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LARGE ROTATION ATTITUDE CONTROL OF SATELLITES WITH FLEXIBLE BODIES

Abstract

Previous research has shown that satellite control can be achieved for a fast, linear, flexible body model and a sub-optimally tuned simple adaptive controller. The controller model was extensively validated related to attitude dynamics and the uncontrolled flexible body simulations verified with commercial software. The coupled simulations were run with short and small angle manoeuvres and showed that it is possible to control small rotations of a satellite with flexible bodies, even with a sub-optimally tuned controller.

However, large manoeuvres are often required, especially in the context of rotation-matching operations or in space-debris removal. One concept of debris removal is to have a second spacecraft intercept a defunct satellite and physically deorbit it. Such a concept has been proposed for Envisat: a chaser satellite synchronises its motion to that of Envisat and latches onto it, to remove it from its current orbit. One of the many technical challenges is to be able to minimise the angular velocity between the inert, but randomly rotating, satellite with flexible bodies and the follower satellite, which may also have flexible appendages. Therefore, a nonlinear large rotation body model should be used to accurately predict the response of an active satellite body undergoing docking or rotation-synchronisation manoeuvres. An additional requirement for the model is that is quick to solve to support the control-system design process that requires a fair number of simulations.

A large rotation model has been incorporated into the simple adaptive controller used in previous research to show that such manoeuvres can be controlled, again with a sub-optimal controller, under motions that would not damage the flexible bodies. Control has been achieved for a hypothetical satellite to match the satellite bus rotations as if to dock with Envisat, to remove it from its orbit, starting from arbitrary orientations. Simulations show that for a known chaser satellite configuration, control can be achieved for various angular velocity and initial orientation combinations. Synchronisation operations cause greater solar panel and antenna deformations than short-duration, small angle rotations; however, with minimal structural damping do attenuate. Control efforts optimising the motion and reducing the structural vibration of the flexible bodies will need to be analysed further.