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SIMULATION AND EXPERIMENTAL TESTING OF AN ITERATIVE LEARNING CONTROL STRATEGY FOR EARTH OBSERVATION ATTITUDE MANOEUVRES

Abstract

Many remote sensing and surveillance space missions are required to perform a periodical sweep over a prescribed terrestrial area to detect eventual changes at different times but with same viewing conditions. To this aim, satellites should be controlled to guarantee a repetitive orientation when passing over a target area to allow for data acquisition. In these cases, Earth Observation (EO) spacecraft can be considered as cyclic dynamical systems, where operations and major disturbances are periodic orbit after orbit. In addition, EO satellites are often equipped with flexible structures, such as solar panels and antennas, whose elasticity and interaction with the attitude dynamics generally cannot be neglected. Recently, intelligent control techniques involving learning have been proposed to improve system response, enhance precision of operations and automate the behaviour of systems. This approach is well suited to the attitude control problem of the described cyclic EO missions, due to the possibility of collecting, elaborating and learning from information gained during previous consecutive orbits. This research focuses on improving the attitude reference tracking performance of a satellite hosting flexible appendages due to the increase in knowledge related to previous repetitive manoeuvre profiles. To this purpose, the Iterative Learning Control (ILC) approach is applied to meet the target task without requiring a high computational effort, as opposed to current machine-learning methods. The system is coupled with a traditional feedback controller, needed to counteract non-periodic disturbances. The ILC strategy produces a sequence of feedforward commands such that the output of the system is as close as possible to the desired one, with the advantage of compensating for un-modelled and uncertain dynamics in the control synthesis. At first, the potentialities of the approach are assessed on a detailed mathematical model of a flexible spacecraft, representative of a typical EO application scenario. Then, the control system is deployed and experimentally tested on a scaled mock-up of the satellite, equipped with solar panels, which is free-floating via air-bearings on a granite table. Promising results are compared with traditional optimal attitude control, and discussed in terms of improved attitude pointing agility, error at stationary, control cost and elastic appendages excitation.