Brain-Inspired Event-Based Sensing and Computing Hardware

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Abstract: Modern sensing systems rely heavily on uniform sampling and synchronous signal processing, where signals are digitized using high-rate analog-to-digital converters (ADCs) regardless of the presence of meaningful information. This conventional paradigm results in significant redundancy in data acquisition, excessive energy consumption, and substantial data movement, which pose major challenges for edge intelligence and resource-constrained systems.

In contrast, biological systems such as the brain operate using event-driven and asynchronous computation, where information is processed only when significant changes occur in the environment. Inspired by this principle, this project aims to develop brain-inspired event-based sensing and computing architectures that enable opportunistic sensing and sparse, asynchronous information processing.

The research will explore event-based sensing mechanisms across multiple modalities, including vision, acoustics, and neural signal acquisition. Instead of continuous uniform sampling, these systems will detect and encode salient temporal events directly in the analog domain, potentially bypassing conventional high-rate ADC signal chains and significantly reducing power consumption and data bandwidth.

On the computational side, the project will focus on the design of ultra-low-power spiking neural network (SNN) architectures capable of efficiently processing sparse event streams. The work will involve algorithm–hardware co-design, leveraging temporal sparsity, asynchronous communication, and local computation to build highly energy-efficient neuromorphic processing systems.

The broader objective is to develop a fully integrated event-driven sensing-to-computing pipeline, spanning sensor front-ends, event encoding circuits, and neuromorphic hardware architectures. Such systems could enable a new generation of low-power intelligent edge devices for applications in autonomous sensing, wearable health monitoring, brain–machine interfaces, and distributed IoT systems.

Preferred background:

The ideal candidate should have a background in analog and/or digital integrated circuit design, signal processing, or neuromorphic computing. Experience with FPGA-based system development, linear algebra, and programming (e.g., Python) will be beneficial. An interest in brain-inspired computing, event-driven signal processing, and low-power hardware architectures is essential.