Brain-Inspired Ionic Computing

Narayana Aluru, Professor, Walker Department of Mechanical Engineering

Abstract: The explosion of Artificial Intelligence (AI) in everyday activities has led to an unprecedented demand for computing and energy. Alternative computing technologies, e.g., those that are inspired by how brain stores and computes on data, can be attractive platforms for AI related tasks for two important reasons: brain operates using very low power and the data and processing are co-located. Neuromorphic computing, also known as brain-inspired computing, has been an active area of research for many years. Most, if not all, of the existing neuromorphic computing architectures are based on electron transport through solid materials. In some recent research, ionic transport in solid materials has also been exploited. However, brain does not use electrons or ionic transport in solid materials for computing. Rather, it uses ions in an aqueous solution to perform much of the computing tasks. The objective of this proposal is to replicate key elements of the brain functionality – namely, synaptic junctions, to perform computing tasks. In particular, some of the key functionality of the brain can be mimicked by creating memristors – defined as resistors with memory. This proposal focuses on creating memristors using ions in an aqueous solution. We will design channels and pores with angstrom scale dimensions to establish scientific foundations of ionic memristors. We will develop multiscale computational approaches combining quantum to continuum methods to facilitate studies on ionic memristors. Subsequently, we will use the ionic memristors to design nodes/neurons in a neural network to perform AI functions such as recognition, classification and computing.