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BRAINSAT: HARDWARE DEVELOPMENT OF A NEUROMORPHIC ON-BOARD COMPUTER APPLIED TO METHANE DETECTION FROM LOW EARTH ORBIT.

Abstract

Machine learning applications for space require fast and intensive computation. The challenge however is that embedded computing is usually constrained in size, weight and power (SWaP) as well as thermal dissipation footprints. While compute efficiency gains have traditionally been made through smaller manufacturing nodes, this approach is reaching its limits, and new architectures are needed to meet payload computation needs in a Low-SWaP manner. Neuromorphic Computing (NC) mimics traits of biological brains, such as sparseness, spiking networks, and in-memory processing, thus offering better performance compared to traditional computing architectures, with drastically reduced footprints.

The paper proposes an on-board computer design leveraging NC, with advanced processing capabilities within the size, mass and power constraints of a low earth orbit small satellite mission. We introduce and review current Neuromorphic computing approaches and define a set of requirements dictated by said space mission and its spacecraft design. We then perform a preliminary design of the hardware and software of the Neuromorphic-enabled computer for this mission, comparing its performance to that of a conventional digital processor on key metrics (size, weight and power consumption). We finally discuss aspects of production and testing (VV) for the novel design, closing out with recommendations charting a potential path towards implementation.

The paper also details the challenges faced by Neuromorphic processing within the Space environment, and proposes a product-driven Systems Engineering Approach, paving the way for widespread future use of Neuromorphic hardware in Space. The paper aims to act as a reference point for other system integrators wishing to implement such hardware into future missions.