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A CRAMER- RAO LOWER BOUND-BASED EVALUATION OF SPACE SURVEILLANCE NETWORK DATA FOR COLLISION RISK ASSESSMENT

Abstract

Due to increased human activity in the last two decades, near-earth space is becoming congested from non-functional satellites and space debris. These space objects of human origin possess collision risk to the functional and expensive satellites. It is imperative to evaluate collision risks to the active satellites from these space debris, which requires orbit information of these Resident Space Objects (RSO). One of the major sources of orbit information for various RSO is the US Space Surveillance Network (SSN). SSN disseminates the orbit information using the Two Line Element (TLE) format, which removes the periodic variances of the Keplerian elements. These TLE data can be used to predict future orbits of all tracked RSOs in a deterministic sense. However, the motion of an RSO in orbit must be interpreted as a stochastic process for collision risk assessment. This article focuses on assessing and benchmarking the performance of the TLE data for collision risk assessment from a statistical perspective. This analysis is done by computing the Cramer-Rao Lower Bound (CRLB) of future variance in the position of an RSO that can be achieved using the historical periodic variances observed in the TLE data. The CRLB is calculated from the Fisher Information Matrix (FIM), which is constructed from the likelihood function of the past Keplerian Elements of space debris, given a predicted position of the same in the future. The lower bound is evaluated for the Low Earth Orbit (LEO), Medium Earth Orbit (MEO), Geostationary and Geosynchronous Orbits. This lower bound-based evaluation explicitly benchmarks the acceptability of the TLE data for collision risk assessment.