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OPTIMAL ORBITAL CONFIGURATIONS OF SPACEBORNE OPTICAL SENSORS CONSTELLATIONS FOR SPACE SURVEILLANCE

Abstract

With the increasing number of satellites, there is a progressively higher demand for accurate surveillance and collision risk analysis systems. Most of the space situational awareness domain depends today on ground-based telescopes and radar sensors, which have the disadvantage of being highly constrained in terms of their potential geographic positions. A more versatile approach may instead be the use of a constellation of spacecraft carrying space-based sensors that can cover any desired orbital region allowing for complete coverage of the orbiting population, enabling a more accurate orbit estimation and consequent collision risk analysis. This work investigates the optimal orbital configurations of a LEO constellation of satellites carrying optical sensors when these are used for the orbit estimation and the conjunction assessment of resident space objects. Collision risk assessment is performed through covariance analysis using unscented transform techniques and unscented Kalman filtering and assessed using Monte Carlo analysis. The optimal configuration of the constellation is found using nonlinear optimization techniques, maximizing the performance in terms of estimation accuracy, number of detected conjunction events, and probability of collision over short and long-term periods. Different requirements and drivers will be considered and traded off in the analysis, including specific orbital regions to be covered by the system, different capabilities of the optical instruments, and lead time on the detection and transfer of the eventual warnings to ground stations. The outcome of the study will be the set of optimal orbital configurations of the constellation for an increasing number of constellation satellites and the given population of LEO target satellites. The results thus obtained will inform on how to optimally deploy constellations of satellites carrying optical sensors for surveillance and collision assessment of uncooperative spacecraft and on the effect that the number of constellation satellites has on performance.