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Author: Dr. Matteo Dentis
Politecnico di Torino, Italy, matteo.dentis@polito.it

Dr. Elisa Capello
Politecnico di Torino, Italy, elisa.capello@polito.it
Dr. Gioacchino Scire
Sapienza University of Rome, Italy, scire.gio@gmail.com
Dr. Luca De Filippis
Sitael Spa, Italy, luca.defilippis@sitael.com
Prof. Giorgio Guglieri
Italy, giorgio.guglieri@polito.it

TRMPC ATTITUDE CONTROL ALGORITHM FOR PRECISE POINTING OF SMALL SATELLITES

Abstract

In this paper, an advanced Attitude Control Algorithm has been designed and preliminary tested. The proposed attitude control law is based on a Tube-based Robust Model Predictive Control (TRMPC). The proposed TRMPC control system, differently from a Classical MPC, is able to effectively manage system uncertainties and external disturbances according to a proper design of the "tube" and system constraints. Indeed, a TRMPC controller is robust, by definition, against system disturbances, provided that such disturbances are bounded by a well-defined convex set. In addition, a proper design of the "tube" by a Linear Matrix Inequalities (LMI) approach ensure robustness against system uncertainties as well. For example, uncertainties in the spacecraft inertia and limited, and bounded, orbital disturbances, typical of a Low Earth Orbit (LEO) environment, can be effectively managed by a TRMPC-based AOCS. Advantage of using a TRMPC control law with respect to a classical MPC is that control robustness is ensured introducing a simple static feedback gain, which is the implementation of the tube. In addition, compared with classical Proportional-Integral-Derivative (PID) control laws, a TRMPC controller is able to inherently manage system constraints, without using complex tuning techniques. The proposed TRMPC control law has been tested and validated for different mission scenarios considering LEO orbits and considering different small spacecraft platforms. In addition, different reaction wheels configurations have been investigated, in order to support the system design of the spacecraft platforms: specifically, a pyramidal and tetrahedral reaction wheels configurations have been considered. Effectiveness of the proposed TRMPC control law is also investigated in a reaction wheels failure scenario: according to system requirements, the proposed control law must ensure mission accomplishment in case of one wheel failed, considering a proper Fault Detection, Isolation and Recovery (FDIR) procedure. Extensive simulations have been executed, supported by a detailed orbital simulator which implements LEO orbital disturbances, such as magnetic dipole, residual aerodynamic torque, gravitational torque and solar radiation pressure torque.