through orbital propagation models; the satellite's kinematics and controllers are implemented with modified Rodrigues parameters (MRP) as attitude coordinates, and kinetics cover the non-linear aspects of the Spacecraft mathematical model. Lyapunov theory is used as a mathematical tool to validate the stability in the implementation of two non-linear controllers: one by non-linear feedback and the other is the sliding mode controller (SMC). Each controller carries out the three pointing individually, the orbital, satellite and controller dynamics is integrated in the same simulation environment.

Simulation results show non-linear controllers are able to perform pointing maneuvers rejecting disturbances and meet the established requirements. Finally, due to the pointing error and power consumption analysis it is possible to concluded that whether non-linear control techniques are a viable option and an alternative to the controllers typically used.