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Orbit Determination and Propagation - SST (9)

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IMPROVING ORBIT PREDICTION IN LEO WITH MACHINE LEARNING USING EXOGENOUS VARIABLES

Abstract

The increasing number of space objects in Earth's orbit has led to a significant challenge in Space Situational Awareness (SSA). Orbit determination is a key part of SSA as it is necessary to know in advance the position and velocity of space objects, for collision avoidance and space debris mitigation. One of the sources of uncertainty in orbit determination is the effect of non-conservative forces on the spacecraft, such as atmospheric drag, solar radiation pressure and gravitational perturbations. Usual propagator methods such as the SGP4 misrepresent these forces, while more computationally expensive propagators rely on empirical models that can be inaccurate to the dynamic and unpredictable nature of the space environment. To overcome these limitations, we propose an orbit determination algorithm that uses machine learning to forecast the unmodeled forces acting on a spacecraft, using the previously known positions, and a set of exogenous variables including environmental parameters. The environmental parameters include information about the Earth's gravity field, atmospheric density, and solar flux, which are obtained from external data sources. The orbital data used in the paper is gathered from precision ephemeris data from the International Laser Ranging Service (ILRS), for several satellites in Low Earth Orbit and for the period of 1 year. We show how the use of machine learning and time-series techniques can reduce the position error with low computational cost, thus significantly improving SSA capabilities by providing more accurate and reliable orbit determination for space objects.