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ANALYSING THE INFLUENCE OF PHOTOMETRIC FILTERS ON LEO SATELLITE ORBIT DETERMINATION

Abstract

As the space industry continues to populate the orbits near Earth, the challenge of monitoring and managing Resident Space Objects (RSOs) has become increasingly complex. The proliferation of satellites and space debris necessitates a high level of precision in tracking RSOs within crowded orbits, such as Low Earth Orbit (LEO). Space Surveillance and Tracking (SST) services are indispensable in this context, offering crucial capabilities for the accurate mapping of object trajectories, thereby ensuring the operational safety and long-term sustainability of activities in LEO. In response to these challenges, this paper, conducted by the research team at Sapienza Space Systems and Space Surveillance Laboratory (S5Lab), proposes a methodology for processing and analysing ground-based optical observations of LEO satellites for Orbit Determination (OD) purposes. The objective of this study is to evaluate the benefits and limitations of using optical measurements obtained through various photometric filters for precise OD. Depending on the RSOs' surface properties, shape, and orientation, the selection of a particular filter may influence the accuracy of satellite centroid detection. By optimizing the choice of optical filter to match the specific electromagnetic spectrum segment most relevant to the target, this approach seeks to enhance the OD accuracy through more precise photometric observations. This research presents a comprehensive analysis of the collected observational data and an astrometric analysis, employing an angles-only OD technique for precise orbit estimation of LEO satellites. The proposed methodology focuses on the study of satellites for which accurate orbit data are available, such as Sentinel and Starlink satellites. This choice enables a direct comparison between the estimated orbits derived from the optical data and the satellites' true known states. Such comparative analysis is essential for validating the accuracy and reliability of the proposed OD procedure. Observational data for this study is acquired from telescopes directly managed by the S5Lab research team, using the Johnson V and Sloan g', r', i' filters. These observations are carried

out during multiple passes and nights for LEO satellites, both consecutive and non-consecutive nights, to ensure a comprehensive dataset for analysis and to assess orbit accuracy sensitivity to tracking cadence, revisits, and duration. The OD accuracy of the results is compared between data collected using the different filters to assess the performance dependence on the selected filter.