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COUPLED ORBIT AND ATTITUDE DYNAMICS OF A RECONFIGURABLE SPACECRAFT WITH SOLAR RADIATION PRESSURE

Abstract

Large, gossamer spacecraft have been investigated in the literature for a number of potential applications. Similarly, distributed (fractionated) spacecraft architectures have also raised significant interest due to their robustness and flexibility in achieving different mission goals. In this paper these two concepts are combined into a modular, distributed spacecraft which can vary its morphology. We consider future reconfigurable multi-panel systems able to change their shape during their mission. This can be enabled either by changing the relative position of the individual units, or by using articulated mechanisms. It is envisaged to use a morphing solar sail as a multi-functional device that can deliver additional key mission functions such as power collection, sensing, communication, pointing and a more flexible solar radiation pressure (SRP) force vector control. For example, the spacecraft can be configured as a flat sail for solar propulsion during an interplanetary trajectory. In close proximity to the target body, the sail can reconfigure to a parabolic shape, and its membrane can be used as a remote sensing device, before continuing in a flat propulsion mode. A multi-functional sail membrane could also be used as a telecommunication antenna. The dynamics of such large spacecraft requires the use of coupled orbit-attitude equations. The problem is even more complex due to the modularity and the shape-changing capabilities of the system. Therefore, a simplified system model is adopted, in which an N-body formation of point masses is connected by rigid, massless links. The system is subject to a central gravitational force field and SRP forces. The system is controlled by changing the reflectivity coefficients of the elements, through the use of electro-chromic coating on the surfaces. Accordingly, the point masses model reflective spheres and the links model large reflective surfaces. Both an analytical non-linear Hamiltonian approach and numerical investigations are used to study the behaviour of the system in Earth- and Sun-centred orbits. The creation of artificial stable and unstable equilibria of the system and potential homoclinic and heteroclinic connections in the phase space of the problem are investigated. In particular, it will be shown that the system can be stabilised at naturally unstable equilibria through the use of active SRP force control. It is foreseen that the spacecraft is eventually capable of reconfiguring between different configurations using minimum actuation effort.