Project: Using transformers to detect epileptic spikes from brain activity recordings with MEG

Host laboratory: Lyon Neuroscience Research Center (CRNL).
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EDUWELL team (https://www.crnl.fr/fr/equipe/eduwell)

Internship supervisors:
Romain QUENTIN, Researcher, CRNL
Pauline Mouches, Postdoctoral researcher, CRNL
Carole Lartizien, CNRS Research director, CREATIS

Scientific context and Objectives

Brain neural activity recordings of epilepsy patients contain brief morphologically defined events between seizures, called interictal spikes. Their detection allows the localization of the brain region from which seizures originate[1]. However, they are often detected manually by clinicians, making it a time-consuming and error-prone task.

The data consists of 45 minutes recordings of brain activity of epileptic patients from 274 magnetometer sensors acquired with a CTF magnetoencephalography (MEG). Timing of the spikes were annotated by clinicians. In the current state of the project, the data is cropped into short time windows (200ms) and the problem consists of classifying each window as containing a spike or no.

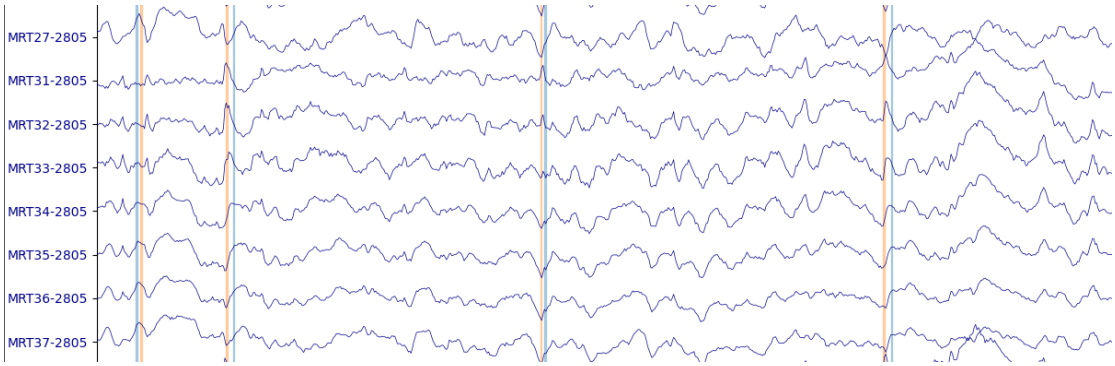

Figure 1: Example of magnetoencephalography data with epileptic spikes annotated, for one patient.

In this internship, we will explore methods for automated spike detection using transformers. Within the team, baseline models using convolutional neural networks and graph convolutional networks have

[1] Jung et al., « The value of magnetoencephalography for seizure-onset zone localization in magnetic resonance imaging-negative partial epilepsy ».

already been developed [2]. The internship project will focus on improving these baseline model performances.

Transformer model architectures are highly efficient on sequence data. Biosignals in general can be considered as univariate or multivariate time series, and thus treated as sequences. Transformers have been widely studied for biosignals analysis[3], with few attempts for seizure detection, which resembles our problem and could be adapted to our task[4].

The internship will consist in:

- Conducting a literature search for transformer models for interictal spikes detection,
- Identifying the most promising model architectures and adapting it to our data and task,
- Comparing results with our baseline models.

Main challenges encountered with the model will include designing the tokenization of the data and exploring model pre-training options as we have limited amount of fully annotated data. Main challenges encountered with the data will include working with imbalanced data and noisy labels. This internship will allow the intern to gain experience in deep learning and to conduct a project using medical data in collaboration with clinicians. Models will be implemented in Python using the Pytorch library.

Skills and work environment

Candidates should have a background either in machine learning and/or deep learning for image or signal analysis as well as good programming skills. Experience with deep learning libraries such as Pytorch would be appreciated but is not mandatory. We are looking for an enthusiastic and autonomous student with strong motivation and interest in multidisciplinary research (image processing and machine learning in a medical context).

This internship project is part of the ANR project SEIZURE staring in Dec 24 with the objective to extract the most informative biomarkers from mp-MRI, PET and MEG associated to clinical data and combine them into a single statistical model that will directly provide the localization of the epileptogenic zone to the clinicians. The proposed analysis framework will leverage the most advanced statistical machine learning methods for image and signal graph processing as well as fusion of heterogeneous data. SEIZURE is a highly transdisciplinary project and the candidate will have the opportunity to interact with clinicians and members of the CREATIS and ENS partners of the project. He will have access to a database of about 100 MEG recordings of epilepsy patients.

The candidate will be co-supervised by Pauline Mouches and Romain Quentin from CRNL as well as Carole Lartizien from CREATIS. The candidate will be based mainly at CRNL but may also come to CREATIS and take part in MYRIAD team scientific meetings to discuss AI methodological aspects.

Applications

Interested applicants are required to send a cover letter, CV and any other relevant documents (reference letter, recent transcripts of marks,…) to: romain.quentin@inserm.fr, pauline.mouches@inserm.fr and carole.lartizien@creatis.insa-lyon.fr

[2] Mouches et al. « Time CNN and Graph Convolution Network for Epileptic Spike Detection in MEG Data ».
[3] Anwar et al., « Transformers in biosignal analysis: A review ».
[4] Yang et al., « Biot: Biosignal transformer for cross-data learning in the wild ».