18th IAA SYMPOSIUM ON SPACE DEBRIS (A6)
Orbit Determination and Propagation (9)

Author: Mr. Claudio Carloni
Fraunhofer FHR, Germany

Mr. Matteo Budoni
Fraunhofer FHR, Germany
Dr. Delphine Cerutti-Maori
Fraunhofer FHR, Germany
Prof. Wolfgang Koch
Germany

KALMAN FILTERS AND BATCH FILTERS FOR ORBIT DETERMINATION WITH TIRA

Abstract

This paper investigates the performance of Kalman filters and batch filters for the orbit determination with the TIRA (Tracking and Imaging Radar) system, developed and operated at Fraunhofer FHR. The main goal is to understand which are the best estimates of the state vector and of the covariance matrix we can obtain by observing space objects with TIRA.

Two different kinds of Kalman filters were examinated: the Extended Kalman Filter (EKF) and the Unscented Kalman Filter (UKF). The EKF is a nonlinear estimator, which linearizes the nonlinear model in order to apply the standard equations of the Kalman filter to linearized systems. The UKF introduces the Unscented Transformation to provide a more direct and efficient method for transforming the mean and the covariance information. Some results about the performance of the EKF and the UKF were already presented in Budoni et al. "Autonomous tracking mode with space observation radar: Initial Orbit Determination and Tracking", Esa Neo and Debris Detection Conference, Darmstadt (Germany), January 2019.

In this paper, two different kinds of batch filters are investigated and compared to the Kalman filters: the batch least squares filter and the unscented batch filter. The batch least squares filter selects the estimate of the state at a chosen epoch as the value that minimizes the sum of the squares of measurements residuals and it is processed by using the whole set of measurements. The unscented batch filter is a non-recursive application of the UKF that estimates the state at a chosen epoch using all the measurement set of data.

Concerning the orbit determination with TIRA, for real-time applications a trade-off between processing speed and tracking filter complexity is needed. This study will show an analysis between the implemented filters in terms of tracking performance, reliability and accuracy, covariance matrix propagation, computational cost and processing time. Results will be compared with high precision ephemerides and presented in terms of residuals on the observation vector.