

Lab 10: Seizure detection

Introduction

The past nine labs introduced a variety of neural engineering tools for exploring neural phenomena. In this lab, we're given a not-yet-solved challenge in translational neural engineering. This will provide an opportunity to expand your familiarity with the tools picked up in past labs and apply them to a real clinical challenge.

Software

This lab must be completed using MATLAB.

Part 0) Introduction to data and methods

Patient_A.mat and Patient_B.mat each contain three channels of ECoG data sampled at 3 kHz. In the Patient A recording, a seizure can be seen on channel 3, at sample 2480000. For Patient B, a seizure can be seen on channel 2 at sample 2800000.

In Parts 1 and 2, you will design seizure and HFO detectors. Your algorithms should work on both patients. In situations like this, it is common to train the detector on one patient, and then validate it on the second patient without changing any of the training parameters.

Part 1) Seizure detector

Seizures produce coherent, rhythmic oscillations. The frequency of those oscillations might change from patient to patient. In class we talked about 3 simple algorithms that Neuropace uses to detect seizures: signal amplitude, zero crossings, and line length.

1. Implement these three features in MATLAB. Plot each of them over the whole dataset and see if you can already see how these features may relate to seizure onset. Use a ten second window as the time bin for calculate a feature value.
2. Using these three features, create a simple rule based on thresholds of these features to detect seizures. Set these thresholds on one patient and test them on the other. By the way, you can use the resulting "expert" labelled data with the machine learning tool below.
3. Create a binary vector showing when the algorithm detects seizures in your test case(s) and plot it with the actual data to see if your simple rule works. Also plot the three features on the same time scale.
4. Using a machine learning tool discussed in one of the previous labs, design another seizure detection algorithm, and validate its performance in the same way as above. Feel free to use additional features in the data.

Part 2) HFO detector

High-frequency oscillations are a feature that can be used to help detect seizures. By definition, they occur at frequencies above 100 Hz. However, it turns out that they're not trivial to extract from ECoG signals.

1. First filter the data so that things that aren't HFOs are removed. Remember to use `filtfilt()` to avoid phase changes in the data. Once filtered, HFOs should "stand out" from the signal background.
2. Using the same features as in Part 1, and any additional features you think would be helpful (such as frequency power), create an algorithm to detect HFOs. Note that HFOs are quite brief, so if you use a smoothing window, make it no longer than 20 ms.
3. Train and validate your algorithm in the same way as in Part 1. Use the same types of figures to demonstrate performance.
4. Describe the relationship between HFOs and seizure.

Guidelines for Lab Report (on Labs 10 and 11 together)

Introduction: The introduction should be one paragraph long summarizing the motivation for developing the tools used in this lab and what they can be used for, along with a brief summary of everything you will show in this lab report.

Methods: From Lab 10, there should be methods paragraphs (and diagrams where necessary) on:

1. Descriptions of the features used
2. Rationale for the development of each algorithm
3. How the algorithms were implemented

Include the code as an Appendix to your report. Cite sources for any values used in your models.

Results: You should include the following in your Results:

1. The (qualitative or quantitative) performance of each algorithm
2. How different parameters effect the performance of each algorithm

Include all figures produced by MATLAB that could help explain and illustrate your findings.

Discussion: Should be ~2 paragraphs long describing what you could use these tools for in the future.

This report will be combined with Lab 11 to create one cohesive report. The report (not including Appendix and figures) should be no longer than four pages. Use 12 pt. font and 1.15-1.5 line spacing. If your text is over the 4-page limit with figures, you can move your figures to an appendix section that goes beyond the 4-page limit. Please upload your report to Canvas.