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FORMULATION OF RADIOMETRIC CALIBRATION FOR STUDENT SATELLITE MISSIONS

Abstract

Cameras have a linear response curve mapping the spectral radiance with digital numbers (bit depth). Owing to the storage and degradation of the camera on Earth as well as the continuous exposure to radiation in space, the gain and offset change over time, thus changing the radiometric response. Hence, the camera needs to be calibrated to correctly interpret the images. An onboard as well as on ground calibration plan should be formulated depending on the type of sensor, scientific objective, and mission requirements. This is generally overlooked by student-satellite missions, which leads to optical anomalies and inadequate information retrieval from the sensor. The sensors, if they remain uncalibrated, will lead to erroneous results and may even lead to failure of the mission objective. Through this paper, on-ground radiometric calibration using a monochromatic camera (Bassler acA1300-200um) has been demonstrated. A monochromatic camera yields a singular set of gain and bias for the sensor field. This method can be extended to obtain the respective coefficients for multispectral cameras by measuring digital numbers of different bands in the camera. This study has potential to help for other student satellite missions to calibrate their cameras in the constraints of a student satellite mission. A trade-off analysis is presented of different on-board calibration methods for CubeSats that employ in-orbit sources like stars, moon, other celestial objects (planets, asteroids), as well as the earth's surface (vicarious calibration). For the mission, celestial objects like stellar and lunar calibration were discarded owing to the stringent pointing requirements. Meeting such accuracies without a star tracker is an extremely challenging task. This decision was also influenced by the type of filter and the difficulty of associated maneuvers needed to perform calibration. Based on the mission requirements and scientific objective, vicarious radiometric calibration was finalized. The same was implemented on MATLAB. This paper highlights a reliable method of performing radiometric calibration, both on-ground and vicarious, which can be implemented by a student satellite mission. This paper also offers a trade-off analysis between other calibration techniques, including but not limited to stellar, lunar, and radiometric calibration.