Neuromorphic Computing (Implementing AI/ Ml in Edge Devices)

Course Duration: 19th to 23rd June, 2023

A brief introduction of the course offered:

Neuromorphic computing is an interdisciplinary research area involving brain-inspired device-circuit-system-algorithm co-design and co-implementation in order to carry out artificial intelligence (AI)/ machine learning (ML) tasks very fast and with very high energy efficiency. Possible applications of neuromorphic computing are in implementation of AI in edge devices where the data need to be processed very fast and the energy budget is very tight. Edge healthcare, robotics, and wireless sensor networks are considered to be a few such edge-AI applications. In this course, we will go through the basic principles of neuromorphic device, circuit, system, and algorithms design and discuss how each of these levels of abstraction depends on the other levels of abstraction. Given the interdisciplinary nature of the subject, preliminary background in physics of materials, analog circuit design, ML algorithms, and even neuroscience will be provided in the course so that the students can better appreciate the different neuromorphic design principles at different levels of abstraction. We will also explore various neuromorphic applications like edge healthcare and robotics, where the signals are acquired from the environment through neuromorphic sensors and then neuromorphic circuits and algorithms are designed to process these signals fast and with high energy efficiency.

Reference: D. V. Christensen et al., "2022 roadmap on neuromorphic computing and engineering,"*Neuromorph. Comput. Eng*. vol. 2, no. 022501 (2022)

Take-away message from the course:

1. The students will learn the fundamental operating physics of various non-volatile memory (NVM) materials and devices used for neuromorphic computing, like resistive Random Access Memory (RRAM), phase change material (PCM), nano-magnetic and spintronic devices, etc.
2. The students will learn how to design neuromorphic circuits and systems like electronic-crossbar arrays using the aforementioned NVM devices.
3. The students will learn about various neuromorphic algorithms including spiking neural network (SNN) algorithms and oscillator-based algorithms, which are inspired by the working of the brain.
4. The students will learn about various applications of neuromorphic computing and engineering like edge healthcare and robotics.

Instructor bio:

Dr. Debanjan Bhowmik is currently an Assistant Professor in the Department of Electrical Engineering, Indian Institute of Technology (IIT) Bombay, and was formerly an Assistant Professor in the Department of Electrical Engineering, Indian Institute of Technology (IIT) Delhi (2017–21). He obtained his BTech degree in Electrical Engineering from Indian Institute of Technology Kharagpur in 2010. He obtained his PhD degree from the Department of Electrical Engineering and Computer Sciences,

University of California Berkeley, in 2015, working in the field of nanomagnetism and spintronics. Currently, he works on neuromorphic computing/ artificial intelligence based on emerging devices, e.g., spintronic devices, and emerging architectures, e.g., crossbar-array architecture and quantum architecture. Thus far, in the areas of spintronics, neuromorphic computing, and quantum computing, Dr. Bhowmik has published about 20 journal publications and 10 peer-reviewed conference proceedings, with about 1200 citations in total (Source for information on number of citations: Debanjan Bhowmik - Google Scholar)