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IMPROVED TRACKLET CORRELATION FOR INITIAL ORBIT DETERMINATION

Abstract

Initial orbit determination (IOD) for space debris is challenging, especially in the case where only optical observations, i.e. angles-only observations, are available. Due to the fact that information of range cannot be extracted from a tracklet that contains few optical observations, multiple tracklets need to be combined to determine the orbit of the space debris. In this case, the main difficulty is to identify multiple tracklets that originated from the same target. Recently, many tracklet correlation methods have been proposed using the approach of constructing an admissible region (AR). The main procedure is to generate a set of hypothetical orbits from each AR; then to propagate all the hypothetical orbits to a specific epoch and determine the closest distance between them.

The above methods may encounter difficulties when two tracklets originating from different objects have similar orbital elements. This study is to address this issue using a new approach that initially correlates the hypothetical orbits before the propagation and cross correlate the propagated orbits in the topocentric spherical space. Its procedure is, first, the hypothetical orbits are mapped to five-dimensional bins in the alternate equinoctial orbital elements space since these alternate equinoctial variables keep constant during the orbit propagation. Given two sets of uncorrelated tracklets, if their hypothetical orbits fall into all five-dimensional bins, then they are regarded in similar orbits in terms of shape and orientation. The second step is the cross correlation for further evaluating the similar orbits if they have close angular position. This is achieved by assessing the L_2-norm distance between the estimated observations generated from hypothetical orbits and real ones.

The new approach is tested using both simulated data and real observations collected at the Mt. Stromlo observatory, Canberra, Australia for different IOD scenarios. Results show that the new approach is efficient in identifying correlation between two tracklets from the LEO, MEO and GEO regions. When correlating two tracklets of observations from objects within a constellation, desired results can be obtained if a high-fidelity orbit propagation model is employed. These results illustrate the better performance of the new approach over the traditional ones for IOD.