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Research Statement

Motivation and Vision: To reform the current paradigm of computing, to reduce every watt our deep learning applications burn today, is indispensable to the pursuit of fair and accessible technology. In a world constrained by resources, powering such models with a disproportionate amount of energy is unjust. The desire for this justice fuels my focus on neuromorphic computing: to develop this framework to serve the same applications as conventional neural networks and more, but also with dramatically better power efficiency and accessibility.

My research interests can be broadly framed as the further development of transistor-level fundamental blocks such as silicon neurons for neuromorphic accelerators geared towards large scale integration that reduces power demands of neural networks applications.

Origin of Interest: In 2023, as part of a five-member team, I co-developed an assistive mobility device for visually-impaired individuals navigating complex environments in India. Our system relied on deep learning inference at the edge. However, the power consumption in the current paradigm of GPU-based inference made it infeasible to meet our energy budget. This challenge sparked my exploration towards emerging computing paradigms.

Exploration of Emerging Paradigms: To pursue this goal, I explored emerging paradigms of computing through coursework at IIT Madras. As part of a collaboration with IBM Research, our three-member team contributed open-source quantum computing datasets to the IBM Qiskit framework. While Quantum Computing was exciting too, it was only when I found brain-inspired computing that I got a new found optimism towards my goal. I then undertook the course "Devices and Technologies for AI and Neuromorphic Computing" (by Prof. Bhaswar Chakrabarti) which introduced me to emerging memristive cells. As a follow-up, we explored co-designing quantization aware networks as a replacement for post-training quantization.

In the subsequent offering of the course, I joined as a teaching assistant. Prof. Rajkumar Kubendran (UPitt) was invited for guest lectures on neuromorphic computing at scale, covering subthreshold design, log-domain circuits, silicon neurons, and AER. I conducted tutorials and supplementary lectures on designing and simulating the Adaptive Low-Power Integrate-and-Fire neuron (Indiveri, 2003), Tau Cell Neuron (van Schaik et al., 2010), and DenRAM Synapses (Payvand et al., 2024). This experience deepened my interest in event driven asynchronous computation and in the further development of these fundamental blocks.

Foundation in IC Design: My ongoing master's thesis, under Prof. Aniruddhan Sankaran, involves the tape-out of a 7 GHz transceiver in 65 nm CMOS technology. The design of this RF IC has taught me to operate at the edge of technological limits: perspectives I aim to carry forward in my approach towards energy-aware architectures. Further, I also hope to bring complementary perspectives from this flavour of IC Design to the neuromorphic.

Having been responsible for the complete design flow, I have gained hands-on experience across the IC design and testing life cycle, including tools such as Cadence Virtuoso and Innovus. I also bring a working understanding of contemporary deep learning techniques through an internship at Microsoft. Equipped with this discipline and my Digital and Analog IC design coursework, I aspire to take existing models of silicon neurons and other fundamental cells closer to biological fidelity and help break the accuracy bottlenecks seen in SNNs today.

Future Direction: Motivated by my pursuit of accessible technology, I aim to pursue doctoral studies with focus in energy-aware analog design for neuromorphic systems. In the long term, I also strive to help advance neuromorphic computing as a robust paradigm superseding today's architectures not only limited to edge applications but also in large-scale server-side AI hardware.