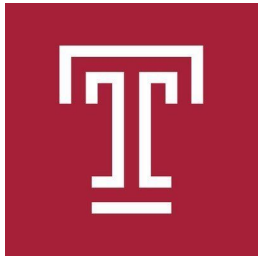

TABS: Transformer Based Seizure Detection

IEEE SPMB 2020

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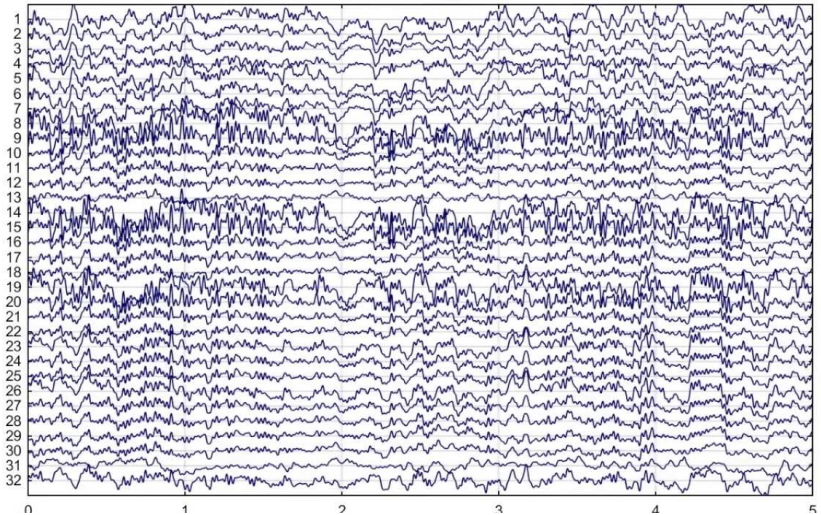
Background

- EEGs are the primary means by which physicians diagnose brain-related illnesses such as epilepsy and seizures
- Before Temple's large EEG corpus, Deep Learning required too much data to be applicable
- Current Machine Learning models suffer from unacceptable false positive rates due to the low SNR

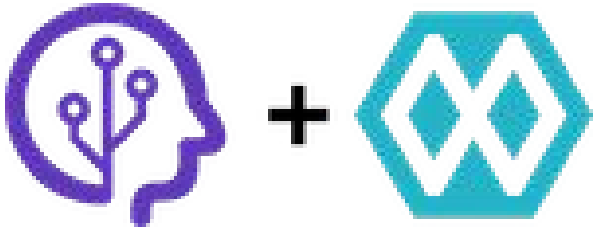


Temple University EEG Dataset

Dataset v1.5.1 Summary:

1. 642 Subjects
2. 1,423 Sessions
3. 447 Sessions Contain Seizures
4. 922 Hours of Data
5. 63 Hours or 6.8% being Seizures

Neureka™ 2020 Epilepsy Challenge



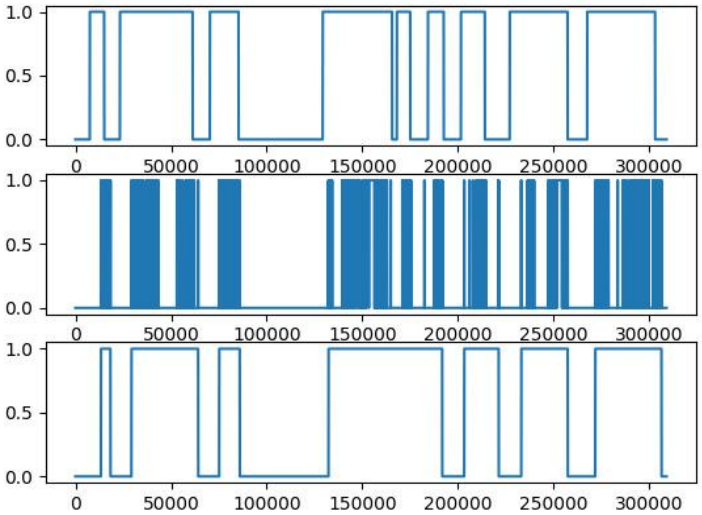
“We propose a month-long challenge on seizure prediction using the TUH EEG Seizure dataset. The goal is to have the best performance across subjects while using as little channels as possible.”

$$Points = Sensitivity - 2.5 * False\ Alarm\ Rate/\ 24\ hours - 7.5 * \frac{Number\ of\ Channels}{19}$$

Our Contributions

1. Developed robust training pipeline
2. Developed scripts to automate data pre and post processing
    a. Showed that we did not need to use fancy signal processing hand crafted features (preprocessing stage)
    b. Used a lightweight post processing that consisted of thresholding, voting, and filtering
3. Developed Novel Deep Learning Architecture
4. Filtered
    a. Voting
    b. Moving average (low pass)
    c. Savitzky Golay

Threshold 0.8



Architecture Search

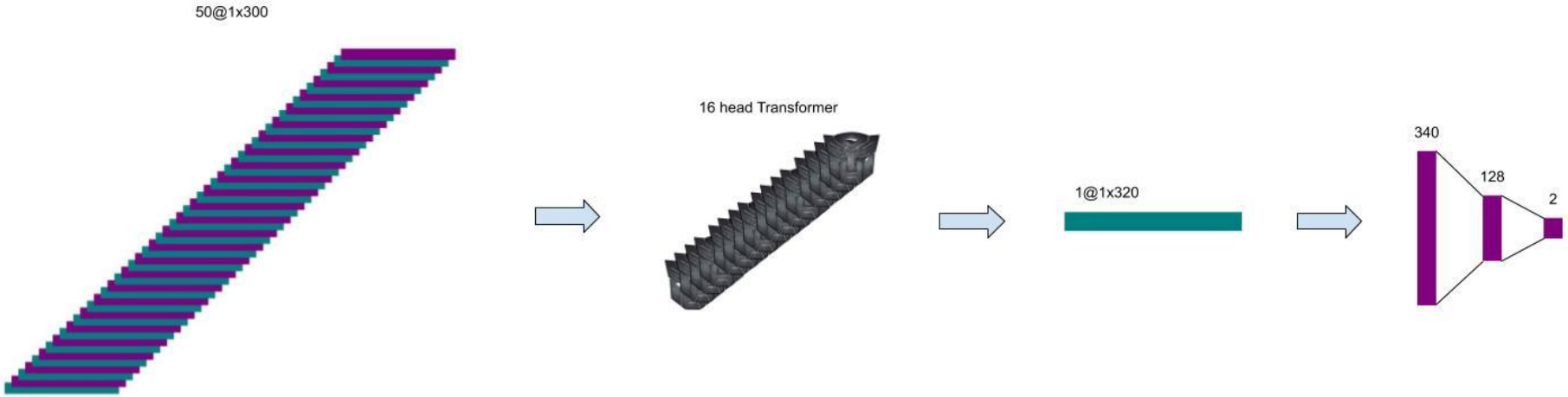
- The original research group used CNNs and LSTMs
- We built a transformer based model we call TABS, or **Tra**nsformer **B**ased **S**eizure Detector
- What is a transformer?

$$\text{Attention}(Q, K, V) = \text{softmax}(\frac{QK^T}{\sqrt{d_k}})V$$

$$\text{MultiHead}(Q, K, V) = \text{Concat}(\text{head}_1, ..., \text{head}_\text{h})W^O$$

$$\text{where head}_\text{i} = \text{Attention}(QW_i^Q, KW_i^K, VW_i^V)$$

TABS: Transformer Based Seizure Detector



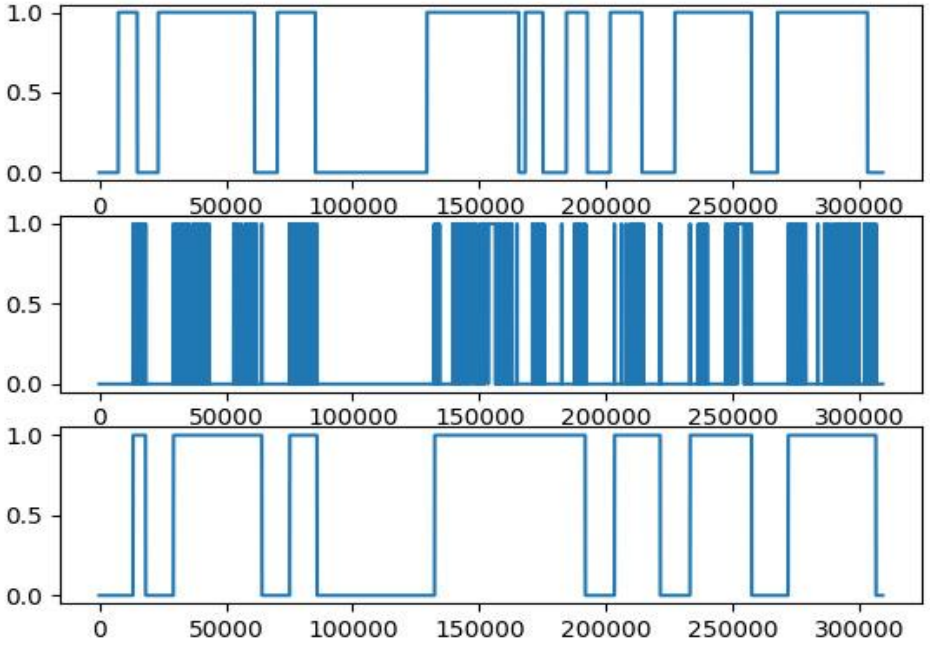
Training Pipeline

- Data preprocessing
- Training
- Validating
- Evaluating

Post-Processing Filters

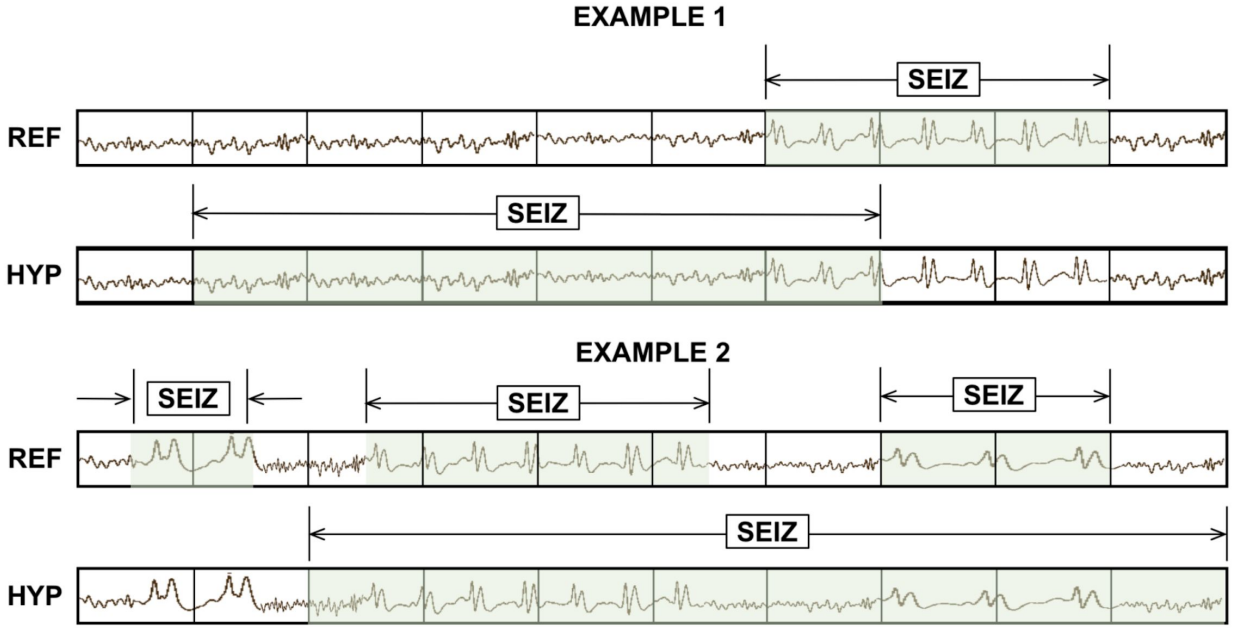
- Voting
- Moving average (low pass)
- Savitzky Golay

Threshold 0.8



Evaluation Metrics

Any Overlap (OVLP) vs Time Aligned Event Scoring (TAES)



Results (using the OVLP metric)

Model Description	Dataset	Smoothing	Threshold	Sensitivity	Specificity	FA per 24 hours
TransformerModel 7	contest — 50-50	sg: ws:fileLen, poly:18 -> threshold	0.3	30.86	86.7	33.85
TransformerModel 7	contest — 50-50	sg: ws:fileLen, poly:18 -> threshold-> 500-1 -> 50-1	0.3	30.04	88.86	27.38
TransformerModel 7	contest — 50-50	sg: ws:fileLen, poly:18 -> threshold	0.2	47.61	70.21	88.61
TransformerModel 7	contest — 50-50	sg: ws:fileLen, poly:18 -> threshold-> 500-1 -> 50-1	0.2	47.61	74.28	69.92
TransformerModel 7	contest — 50-50	sg: ws:fileLen, poly:18 -> threshold-> 1000-1	0.3	30.04	89.02	26.93
TransformerModel 7	contest — 50-50	sg: ws:fileLen, poly:18 -> threshold-> 50-1	0.3	30.04	88.75	27.67
TransformerModel 7	contest — 50-50	sg: ws:fileLen, poly:18 -> threshold-> 50-1	0.2	26	83.83	43.11
TransformerModel 7	contest — 50-50	sg: ws:fileLen, poly:18 -> threshold-> 50-1	0.3	14.7	89.05	28.18

Neureka™ 2020 Epilepsy Challenge Results (TAES)

Position	Team or Individual	Sensitivity	FAs/24hr	Avg. No. Channels	Score
1	**Biomed Irregulars**	**12.37**	**1.44**	**16**	**2.46**
2	**NeuroSyd**	**2.04**	**0.17**	**2**	**0.82**
3	USTC-EEG	8.93	0.71	17	0.45
4	RocketShoes	5.98	3.36	3	-3.60
5	Lan Wei (Ind.)	20.00	15.59	4	-20.56
6	EEG Miners	16.00	16.54	9	-28.89
7	Anonymous (Ind.)	21.65	28.05	4	-50.05
8	James Msonda (Ind.)	11.33	29.27	10	-65.79
9	TABS	9.03	31.21	19	-76.50
10	cpl team	5.66	94.34	1	-230.59
11	DeepAlert	9.86	172.92	10	-426.40
12	Interfaces	26.53	186.63	1	-440.44
13	Neurocomputación	0.22	758.48	11	-1,900.32
14	TeamPT2	34.75	927.12	19	-2,290.53
15	Last Dance	10.13	1,385.03	1	-3,452.83

Conclusion

- **Deep Learning** > **Signal Processing Pre-processing**
- Comparable results to Temple’s SOTA
- Scoring metric has large influence over results

Questions?