

# Facilitating the Annotation of Seizure Events Through An Extensible Visualization Tool<sup>1</sup>

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An electroencephalogram (EEG) is a multi-channel signal which describes the electrical activity in the brain via voltages measured in a variety of locations on the scalp. EEG recordings can be interpreted using montages, which redefine channels as the difference of channel voltages. EEG recordings are most commonly stored as raw signals in the European Data Format (EDF). Existing EEG visualization tools, such as EDF Browser [1] and EEGLab [2], do not allow users to annotate directly over their signal displays. Furthermore, it is not possible to easily add new visualizations to these tools. Our tool displays annotations in a time-aligned format, and allows the direct creation and manipulation of these annotations. We provide an extensible framework that allows for the creation of new visualizations or analytics based on user needs. In addition to the conventional multi-waveform viewing capability to which neurologists are accustomed, we provide a spectrogram and/or energy visualizations. These visualizations are becoming increasingly popular with clinicians as an efficient way to review continuous EEGs [3] (cEEG). In this presentation, we will introduce a software tool that facilitates annotation of EEG signals.

The user can create, select, and operate on sets of annotations via an interface which pairs click and drag interaction with context menus for selection of annotation type or preferred action. The annotations themselves will “snap to boundary” in a manner similar to digital audio workstations such as Audacity – boundaries are adjustable but overlap is prevented. This interface facilitates the annotation process through simplicity and efficiency, while ensuring the accuracy and precision of the user’s actions.

Our viewer includes a configurable filter, allowing the user to view the EEG signal with various ranges of frequencies removed. A typical usage of this filter is to low-pass the signal and reject both DC offset and 60 Hz hum. The filter also includes several bandpass presets that reject all but a range of frequencies (i.e. the frequencies associated with theta or alpha waves).

Annotators also make use of a feature which allows for per-channel setting of gain. This kind of manual adjustment is useful when a channel, such as the Electrocardiogram (EKG) channel, has a gain disproportionate to that of the other channels. The signal can also be “played”, meaning that it automatically scrolls through the signal until a user finds a region of interest to annotate.

The viewer also integrates a search API for querying the TUH EEG Corpus [4]. The results returned by the API offer clinical reports, along with corresponding EEG data. We allow for the user to visualize this data with the same features as previously described. This search API is part of a new capability, called cohort retrieval [5] that allows users to do multimodal queries on EEG records. The system integrates knowledge extracted from the unstructured EEG reports with EEG signal events automatically extracted from the signal. The system returns a list of the top ranked reports and lets users easily reviews reports and EEG signals in the same framework that the display tool uses.

Many of the features described are customizable via an integrated preferences window. This allows the customization of virtually all aspects of the available analytics. These parameters can be saved to a file for later use. For example, the montage used to interpret EDF files can be adjusted from within the program. This is a critical capability because channel labels vary from site to site, and users must be able to adapt to each site’s naming conventions to the preferred visualization (e.g., defining a TCP montage).

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Since this viewer is written in Python, it is easy to integrate with other software. It is developed with PyQt, a set of Python wrappers to the Qt GUI framework, making it cross-platform software capable of running on almost any OS. We currently use it on OSX, Windows, and Linux.

#### REFERENCES

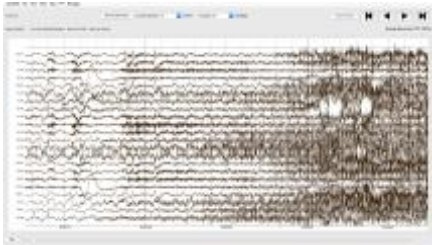
- [1] Beelen, T. van. (2013). EDFbrowser. Retrieved from <http://www.teuniz.net/edfbrowser/>.
- [2] Delorme, A., & Makeig, S. (2002). EEGLab. Retrieved from <https://scn.ucsd.edu/wiki/EEGLAB>.
- [3] Ney, J. P., van der Goes, D. N., Nuwer, M. R., & Nelson, L. (2016). Continuous and routine EEG in intensive care: utilization and outcomes, United States 2005-2009. *Neurology*, *81*(23), 2002–2008.
- [4] Obeid, I., & Picone, J. (2016). The Temple University Hospital EEG Data Corpus. *Frontiers in Neuroscience, Section Neural Technology*, *10*, 196.
- [5] Obeid, I., Picone, J., & Harabagiu, S. (2016). Automatic Discovery and Processing of EEG Cohorts from Clinical Records. In *Big Data to Knowledge All Hands Grantee Meeting* (p. 1). Bethesda, Maryland, USA: National Institutes of Health (available at: [https://www.isip.piconepress.com/publications/conference\\_presentations/2016/nih\\_bd2k/cohort](https://www.isip.piconepress.com/publications/conference_presentations/2016/nih_bd2k/cohort)).

## Abstract

- An electroencephalogram (EEG) is a multi-channel signal which describes the electrical activity in the brain through electrodes placed on the scalp.
- Other EEG visualization tools do not allow users to annotate directly over their signal displays. Similarly, it is difficult to add new visualizations to these tools.
- This visualization tool allows users to create annotations through the interaction of context menus and click and drag actions.
- A search API has been integrated to this viewer. Users can query the TUH EEG Corpus for reports and EEG signals.
- The features within the viewer are customizable through a preferences window, allowing users to save settings based on their annotation and visualization needs.
- This visualization tool is written in PyQt, which allows for Graphical User Interface programming that is supported across multiple platforms.

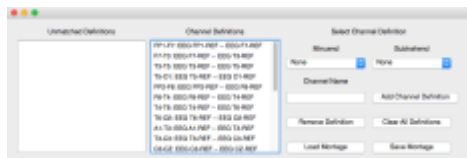
## Overview of the Visualization Software

- The viewer loads EEG signals in a European Data Format (EDF), and provides a user interface to view and manipulate the signal.



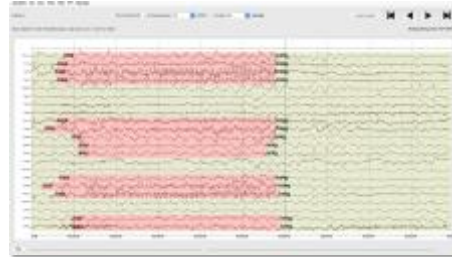
## Clinical EEG Data

- EEG signals are stored as sampled data signals in an EDF format.
- To reduce the noise and enhance certain features of the signal, a montage is applied.
- A montage is used to redefine channels as the difference of channel voltages. This kind of differential analysis reduces noise.
- A TCP montage is most commonly used. However the tool offers a user interface to customize and create any montage to match the given EDF file.



## Facilitating EEG Annotation

- The visualization tool provides an interface to view, create, and edit annotations directly over the EEG signal.
- Annotations are colored overlays containing a label defining the event type. These events include various seizures, artifacts, and other markings used for our research.
- An annotation is created independently of the other channels, allowing for the precise annotating of boundaries and event types.



- The tool utilizes annotation navigation buttons to easily scroll through the EEG to find regions of interest.
- Creating annotations is accomplished through selecting channels and the annotation label via a windowed interface.



## Increasing Visibility

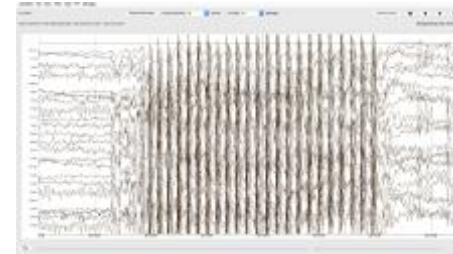
- The ability to change the timescale of the plotting window from the traditional 10 seconds allows for users to more easily visualize and annotate events on a single window.
- Channels suffering from heavy lead artifact or containing electrocardiogram (EKG) signals often clutter the plotting visualization. A per-channel gain setting is utilized to increase the visibility of events during such cases.
- A customizable filter is also integrated into signal plotting, allowing the user to remove various frequency ranges and bands. This filter includes various bandpass presets to, for example, only show frequencies in the alpha or theta bands. A common use of this filter is to apply a band-reject filter to remove the 60Hz hum from the EEG signal.

## Alternate Visualizations

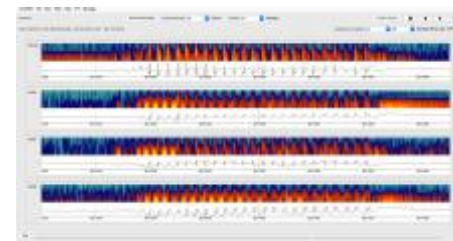
- The visualization tool currently supports three visualizations: Waveform (default), Spectrogram, and Energy.
- The Waveform view is the format through which professional neurologists traditionally prefer to view EEG data.
- The Spectrogram view is a graphical plot of the frequency content of the EEG signal as a function of time. The data is plotted with time on the horizontal axis, frequency on the vertical axis, and color used to indicate the intensity of the frequency.
- The Energy view calculates the energy of the signal over time, and plots the data on a logarithmic or linear scaled axis.

## Sample Visualizations

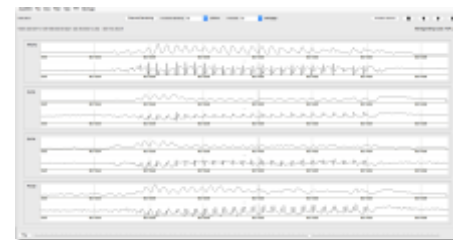
- Waveform Only:



- Waveform/Spectrogram Combined:



- Waveform/Energy Combined:



- Above is an absence seizure event, shown through each visualization supported by the software. Each visualization can be uniquely utilized to extract information from an EEG event.

## Cohort Retrieval

- A cohort retrieval system allows users to find EEGs similar to the EEG being viewed.
- Keyword search and natural language interfaces are supported (e.g., "show me all the EEGs that have...").
- The search API queries the TUH EEG Database, and returns EEG reports matching the search query.
- Cohort Retrieval integrates knowledge from the unstructured EEG reports with EEG events automatically extracted from the signal.
- The cohort retrieval system returns a list of top ranked reports and EEG signals based on the query.



- This interface establishes the ability to view multiple windows of EEG signals, along with their respective medical reports.
- Each new plotting window contains all functionality provided in the framework that the original visualization tool utilizes.

## Summary

- This visualization tool facilitates EEG annotation through a simple and efficient user interface.
- The viewer has multiple visualization options, allowing users to analyze EEG events in manners outside the traditional waveform visualization.
- It has been programmed in a fashion such that new features and visualizations can easily be integrated in the existing framework.
- All features and options contained within the tool are customizable through an integrated preferences window.
- Since the tool is written in PyQt, it runs on any platform that supports Python.

## Acknowledgements

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