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LOW EARTH ORBIT DETERMINATION USING HETEROGENEOUS SENSOR DATA

Abstract

Orbit Determination (OD) for Space Situational Awareness (SSA) is crucial with the increasing quantity of objects around Earth and the new policies to reduce space debris. Keeping track of space objects is a key component of maintaining an orbital catalogue, upon which rely critical services such as collision avoidance.

Tracks in a space catalogue are updated through an OD step, typically involving a Least-Square Method (LSM), in which a track's orbital trajectory is corrected in order to fit a stream of measurements associated to it. While ODs relying on a homogenous set of measurements (i.e., collected from a single sensor) are fairly standard and straightforward to implement, expanding the method to a heterogeneous set of data remains challenging. Most notably, mixing measurements from sensors with widely different data rates may result in imbalanced OD results downplaying the information carried by low-data-rate sensors. This effect can be somewhat mitigated by sub-sampling the output of high-data-rate sensors, but if is often done in an arbitrary manner for lack of better options.

Our assumption is that, if the propagation model and the sensor models were well established, the quality of the LSM would not be adversely affected by the volume of measurements, and the disparity among sensor data rates would not be detrimental to the overall OD process. Correlation in the sensor noise across a stream of measurements and/or in the process noise across an observation arc, however, are rarely considered in the context of LSM; yet, we wonder if such modeling mismatches can have a negative effect on the quality of the updated state that is growing with the volume of data and/or the duration of the observation arc.

This paper will analyze our assumption in simulated SSA scenarios, involving typical sensors and orbital trajectories in the LEO regime, considering different sensor data rates, and integrating various modeling mismatches on the propagation and/or the observation processes. By doing so, this paper will provide some insight on the effect of mismodeling in OD with heterogeneous sensors, and some guidance in the tuning of a LSM-based update in a real catalogue of space objects.

Key words: Orbit Determination, LEO Objects, Space Debris, Radar, Noise, Data Rate