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AN ENERGY-BASED APPROACH TO SATELLITE ATTITUDE CONTROL IN PRESENCE OF DISTURBANCES FOR A CUBESAT MISSION

Abstract

The aim of this paper is to present a novel control strategy of the satellite attitude control problem on an energy-based setting, more specifically on the port-Hamiltonian framework. Controlling the orientation with respect to an inertial frame of reference becomes challenging in presence of nonlinear external disturbances such as the gravity-gradient torque and the atmospheric drag, which are external torques coming from the iteration of the spacecraft with external entities. We make use of the advantages of representing the system under study via the port-Hamiltonian framework due to its clear control design philosophy. The structure presented on the energy setting shows the interconnection of energy storage and dissipation elements plus the input and output ports pair, i.e., efforts and flows of the mechanical system. Then, the provided approach attains an asymptotic stable orientation where the key control strategy depends on the orientation and rotation velocity measurements, together with and an integral action on the system's output. Furthermore, the advantage of our approach relies on an energy consumption optimization of the controller, together with the lack of linearization strategies due to the modeling-based framework. In addition to this, the closed-loop system shows robustness in terms of parameters uncertainty due to the nature of the port-Hamiltonian approach. Moreover, a numerical propagation of the spacecraft attitude states is provided where we have considered a satellite placed in an orbit that experiences gravity gradient and atmospheric drag external torques similarly to the orbit and external torques experienced by the International Space Station orbit. Here, the perturbations are simulated by propagating both the attitude and the orbit of the spacecraft, with atmospheric drag modeled as a coupled orbit and attitude dependent perturbation. The propagation is done modeled to replicate the conditions of the mission GWSat, a 3-unit CubeSat mission lead by the George Washington University, with the Costa Rica Institute of Technology providing the design of the attitude control system. The latter is done to demonstrate effectiveness of our controller for a realistic scenario. Finally, a classical PID approach is also included in order to compare its performance with our proposed strategy.