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INVESTIGATION ON SUSTAINING THE AUTONOMOUS SATELLITE NAVIGATION SYSTEM USING ONLY INTER-SATELLITE LINKS

Abstract

Autonomous satellite navigation system is of great interest to the navigation community and to the space missions, since it allows robust performance with little or no dependence on ground support. For deep space explorations, it minimizes the time to respond to any possible contingencies and the time for decision making. However, it is rigorously proved in theory, that it is impossible to sustain an autonomous system forever, using only inter-satellite links (range and range-rate). Additional support is essential to link the constellation to a fixed terrestrial or celestial frame, otherwise the overall rotation of the constellation is inevitable in the long term.

In this work, we investigate the performance of an autonomous navigation constellation using only inter-satellite links (ISL). Recognizing the fact that a self-sustained constellation will nonetheless gradually diverge due to rotation, it is still worthwhile to understand how ISL contributes to containing the relative accuracy within the constellation and the overall error within a given time period. If the ISL can suppress the error for a reasonable time period, it still helps to reduce the dependency on external support and improve the autonomy.

To this end, we employ a *centralized filtering* strategy. Instead of each satellite filtering its own measurement, all measurements within the constellation are collected via ISL to a server satellite, where all measurements are filtered together. By fixing (dynamically propagated but not updated) only one element Ω (RAAN: right ascension of ascending node) of only one satellite, the overall rotation is eliminated and the whole constellation is observable. Although the initial error of the fixed RAAN inevitably affects the filtered orbits, best performance can be expected by constraining all satellites at the same time. The simulated constellation in this work resembles current major operational Global Navigation Satellite Systems. The simulations are computed with reasonable initial errors and model errors. Considering the onboard computing capacity (CPU and memory) and the *centralized filtering*, we also revise the filtering procedures for lower computation load and memory requirement (regarding lunisolar ephemerides). We will present how the filtering accuracy of the constellation changes with respect to operational time, when the system runs autonomously with the *centralized filtering*.