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PROVIDING ORBITAL INFORMATION FOR OBJECTS IN EARTH ORBITS AS CHEBYSHEV POLYNOMIALS

Abstract

The goal of a space surveillance system is to detect, track, and catalogue objects in Earth orbits. Many services of such a system, like collision avoidance or re-entry prediction, rely on the catalogued information. The most comprehensive system today is the US Space Surveillance Network (SSN) operated by USSTRATCOM, which provides public information on more than 17,000 on-orbit objects via the Two-line elements (TLE) catalogue. In order to use TLE in operational applications, however, one has to process the orbit information with SGP4, which is the analytical theory providing the TLE. Switching to an alternative method, for example Special Perturbations and osculating states, implies using the same method on the user side to recover the maximum achievable accuracy from the provided data.

In this paper, an approach is analysed, which allows to provide orbital information without being dependent on the orbit theory used in the cataloguing system. The idea is not new: the Jet Propulsion Laboratory (JPL) provides Chebyshev polynomial coefficients for solar system bodies for distinct time intervals. That concept is applied in this paper to satellites in different Earth orbits in order to see the requirements on the interpolation interval size and the polynomial degree given a certain accuracy threshold. Update cycles and the continuous connection of subsequent interpolation intervals are discussed, as well as the storage requirements of providing polynomial coefficients compared to current data exchange standards like TLE. The characteristics of using Keplerian elements as opposed to Cartesian states are analysed and, finally, an outlook on a possible implementation within a space surveillance system is provided. Such a system is likely to provide ephemerides (or mean Keplerian elements) as well as the associated variance-covariance matrix, which can all be converted into polynomials. An additional option for providing a polynomial for the envelope of the variance-covariance matrix shall be also discussed.