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NONLINEAR EFFECTS IN THE CORRELATION OF TRACKS AND COVARIANCE PROPAGATION

Abstract

The most fundamental challenge to the creation and maintenance of a space object catalog is the ability to associate sensor observation data with a unique space object. When space surveillance observation data cannot be associated to a known object, it is known as an UnCorrelated Track (UCT). UCTs typically result from unmodeled accelerations, such as satellite maneuvers, that significantly change the original orbit, fragmentation events where potentially thousands of new objects in similar orbits become visible to space surveillance sensors, marginally observable objects where insufficient data is available to maintain an accurate orbit, and through sensor improvements where existing space objects are seen for the first time due to increased observation capabilities.

To determine if two tracks are from the same object the state from the first track is propagated to the epoch of the second track and the two states compared. The current approach for track association is static in that only the states are compared by determining if a subset of the difference in the states is within a specified box. Reference 1 proposed a new approach in which the statistical distance between the tracks is used to correlate the tracks. The statistical distance used is the Mahalanobis distance which uses the uncertainty in the tracks. The covariance propagation is a linear propagation and the system nonlinearities can have a deleterious effect on the correlation if the nonlinearities are significant. Reference 2 investigated the use of orbital elements and a curvilinear coordinate system in lieu of Cartesian coordinates for minimizing the effects of the nonlinearities on associating UCTs. The nonlinear effects grow with propagation time so the ability to correlate tracks is affected by the time between tracks. This paper further investigates the nonlinear effects on the accuracy of the covariance for use in correlation. The use of the UKF and/or nonlinear propagation for providing a more accurate covariance are investigated along with assessing how these approaches would result in the ability correlate tracks that are further separated in time.

References 1. Alfriend, K.T., "A Dynamic Algorithm for UCT Processing", Paper No. AAS 97-607, 1997 AAS/AIAA Astrodynamics Specialist Conference, Sun Valley, ID, August 1997. 2. Sabol, C., Sukut, T., Hill. K, Alfriend, K.T., Wright, B. and Schumacher, P.W., " Linearized Covariance Generation and Propagation Analysis via Simple Monte Carlo Simulations," Paper No. AAS 10-134, AAS/AIAA Space Flight Mechanics Conference, San Diego, CA, 14-17 February 2010.