DDT: Dementia Detection Tool

Erdos Institute Fall 2023 Bootcamp

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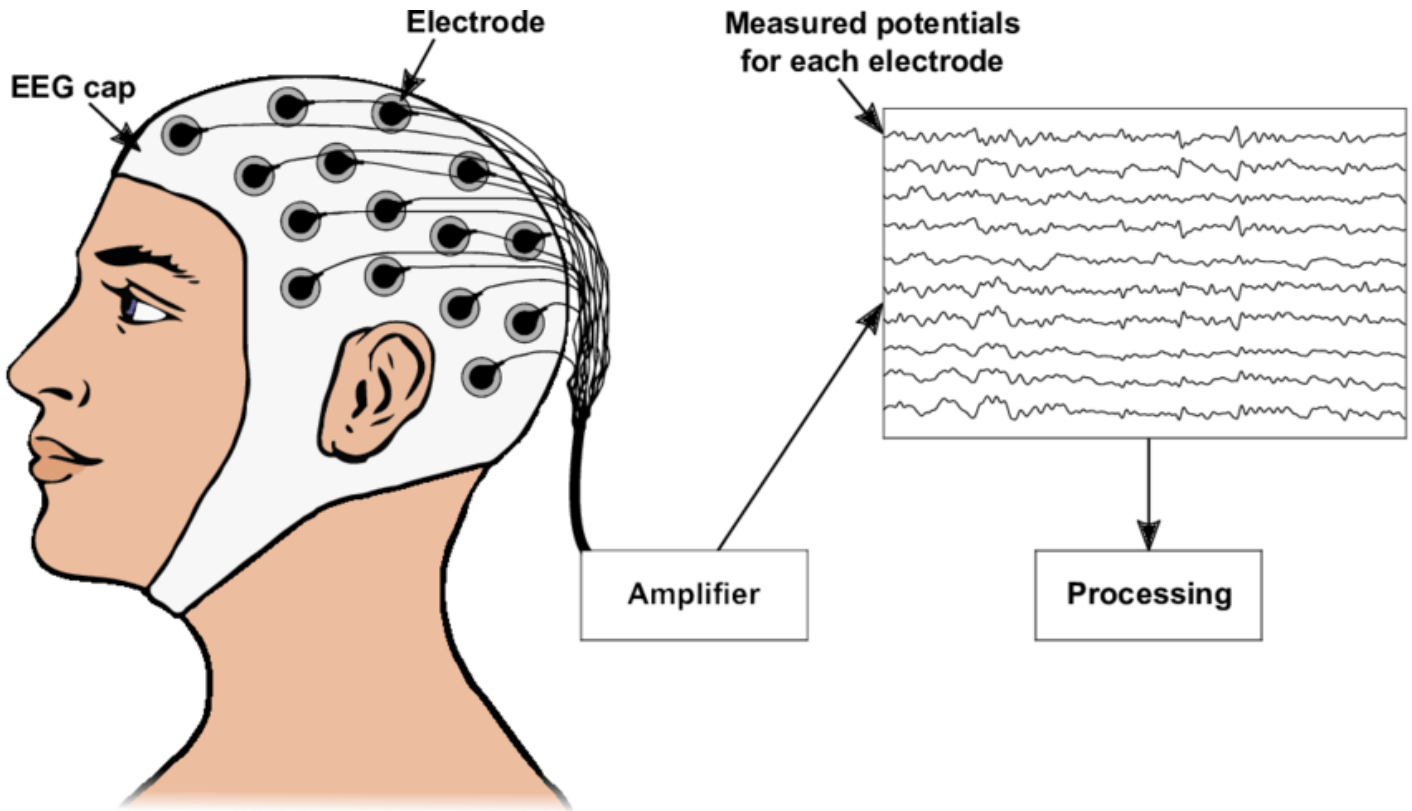
Motivation

- **Alzheimer's disease** (AD) is one of the most common types of dementia and frequently affects the elderly. **Electroencephalography** (EEG) is a non-invasive technique to measure the brain activity using external electrodes and may help provide improved diagnosis of AD.
- **Goals:** (1) Develop an accurate classifier based on EEG data for predicting if a patient has AD or is healthy. (2) Infer which features in EEG data can be used to distinguish AD versus healthy.
- **Use Cases:** Useful in hospital and lab settings to screen patients before subjecting them to more invasive treatments or tests.
- **KPI:** Prediction accuracy in distinguishing patients with AD from healthy subjects.

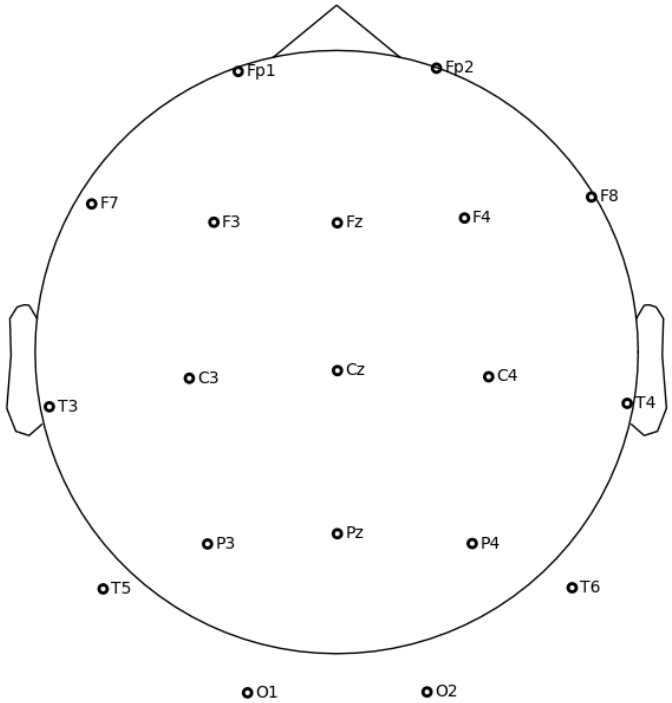
Data Visualization

- EEG data collection process:



Data Visualization

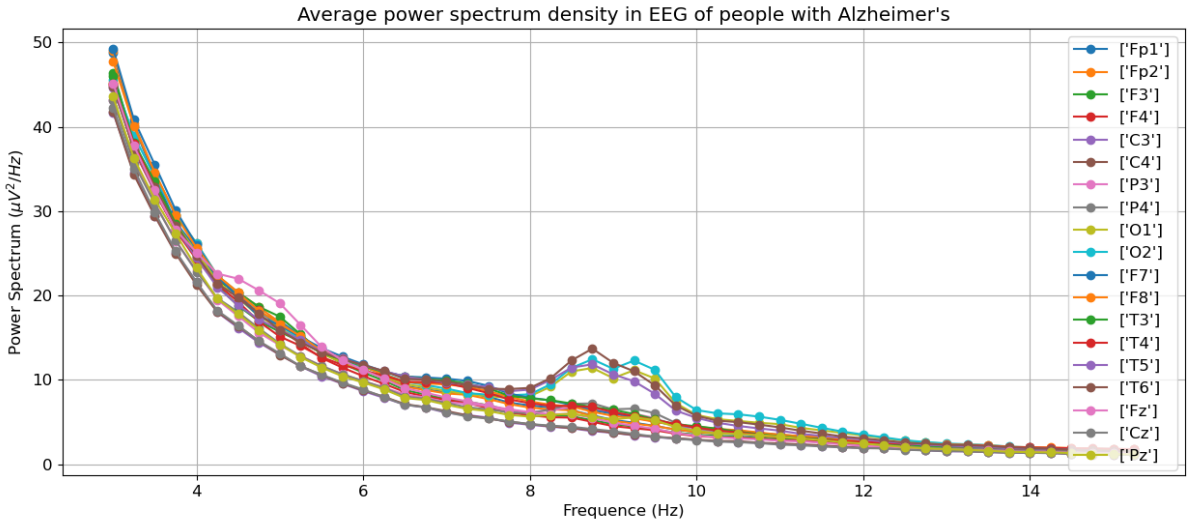
- Our data[1] consists of EEG signals from 19 channels (or electrodes) on the scalp, arranged as follows:

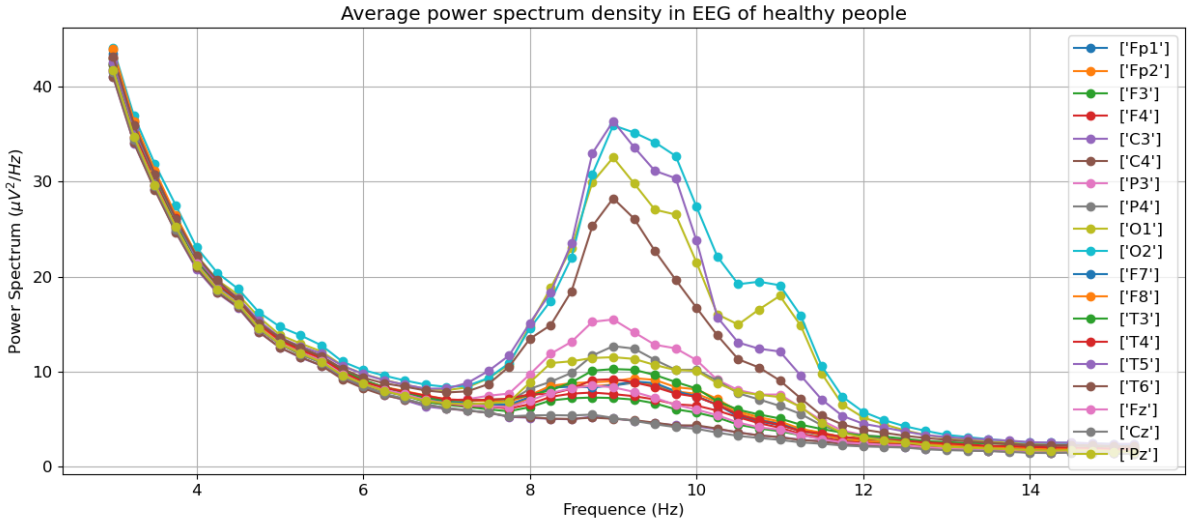


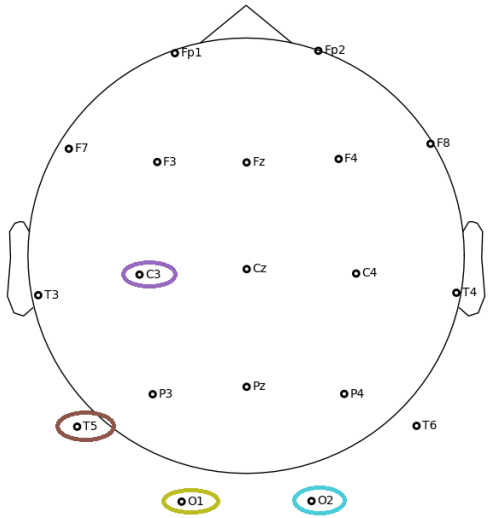
- Analyzing the power spectrum of the EEG data in the frequency domain is more distinctive than studying the time series directly.

[1] EEG Dataset: https://openneuro.org/datasets/ds004504

Data Visualization







Data Source: openneuro.org/datasets/ds004504

Feature and Model Selection

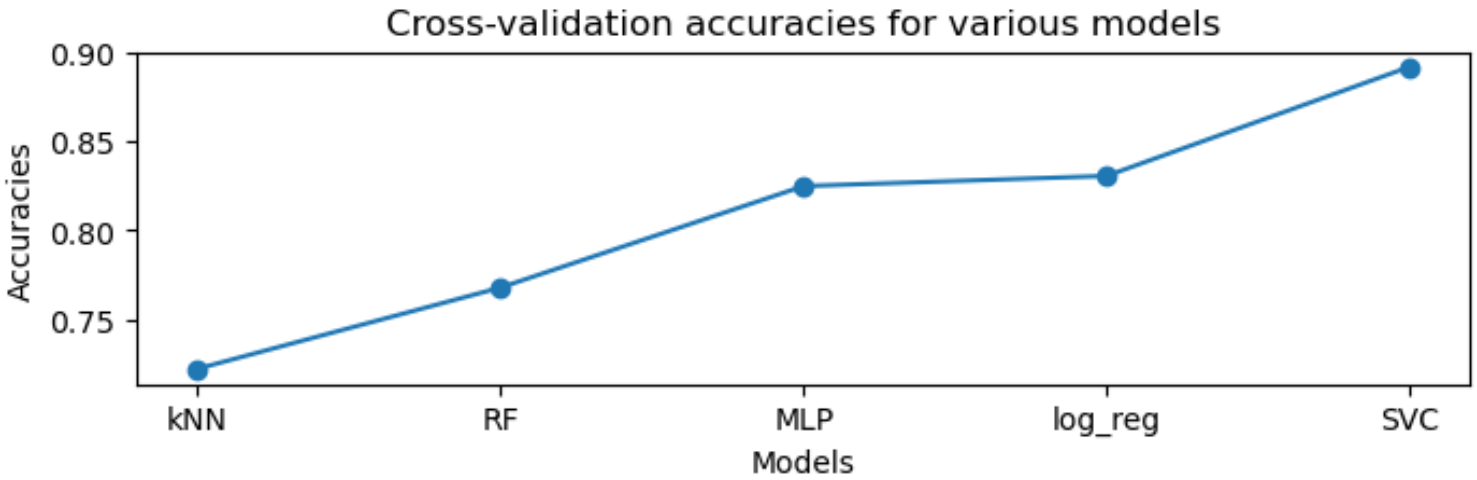
- A common practice is to divide the full length EEG into smaller time windows, or epochs, with some overlap.
- In each epoch we compute the power spectrum and then the relative band power (RBP) for various frequency bands.
- Based on our exploratory data analysis and cross-validation, we chose optimal frequency bands, epoch lengths, and channels:

	Literature	Erdos DDT
Bands	(0.5- 4 Hz), (4- 8 Hz), (8 - 13 Hz), (13- 25 Hz), (25 - 45 Hz)	(0.5- 4 Hz), (4 - 7 Hz) (7 - 9 Hz), (9 - 11 Hz), (11- 13 Hz), (13 - 25 Hz)
Epochs	4s - 30s	2 minutes
Channels	All channels	Left out F3, F4, C4 F8

Model performance

- Leave-one-subject-out (LOSO) cross-validation was used for model selection and tuning hyperparameters.

	acc.	sens.	spec.	F1
kNN	72%	76%	67%	74%
RF	76%	79%	74%	78%
MLP	82%	84%	80%	83%
log. reg.	83%	85%	79%	84%
SVC	89%	91%	86%	90%



Model performances

- SVC model with a linear kernel gives the best performance in cross-validation, with a validation accuracy of 89% and a test set accuracy of 81%.

Performance comparison with existing literature models				
	acc.	sens.	spec.	F1
Our SVC model	89%	91%	86%	90%
Best literature RBP based method[2]	77%	78%	81%	75%
DICE-NET: A CNN based method [3]	83%	79%	87%	84%

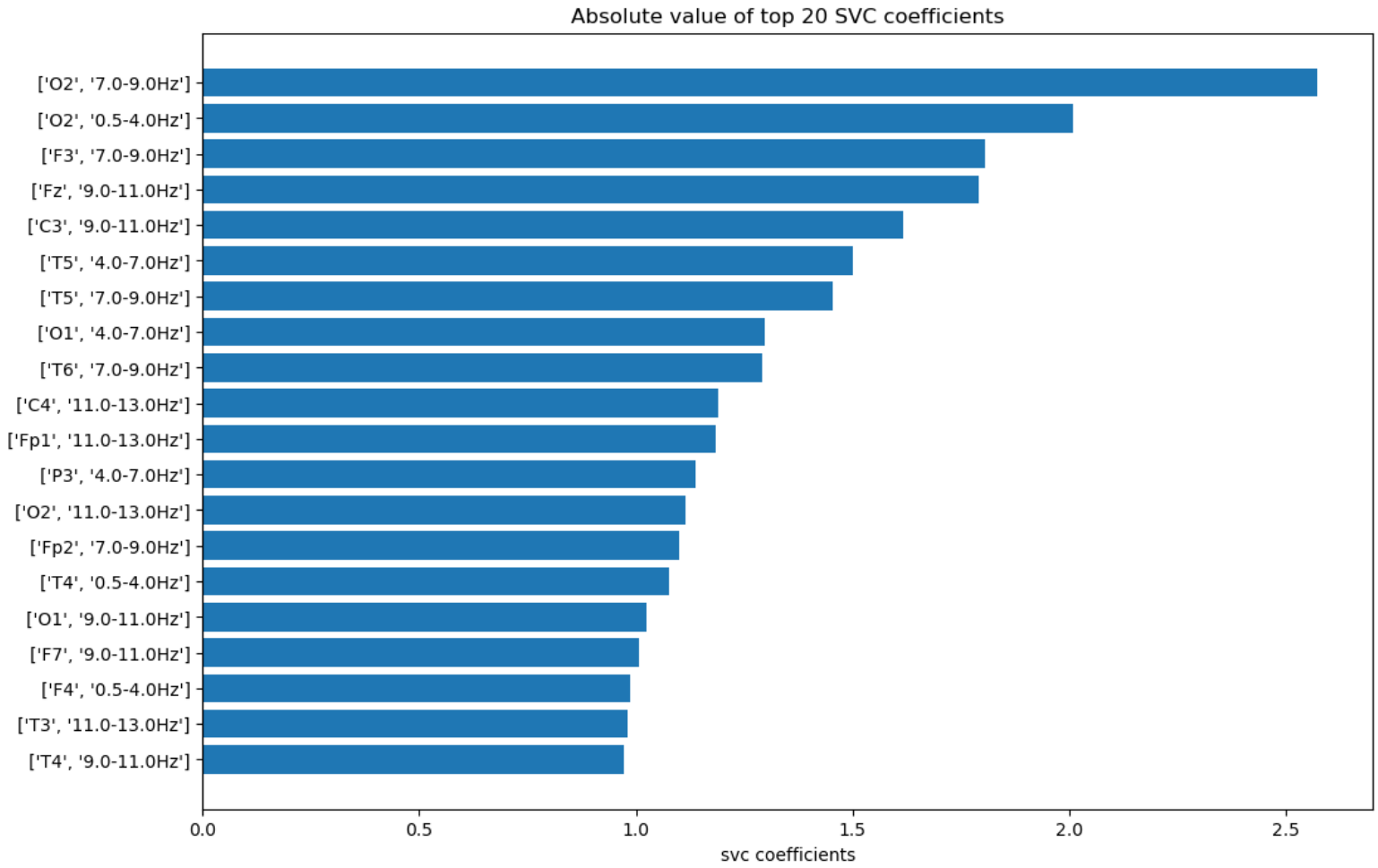
- We achieved a better LOSO validation accuracy than all the existing models in literature.

[2] This is RF model in OpenNeuro, doi: 10.18112/openneuro.ds004504.v1.0.1

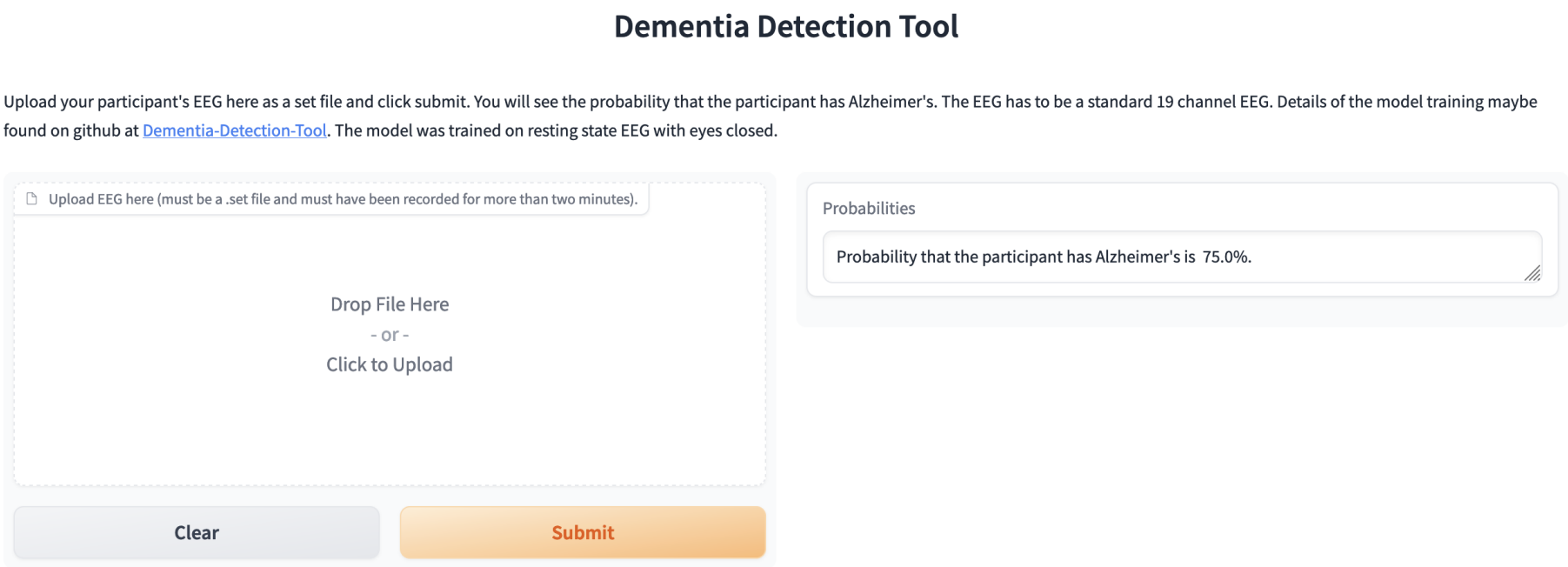
[3] This is a convolutional neural network based model in IEEE, doi: 10.1109/ACCESS.2023.3294618

Feature importances

- To gauge which of the 90 features (15 channels and 6 freq. bands) are more important, we plot the absolute value of top twenty coefficients from SVC classifier.



Product: App



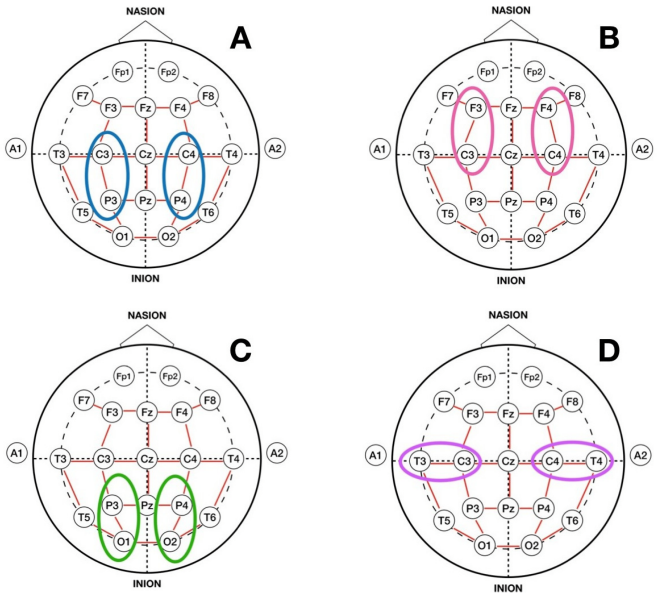
- We have hosted the trained model on a web-based app on Hugging Face. It takes in a EEG file and uses our model to predict the probability that the EEG belongs to a patient with Alzheimer's.

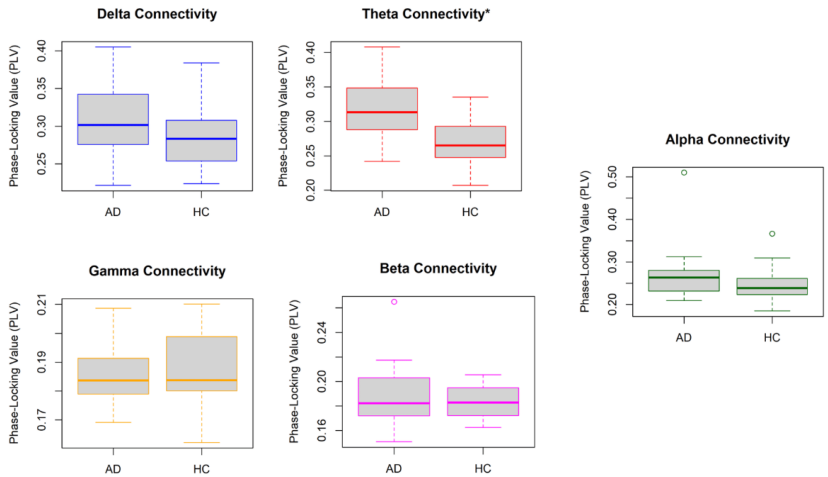
Conclusions and Future Directions

- We showed that a support vector classifier trained on power spectrum of EEG identifies Alzheimer's in patients of age above 50 yrs with an accuracy of over 89%.
- We observed that modifying the frequency bands compared to what is used in the literature and in particular: splitting beta band (8-13 Hz) into subbands greatly improves the accuracy.
- We also identified that 'O2' channel of the EEG (located at the rear of the scalp) in the frequency range 7 - 9 Hz is the most useful distinguishing feature for Alzheimer's.
- This will help in building an early screening tool for Alzheimer's.
- For future: it will be helpful to use this technique for also distinguishing Alzheimer's from other types of dementia: such as Frontotemporal dementia. We are currently exploring usefulness of other features such as spectral connectivity, in addition to power spectrum, for this problem.

Future Directions: Spectral Connectivity Features

- Spectral connectivity (SCC) is a method for studying EEG data by analyzing correlations between different regions (nodes) of the brain.





- Preliminary work suggests that combining SCC and power spectrum features is promising for distinguishing patients with Alzheimer's versus those with frontotemporal dementia.

Image taken from: DOI: 10.3390/app12105162