Developing A Low-Power Neuromorphic System for Motor Prosthetics and BCI Applications

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A brain-computer interface (BCI) system controls prosthetic devices using brain signals. Such BCI systems can have applications ranging from rehabilitation after brain injury to reanimating paralyzed limbs and enhancing memory. We focus on designing and developing a low-power real-time machine learning-based neuromorphic system for simultaneous decoding and encoding for closed-loop control and plasticity induction and addressing the challenge of multi-channel decoding and encoding. This neuromorphic system can be used to jointly optimize cost functions with the nervous system to achieve desired behaviors ranging from targeted neuro-rehabilitation to augmentation of brain function. We aim to design and develop hardware-optimized decoder algorithms and demonstrate them on FPGA platform, and the eventual goal is to develop a BCI decoder integrated circuit (IC). The system will decode and process the signals like an ElectroEncephaloGram (EEG), ElectroCorticoGraphy (ECoG), or Local Field Potential (LFP) received from the Brain in real-time using signal processing and Machine Learning (ML) algorithms. The processed output will be re-encoded to the Brain either through neurofeedback or by actuating external devices such as prosthetic arms.

Over the course of the PhD, the student would get trained in various aspects related to Machine Learning/Deep Learning, Signal Processing, Computational Neuroscience, Neuromorphic Computing, FPGA Design, etc.

Pre-requisites:
The ideal candidate should have a background in Digital Signal Processing, Linear Algebra, and FPGA design and be proficient in programming (Matlab/Python). The candidate should have an interest in understanding the Brain.