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

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FLAT FIELD CALIBRATION OF OPPORTUNISTIC SENSORS FOR IN-SPACE SITUATIONAL AWARENESS

Abstract

Astroscale's ELSA-d mission has demonstrated in-orbit servicing (IOS) techniques that are vital to performing End-of-Life (EOL) services, Active Debris Removal (ADR) and Life Extension (LEX) activities to address the risks created by the presence of debris. The End-of-Life Services by Astroscale – demonstrator (ELSA-d), launched in 2021, comprises the Servicer and Client spacecraft, initially connected through a ferromagnetic docking system, which successfully performed a number of rendezvous proximity operations (RPO) in orbit. Following the completion of the demonstration activities, the onboard visible camera (VISCAM) was repurposed to perform In-Space Situational Awareness (ISSA) imaging of catalogued debris objects. VISCAM was designed for the sole purpose of executing RPO and, hence, was only intended for imaging objects at close range. In repurposing this camera for SSA activities numerous capabilities had to be developed to capture images of debris objects, such as how to time the image acquisition and how to calibrate the camera that has no previous calibration for performing ISSA imaging. Typically for imaging missions, calibration frames such as dark frames, flat fields and biases are performed pre-flight, or flat fielding capabilities are included on the spacecraft, for use in post-processing of images to remove camera defects and artifacts. With VISCAM, various on-orbit calibration techniques are explored, including on-orbit flat fielding without any inbuilt onboard capacity. Annealing a sensor, heating the sensor and dissipating the heat to nominal levels, is the conventional method of reducing the effect of hot pixels — pixels with a readout level consistently greater than the background average. ELSA-d has no temperature controls nor temperature monitoring capabilities for VISCAM and therefore annealing must be performed through another method. One such method is to use the Sun as a heat source for the camera, which is investigated here for use on VISCAM with its lack of temperature monitoring abilities. Available sensors onboard satellites present an opportunity to yield more data about resident space objects and to this end, we present methods for calibrating cameras that were not designed for ISSA purposes to obtain useful observations. Different operational capabilities of the satellite and camera are considered; for example, a basic, uncalibrated camera with attitude control like VISCAM. At Astroscale, these techniques are used to inform the imaging capabilities of our different platforms, including a UK Space Agency-funded ADR mission to design a dedicated ISSA payload, and are also used in informing ELSA-M ISSA imaging capabilities with RPO cameras.