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AN ADVANCED TOOL TO DETERMINE THE APPARENT ROTATION PERIOD OF A SPACE OBJECT FROM A FUSION OF MEASUREMENTS

Abstract

Determining the attitude of a space object from space situational awareness (SSA) data is interesting for several applications such as contingency operations in case of loss of signal from a satellite, support to active debris removal missions or characterization of unknown objects. A first step in this determination process is to detect whether the satellite is rotating or not and estimate its rotation period.

This paper presents the results of a CNES RD activity performed by GMV to develop a robust and automated way of determining the apparent rotation period of a satellite by fusing different types of SSA measurements: telescope and laser light curves, radar cross section and laser range measurements (for cooperative objects equipped with a retroreflector). The process is based on the computation of a Lomb-Scargle periodogram, allowing to detect all possible candidates for the rotation frequency, and an iterative epoch folding method on each candidate to optimize its frequency. The selection of the real rotation frequency within the list of optimized candidates is based on the comparison of their folding error.

Lomb-Scargle periodogram has already been used in previous publications (Balachandran, K. et Subbarao, K. Estimating Sidereal rotation period of Resident Space Objects using non-uniformly sampled light curves. 2018), but only applied to a single type of measurement and retaining the most powerful frequency as the real rotation one. The advantage of fusing measurements is presented in this paper. It will be shown that it helps removing spurious frequencies from the periodogram, emphasizing the real rotation frequency of the object and its eventual harmonics. In addition, as measurements noise adds uncertainty to the periodogram, some treatments have been added to remove noise from the periodogram and make the automatic selection of candidate frequencies less ambiguous.

Using epoch folding method to optimize candidates and folding error to select the best candidate for the real rotation frequency has been proposed in the past (Cognion, Rita L. Rotation rates of inactive satellites near geosynchronous earth orbit. 2014), but always using the whole set of measurements. An

upgrade to this approach consists in using the best interval of measurements (the one with the best compromise of low noise and high data density) with a limited duration (two or three candidate periods). The advantage of using this approach is a drastic reduction of the ambiguity when comparing the folding error of optimized candidates, allowing a more confident selection of the best candidate for the real rotation frequency.

The tool (GLADIATOR) has been tested using simulated measurements, but also real measurements of well-known rotating satellites (Meteosat). It has also been used to analyze the rotation of some well-studied satellites in the literature with similar accurate results (Topex), showing the validity of the proposed methodology and the associated tool to successfully determine the rotation period of space objects through SSA data fusion.