IAF SPACE SYSTEMS SYMPOSIUM (D1)
Technologies that Enable Space Systems (2)

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EXPLORING NEUROMORPHIC VISION SENSORS IN SPACE EXPLORATION AND APPLICATIONS

Abstract

Traditional image-based sensor in spacecraft operations, astronomy, and remote sensing has relied heavily on Charged-Coupled Device (CCD) technology with its notable success. However, the introduction of Neuromorphic Vision Sensors (NVSs), with their asynchronous event-triggering which is based on logarithmic light intensity changes at the pixel level, marks a significant leap forward in vision technology, expanding the possibilities for advancements in space applications. Moreover, NVS technology enhances efficiency with its exceptional features, including reduced power consumption, reduced processing needs, and communication speed-ups. In this paper, we highlight and showcase the capabilities of NVS in enhancing a wide range of space-related applications, such as spacecraft navigation and control, star tracking, space situational awareness, observation, and astronomical data acquisition. The key properties of NVS and advanced processing algorithms are examined, especially under the harsh conditions encountered in space. Recent advancements in NVS technologies for space applications are reviewed, and their methodologies are explored. Finally, an in-depth analysis of the challenges associated with the current NVS-based applications, along with considerations for future research directions are formulated. We present two use cases, where event cameras can be used: Space Situation Awareness (SSA) and autonomous driving for planetary rovers. Neuromorphic sensors mimic the biological vision system, responding only to changes in light intensity. This event-driven approach significantly reduces data bandwidth and power requirements and allow to observe the night sky continuously. Same cameras can also be used on spacecraft for in-space observation of space objects. We demonstrate how AI based NVS data processing can significantly improve quality of light curve collection and improve precision of orbit determination of space object trajectories. In the planetary rover use case, we will demonstrate how event cameras can improve navigation on planetary surfaces, while reducing mass and power allocation for hazard avoidance cameras.