

MEA Analysis Toolbox

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OF NEUROSCIENCE
International Max Planck Research School

Task

- ▶ Task: Detect peaks, seizure-like bursts & characterize them. Provide GUI.
- ▶ Constraints:
 - ▶ many channels
 - ▶ high sampling rate
 - ▶ high heterogeneity (slices)
- ▶ Existing toolboxes are
 - ▶ proprietary or vendor specific
 - ▶ quality-wise insufficient

What's there

So far...

What is there so far

- ▶ was developed in ≈ 10 weeks,
- ▶ without recording a single slice myself,
- ▶ without analyzing more than 1-2 samples myself,
- ▶ without having extensive knowledge about the setup.

⇒ that's exactly what will follow in the next 6 months.

MEA Analysis Toolbox I

Semi-automated data analysis pipeline with UI.
Currently supports MultiChannel Systems 256 electrode MEA

Condition Input File Path:

Baseline Input File Path:

File type: ☒ Multi Channel Systems

File path: /run/media/someusername/94C2FEC8C2FEA620/DataSets/scn1a-mea/2022-10-27T15-12-09S2_Epileptoform.h5

Date	Program	Version	Comment	MEA System Name	MEA Layout
2022-10-27 15:12:09	Multi Channel Analyzer	2.16.0.20205		256MEA	MEA_256MEA_MEA2100_252_6

Type	Stream	# ch
Analog	Data Acquisition (1) Electrode Raw Data1	252

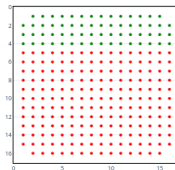
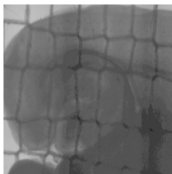
MEA Analysis Toolbox II

Graphical selection of electrodes and time window

Select the desired electrodes and time frame

Select Image File:

/home/someusername/sync/workspace/nb_tue/3/1_lerche/data/Fused_full contr_gamma_adj_bright.tif



Show selected raw signals

Specify a time range for analysis (s:ms:μs):

0:000:000

39:999:999.9999999925404

Apply electrode and time window selection

MEA Analysis Toolbox III

Preprocessing: electrical humming, bandpass, bandstop, downsampling

Remove Electrical Humming:

Apply

Bandpass Filter

Lower Cut-off Frequency

Upper Cut-off Frequency

☐ Butterworth
☐ Chebyshev

Apply

Bandstop Filter

Lower Cut-off Frequency

Upper Cut-off Frequency

☐ Butterworth
☐ Chebyshev

Apply

Downsampling:

New sampling rate

Apply

Next

MEA Analysis Toolbox IV

Exploration & Analysis:

Available Analysis Sections:

Electrode Amplitude Animation

Start time (xmin:mxm)

Stop time (xmin:mxm)

Playback Speed in FPS

Slow down from real time

Generate Video (takes some minutes)

PSD

Periodic Aperiodic PSD decomposition

Spectrogram

Detect peaks by absolute Amplitude

Baseline std of same electrode factor:

2.5

Baseline std of all electrodes factor:

0.5

Start

Detect event by moving deviation measures

Baseline std of moving std or MAD of same electrode factor:

☒ Moving Std

☐ Moving MAD

1

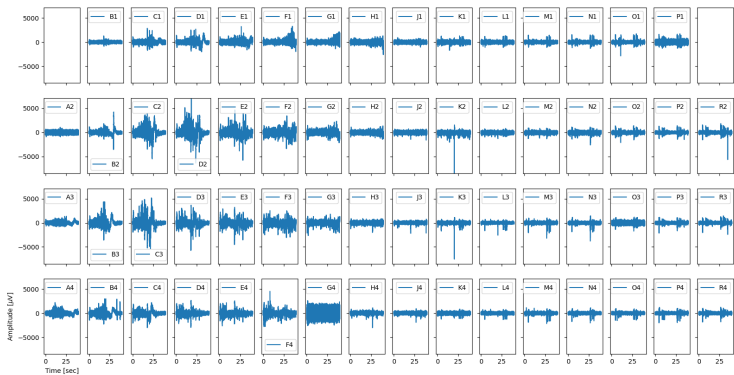
☐ Export

Enter full file path for file to exp

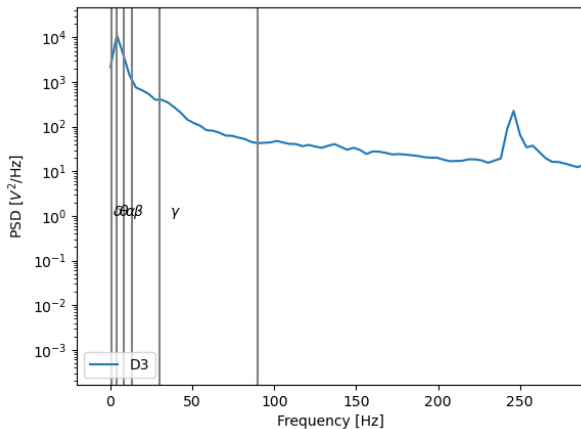
Start

MEA Analysis Toolbox V

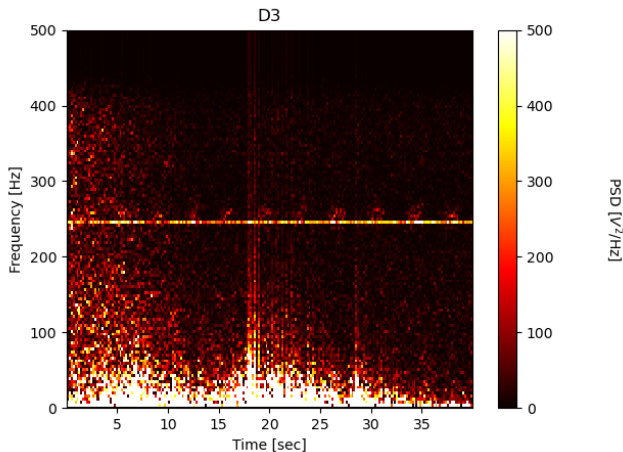
Exploration: raw signals, absolute amplitude animation, PSD, spectrogram



MEA Analysis Toolbox VI

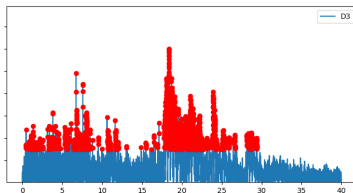
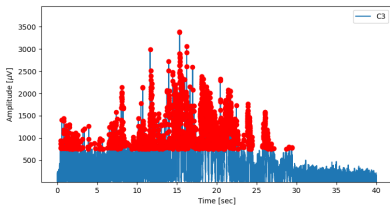
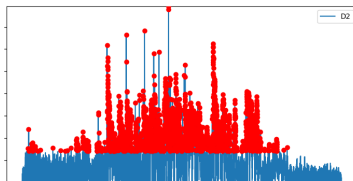
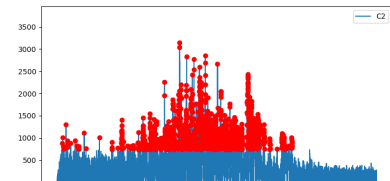


MEA Analysis Toolbox VII

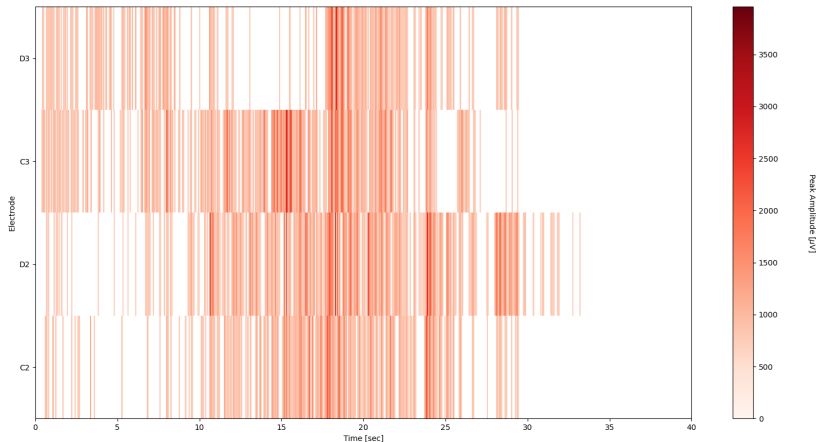


MEA Analysis Toolbox VIII

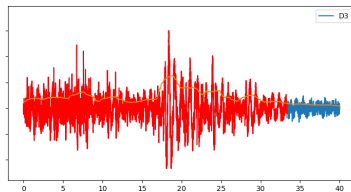
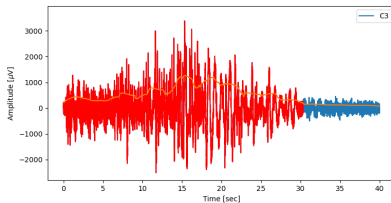
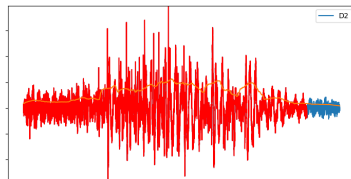
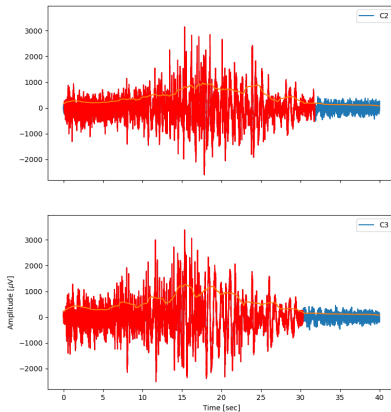
Analysis: Peak detection by threshold based STD per channel, burst detection based on moving STD or moving mean absolute deviation



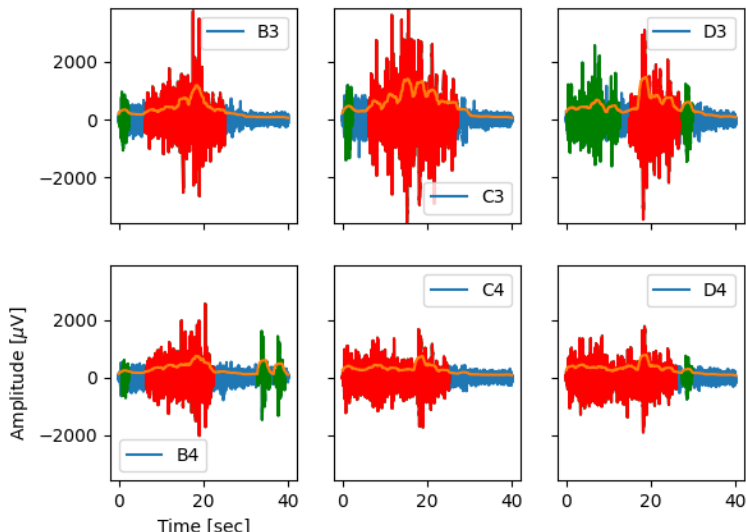
MEA Analysis Toolbox IX



MEA Analysis Toolbox X



MEA Analysis Toolbox XI



The next 6 months (and further)

Computing

- ▶ batch processing (multiple files/recordings)
- ▶ server deployment
- ▶ parallelization
- ▶ Qt-based GUI?

Setup

- ▶ HD/CMOS MEA support
- ▶ setup micrograph co-registration
- ▶ if \nexists : protocol & documentation for measurements

Preprocessing

- ▶ Bad channel detection based on SNR, impedances
- ▶ (re-) referencing
- ▶ between group alignment
- ▶ artifact removal using ICA
- ▶ epoching
- ▶ detrending

Visualization

- ▶ per band power animation
- ▶ between group comparisons
- ▶ spatial and temporal visualization of analysis

Analysis I

- ▶ Per electrode:
 - ▶ improve peak detection
 - ▶ improve burst detection
 - ▶ FOOOF: periodic & aperiodic component separation
 - ▶ waveform/event sorting, further features
 - ▶ waveform & spike analysis combined
 - ▶ spectral (and other kinds of) entropy/complexity measures

Analysis II

- ▶ Between electrodes:
 - ▶ current source densities
 - ▶ transfer entropy/granger causality
 - ▶ coherence/"connectivity"
 - ▶ correlation
 - ▶ phase-amplitude coupling
 - ▶ spontaneous activity

Analysis III

- ▶ Within subject: coregistration with atlases
⇒ structure-specific comparison
- ▶ Between subjects: aggregation to group
- ▶ Group analysis: t-tests, automated listing of significant p-values for the above

Famous last words

References

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