

Opportunities in NeuroAI: Bridging the gap between Nanoelectronics, Neuroscience and Machine Learning



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Abstract

The massive explosion of foundation models in the past few years has led to widespread adoption of AI in a plethora of applications. However, the computational resource requirements to enable these platforms are growing at an unsustainable rate. Further, deep learning systems also suffer from algorithmic vulnerabilities such as adversarial susceptibility, lack of explainability, catastrophic forgetting, etc. Brain-inspired neuromorphic computing has the potential to overcome these challenges of current AI systems. This talk reviews recent developments in the domain of NeuroAI from my group guided by an overarching system-science perspective. From the top-down algorithm side, I will delve into methodologies that treat neuromorphic architectures as continuously evolving dynamical systems, revealing intriguing parallels with the learning dynamics in the brain. Our developed methodologies enable brain-inspired models to transition beyond simple vision-related tasks to complex sequence learning problems trained using online local learning. Complementary to this effort, I will also elaborate on a bottom-up perspective of bridging the computational efficiency gap through the exploration of novel ferroelectric and ferromagnetic devices that provide a better match to the computational primitives of AI systems. Our proposed Compute-In-Memory neuromorphic processors enabled with in-situ learning functionalities can potentially achieve two to three orders of magnitude energy improvement compared to state-of-the-art CMOS implementations. From a system implementation standpoint, I will outline several hardware-software co-design strategies to enable variation-aware, robust, self-healing AI hardware. I will conclude my talk with my vision of expanding the scope of neuromorphic computing beyond simple neurons and synapses by forging stronger connections with computational neuroscience, thereby enabling a new generation of brain-inspired computers.

Bio

Dr. Abhronil Sengupta is an Associate Professor in the School of Electrical Engineering and Computer Science at Penn State University and holds the Joseph R. and Janice M. Monkowski Career Development Professorship. Dr. Sengupta received the PhD degree in Electrical and Computer Engineering from Purdue University in 2018 and the B.E. degree from Jadavpur University, India in 2013. He worked as a DAAD (German Academic Exchange Service) Fellow at the University of Hamburg, Germany in 2012, and as a graduate research intern at Intel Labs in 2016 and Meta Reality Labs in 2017.

Dr. Sengupta is pursuing an inter-disciplinary research agenda at the intersection of hardware and software across the stack of sensors, devices, circuits, systems and algorithms for enabling low-power brain-inspired computing systems. He has published over 100 articles in refereed journals and conferences and holds 3 US patents. He has been awarded the IEEE CEDA Ernest Kuh Early Career Award (2025), ARO Early Career Award (2024), Purdue Engineering 38 by 38 Award (2024), NSF CAREER Award (2023), IEEE Electron Devices Society (EDS) Early Career Award (2023), IEEE Circuits and Systems Society (CASS) Outstanding Young Author Award (2019), Meta Faculty Award (2018), among others. His work on neuromorphic computing has been highlighted in media by MIT Technology Review, US Department of Defense, American Institute of Physics, IEEE Spectrum, and Nature Materials. Dr. Sengupta is a Senior Member of the IEEE and ACM. He currently serves as an ACM Distinguished Speaker (2024-2027) and IEEE CASS Distinguished Lecturer (2025-2026).

Host

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