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COMBINED STATION-KEEPING, ATTITUDE CONTROL AND MOMENTUM DUMPING STRATEGY FOR A SPACECRAFT IN AN EARTH – MOON L2 HALO ORBIT

Abstract

Lagrange point orbits in multibody dynamical systems offer a variety of scientific advantages for space exploration. This has led to an exponential increase in the number of missions planned to various orbits both in the Sun – Earth and Earth – Moon systems. Typically, Lagrange point orbits tend to be unstable and therefore any unmodeled disturbance forces and torques will cause the spacecraft to deviate from its reference orbit and lose its attitude pointing accuracy. In practice, spacecraft attitude is continuously regulated using reaction wheels. When the wheels reach their saturation limit, momentum dumping maneuvers are periodically performed using thrusters. The same set of thrusters are used to execute station-keeping manoeuvres to maintain the spacecraft near the reference orbit. Typically, both the maneuvers are implemented separately. This often leads to unwanted cross-coupling of thruster forces and torques. Instead, a combined execution of station-keeping and momentum dumping maneuvers will eliminate any undesired dynamical cross coupling by manipulating the entire six degrees of freedom of the spacecraft. Hence, a robust, autonomous, and computationally efficient strategy is the need of the hour. In this paper, a computationally efficient combined station-keeping and momentum dumping strategy is developed based on the philosophy of Model Predictive Static Programming (MPSP). The current strategies are primarily based on linearized dynamics about the reference orbital and attitude states. This makes them ineffective in the presence of large deviations from reference solution. The MPSP technique iteratively solves a non-linear, finite horizon optimal control problem subject to boundary and algebraic path constraints without making any such approximations. The computational efficiency of the technique is a result of converting the dynamic optimal control problem into a static optimization framework with a static co-state variable. Further, this technique involves calculation of sensitivity matrices which are obtained in a 'recursive' manner for fast computations. Finally, the technique will we effectively applied to a low-thrust spacecraft placed in an L2 Halo orbit in the Earth – Moon system to drive the orbital and attitude pointing errors to zero while simultaneously dumping the accumulated angular momentum in the reaction wheels. The capability of technique will be demonstrated by making comparisons with some of the popular existing strategies.