IAF EARTH OBSERVATION SYMPOSIUM (B1)
Interactive Presentations - IAF EARTH OBSERVATION SYMPOSIUM (IP)

Author: Mr. Andrew Karim
Space Generation Advisory Council (SGAC), Canada

Ms. Amel AlKholeify
Space Generation Advisory Council (SGAC), Kuwait
Ms. Jimin Choi
Space Generation Advisory Council (SGAC), Korea, Republic of
Mr. Jatin Dhall
Space Generation Advisory Council (SGAC), India
Ms. Tan Huda
Space Generation Advisory Council (SGAC), United Kingdom
Mr. Arnav Ranjekar
Birla Institute of Technology and Science(BITS), India
Mr. YOUSFI Yassine
Space Generation Advisory Council (SGAC), France
Mr. Daniel Wischert
European Space Agency (ESA), The Netherlands

SPIKING NEURAL NETWORK DESIGN FOR ON-BOARD DETECTION OF METHANE EMISSIONS THROUGH NEUROMORPHIC COMPUTING

Abstract

Small satellite constellations have shown tremendous success for Earth observation missions and can mimic the performance of large satellite platforms while being cheaper and faster to deploy. Detecting fugitive methane emissions from ageing oil and gas infrastructures is an important use-case, as it helps facility operators to locate and mitigate these leaks, ultimately addressing the global climate crisis. For such applications, it is crucial for the data to be transmitted to the end-user in a timely manner for appropriate actions to take place. Edge Artificial Intelligence (AI) can address this issue by pre-processing the data on-board the spacecraft, dramatically reducing the amount of data to be sent to the ground and thus improving response times and bandwidth. As small satellites are greatly constrained by a low size, weight and power (SWaP), their ability to process AI algorithms with fewer computational resources is essential.

AI applications often depend on real time data processing and analysis, yet most modern computers are inefficient in these tasks. Neuromorphic Computing's (NC) parallel and distributed architecture helps perform complex calculations faster while using less power, enabling more efficient in-orbit data processing and onboard adaptive learning. This paper presents the software design of a novel 6U CubeSat neuromorphic on-board computer, with a case study for point-source methane emissions monitoring. It involves the design, implementation, and evaluation of a Spiking Neural Network (SNN) tailored for small satellite platforms.

The architectural specifications necessary for neuromorphic computing in the resource-constrained satellite environment are outlined. NC principles are incorporated into the SNN architecture design, leveraging event-driven computation to improve energy efficiency and computational throughput. Techniques to quantize synaptic weights, remove redundant connections, and exploit low-ranked structures in

the network are explored to significantly reduce model size while preserving accuracy. The performance of edge computing-aware SNN models for neuromorphic computing is evaluated using annotated hyperspectral images of methane plumes from the AVIRIS-NG instrument. The impact of model compression and neuromorphic computing on classification accuracy and inference speed is evaluated and compared to various greenhouse gas emission monitoring algorithms, including a traditional Convolutional Neural Network (CNN) model with similar model size.

By embracing neuromorphic computing, an innovative approach inspired by the brain, satellites can achieve unparalleled efficiency and accuracy. The SNN model presented contributes to the scarce body of research on edge AI for greenhouse gas monitoring, providing a step forward towards real-time Earth observation.