Paper ID: 84147
oral
student

22nd IAA SYMPOSIUM ON SPACE DEBRIS (A6)
Operations in Space Debris Environment, Situational Awareness - SSA (7)

Author: Ms. Paola Grattagliano
Politecnico di Milano, Italy

Mr. Alessandro Mignocchi
Politecnico di Milano, Italy
Dr. Marco Felice Montaruli
Politecnico di Milano, Italy
Dr. Pierluigi Di Lizia
Politecnico di Milano, Italy
Dr. Alessandra Di Cecco
Agenzia Spaziale Italiana (ASI), Italy
Dr. Marco M. Castronuovo
Agenzia Spaziale Italiana (ASI), Italy

EARLY STAGE CHARACTERIZATION OF ON-ORBIT FRAGMENTATION EVENTS

Abstract

The ongoing rise in the number of orbiting objects is a significant concern in the advancement of space services, posing a great threat to future missions and active satellites. Currently, fragmentation events are the dominant source of space debris, making the Fragmentation Analysis one of the main Space Surveillance and Tracking activities in supporting operators in the space traffic management. Prompt characterization of these break-up events is of paramount importance to achieve fast and accurate forecast of the fragments trajectories. Accomplishing this task implies two essential activities: associating a detected object to the fragmentation event and detecting the event epoch. To this end, a stochastic approach is considered fundamental to act operationally in the period immediately after a fragmentation, when the data are uncertain and scarce.

Concerning the association problem, the Orbital Parameters Intersection Analysis (OPIA) algorithm performs the Chi-Squared test, based on the Mahalanobis Distance, to assess the statistical matching between two distributions found in the RAAN-inclination plane, derived from the last available ephemeris of the parent and from the measurement track of the observed object. The latter is obtained through the admissible region concept, and this allows to apply the approach from a single measurement track and without an Initial Orbit Determination (IOD) result.

When the result of an IOD process is available for a single fragment, a novel version of the FRagmentation Epoch Detector (FRED) algorithm, based on typical tools of Conjunction Analysis, can be exploited. The proposed approach applies Gaussian Mixture Models (GMM) throughout the process to describe and propagate the parent and fragment state uncertainties. The algorithm computes a set of candidate fragmentation epochs, and then ranks them through the Probability of Collision (PoC) metric, to determine the best estimate of the event epoch. The computation of the PoC is also exploited to verify the association of a detected object to the event.

Both OPIA and FRED performances are tested in a realistic simulated scenario. Concerning OPIA, the simulations demonstrate satisfying accuracy, allowing an accurate event characterization even when the fragmentation epoch is not yet available. Regarding FRED, its robustness to increasing orbit determination errors and presence of dynamical perturbation is verified as well. At the expense of a slight increase in the sensitivity to state uncertainties, the upgraded version of FRED benefits from the GMM-based

approach, which evidently reduces the computational effort.