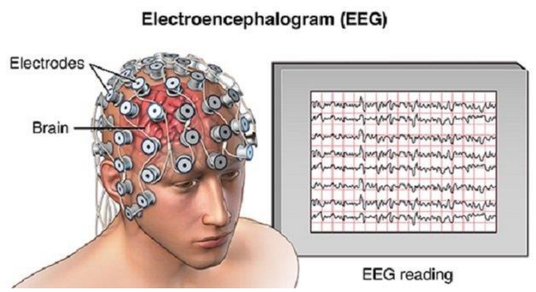
CNN-AIDED FACTOR GRAPHS WITH ESTIMATED MUTUAL INFORMATION FEATURES FOR SEIZURE DETECTION

Bahareh Salafian[1], Eyal Fishel Ben[2], Nir Shlezinger[2],Sandrine de Ribaupierre[1] , Nariman Farsad[3]

[1] School of Biomedical Engineering, University of Western Ontario, London, ON, Canada, N6A 5C1
[2]School of Electrical and Computer Engineering, Ben-Gurion University of the Negev, Be'er Sheva, Israel, 84105
[3]Department of Computer Science at Ryerson University, Toronto, ON, Canada, M5B 2K3

1. Introduction

- About 50 million people worldwide[1] suffer from epilepsy, an abnormal brain activity leading to seizures.
- Epileptic seizures can cause life-threatening symptoms that can affect the quality of life.
- The most common tool used to diagnose seizures is electroencephalogram (EEG)[2].



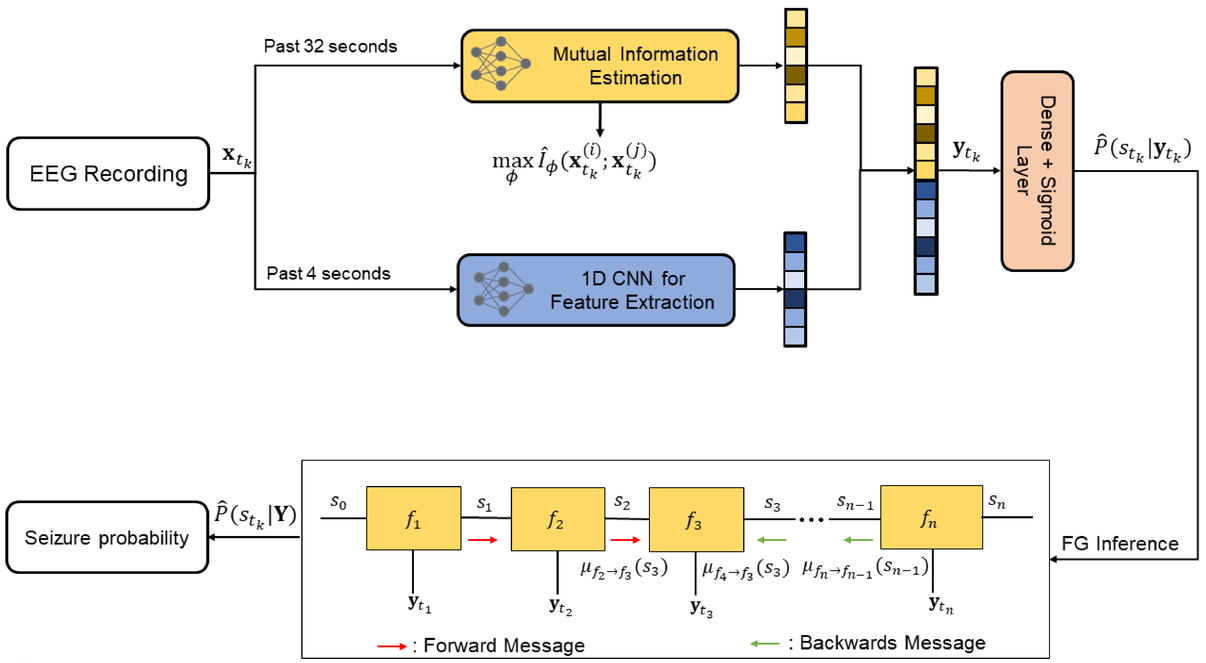
https://autism360.com/news/are-eeg-signals-likely-to-predict-autism/

- EEG recordings exhibit both inter-channel correlation as well as temporal correlation.
- The inter-channel correlation exists since the epileptic activity propagates across different areas in the brain.

2. Methodology

- Exploit both spatial and temporal correlation among EEG signals using a hybrid of model-based and data-driven approaches.
- Use *neural mutual information estimators* to estimate inter-channel correlation.
- Use *learned factor-graphs* to exploit temporal correlations.

3. Mutual Information-based CNN-Aided Learned Factor Graphs (MICAL)



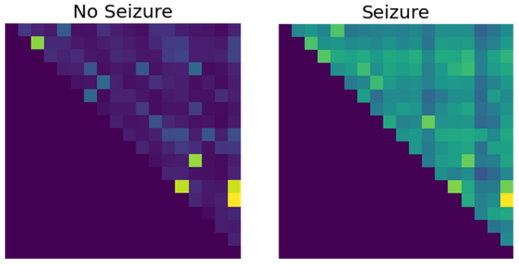
- s_i → Labels
- y_{t_i} → Observed EEG measurements

First-order HMM → Classification the states → ✓Sum-product method ✓Product of messages

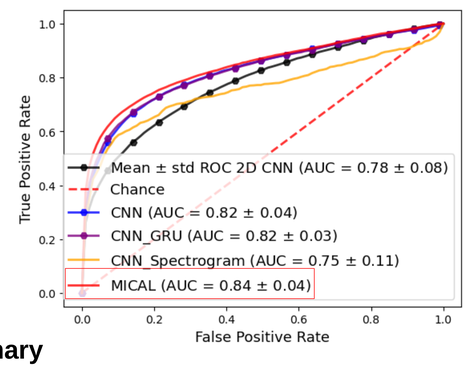
4. Results

- 5 different models are considered for comparison.
- Two baseline SOTA models are included.
- GRU is added to the proposed 1D CNN to have another model that mitigates temporal correlations.
- 6-fold leave-4-patients-out evaluation is conducted.

MI estimation results



AUC ROC



Results Summary

	AUC-ROC	AUC-PR	F1 score
2D CNN[4]	77.81 ± 0.08	37 ± 17.76	88.3 ± 3.37
Spectrogram[5]	75.4 ± 0.11	37.65 ± 10.25	92.77 ± 3.43
1D CNN	82.12 ± 0.04	42.23 ± 12.96	91.47 ± 2.55
1D CNN-GRU	82.28 ± 0.03	44.43 ± 10.71	90.42 ± 6.86
MICAL	$\mathbf{83.8 \pm 0.04}$	$\mathbf{50.38 \pm 13.68}$	$\mathbf{93.42 \pm 1.88}$

5. Summary & Conclusions

- We proposed MICAL, which is a data-driven EEG-based seizure detector designed to exploit both inter-channel and temporal correlations.
- Our neural MI estimation captures the high non-linear relationship among different EEG channels during seizure.
- The combined features from MI estimation ad 1D CNN are used to learn the function nodes in the factor graph to consider temporal correlation at reduced complexity.
- MICAL generalizes well across patients using a leave-4-patients-out evaluation and it achieves significant performance improvement compared to prior SOTA.

6. References

1.https://www.who.int/news-room/fact-sheets/detail/epilepsy
2. physionet.org
3. Song et al. 2020.
4. Boonyakitanont et al. 2019
5. Jana et al. 2020.

7. Acknowledgements

Schulich Medicine & Dentistry
NSERC CRSNG