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TRACK-TO-TRACK ASSOCIATION FOR SPACE OBJECT CATALOGUING WITH OPTICAL SURVEY DATA

Abstract

Efficient and robust track-to-track association (TTTA) methods are needed for building catalogues of Resident Space Objects (RSOs) and use survey sensing data efficiently. Optical tracks, usually referred to as tracklets or Too Short Arcs (TSAs), do not contain enough information to estimate an orbit accurate enough to ensure high correlation success of further tracks and with which provide Space Situational Awareness (SSA) and Space Traffic Management (STM) services due to the too large uncertainty. Being able to associate these tracks belonging to common RSOs is crucial for any Space Surveillance and Tracking (SST) system, since otherwise too many spurious detections may pollute the catalogue. Moreover, advanced TTTA frameworks are very suitable to jointly tackle the catalogue build-up and maintenance, as well as maneuver and fragmentation detection.

In this paper, an operationally feasible Multi Hypothesis Tracking (MHT) algorithm is proposed to solve the TTTA problem. Associations of tracks, or hypothesis, are generated, scored, pruned and promoted making use of several complexity reduction techniques. The underlying estimation, i.e. Initial Orbit Determination (IOD) and Orbit Determination (OD), in the optical survey case is far more complex than the radar counterpart, especially when eccentric RSOs, such as those in Geostationary Transfer Orbit (GTO), are involved. To address this challenge we propose a novel and computationally efficient IOD method to detect first RSOs with low eccentricity (larger share of the population). Then, most eccentric RSOs are detected by means of alternative and more expensive methods and the consideration of multiple hypotheses in terms of number of revolutions and eccentricity. The algorithm scores the hypotheses according to a figure of merit computed directly on the observation space rather than in the orbit space, as other approaches suggest.

Results presented include GTO detection analysis, TTTA correlation metrics and scalability concerns, essential for robust and operational applications. We compare the performance of the proposed IOD method, derived from Izzo's method to solve the Lambert problem, against state of the art alternatives such as Gooding method or purely circular approaches. Besides, we tackle the problem of determining the number of tracks required for the promotion of the hypotheses, i.e. initialization of the RSO in the catalogue. The performance proposed TTTA algorithm has been assessed in simulated survey scenarios, achieving high success rates (around 98%) while keeping a low number of false positives and false negatives (less than 1%).