Week 1: How to hear neurons talking?

Studying the activity of single neurons in vivo (live animal) is essential for understanding the brain mechanisms supporting behavior. Therefore, a large amount of research in neuroscience is based on the study of the activity of neurons recorded extracellularly with very thin electrodes implanted in animals' brains. These microwires are placed in the space between neurons and 'listen' to a few neurons nearby the electrode tip. When the neurons fire action potentials or 'spikes' to communicate with each other, there will be a change in the electric field of the surrounding area. The electrode can record these changes.

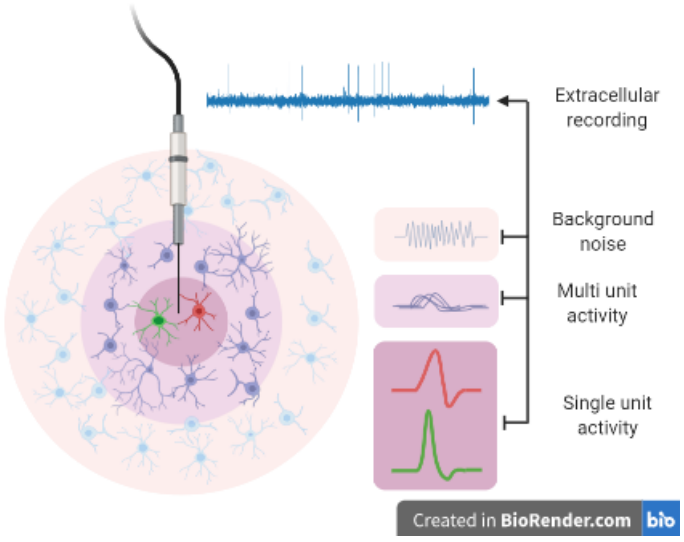

Figure 1: Sample extra-cellular recording of neural activity

We need to know the rate at which each individual cell around the electrode is producing spikes to be able to decode the brain activity. However, the signal that the electrode has recorded contains the activity of several different neurons as well as a mix of background noises. See figure 1 to understand the components of these signals. The question here is first, how to find all the spikes that are present in the signal, and second, how to determine which neuron is spiking at what time.

What you have:

1. You have a dataset that contains the recordings of a brain for two minutes at the rate of 24kHz. The file is called "sample_1.mat".

Your tasks:

1. Identify spike times in your dataset from the recording data.
2. Characterize each spike type and distinguish spikes from different neurons: Plot the average spike waveform of each neuron and it's standard deviation.
3. Report back how the choice of the parameters for your algorithms can affect the final results and why you have chosen the specific method you did.

4. The data for this week is a simulated dataset for which the ground truth is known. Compare your results with the ground truth and see if you need to adjust some parameters to match the true spike times.[1] You are also provided with some extra sample datasets. Validate your method on these new datasets. Compare the activity of neurons in these datasets.

[1] The reference timestamps that are provided in the dataset are approximate.

Week 2: Real epileptic patient data

This week you are given a real dataset which has been recorded from an epileptic patient. This new data is more noisy. See if you can apply your code from last week on this new dataset. What new challenges arise this time?

What you have:

1. The new data from the epileptic patient, recording.npy. The sampling rate for this data is 32.051 kHz.

Your tasks:

1. Identify spike times in your dataset.
2. Characterize each spike and distinguish spikes from different neurons. Plot the average spike waveform of each neuron and it's standard deviation.
3. Report back how the choice of parameters can affect the final results and why you have chosen the specific method you did.