

Software and Data Resources to Advance Machine Learning Research in Electroencephalography

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The Neural Engineering Data Consortium at Temple University has been providing key data resources to support the development of deep learning technology for electroencephalography (EEG) applications [1-4] since 2012. We currently have over 1,700 subscribers to our resources and have been providing data, software and documentation from our web site [5] since 2012. In this poster, we introduce additions to our resources that have been developed within the past year to facilitate software development and big data machine learning research.

Major resources released in 2019 include:

- **Data:** The most current release of our open source EEG data is v1.2.0 of TUH EEG and includes the addition of 3,874 sessions and 1,960 patients from mid-2015 through 2016.
- **Software:** We have recently released a package, PyStream, that demonstrates how to correctly read an EDF file and access samples of the signal. This software demonstrates how to properly decode channels based on their labels and how to implement montages. Most existing open source packages to read EDF files do not directly address the problem of channel labels [6].
- **Documentation:** We have released two documents that describe our file formats and data representations: (1) *electrodes and channels* [6]: describes how to map channel labels to physical locations of the electrodes, and includes a description of every channel label appearing in the corpus; (2) *annotation standards* [7]: describes our annotation file format and how to decode the data structures used to represent the annotations.

Additional significant updates to our resources include:

- *NEDC TUH EEG Seizure (v1.6.0)*: This release includes the expansion of the training dataset from 4,597 files to 4,702. Calibration sequences have been manually annotated and added to our existing documentation. Numerous corrections were made to existing annotations based on user feedback.
- *IBM TUSZ Pre-Processed Data (v1.0.0)*: A preprocessed version of the TUH Seizure Detection Corpus using two methods [8], both of which use an FFT sliding window approach (STFT). In the first method, FFT log magnitudes are used. In the second method, the FFT values are normalized across frequency buckets and correlation coefficients are calculated. The eigenvalues are calculated from this correlation matrix. The eigenvalues and correlation matrix's upper triangle are used to generate feature.
- *NEDC TUH EEG Artifact Corpus (v1.0.0)*: This corpus was developed to support modeling of non-seizure signals for problems such as seizure detection. We have been using the data to build better background models. Five artifact events have been labeled: (1) eye movements (EYEM), (2) chewing (CHEW), (3) shivering (SHIV), (4) electrode pop, electrostatic artifacts, and lead artifacts (ELPP), and (5) muscle artifacts (MUSC). The data is cross-referenced to TUH EEG v1.1.0 so you can match patient numbers, sessions, etc.
- *NEDC Eval EEG (v1.3.0)*: In this release of our standardized scoring software, the False Positive Rate (FPR) definition of the Time-Aligned Event Scoring (TAES) metric has been updated [9]. The standard definition is the number of false positives divided by the number of false positives plus the number of true negatives: $\#FP / (\#FP + \#TN)$.

We also recently introduced the ability to download our data from an anonymous rsync server. The rsync command [10] effectively synchronizes both a remote directory and a local directory and copies the selected folder from the server to the desktop. It is available as part of most, if not all, Linux and Mac distributions (unfortunately, there is not an acceptable port of this command for Windows). To use the rsync command to download the content from our website, both a username and password are needed. An automated registration process on our website grants both. An example of a typical rsync command to access our data on our website is:

```
rsync -auxv nedc_tuh_eeg@www.isip.piconepress.com:~/data/tuh_eeg/
```

Rsync is a more robust option for downloading data. We have also experimented with Google Drive and Dropbox, but these types of technology are not suitable for such large amounts of data.

All of the resources described in this poster are open source and freely available at https://www.isip.piconepress.com/projects/tuh_eeg/downloads/. We will demonstrate how to access and utilize these resources during the poster presentation and collect community feedback on the most needed additions to enable significant advances in machine learning performance.

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Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the official views of any of these organizations.

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Abstract

- Created in 2012, the Temple University Hospital Electroencephalography Corpus (TUEG) is the world's largest open source EEG corpus.
- There are several important subsets of this corpus that were developed and updated this year:
 - TUH EEG Seizure Corpus (TUSZ): expanded to include a total of 739 patients and 1,620 sessions. There are 1,464 files with at least one seizure event and 3,366 seizure events. A blind evaluation set was also developed to support upcoming open source evaluations.
 - TUH EEG Artifact Corpus: used to develop enhanced background models. Five types of artifacts were annotated.
- Several software tools were released to support research and facilitate data distribution:
 - NEDC PyStream: a self-contained Python script that demonstrates how to read and properly decode channels in an EEG signal using the provided channel labels.
 - NEDC Eval EEG: a Python-based scoring package that uses five popular scoring metrics (e.g., Time-Aligned Event Scoring).
 - Anonymous Rsync: a new method for distribution based on the popular tool rsync. Makes incremental download of the data relatively simple.

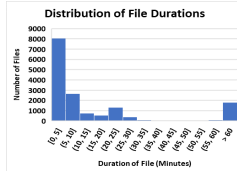
TUH EEG Corpus (TUEG: v1.2.0)

- Increased the size of the corpus:

Item	TUEG (v1.1.0)	TUEG (v1.2.0)	TOTAL
No. Patients	13,539	1,940	15,479
No. Sessions	23,002	3,844	26,846
Avg. Sess/Pat.	1.54	1.98	1.60
No. Files	56,506	15,917	69,423
Hours of Data	15,757	11,295	27,052
Size of Data	0.964T	0.692T	1.656T

- This new data came from mid-2015 through 2016 and consists of patients who, on the average, were monitored for a longer period of time. This manifests itself by a larger number of sessions per patient.

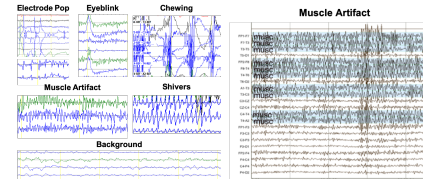
- Our database consists of pruned EEGs – a process where technicians discard uninteresting portions of the EEG signal. This saves a significant amount of disk space.



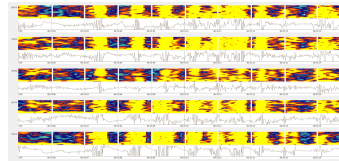
- A majority of the routine sessions are split into files shorter than 30 minutes in duration due to the pruning process.
- However, the long-term monitoring (LTM) files are greater than one hour in duration.

TUH EEG Artifact Corpus (TUEV: 1.0.1)

- This corpus was developed to support modeling of non-seizure events.
- Five artifacts labeled:
 - CHEW: chewing
 - EYEM: eye movements
 - ELPP: electrode pop/electrostatic artifact/ lead artifacts
 - MUSC: muscle artifacts
 - SHIV: shivering
- The data has also been cross-referenced with TUEG.
- Typical examples of artifacts:

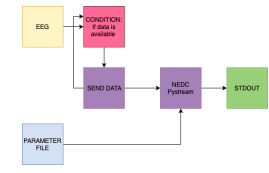


- Artifacts such as chewing resemble features of tonic-clonic and complex-partial seizures.



NEDC PyStream (v1.0.0)

- A self-contained EDF streaming service. It is written in Python using PyEDFlib for portability.
- Demonstrates how an EDF file is correctly read by identifying channels by their associated labels.
- Since channels can occur in any order in an EDF file, correct interpretation of the data requires indexing the channels by their labels.

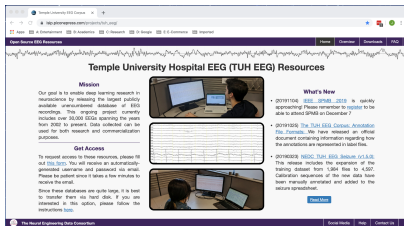


Anonymous Rsync Downloads

- The rsync command effectively synchronizes both a remote directory and a local directory and copies the selected folder from the server to the desktop.
- To use the rsync command, both a username and password are needed. An automated registration process on our website provides access.
- An example of a typical rsync command to access our data on our website would be:
rsync -aux nedc_tuh_eeg@www.isip.piconepress.com:~/data/tuh_eeg/.
- This command is available to both Linux and Mac users. Windows users can use the new Linux Bash shell that is available from Microsoft.

Introduction

- NEDC's historical archive of EEG includes every EEG collected at Temple University Hospital (TUH) since 2012:
www.isip.piconepress.com/projects/tuh_eeg



- This corpus now includes over 2,339 active subscribers and has been updated regularly annually since 2012.
- Documentation about the corpus has been expanded to include:

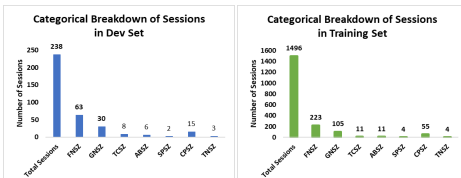
- Electrodes:** explains the how the data was collected (e.g., physical location of the electrodes), visualized (e.g., montages) and stored in EDF files (e.g., channel labels).
- Annotations:** describes the formats used to store annotation information and the way seizure events are classified.

TUH EEG Seizure Corpus (TUSZ: v1.6.0)

- This is a subset of TUH EEG (TUSZ) developed for automatic seizure detection.

Item	TUSZ (v1.5.0)	New Data	TUSZ (v1.6.0)
No. Patients	642	133	775
No. Sessions	1,423	199	1,622
Avg. Sess/Pat.	2.00	1.50	1.92
No. Files	5,610	311	5,921
Hours of Data	923	71	994
No. Seizure Events	1,153	96	1,249

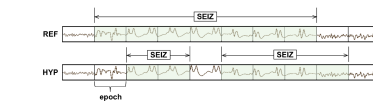
- Each file has been manually annotated by multiple annotators and validated with a variety of machine learning experiments. Inter-rater agreement is high.
- Comparisons with neurologist performance has been impressive – our UG team consistently performs well above neurologist performance.
- Calibration sequences have been manually annotated and added to the seizure spreadsheet.



NEDC Eval EEG (v1.3.0)

- This is a standardized Python-based scoring package that provides useful diagnostic information.
- Five different scoring methods are supported:
 - DPALIGN: dynamic programming-based sequence alignment
 - EPOCH: epoch-based sampling
 - OVLP: assessment of the degree of overlap
 - TAES: time-aligned event scoring
 - IRA: inter-rater agreement
- Standard metrics such as sensitivity, specificity and false alarms are reports for all methods.
- DPALIGN is based on a well-known speech recognition package distributed by NIST.
- OVLP is very popular within the seizure detection community but is misleading.

EPOCH: measure similarity using a temporal sampling approach



TAES: Weight the amount of overlap between the two alignments



Summary

- These corpora and supporting tools are open source and freely available at https://www.isip.piconepress.com/projects/tuh_eeg.
- Future release plans include:

Database	Version	Description	Expected Date
TUEG	V1.3.0	The addition of the sessions from 2017-2019.	January 2020
TUSZ	v1.7.0	The addition of annotated seizure files from 2017- mid 2019.	January 2020
TUEG	v2.0.0	A cumulative release of all sessions and corresponding reports to date	March 2020

- For further information, contact help@nedcdata.org.

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