Pain Classification on EEG and Tabular Data

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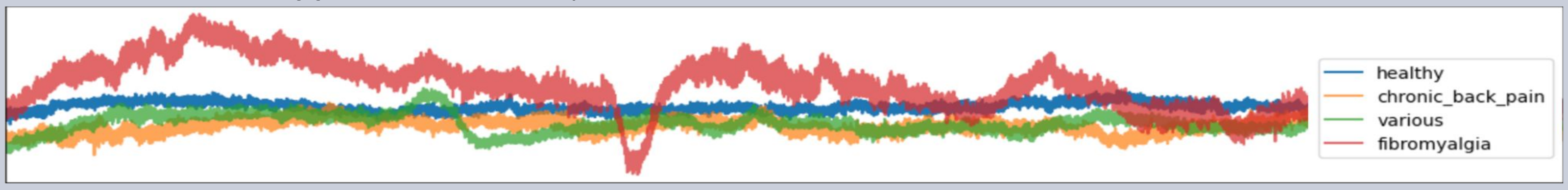
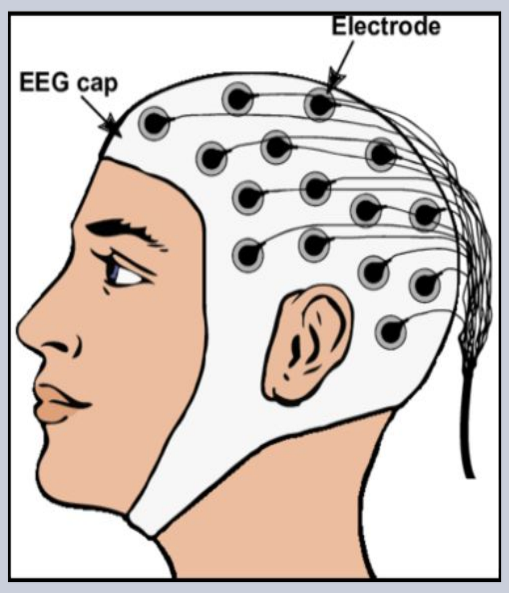
Background and Motivation

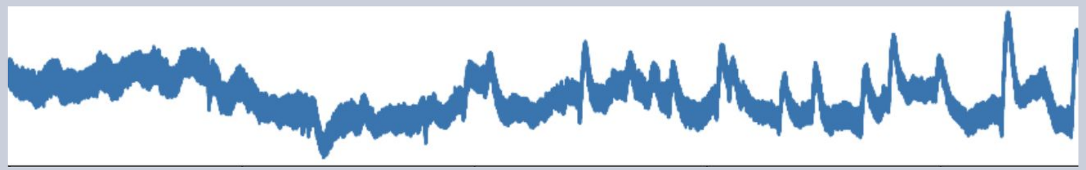
- **Electroencephalogram** is a technique that measures the electrical activity of the brain and helps in the **diagnosis of diseases** such as chronic pain.
- EEG signals are hard to interpret by humans, **ML models** could be useful in **supporting doctors**.
- **Multimodal ML approaches** for this problem are not well researched.





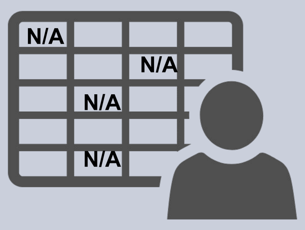
Method

Dataset [1]



Resting-state EEG (65 channels, 275sec)

+

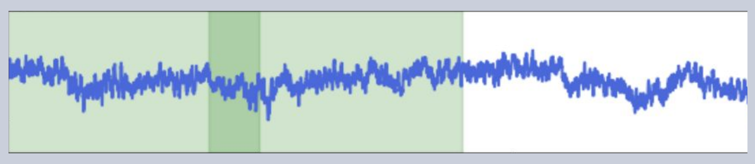


- demographic data
- pain indicators
- depression measures
- medication quantifiers

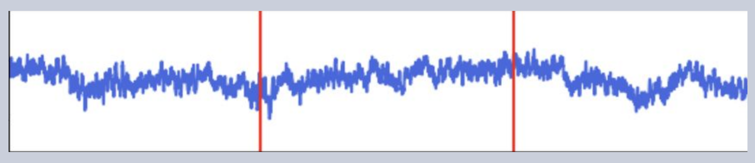
sample count:
chronic back pain(60), fibromyalgia(23), various(59)

Signal Splitting

segmentation

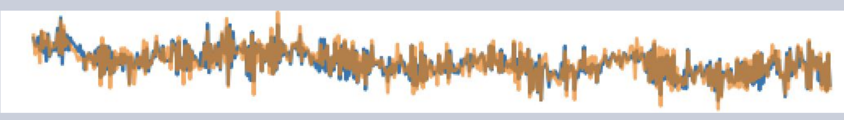


subsampling

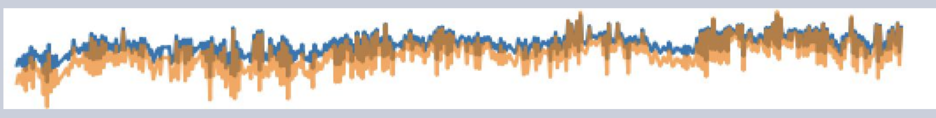


Data Augmentations (50% chance for each to be applied)

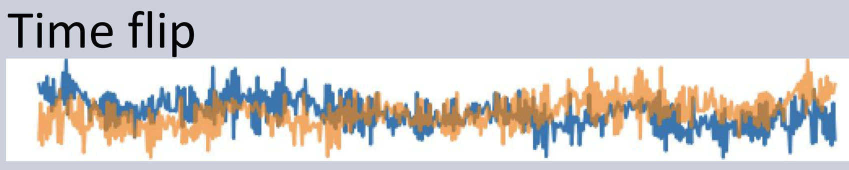
Gaussian noise



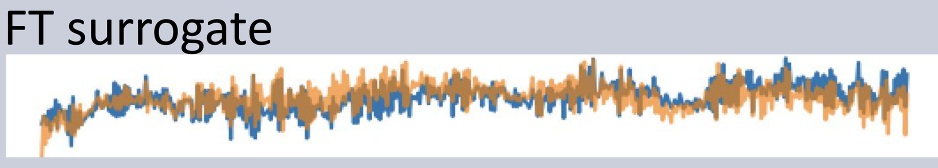
Rescale



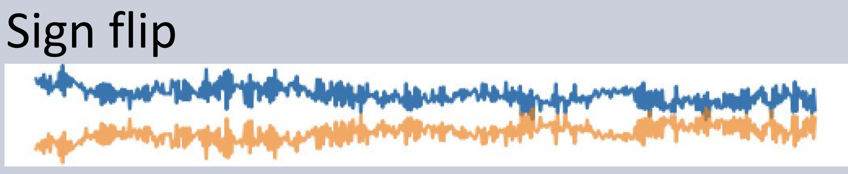
Time flip



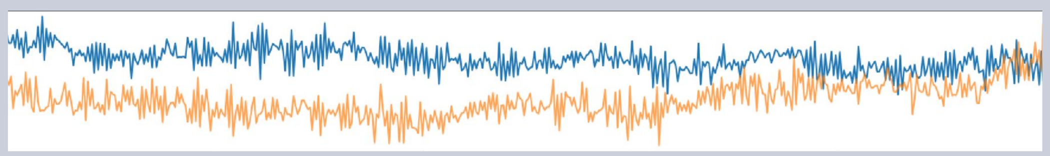
FT surrogate



Sign flip

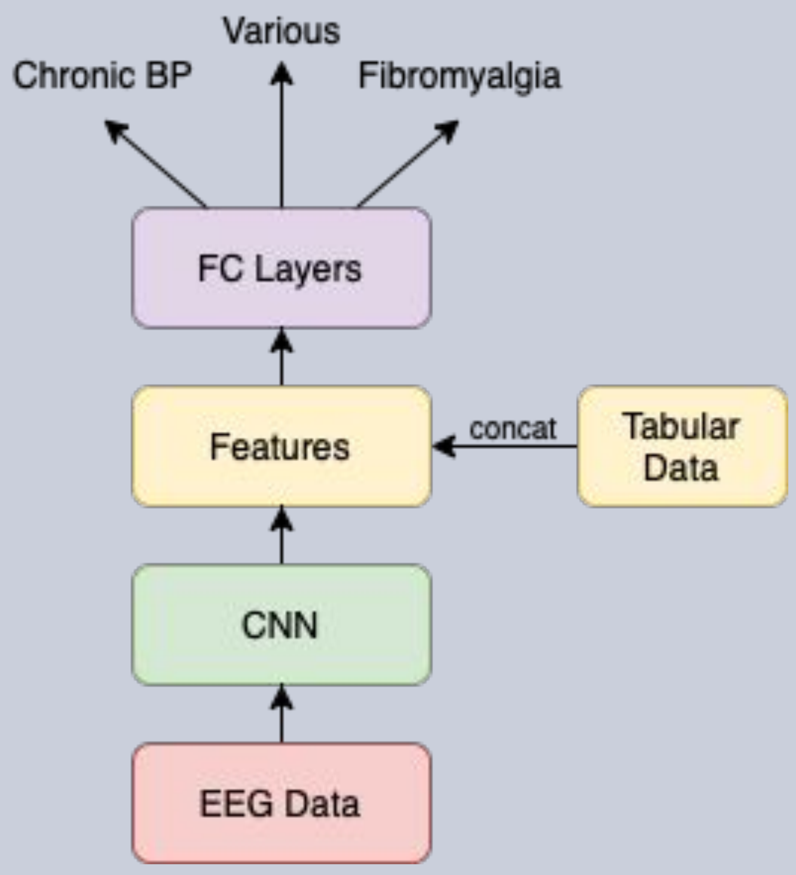


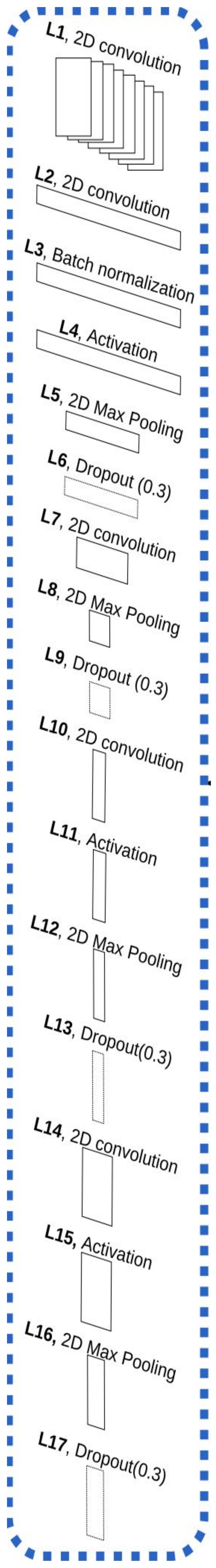
Freq. shift



Original (blue) vs. Fully Augmented (orange) signal

General Architecture





Architecture [2]

Results

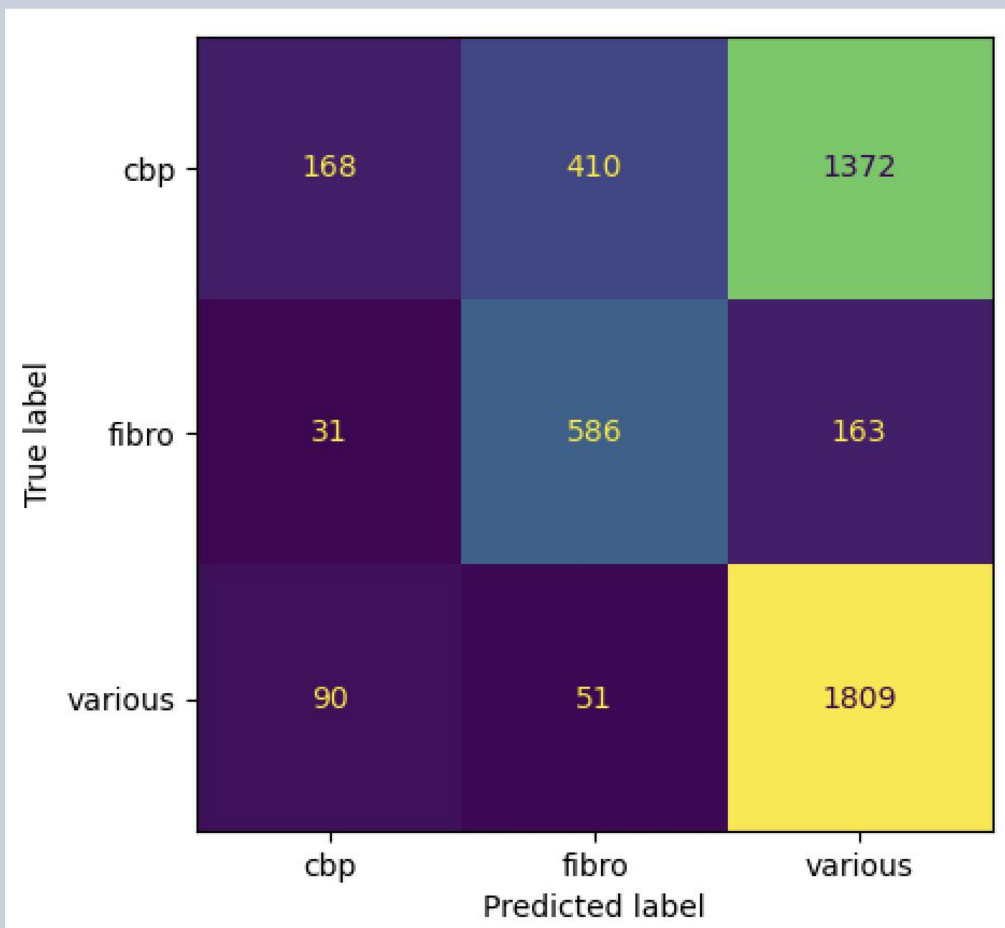
Mean ROC-AUCs (4-fold cross-validation)

	Baseline	EEG	EEG+Tabular
CBP	0.49	**0.53**	0.52
Fibromyalgia	0.62	**0.95**	**0.95**
various	0.43	**0.72**	0.71

Ablation Study - AUC (EEG frequency bands)

	CBP	Fibro	Various
delta (1-4Hz)	0.31	0.66	0.68
theta (4-8Hz)	**0.46**	**0.78**	**0.75**
alpha (8-12Hz)	0.41	0.62	0.56
beta (12-30Hz)	0.25	0.69	0.50
gamma (30-100Hz)	**0.48**	**0.82**	**0.78**

Confusion Matrix



Conclusion / Main Findings

- **Theta and Gamma are important** frequencies bands for pain classification.
- **Tabular data** use shows **no improvements**, which requires further exploration with complete datasets or additional features.
- High confidence for **Fibromyalgia** classification caused by clear patterns in the EEG data (**strong oscillations**).
- Signal **data augmentations** applied to EEG can help when dealing with a **small dataset.**

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References

[1] Ta Dinh, S., Nickel, M. M., Tiemann, L., May, E. S., Heitmann, H., Hohn, V. D., Edenharter, G., Utpadel-Fischler, D., Tölle, T. R., Sauseng, P., Gross, J., & Ploner, M. (2019). Brain dysfunction in chronic pain patients assessed by resting-state electroencephalography. Pain, 160(12), 2751–2765. https://doi.org/10.1097/j.pain.0000000000001666

[2] Chen, D., Zhang, H., Kavitha, P. T., Loy, F. L., Ng, S. H., Wang, C., Phua, K. S., Tjan, S. Y., Yang, S. Y., & Guan, C. (2022). Scalp EEG-Based Pain Detection Using Convolutional Neural Network. IEEE transactions on neural systems and rehabilitation engineering : a publication of the IEEE Engineering in Medicine and Biology Society, 30, 274–285. https://doi.org/10.1109/TNSRE.2022.3147673