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Space Debris Detection, Tracking and Characterization - SST (1)

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LIMITING FACTORS FOR ON-ORBIT DEBRIS DETECTION USING COMMERCIAL STAR TRACKERS

Abstract

As the number of resident space objects (RSOs) in low Earth orbit (LEO) grows, the risk of collision between RSOs increases dramatically, threatening the sustainability of space as a resource. The U.S. Space Surveillance Network (SSN) currently tracks over 23,000 RSOs in LEO, including functional and decommissioned satellites and debris. The SSN uses ground-based radar and optical methods, which are susceptible to variations in atmosphere, weather, and lighting conditions. These barriers limit the focus of the ground-based surveillance methods to objects with characteristic length greater than 10 cm. Consequently, millions of smaller LEO RSOs remain untracked by ground-based methods, which reduces overall space situational awareness.

Onboard satellite sensors offer a space-based alternative to tracking RSOs. Prior research has investigated the feasibility of using commercial star trackers (CSTs)—optical sensors prevalent on most active spacecraft—to observe, detect, and estimate the position and velocity of RSOs to improve tracking for RSOs larger than 10 cm. In a recent effort, we expanded on these feasibility studies by assessing the capabilities of CSTs to detect debris particles smaller than 10 cm in characteristic length. In particular, we modelled debris particles as Lambertian spheres with zero phase angle and ten percent reflectivity. We characterized detection capability using the Barker (2004) model for optical measurements of near-Earth objects illuminated by the Sun to determine an object's apparent visual magnitude as a function of RSO-CST distance and object size. We analyzed a range of optical imagers of varying sensitivity levels to determine the maximum distance at which a given imager can detect debris of a given size.

In this paper, we expand on our previous study by investigating additional CST sensor characteristics that limit their successful detection of debris. We identify a number of representative CSTs with publicly available optical characteristics and consider the effects of properties such as pixel pitch, diffraction limit, and field of view on the parameter space (in terms of debris size and distance) that can feasibly be detected by each CST. We find a general reduction in the feasible region, as well as additional practical limits on the ability of a CST to distinguish two separate debris particles captured in the same image. Despite these limitations, we find that CSTs have the potential to substantially improve the state of the art in space-based debris detection.