EEG Artifact Detection via Time series Segmentation (EAD)

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EAD — Content

1. Introduction
2. Overview of EEG recordings
3. Methods:
    a. TUAR Dataset
    b. Preprocessing
    c. SUMOv2 Model
    d. Metrics: F1-Score
4. Results
5. Discussion
6. Summary

EAD – Introduction

- Electroencephalography (EEG) is an **invaluable tool** in **medicine** and **research**.
- **EEG data** is highly **susceptible** to disturbances (**artifacts**).
- **Removing artifacts** enables **better diagnosis** and **sharper analysis**.

[1]

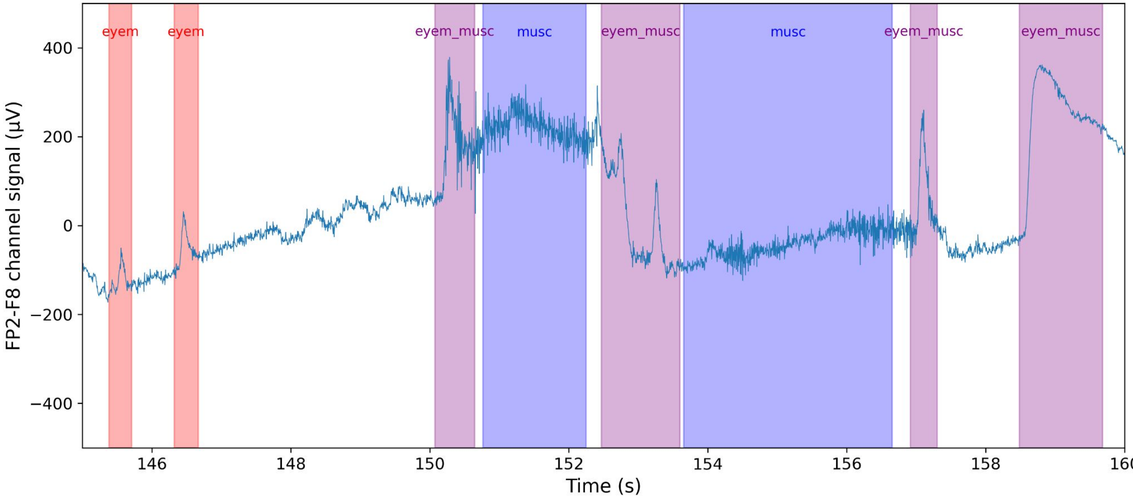
Image credits: yacobchuk on Getty Images. | **[1]:** Teplan M et al. Fundamentals of EEG measurement.

EAD – Overview of EEG recordings

Key technical characteristics of EEG recordings include:

- **Montage** used while recording (which **determines** the **channels**).
- Duration.
- Recording **frequency** (e.g. 250 Hz).

[1]



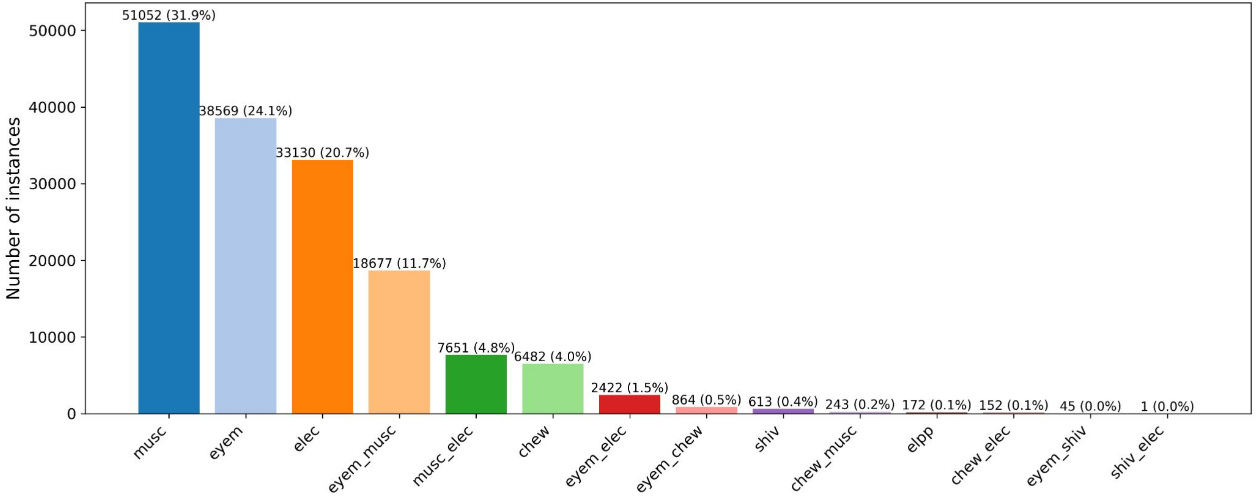
An example that showcases a snippet of EEG data with artifacts. Here, for clarity purposes, only a single channel, namely the FP2-F8 channel, is shown.

EAD – Methods – TUAR Dataset

Relevant information about the TUAR dataset:

- **310** EEG **recordings** (~**100 hours** total).
- **213 patients** (54% F., 46% M.).
- **160073 artifact** instances.
- **1901 hours** of **data** *.

[1]



The number of EEG artifacts in TUAR by kind (class)

Label	**musc**	**eyem**	**elec**	**chew**	**shiv**	**elpp**
Signif-icance	stands for and represents muscle movement	stands for and represents eye movement	represents all kinds of electrical related events	stands for and represents chewing	stands for and represents shivering	un-specified

The different artifact classes' labels and what they represent.
Compound labels signify both events happening at the same time.

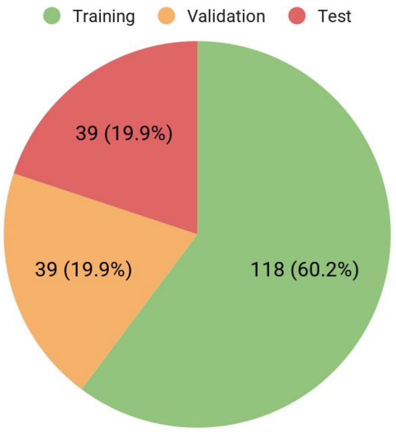
* 1901 hours of data after removing seizure recordings.

[1]: Hamid A et al. The Temple University Artifact Corpus: An Annotated Corpus of EEG Artifacts.

EAD – Methods – Preprocessing

The preprocessing steps that were taken:

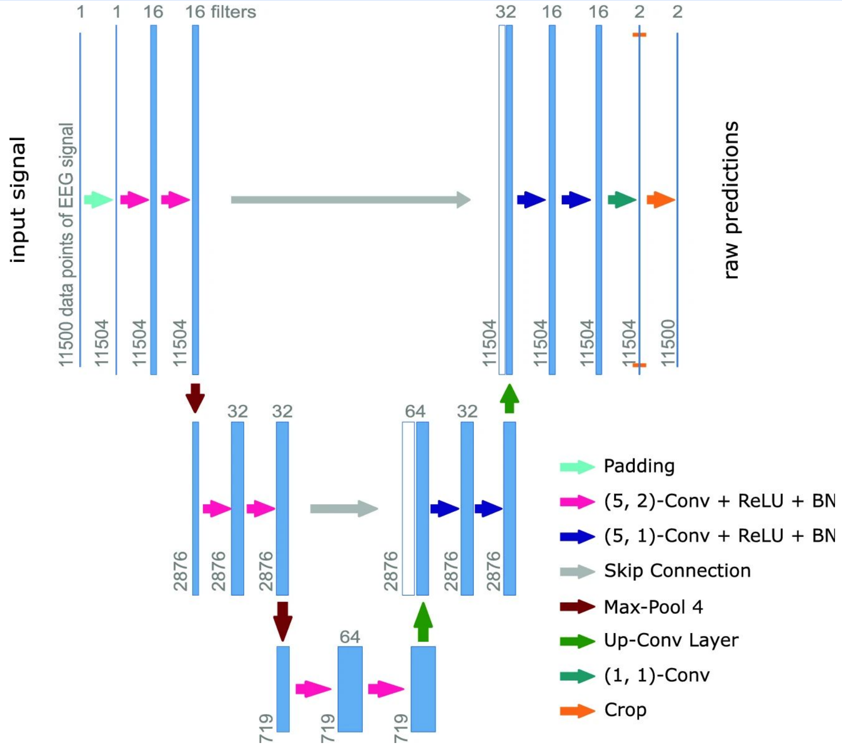
1. **Removing seizure** recordings. → ~~310~~ **268** EEG **recordings** from ~~213~~ **196 patients**
2. **Recomputing** the EEG data **in** the **TCP montage**.
3. **Splitting data** into training, validation, and test sets.
4. **Filtering** channels' **signals** with a 5th-order **Butterworth** band-pass filter (**0.5-80 Hz**)
5. Applying a **60 Hz Notch filter** (quality factor 15)
6. **Downsampling** signals to **170 Hz**.
7. **Clipping** values **outside** the **-500** to **500 µV** range.
8. **Segmenting** data into **10-second** segments.



Number of patients per split

EAD – Methods – SUMOv2 Model

We use **SUMOv2** [1], a **U-Net** [2] **based model** with two decoder and two encoder blocks.



SUMOv2 architecture. This architecture diagram has been copied from the original SUMO paper. More information and details about SUMO can be found in said paper too [3].

[1]: Grieger N, Mehrkanoon S *et al*. From Sleep Staging to Spindle Detection: Evaluating End-to-End Automated Sleep Analysis.
[2]: Ronneberger O, Fischer P, and Brox T. U-Net: Convolutional Networks for Biomedical Image Segmentation.
[3]: Kaulen L, Schwabedal JTC, Schneider J *et al*. Advanced sleep spindle identification with neural networks.

EAD – Methods – Metrics: F1-Score

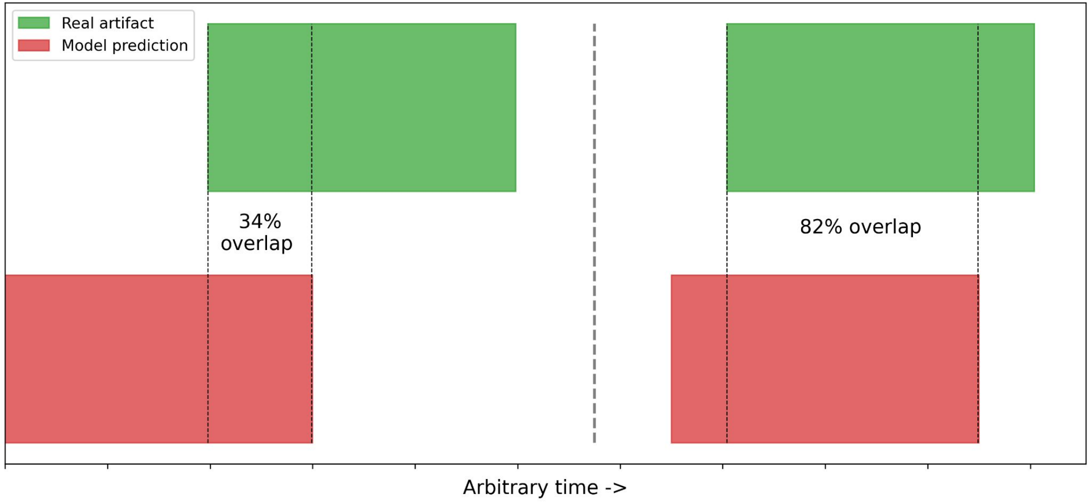
$$F1 = \frac{2 \times (\text{precision} \times \text{recall})}{\text{precision} + \text{recall}}$$

$$\text{precision} = \frac{TP}{TP + FP}$$

$$\text{recall} = \frac{TP}{TP + FN}$$

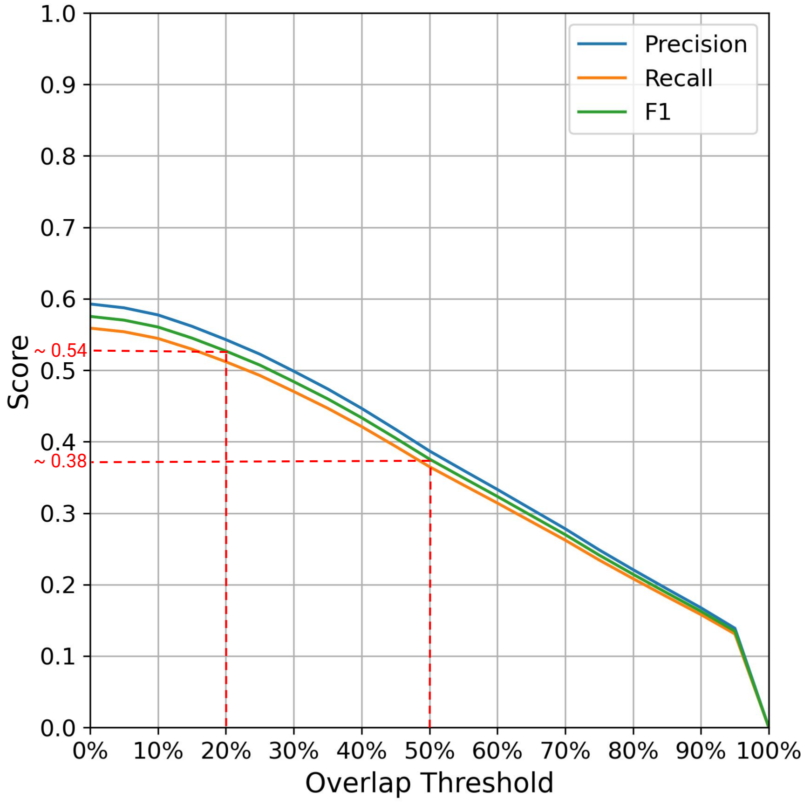
Where **TP**, **FP**, and **FN** stand for **True Positive**, **False Positive**, and **False Negative**, respectively.

[1]



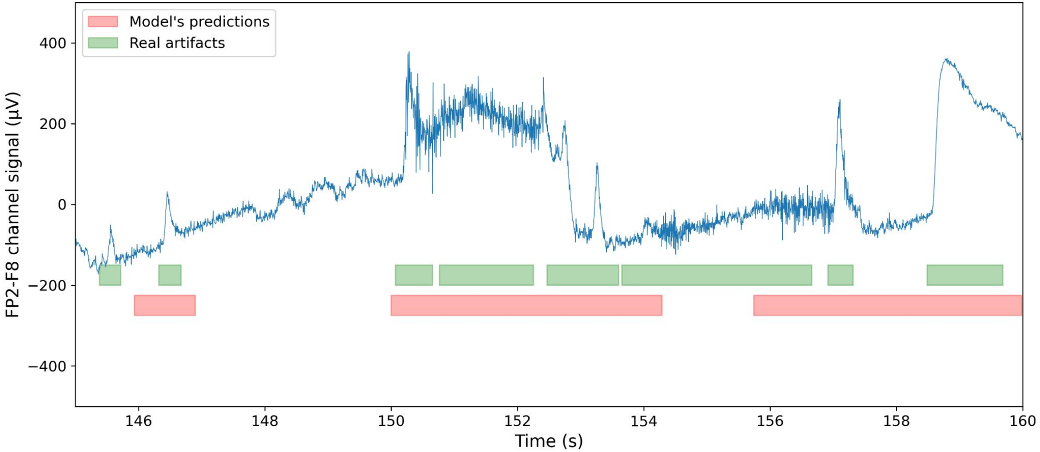
An illustrative example to help the explanation of the overlap threshold of TP, FP, and FN.

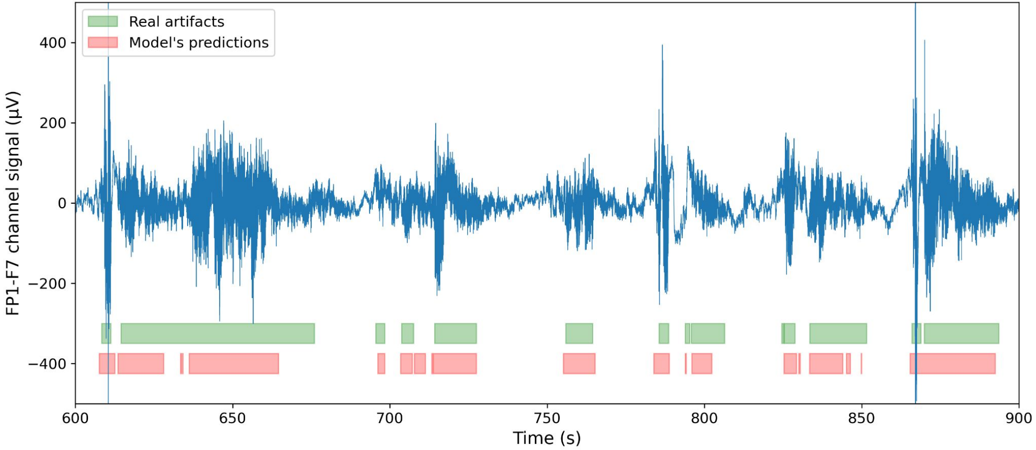
EAD – Results



The model's F1 score over different overlap thresholds

EAD – Results – Predictions examples

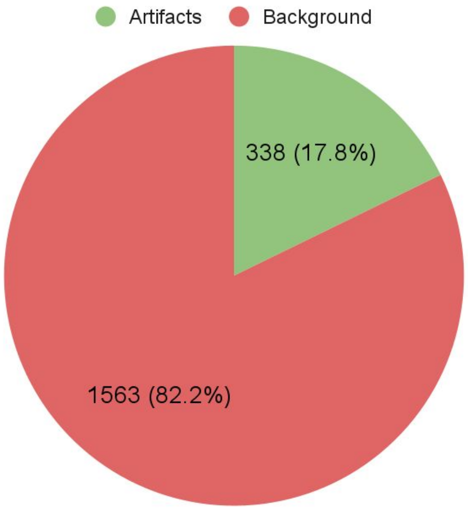




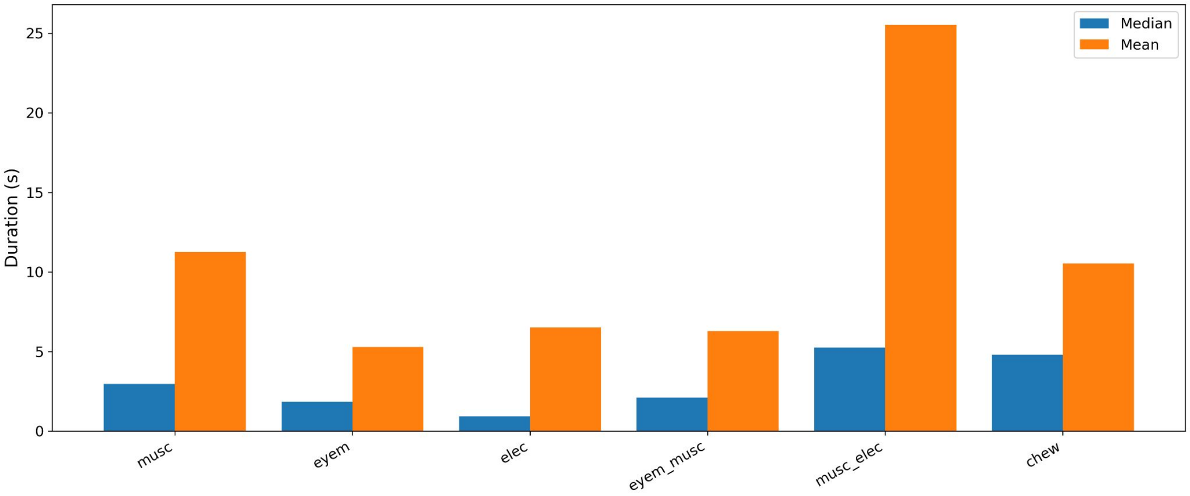
Two examples of the model's predictions of where the artifacts are

EAD – Discussion

Hypotheses that could explain the achieved results:



The amount of artifacts and background data in hours.
(After removing seizure recordings.)



The median vs. the mean of the duration of the 6 most common artifact classes

EAD – Summary

In this presentation, we covered:

- what **EEG recordings** are,
- relevant information about the **TUAR dataset**,
- the U-Net based model **SUMOv2** that we used,
- the **F1-Score** metric used for evaluation,
- the **results** we achieved,
- and, finally, potential reasons for the model's performance and ways in which the results could be improved.

Thank you for your attention!

Please feel free to ask any questions!