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ADAPTIVE STRUCTURES FOR SPACECRAFT ORBIT CONTROL

Abstract

Shape-adaptive or 'morphing' deployable structures have the potential of enabling orbit and attitude control strategies by effectively taking advantage of solar radiation pressure. Control strategies based on the exploitation of orbit perturbations allow a significant reduction in the amount of on-board propellant required. Solar radiation pressure is a function of the satellite projected area and its orientation; thus, changing the former parameter could have a beneficial impact on applications, such as station-keeping and attitude control. The traditional approach instead aims at cancelling out disturbance accelerations to maintain the desired orbit. This effect is meaningful in the restricted three-body problem with a considerable ΔV required for station-keeping operation (i.e. 30-100 m/s in L1/L2).

This paper investigates the use of adaptive structure feedback control for distant periodic orbits in the restricted three-body problem. A family of periodic orbits around the second primary, originally identified by Hénon as "g-family", is taken as the reference mission. The existence of ice on planetary satellites like Europa motivates, for example, a scientific interest in g-orbits. These orbits are stable when close to the second primary, and then they become unstable for increasing initial displacement from the second primary. The effect of changing the projected area on orbit stability shows that unstable g orbits become elliptic and stable. Consequently, it is possible to extend the stability to higher altitudes. Such stable orbits show an anti-heliotropic behaviour which can be exploited for studying the Earth magneto-tail. Moreover, it will be investigated how controlling the projected area is equivalent to modifying the equivalent mass of the three-body system. Therefore, starting with the same initial condition, the spacecraft can transfer from one family of periodic orbits to another by simply changing the projected area. This evidence suggests using morphing structures for orbit transfer within the restricted three-body problem.

Based on the design of the feedback control, the purpose of this study is then to identify the structural drivers in terms of projected area and its physical properties. Furthermore, different concept solutions will be investigated using existing on-board deployable satellite structures. Possible solutions for effectively changing the projected area include: solar panel flaps, membrane mirror surface control, reflective control devices and attitude strategies of sunshield surfaces.The exploitation of these structures could potentially be extended to other mission application.