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ROBUST MEASUREMENT PLANNING FOR RELATIVE ATTITUDE AND ORBIT ESTIMATION IN
SATELLITE FORMATION FLYING**Abstract**

This paper introduces a robust measurement planning methodology for relative attitude and orbit estimation of two low Earth orbit satellites flying in formation. Particular attention is given to the drag effect through a variable atmospheric density, and to the use of intersatellite laser ranging capabilities. Star trackers sensors and GPS receivers complete the assumed suite of sensors. It is assumed that relative attitude and orbits are estimated via Kalman filtering. Optimal relative attitude and position sensing is planned by choosing the sequence of times and measurement noise intensities that minimize an upper-bound of the estimation error covariance matrix, subject to an integral constraint on the noise intensities. In addition, the problem of maximizing that same upper bound with respect to a time-varying noisy atmospheric density under a similar integral constraint, is formulated and solved. The focus and the contribution of this work lies in the combined solution to both problems, which provides an attitude and position measurement planning that is robust to the worst case of the atmospheric density profile along the scheduled trajectory. These problems are solved iteratively. The results are sequences of few measurement acquisition times, few air density impulses, along with the associated optimized intensities. There is a clear advantage in sparse rather than continuous measurements, given the same budget of sensing accuracy. Similarly there is a practical advantage in working with sparse rather than continuous profiles of perturbations, given similar energies along the mission duration. Navigation filter performances, even when computed using consistent Kalman filters, might violate their upper bounds if based on erroneous air density profile assumptions. The proposed example features a Kalman filter that assumes a regular air density with uniform rather than impulsive air variability. As a result the upper bounds on the estimation navigation errors are severely violated by the actual filter performances. The foremost value of the proposed methodology is thus to provide guaranteed performances in attitude and orbit estimation under worst-case behavior of the air density along the mission, even if the latter is totally unknown prior to the mission start. The theoretical foundations of the proposed approach will be presented in the manuscript, along with an algorithm for iterative solution, and extensive Monte-Carlo simulations results will be shown in order to validate the method.