A Mixed-Signal Multi-Core Neuromorphic Processor Enabling Online Local Dendritic Learning and Sparse Evolutionary

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We will introduce our latest mixed-signal, multi-core neuromorphic processor built using GlobalFoundries® 22FDX FDSOI 22 nm technology, which is scheduled for tape-out by the end of this year. This chip consolidates the key innovations our group has developed over the past few years.

From an analog computation perspective, we have proposed population-based neural computation and a local spike-based dendritic learning mechanism, developed through algorithm-hardware co-design on advanced technology. These innovations enable robust analog computation and adaptability to changing environments.

On the digital communication front: We implemented a cost-effective asynchronous digital Network-on-Chip[1] to manage spike communication between neural cores. We developed a scalable neuron arbitration encoding mechanism and an efficient Content-Addressable Memory (CAM)[2] for each plastic synapse, serving as receptors. We also introduced mechanisms for static connectivity compression and dynamic online local structural plasticity, significantly reducing the on-chip memory footprint.

These innovations will empower artificial sensory-processing systems to handle continuous data streams in real-world applications with ultra-low power consumption.

[1] Z. Su *et al.*, "An Ultra-Low Cost and Multicast-Enabled Asynchronous NoC for Neuromorphic Edge Computing," in *IEEE Journal on Emerging and Selected Topics in Circuits and Systems*, vol. 14, no. 3, pp. 409-424, Sept. 2024, doi: 10.1109/JETCAS.2024.3433427

[2] Z. Su, H. Hwang, T. Torchet and G. Indiveri, "Core Interface Optimization for Multi-core Neuromorphic Processors," *2023 28th IEEE International Symposium on Asynchronous Circuits and Systems (ASYNC)*, Beijing, China, 2023, pp. 89-98, doi: 10.1109/ASYNC58294.2023.10239574.