EEG and MEG Data Preprocessing

Oral presentation

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Introduction

EEG and MEG data are prone to a lot of different artefacts such as steps, ringing, slow drift and glitches.

The article we studied [CA18]. introduces methods to preprocess EEG and MEG data.

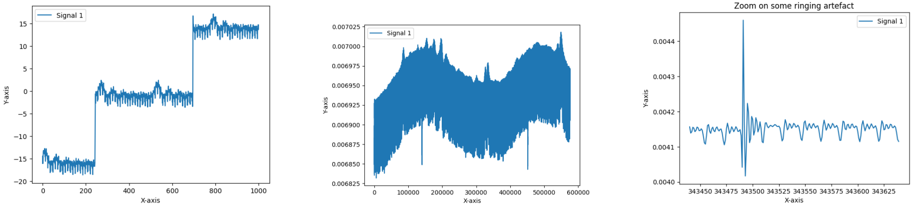

Figure: MEG steps on the left, trend on the middle and ringing on the right.

Alain de Cheveigné and Dorothée Arzounian. 'Robust detrending, rereferencing, outlier detection, and inpainting for multichannel data'. In: *NeuroImage* 172 (2018), pp. 903–912. ISSN: 1053-8119. DOI: https://doi.org/10.1016/j.neuroimage.2018.01.035. URL: http://www.sciencedirect.com/science/article/pii/S1053811918300351.

Contributions

Existing implementation : matlab. Not used (because matlab...).
Releasing code only in matlab is bad for reproducible science and should not be considered as a proper release.

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New implementation : python.

Work repartition:

- Esteban implemented painting, outlier detection and ringing removal.
- Alexi implemented detrending, rereferencing, step removal.
- The data has been gathered and exploited as a combined efforts.
- The same goes for the experiments.
- This report has been written by both students with an equal repartition.

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Robust detrending

Usual detrending methods are sensible to artefacts.

$\Longrightarrow$ Robust detrending: estimate the trend ignoring outliers, and flag high errors as outliers for the next iteration

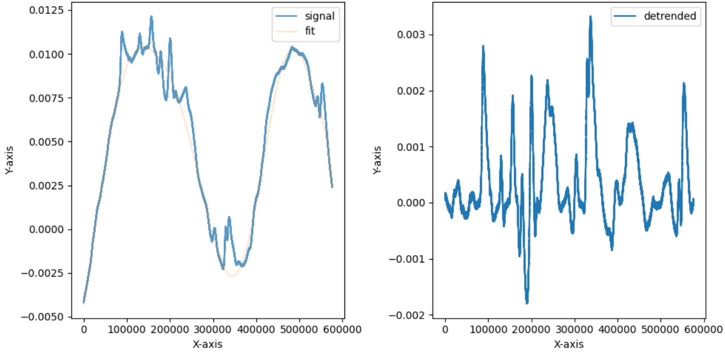

Figure: Application of the detrending algorithm.

Inpainting

Inpainting is the process of reconstructing the signal at timesteps affected by glitches. Here, we assume that glitches locations are known.

This algorithm first estimates the linear relationship between channels and use it to reconstruct the signal.

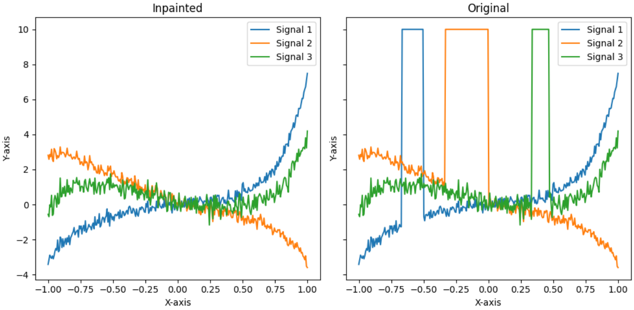

Figure: Application of the inpainting algorithm.

Outlier detection

To flag outliers, we use the previous algorithm and flag poorly reconstructed values as outliers for the next iteration.

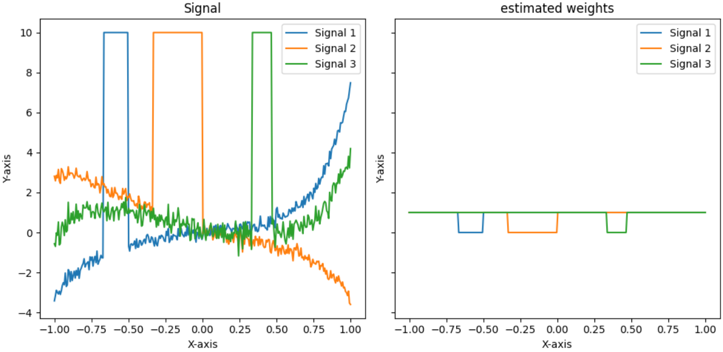

Figure: Application of the outlier detection algorithm.

Robust rereferencing

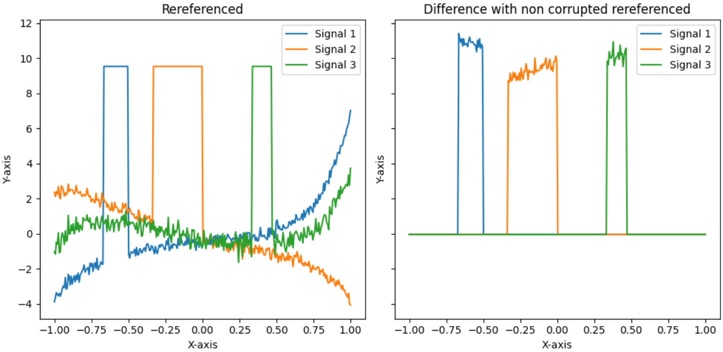

Figure: Application of the robust rereferencing algorithm.

Step removal

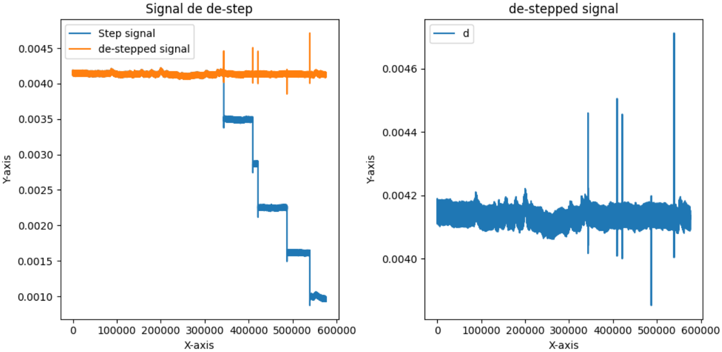

Figure: Application of the step removal algorithm.

Ringing removal

Ringing artefacts are caused by the antialiasing filter. First, we estimate the parameters of this filter to model its impulse response and cancel it, which removes ringing artefacts.

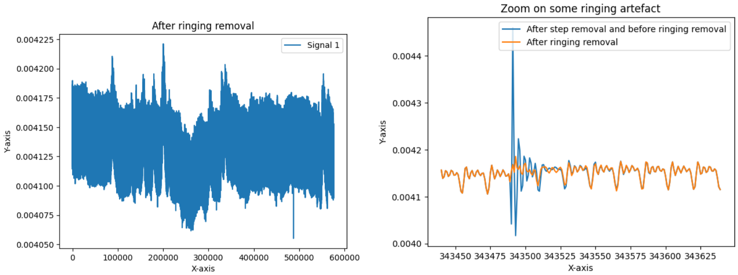

Figure: Left: A full signal. Right: zoom on an artefact

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Data

MEG Data we used : Litvak [Lit16]
Recordings of the data : Oswal et al. [Osw+16]
4 min long MEG recording at 2400Hz with 303 channels
$\implies 174'528'000$ samples

We used only 16 channels because we have limited compute capabilities.

Vladimir Litvak. 'Magnetoencephalography (MEG) recordings from a phantom with Deep Brain Stimulation (DBS) artefacts'. In: (Oct. 2016). DOI: 10.6084/m9.figshare.4042911.v3. URL: https://figshare.com/articles/dataset/phantom090715_BrainampDBS_20150709_01_ds_zip/4042911.

Ashwini Oswal et al. 'Analysis of simultaneous MEG and intracranial LFP recordings during Deep Brain Stimulation: a protocol and experimental validation'. In: *Journal of neuroscience methods* 261 (2016), pp. 29–46.

A complete pipeline for preprocessing

Remove steps → Remove ringing artefacts → Robust detrend → Detect outliers → Inpainting → Robust rereference.

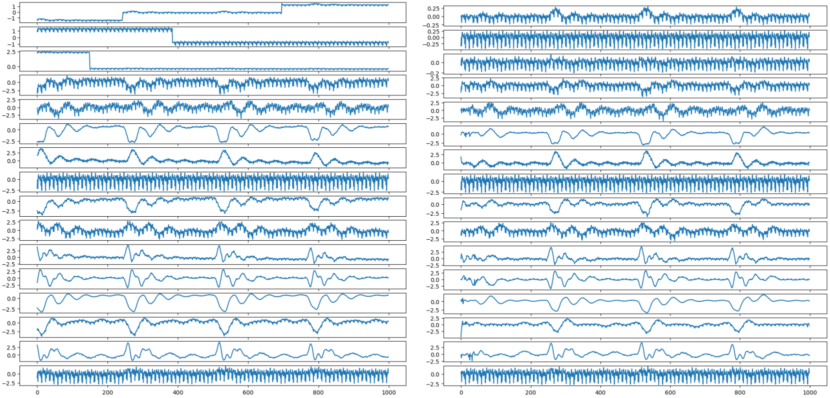

Figure: Left: Raw MEG data. Right: Cleaned MEG data

Results

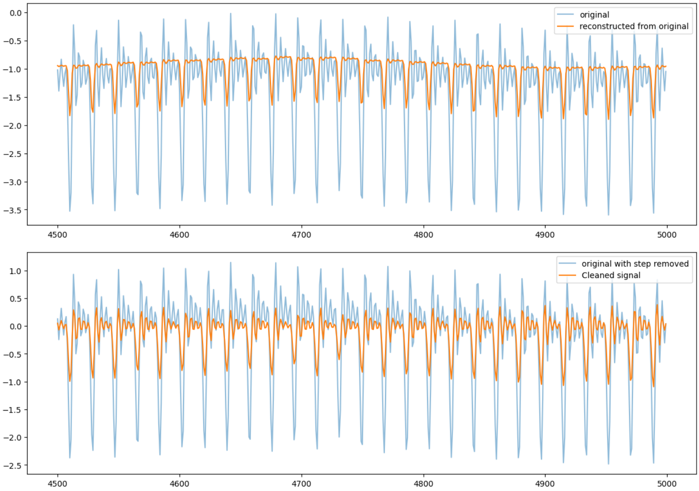

Figure: Top: Raw MEG and its reconstruction. Bottom: Cleaned MEG with its reconstruction

References I

[CA18] Alain de Cheveigné and Dorothée Arzounian. 'Robust detrending, rereferencing, outlier detection, and inpainting for multichannel data'. In: *NeuroImage* 172 (2018), pp. 903–912. ISSN: 1053-8119. DOI: https://doi.org/10.1016/j.neuroimage.2018.01.035. URL: http://www.sciencedirect.com/science/article/pii/S1053811918300351.

[Lit16] Vladimir Litvak. 'Magnetoencephalography (MEG) recordings from a phantom with Deep Brain Stimulation (DBS) artefacts'. In: (Oct. 2016). DOI: 10.6084/m9.figshare.4042911.v3. URL: https://figshare.com/articles/dataset/phantom090715_BrainampDBS_20150709_01_ds_zip/4042911.

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