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OPTIMAL CONTROL OF J2 FORMATIONS SUBJECT TO DRAG USING MPC

Abstract

Formation flying, i.e., the practice of using multiple satellites in formation has enabled the possibility of complex multi-satellite missions that were not possible before. .However, the advantages of the multiple platform concept require a strict control of the relative dynamics. In this paper we develop an MPC control scheme based on a Modified Predictive Controller (MPC) that already encapsulates the effects of osculating J2 perturbation using GVE (Gauss' variational equations). The MPC controller hence developed is subjected to a more realistic mission scenarios typical of Low Earth Orbit (LEO) where satellites are significantly perturbed by the effect of atmospheric drag.

The MPC controller initially developed with osculating J2 effects is already a reasonably accurate model for formation flying scenarios. In literature the effect of drag is less considered, as difficult to introduce (dissipative perturbation) and strongly case dependent. Satellites flying in formation are usually at close distance, so that the environment (density) can be considered common. Moreover, the general assumption is the fact that the satellites in formation are identical, so that – if attitude is also commo or similar (like nadir-pointing) the cross sections will be too, and no differential effects will appear in the relative dynamics. These assumptions are reasonably valid as a first approximation for most mission scenarios. However there exists lot of missions where the assumptions do not hold. The simpler MPC designed from J2 is not enough, and its evolution, including drag, is therefore introduced.

The case to be presented in the paper refers to a time varying control in a highly elliptic orbit. The time horizons adopted for MPC depend on several factors including drag effect, collision avoidance and control limits. The length and intensity of control in the time horizon depends on the control amount required. The results once obtained are compared with control efforts for a J2 modified MPC and with a highly linear MPC based on HCW equations (Hills-Clohessy-Wiltshire). The differences in control effort for all 3 scenarios are studied and the performance vs complexity for all the 3 controls will be analyzed.