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Space Debris Detection, Tracking and Characterization (1)

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BISTATIC OPTICAL MEASUREMENTS FOR DYNAMIC CHARACTERIZATION OF LEO OBJECTS

Abstract

The constant increase of space debris constantly raises the probability of impacts between two debris objects or between a debris object and an active satellite. In the past 50 years, the space around the Earth is passed from a debris-free environment to a populated region with man-made objects that threaten launches, active satellites, and the International Space Station (ISS). This involves an increasing international interest in Space Surveillance and Tracking. In this complex framework, monitoring of space debris, achievable through a variety of sensors deployment and operations, is contributing to Space Situational Awareness (SSA) and functional to future Space Traffic Management (STM) tasks. Orbiting object optical observation allows to obtain useful information for altitude and the attitude determination, which is of key importance for trajectory estimation of re-entering debris. Indeed, drag force heavily affects low-altitude debris during re-entry, being primarily influenced by air density, as function of altitude, and ballistic coefficient, depending on the objects attitude with respect to the motion direction. Simultaneous optical observations by two different observers with an adequate baseline, i.e. ground distance between the observation sites, and sufficient time synchronization allows to obtain an excellent estimate of the object's altitude. Attitude reconstruction can be achieved from acquisition and analysis of light curves, i.e. luminosity trends of the debris over the observation time. Measured light curves, acquired through photometric analysis of the optical data, can be compared to "synthetic" light-curves. These are retrieved from a rendering algorithm that simulates the space environment, by considering the atmospheric extinction, the shape and materials of the object and the phase angle with the Sun direction. The minimization of the differences between acquired and synthetic light-curves, operated through a genetic algorithm, can lead to optical attitude determination of the debris. The observatories' optical systems consist of a telescope connected to a scientific Complementary Metal-Oxide Semiconductor (sCMOS) camera, which allows high frame rate acquisitions, thus increasing the amount of obtainable data, improving the accuracy

of space debris' trajectories. In this paper the Sapienza Space Systems and Space Surveillance Laboratory (S5Lab) in collaboration with the Institute for Complex Systems (ISC) of the Italian Nation Research Council (CNR), present the result of an observation campaign based on bi-static synchronized optical observation strategy, implementing sCMOS sensors and time synchronization. The light curve analysis results obtained from different observatories will be shown, along with the final assessment on altitude and attitude reconstruction.