Technische Universität München

Neurowissenschaftliche Systemtheorie

MASTER THESIS

Spiking Neural Network for EMG signals De-noising and decoding for an improved upper-limb prosthetic-hand control

Problem description:

A fundamental component of many modern prostheses is the myoelectric control system, which uses the Electromyography (EMG) signals from an individual's muscles to control the prosthesis movements. Thus, traditional myoelectric pattern recognition (MPR) has shown promise in the control of prosthetic limbs**.** However, **interfering noise, motion artifacts, misplacement of electrodes and muscle fatigue** have hindered the use of myoelectric pattern recognition outside controlled environments, and thus represent an obstacle for clinical use and in nowadays prostheses [1]. Spiking neural networks (SNNs), which are considered as the third generation of brain-inspired neural network techniques, seem to classify more accurately noisy and non-stationary signals such as surface EMG. As a result, SNNs can be used to de-noise the EMG signals, improve classification accuracies and accelerate the new generation of neuroprostheses. **The main objective of this thesis** is to advance an algorithm developed by Matthew Cook's group at ETH Zürich based on structural plasticity proposed in [2]. The student shall implement the algorithm on spiNNaker neuromorphic hardware and adapt it to be used for EMG de-noising and decoding. Combined with our algorithm presented in [3], the spiking decoder will be able to reduce the noise in the multi-channel recorded EMG signals by delete weak synapses (rearrangement of synaptic connections between target and source neurons), learn the correlation between different EMG channels during different grasping movements and infer missing input channels which lost contact during the recording. The reconstructed/de-noised EMG signals will be thereafter classified by an existing spiking decoder presented in [3]. Finally, the implemented algorithm will run on low-power spiNNaker neuromorphic hardware which presents an ideal platform for assistive patient devices, such as brain-machine interfaces and neuroprosthesis.

Optional task:

This master thesis project requires the student to:

- Implement the algorithm proposed in [2] for EMG de-noising on spiNNaker neuromorphic platform
- Combine the developed algorithm with an existing SNN [3] for EMG signals classification
- Compare the results obtained with state-of-the art-results in literature.

Optional task:

- Test and validate in a real-time scenario (EMG recording system, prosthetic hand)

Bibliography:

[1] Julian Maier, Adam Naber, and Max Ortiz-Catalan, "Improved prosthetic control based on myoelectric pattern recognition via wavelet-based de-noising", IEEE Transactions on Neural Systems and Rehabilitation Engineering, **November 2017**

[2] Robin Spiess, Richard George, Matthew Cook and Peter U. Diehl, " Structural Plasticity Denoises Responses and Improves Learning Speed", Frontiers in Computational neuroscience, 2016

[3] Tayeb, Zied, Emeç Erçelik, and Jörg Conradt. "Decoding of motor imagery movements from EEG signals using SpiNNaker neuromorphic hardware." Neural Engineering (NER), 2017 8th International IEEE/EMBS Conference, 2017

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Start:	November/December 2017
Intermediate Report:	10.03.2018
Delivery:	10.05.2018

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