15th IAA SYMPOSIUM ON SPACE DEBRIS (A6)
Orbit Determination and Propagation (9)

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DEBRIS OBJECT ORBIT INITIALIZATION USING THE PROBABILISTIC ADMISSIBLE REGION WITH ASYNCHRONOUS HETEROGENEOUS OBSERVATIONS

Abstract

One of the most challenging problems in treating space debris is the characterization of the orbit of a newly detected and uncorrelated observation. The admissible region is defined as the set of physically acceptable orbits (e.g., orbits with negative energies) consistent with one or more observations of a space object. Given additional constraints on orbital semi-major axis, eccentricity, etc., the admissible region can be constrained, resulting in the constrained admissible region. Based on known statistics of the measurement process, one can replace hard constraints with a probabilistic admissible region (PAR).

The PAR concept was introduced in 2014 [1]. In that paper, a Monte Carlo approach was used to construct the PAR in the range/range-rate space. An expectation-maximization algorithm was proposed to convert the particle cloud into a Gaussian Mixture Model (GMM) representation of the PAR. This GMM can be used to initialize a Bayesian filter. Using the GMM or particle cloud representations of the PAR, orbits can be prioritized for propagation in a multiple hypothesis tracking framework such as Finite Set Statistics [2]. In a recent paper, the PAR was adapted to enable the processing of radar range data [3].

In all the work on the PAR to date, observations were collected concurrently and by the same sensor. In this paper, we allow observations to have different time stamps. We also allow for non-collocated sensor collections; optical data can be collected by one sensor at a given time and range radar data collected by another sensor located elsewhere. We explore scenarios including mixed and unmixed optical and radar synchronized and asynchronous observations. Lack of observation synchronicity adds a new element to the analysis, namely that the orbit may change from one observation time to another due to orbital perturbations. Thus, we also explore the impact of perturbations on the construction of the PAR.

[1] I. I. Hussein, C. W. T. Roscoe, P. W. Schumacher, Jr., and M. P. Wilkins. “Probabilistic Admissible Region for Short-Arc Angles-Only Observations,” Advanced Maui Optical and Space Surveillance Technologies Conference, Wailea, HI, September 9–12 2014.

[2] I. I. Hussein, W. Zaidi, W. Faber, C. W. T. Roscoe, M. P. Wilkins, and P. W. Schumacher, Jr. "Application of Sequential Monte Carlo Methods for Space Object Tracking," 2017 Space Flight Mechanics Meeting, San Antonio, TX, 2017.

[3] B. Jones. "CPHD Filter Birth Modeling Using the Probabilistic Admissible Region," Journal of Aerospace and Electronic Systems, under review, 2017.