TITLE Thesis proposed by: STADIUS

DESIGN OF DEEP ARCHITECTURES FOR RESOLVING SPIKE OVERLAP IN NEURONAL SPIKE SORTING

GUIDANCE

• Promotor(s): Prof. Alexander Bertrand	alexander.bertrand@esat.kuleuven.be
• Daily advisor: Jasper Wouters	jasper.wouters@esat.kuleuven.be
• Number of students	2

CONTEXT

After more than a century of brain research, and despite many breakthroughs, it is still largely unknown how brain activity gives rise to cognition. To aid researchers in getting a better understanding of brain function, extracellular recordings are performed by inserting an array of electrodes into the brain. Electrodes that are in close proximity to a neuron will pick up a transient potential, referred to as a spike, when the neuron fires an action potential. Typically many neurons surround a single electrode, leading to spikes from several neurons to be picked up by the same electrode. On the other hand, in high-density recordings a spike from a single neuron is picked up by multiple electrodes. To resolve the mixture of spikes from several neurons and extract the spike times of the individual neurons embedded in the recordings, a spike sorting [1] algorithm can be applied to the electrophysiological recording. Most spike sorting algorithms still rely on classical machine learning techniques. One of the main reasons for the slow adoption of deep learning approaches in spike sorting, is that spike sorting is an unsupervised learning problem. Only very recently, research has been conducted that investigates the use of deep learning methods in spike sorting.

GOAL

In our research lab, we have developed a neural network for use in spike sorting, which aims at solving the overlapping spikes problem, i.e., classify spikes generated by multiple neurons that occur simultaneously in time, in an innovative way. The goal of this thesis is to investigate the use of deep architectures for this application. Besides this application, there are still many opportunities and open problems that could benefit from the use of deep learning methods.

METHODOLOGY

At the start of this thesis you will conduct a brief literature study to become accustomed to the spike sorting problem and investigate which deep learning methods have been applied in the context of spike sorting. Next, you will design a deep architecture for resolving overlapping spikes. Within the lab, we have plenty of ground truth data (both synthetic and real recording) available, so you can focus on getting the network up and running. Depending on your available time and progress, there are many more open problems that you can attempt to solve using deep learning.

PROFILE/REQUIRED SKILLS

This is a hands-on thesis. Required skills: Python, preferably some previous experience using a deep learning python framework (e.g., Keras, PyTorch, Tensorflow, or others).

REFERENCES

[1] Gibson, Sarah, Jack W. Judy, and Dejan Marković. "Spike sorting: The first step in decoding the brain." *IEEE Signal processing magazine* 29.1 (2011): 124-143