TU Delft
Faculty of Electrical Engineering, Mathematics, and Computer Science
Circuits and Systems Group

EE4C03 STATISTICAL DIGITAL SIGNAL PROCESSING ASSIGNMENT

Epileptic seizure detection using EEG

1. Context

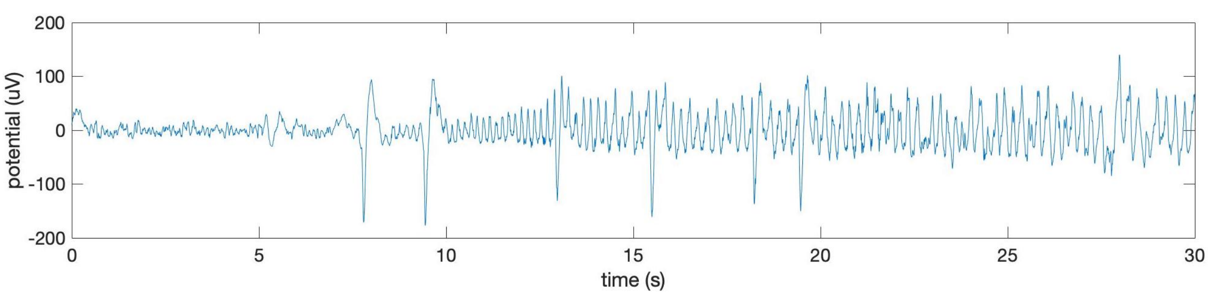
Epilepsy, the second most common neurological disorder after stroke, occurs in over 0.5% of the world population. This disease is manifested through recurrent epileptic seizures, resulting from an abnormal, synchronous activity in the brain involving a large network of neurons. Depending on the brain regions involved in the seizure, the patient may have diverse clinical symptoms, including sensory dysfunction, loss of consciousness, motor automatisms, etc.

The electroencephalogram (EEG) measures the electrical activity of the brain and is a well-established technique in epilepsy diagnosis and monitoring. As EEG monitoring takes several days, the amount of information to be processed is huge. The benefits of the automatic analysis of EEG recordings are twofold. An automatic seizure detection technique supporting visual analysis would drastically decrease the workload of clinicians. Besides, due to its fine temporal resolution, EEG can provide accurate information about the onset of the seizure. As the seizure spreads quickly through the brain, the early detection of the seizure is essential.

2. Problem

A typical machine-learning based seizure detection pipeline consists of 3 steps: 1. segmentation 2. feature extraction 3. classification. During segmentation the continuous EEG is divided into shorter windows, typically of fixed length. The choice of the length represents a trade-off: the windows should be short enough such that the otherwise non-stationary EEG is seen stationary within the window, but they should be long enough to allow accurate feature extraction. Indeed, popular features for seizure detection include, among others, spectral peak or AR model parameters, which require to fit a signal model using a sufficient amount of samples. A classifier can distinguish between segments that belong to the seizure and non-seizure classes, if the features are different enough across classes, but consistent enough within a class.

3. Dataset



A short single-channel EEG recording is provided (see figure 1). The recording starts with normal background EEG, and a seizure appears after some seconds. The seizure is characterized by a rhytmic, oscillatory pattern in the so-called theta band (4-8Hz). Note that the EEG is contaminated with eye blink artefacts at 7, 9, 13, 15, and 19 seconds.

4. Assignment

In a group of 2 students, write a compact essay where you briefly present the seizure detection problem, considering segmentation and feature extraction (Note that classification is out of the scope of the current assignment.) More specifically, show that the provided EEG signal is non-stationary, segment the signal, propose a signal model and implement a feature that captures the characteristic seizure patten, i.e. theta band oscillation. Using the extracted feature, can you establish when exactly the seizure starts? In your report, explain how certain choices, such as the segmentation and model parameters, influence your results.

5. Hints

Conduct a brief literature study to orient yourself on this problem. An overview of existing seizure detection algorithms is found in [1]. A textbook on biomedical signal processing is available in the TU Deflt library in e-book format [2].

6. Consultant

dr. Borbala Hunyadi
Email: b.hunyadi@tudelft.nl
Room: HB 17.120

References

[1] T. N. Alotaiby, S. A. Alshebeili, T. Alshawi, I. Ahmad, and F. E. A. El-Samie, "Eeg seizure detection and prediction algorithms: a survey," *EURASIP Journal on Advances in Signal Processing*, vol. 2014, no. 1, p. 183, 2014.

[2] R. M. Rangayyan, *Biomedical signal analysis*, vol. 33. John Wiley & Sons, 2015.