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OPTIMIZATION OF ELECTROSPRAY THRUSTER CONFIGURATION AND CONTROL ALLOCATION FOR SPACECRAFT ATTITUDE CONTROL

Abstract

The space economy is evolving rapidly due to the establishment of small satellites, which offer cost effective access to space with growingly high performance. One of the main challenges is related to advanced applications, as precise attitude actuation systems. In combination with conventional actuation systems, electric propulsion is a suitable candidate thanks to its high specific impulse; however, a substantial number of thrusters may be needed due to its small thrust and for reliability purposes. This could lead to an over-actuated system that needs a control allocation algorithm aimed at optimizing the thruster's utilization. This study is related to the definition of optimal control allocation as well as thruster configuration for a given satellite. The problem is a multi-objective optimization-based algorithm, with pointing error and fuel consumption as objectives to be minimized, including the definition of number, position, and orientation of thrusters. The developed methodology is based on hybrid optimization of thruster configuration and control allocation. The former is solved through a stochastic algorithm, in which the satellite is discretized into potential areas for thruster placement, allowing the imposition of forbidden regions and avoiding plume impingement or contamination of optics. Control allocation, on the other hand, is studied with a convex optimization problem solved via quadwright algorithm. A set of cases is analysed using electrospray thrusters, and the results show that the optimization of control allocation yields improved results against the pseudo-inverse thrust allocation. This study offers insight into the applicability of electrosprays for attitude control of small satellites, emphasizing the importance of determining their configuration and associated thrust allocation in early mission design.