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NEUROMORPHIC VISION SENSOR NOISE CHARACTERIZATION AND DETECTION FOR CUBESAT TECHNOLOGY DEMONSTRATION MISSION

Abstract

Event cameras are bio-inspired, asynchronous sensors that detect changes in pixel brightness, providing data updates at a microsecond temporal resolution with low power consumption. Due to their increased dynamic range and spatiotemporal sensitivity, these cameras can capture dim objects that are moving very fast. These benefits make this type of camera well-suited to space applications, but there are very few perception algorithms developed for the computational constraints of onboard-satellite use. Furthermore, event cameras introduce a new paradigm for computer vision algorithms, with updates occurring on a pixel-by-pixel basis rather than a traditional frame-by-frame update, rendering most existing perception methods unsuitable. This paper discusses the development of on-board noise filtering and object detection algorithms for a CubeSat technology demonstration mission of event-cameras. We first discuss experimental efforts towards modelling noise for the event camera, as the noise properties for this type of sensor are poorly characterized for spacecraft operating temperatures and lighting. We describe our test chamber, and development of a testing procedure for evaluating the light in low-light settings such as space. Then, we present our noise sensitivity results from thermal chamber testing, and discuss the resultant noise modelling we have developed to characterize the noise for different anticipated spacecraft heating modes for the mission. We offer an in-depth analysis of the various noise classifications observed by this class of camera, discuss the limitations of experimental noise modelling, and present key lessons learned from our experimental tests and subsequent modelling efforts. Using our noise models, we then present our event-based approach towards filtering and object detection for resident space objects for different heating spacecraft modes. Through experiments, we demonstrate the computational efficiency of our algorithm and its detection rates in a variety of observational scenarios. We also analyze the associated dissipative heating to the CubeSat as a result of the computational effort associated with our proposed methodology. The results from our approach are then used to inform the expected data storage requirements and processing for the onboard computing system within the CubeSat.