14TH IAA SYMPOSIUM ON SPACE DEBRIS (A6)
Orbit Determination and Propagation (9)

Author: Mr. Jullian Rivera
Rutgers, The State University of New Jersey, United States

IMPROVING THE ORBIT PROPAGATION ACCURACY OF TWO-LINE-ELEMENT SATELLITE DATA

Abstract

Propagating publicly-available Two-Line Element satellite orbit data using the simplified perturbation models such as SGP4 which is often used in conjunction with the Two-Line Elements suffer from large and highly variable uncertainties. Such uncertainties vary for different orbital object being tracked and depend on the source of the tracking data. This creates difficulty in using the Two-Line Elements data to accurately and reliably screen and avoid possible collisions with other orbiting objects in important and densely populated regions in space, especially for the mission operations that only have the Two-Line Elements data as the data source. However, by analyzing historical TLE data and the TLE SGP4 propagator's ability to propagate to future orbital states, it is possible to train an error prediction model to compensate for observable error patterns in Radial, In-track, and Cross-track positions that arise as propagation time increases. We determine the error in the SGP4 propagation by performing consistency tests between subsequent TLE records. We focus on propagating records of exemplary satellites from LEO and GEO orbits and of varying eccentricities over the course of 15+days and compare propagated positions to TLE reported positions at the same epoch. The difference between the positions is used as the consistency error. We have discovered strong error patterns with LEO satellites and developed polynomial models to fit the prediction errors using Least Squares Regression. Our results demonstrate that the proposed prediction model can approximate and compensate for the TLE SGP4 propagation error, leading to errors within 5km over a span of 15 days. This is approximately a 90% reduction in overall maximum position propagation error from SGP4. In future work, we will further analyze other satellites with different and more complex error patterns. We will also program and incorporate other advanced machine learning algorithms such as neural network and support vector machines to create prediction models. Our final paper will show that the error models for the current TLE satellite catalog can be incorporated and used to reliably increase conjunction screening accuracy using the proposed prediction methods.