Technische Universität München

Neurowissenschaftliche Systemtheorie

MASTER THESIS

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NeuCube Spiking Neural Network Algorithm for EEG Signals Decoding on SpiNNaker Neuromorphic Hardware

Problem description:

Spatio- and spectro-temporal data (SSTD) are the most common data collected to measure dynamic brain signals. In order to make sense of such data, e.g. non-invasively recorded using electro-encephalography (EEG), decoding algorithms should take the spatio-temporal structure into account. Brain-inspired spiking neural network (SNN) algorithms such as NeuCube [1] work towards that goal by using trains of spikes (binary temporal events) transmitted among spatially located synapses and neurons. NeuCube encodes both spatial and temporal information as locations of synapses and neurons and time of their spiking activity respectively [2]. Since it is based on SNN it can be efficiently implemented on contemporary neuromorphic computers such as SpiNNaker [4] or TrueNorth, which could allow for portable, low-power brain–computer interfaces (BCIs). A different hurdle to clinical translation of BCIs is that current decoders, which are trained from a small quantity of recent data, become ineffective when neural recording conditions subsequently change [3]. Therefore, it becomes of the utmost importance to have a decoder that is robust to this inevitable neural variability.

The main objective of this thesis is to adapt the NeuCube-SNN algorithm to decode EEG during motor imagery movements and to implement it on a SpiNNaker neuromorphic computer [4], such that the algorithm can achieve real time performance. In order to demonstrate the system, a robot arm shall be controlled from live input of our EEG system monitoring a human subject.

Tasks:

This master thesis project requires the student to:

- Implement the NeuCube algorithm for EEG signals decoding on SpiNNaker
- Compare the results obtained by NeuCube algorithm with state-of-the art-results in literature

Optional tasks:

- Introduce **hybrid BCI** (hBCI) concept by simultaneous decoding of EEG and EMG using NeuCube algorithm during reach-to-grasp movements
- Port the developed NeuCube algorithm onto TrueNorth IBM's chip

Bibliography:

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[3] Dethier J, Nuyujukian P, Eliasmith C, et al. "*A Brain-Machine Interface Operating with a Real-Time Spiking Neural Network Control Algorithm*", Advances in neural information processing systems, 2011

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