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ANALYSIS AND EXPERIMENTS FOR A SYSTEM OF TWO SPACECRAFT PAIRED BY MEANS OF A FLEXIBLE LINK

Abstract

A field of great current interest in space technology is the on-orbit operation concept, that envisages the use of one active spacecraft (often called chaser) for reaching and grabbing another orbiting body (the target) for a variety of purposes, including assembling, refueling, refurbishing, and deorbiting. In these missions concepts, a physical link must be established between the chaser and the target spacecraft. This is usually accomplished by means of robotic manipulators, or, in some other cases, by tethers or nets. In all cases, due to the special requirements imposed to the space systems, in particular the constraints on the mass at launch, the mechanical interface devices connecting the two spacecraft are usually characterized by a high degree of flexibility.

Attitude control of such a class of platforms is an intriguing problem, which can be investigated building on a large deal of studies carried out in the past for the orbiting space station on a side (i.e. the rigid link case) and on the tethered systems on the other side (i.e. the extremely flexible case). Yet this intermediate scenario owns special characteristics that are worth of a dedicated study.

The proposed paper begins with an in-depth formulation of the attitude problem of the "connected spacecraft", considered as a flexible multibody system, by means of an adequate mathematical model. Attitude maneuvers to be performed by the chaser, with torques provided by either cold gas thrusters or powerful reaction wheels, are computed in order to acquire/maintain the coarse attitude of the compound while decreasing as much as possible the flexible-rigid dynamic interaction. Control techniques able to damp the vibrations out – as the shape input technique - are considered to obtain the accurate pointing.

The focus of the paper is represented by the description and discussion of the experiments, set to implement the proposed technique and to investigate the relevant issues. To this aim, two microsatellite-seized (slightly less than 10 kg) free floating platforms, flexibly linked, are considered. Their controlled behavior is analyzed for different cases (simple and advanced controllers, more or less flexible links) and the relevant control performance is compared to the numerical models developed, with a discussion of the limits and possibilities of extending these results to the real orbital scenario.