Extraction of Feature from EEG Signal to Detect ADHD

U.PORTO

FEUP FACULDADE DE ENGENHARIA UNIVERSIDADE DO PORTO

Master's in Data Science and Engineering

Fundamentals of Data Sciences - Signal Processing Module

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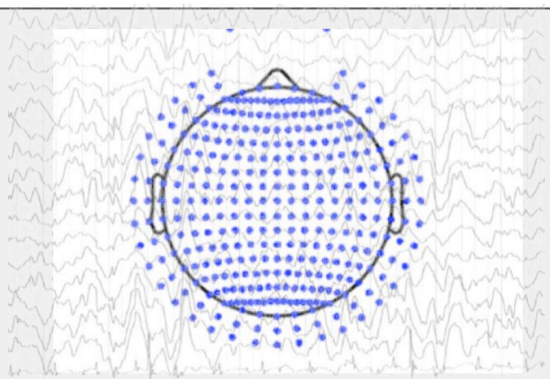
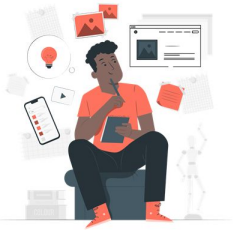


Attention Deficit Hyperactivity Disorder (ADHD)

SYMPTOMS OF ADHD

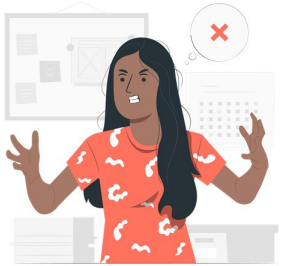


Difficulty focusing

Forgetfulness

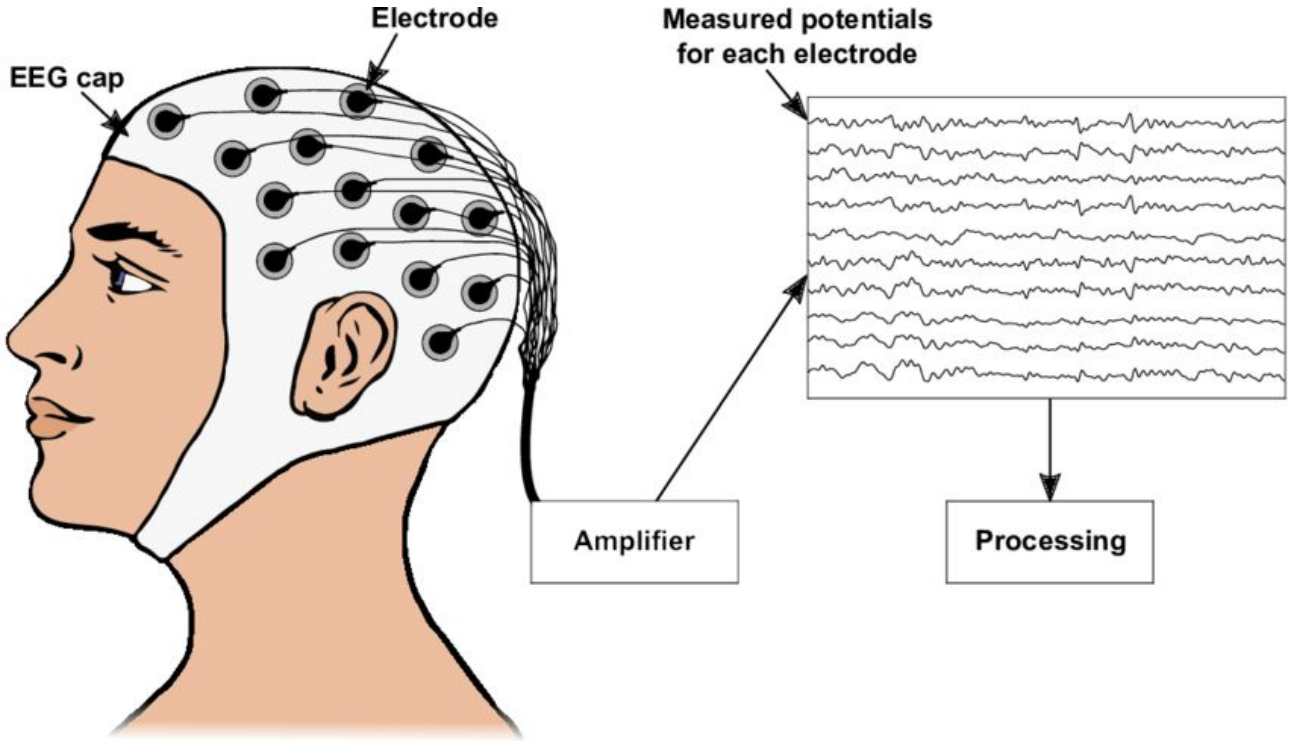
Always remain worried

Easily distracted

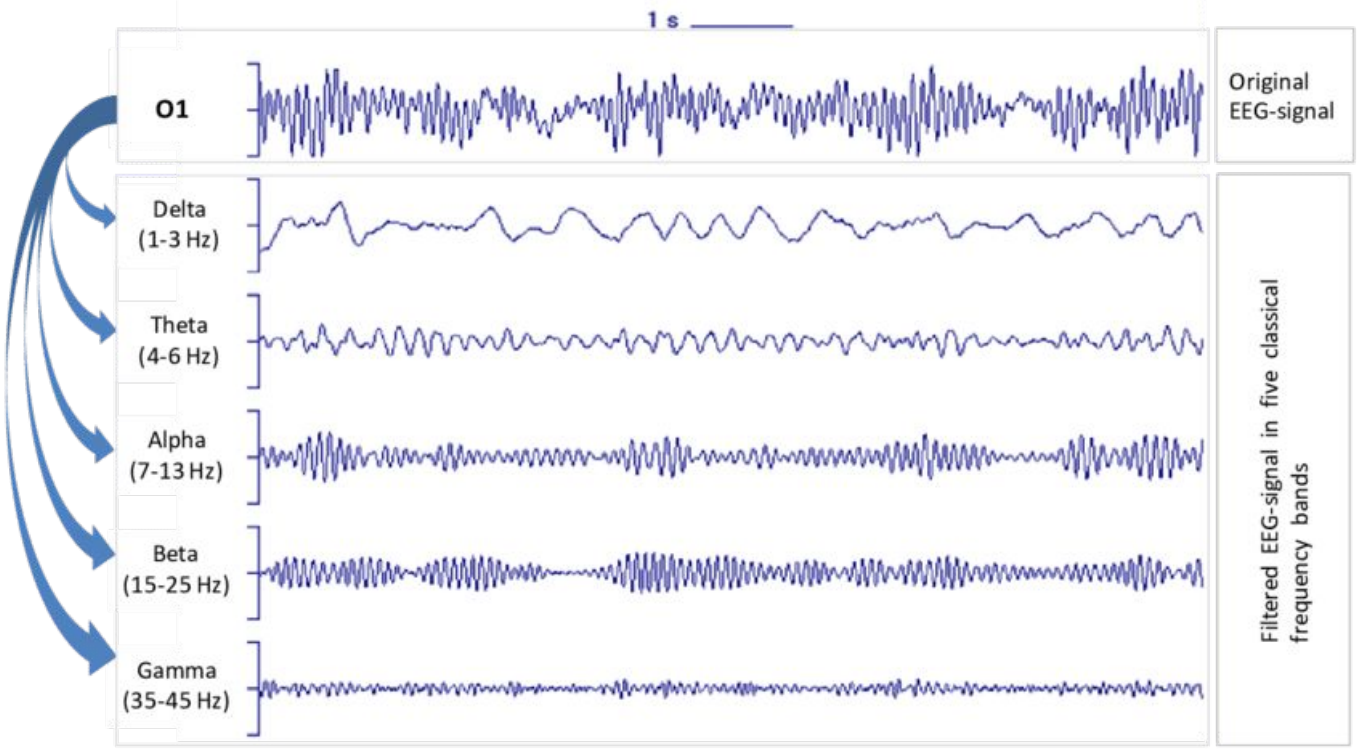


Easily get irritated

Electroencephalography (EEG)



EEG Signal


1 s
O1
Original EEG-signal
Delta (1-3 Hz)
Theta (4-6 Hz)
Alpha (7-13 Hz)
Beta (15-25 Hz)
Gamma (35-45 Hz)
Filtered EEG-signal in five classical frequency bands

Materials

10 EEG files

- 4 Control
- 6 ADHD diagnosed
- All signals are from 6 - 9 year old patients

Properties

- Each one has 19 columns (19 electrodes)
- Average of 7 minutes of data
- Sampling frequency of **256 Hz**
    - T = 4 ms

EEG Signal Pre-processing

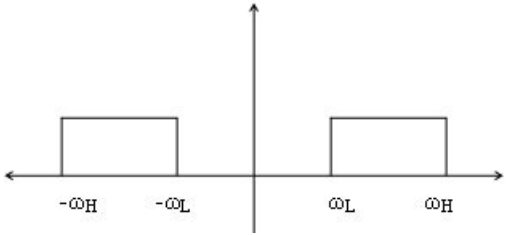
Choose one of the 19 columns

Column #7

Central frontal position

Apply Fast Fourier Transform (FFT)

N = length of EEG

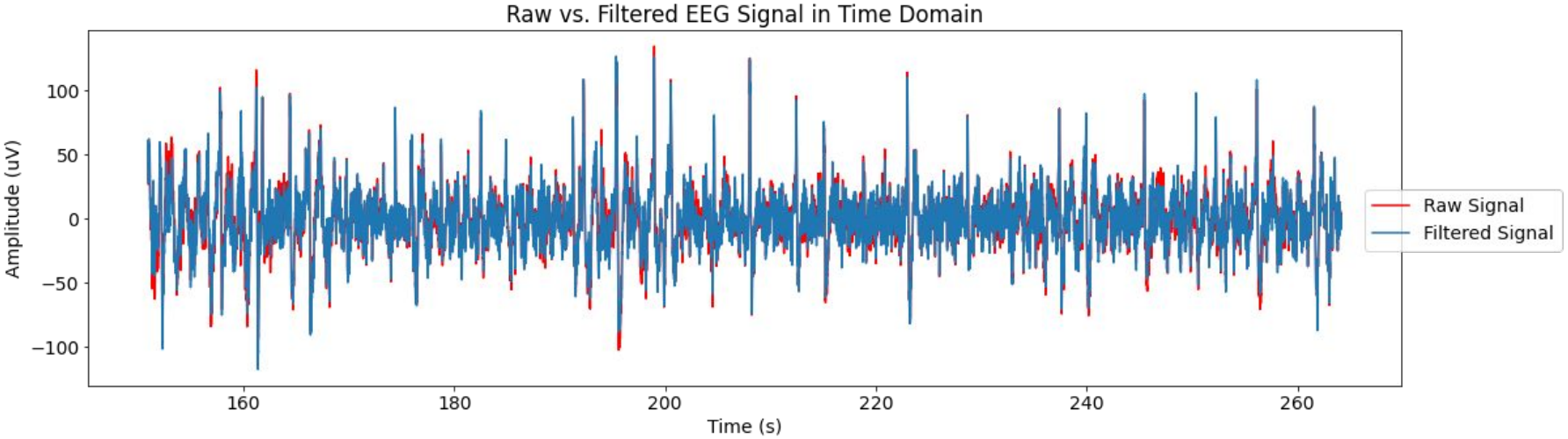


Remove noise (Ideal band-pass filter)

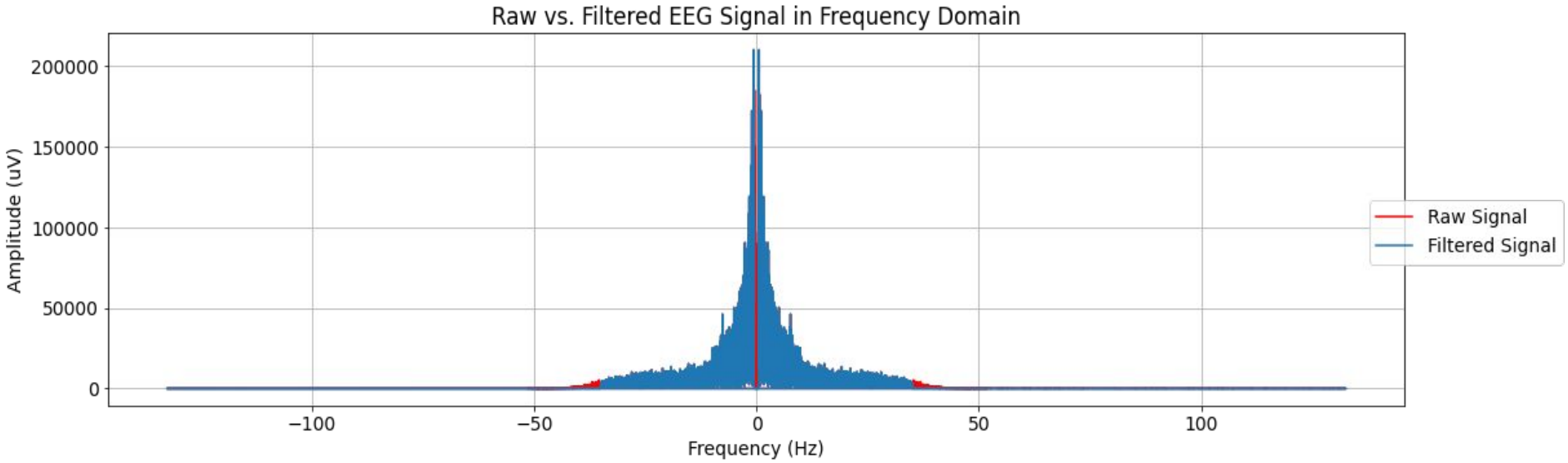
|Frequencies| > 35

|Frequencies| < 0.5

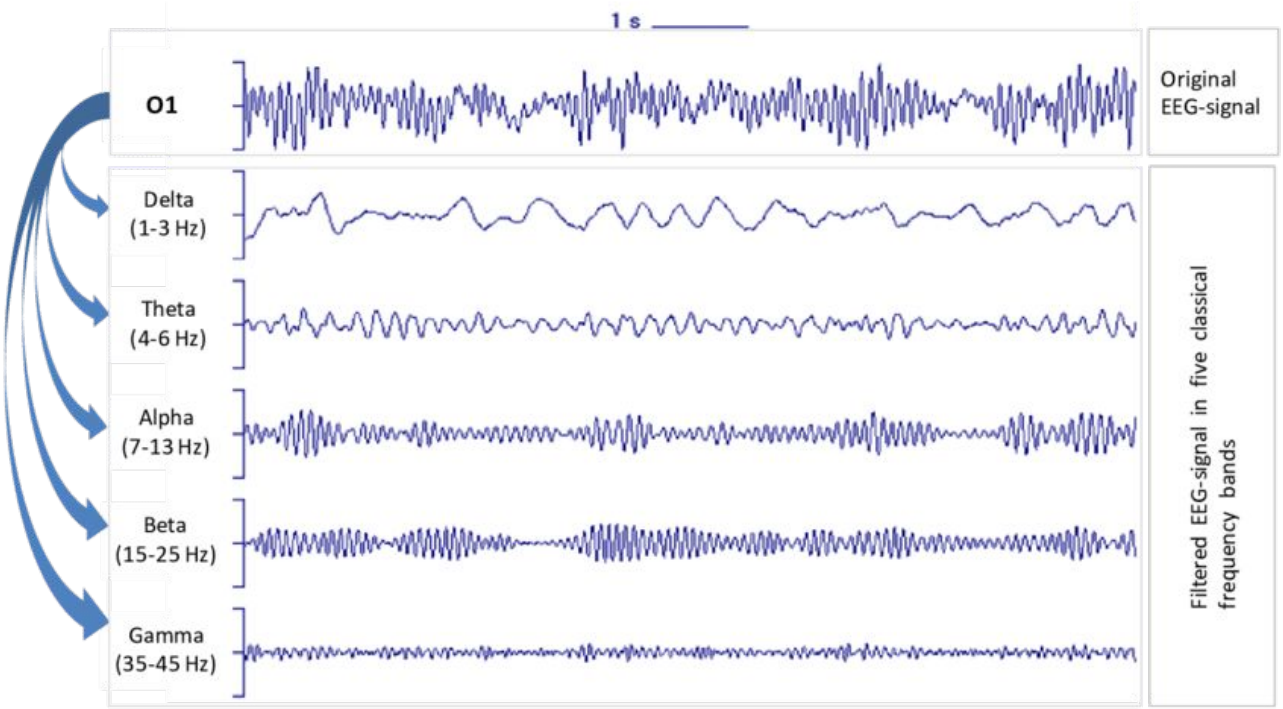
Before and After Noise Removal



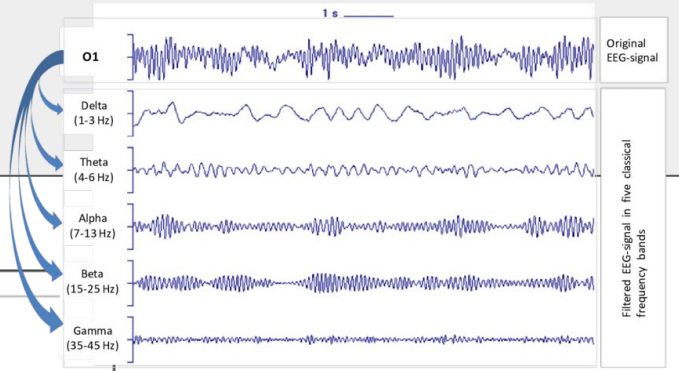
Before and After Noise Removal

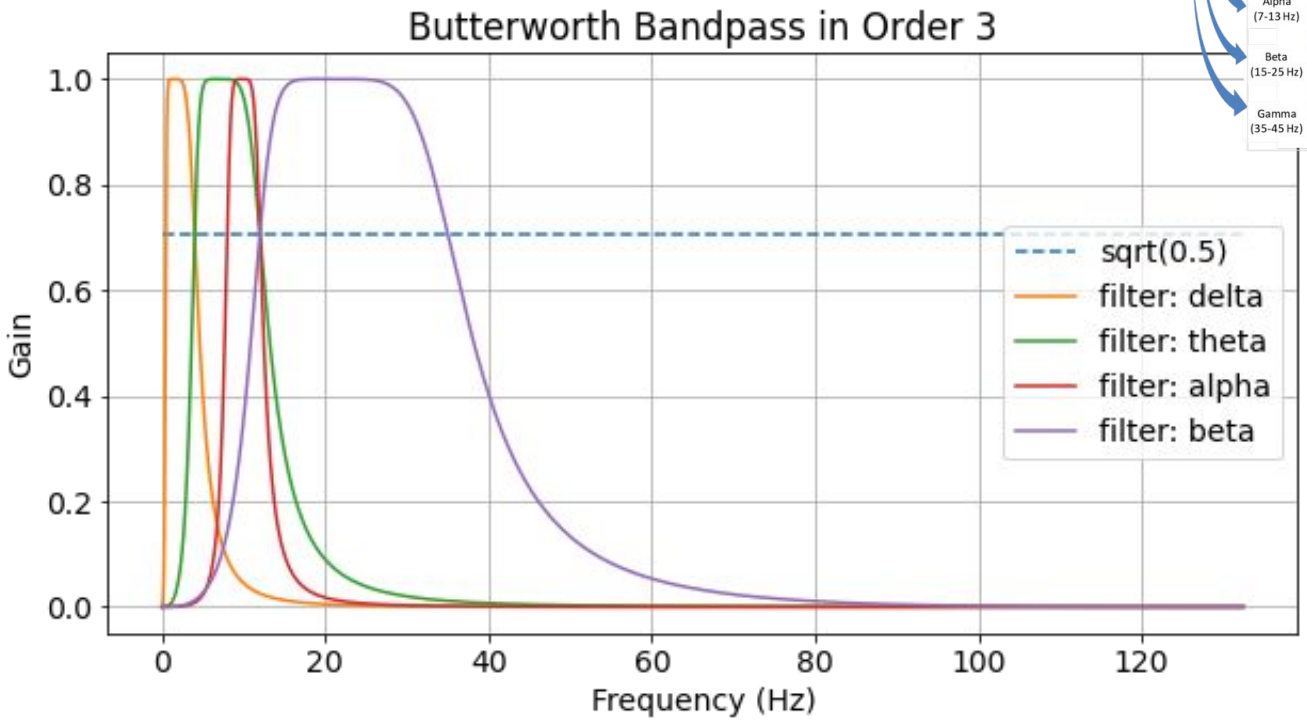


Wavelet Decomposition Filters

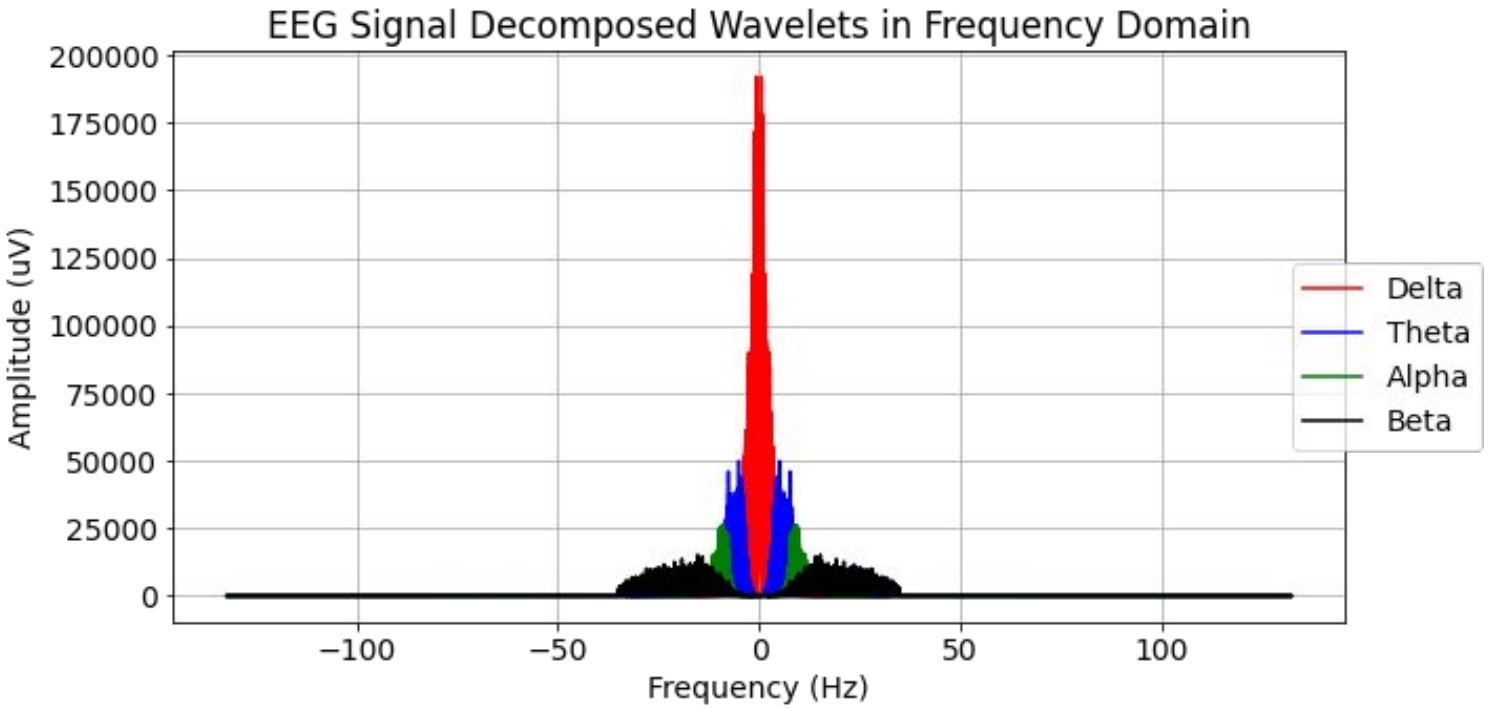


Wavelet Decomposition Filters



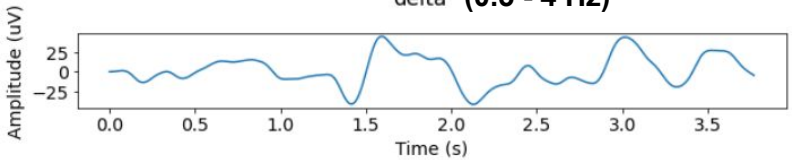


Wavelet Decomposition Result (F domain)

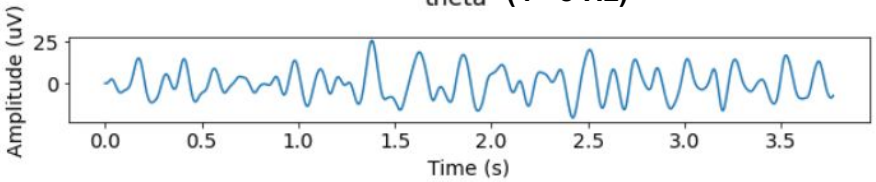


Wavelet Decomposition Result (Time domain)

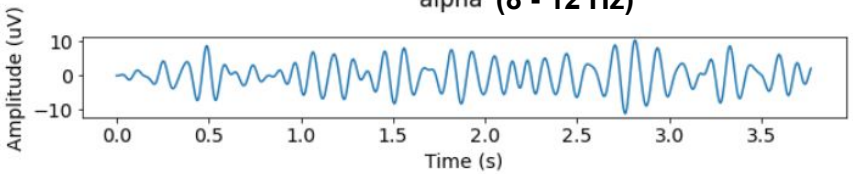
delta **(0.5 - 4 Hz)**



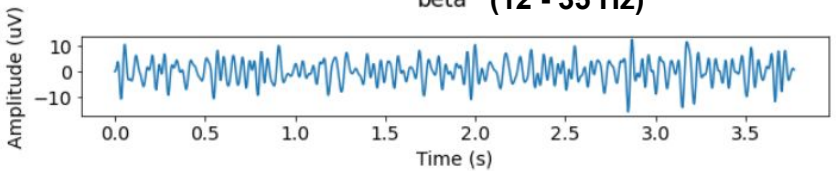
theta **(4 - 8 Hz)**



alpha **(8 - 12 Hz)**



beta **(12 - 35 Hz)**



Feature Extraction

For each of the EEG signals

For each of the wavelets

- Minimum amplitude
- Maximum amplitude
- Mean amplitude
- Absolute power

Extracted Features

	d_min	d_max	d_mean	d_abs_power	t_min	t_max	t_mean	t_abs_power	a_min	a_max	a_mean	a_abs_power	b_min	b_max	b_mean	b_abs_power	ta_abs_power	ADHD
Control_6YO_1827C.txt	0.04	191927.38	1161.47	458.52	0.31	49870.57	885.40	94.35	0.01	26225.11	343.22	23.14	0.03	15189.92	725.85	25.30	117.49	0
Control_7YO_1638C.txt	0.15	95917.81	640.19	207.82	0.93	27291.77	539.68	52.59	0.15	15833.69	218.53	14.35	0.19	10357.59	574.98	26.01	66.95	0
Control_6YO_1852C.txt	0.05	71363.69	605.74	164.45	0.04	33167.96	620.38	75.53	0.01	21545.01	257.61	21.40	0.23	10580.60	457.80	16.08	96.93	0
Control_7YO_1813C.txt	0.03	162966.53	1060.74	613.44	0.18	54524.16	714.34	97.33	0.08	21261.98	257.61	18.65	0.00	9950.02	535.37	20.54	115.98	0
ADHD_6YO_1465C.txt	0.09	114703.77	717.63	256.86	0.44	53976.99	809.62	152.99	0.04	39261.34	339.52	40.97	0.29	13367.99	578.93	26.72	193.96	1
ADHD_6YO_1573C.txt	0.12	159095.24	1131.78	551.59	0.06	55569.47	1073.41	226.90	0.02	35609.69	407.30	50.43	0.36	15013.08	745.02	41.13	277.33	1
ADHD_8YO_1807C.txt	0.27	75271.42	555.59	159.75	0.03	25751.57	538.74	64.53	0.02	18994.66	208.57	14.91	0.12	8756.72	435.09	16.59	79.45	1
ADHD_9YO_1843C.txt	0.95	76207.17	615.07	166.66	0.00	44059.05	733.81	117.81	0.01	25030.73	301.58	28.53	0.02	13382.56	627.46	31.84	146.35	1
ADHD_7YO_846C.txt	0.09	83515.65	729.50	204.19	0.02	46475.41	806.08	128.89	0.03	30846.83	302.30	28.90	0.07	11764.39	532.23	20.31	157.80	1
ADHD_6YO_1788C.txt	0.23	126948.21	856.63	369.34	0.02	45453.76	840.19	127.99	0.02	27398.36	370.59	41.17	0.12	23964.69	736.22	54.14	169.15	1

Combined Absolute Power (Theta + Alpha)

ADHD Prediction model

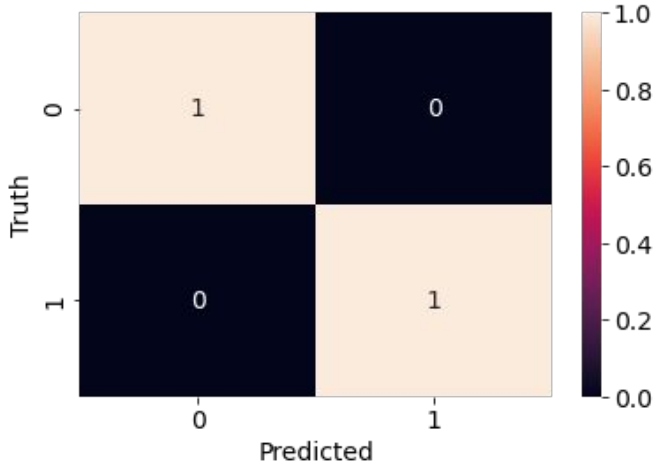
- **1 predictive attribute**
  - Absolute power of theta + alpha (most relevant parameter)

- **1 target attribute**
  - Binary classification
    - 1: ADHD
    - 0: Control

- **Method:** Gaussian Naive Bayes
- **Training set:** 8 EEG files (80% of the whole data set randomly chosen)
- **Test set:** 2 remaining EEG files
- Supervised learning

Prediction Model Performance

	precision	recall	f1-score	support
0	1.00	1.00	1.00	1
1	1.00	1.00	1.00	1
accuracy			1.00	2
macro avg	1.00	1.00	1.00	2
weighted avg	1.00	1.00	1.00	2



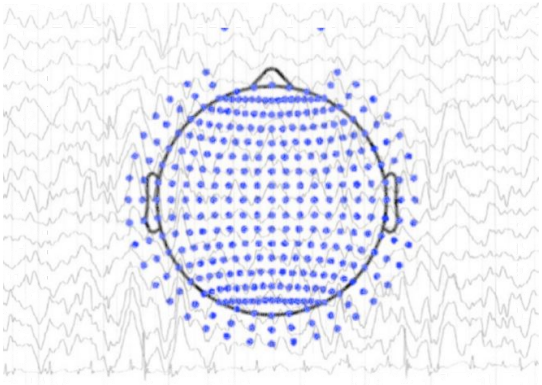
Conclusion

- This work was focused on extracting features from an EEG signal
- 10 EEG signals were evaluated
  - FFT was used
  - Ideal and butterworth band-pass filters were implemented and applied
    - Noise removal
    - Wavelet Decomposition
  - Feature extraction
    - Min, mean, max amplitude
    - Absolute power
    - On average, ADHD cases have higher absolute power of combination of theta and alpha wavelets
  - Predictive model - using relevant extracted features
    - Accuracy 100%
    - Misleading?

Future Works

- A model trained with a bigger dataset could be used in clinical diagnosis
- Explore other machine learning techniques
- Explore other features that can be found relevant for the diagnosis

Thank you!



References

- https://www.cdc.gov/ncbddd/adhd/facts.html
- https://worldpopulationreview.com/country-rankings/adhd-rates-by-country
- https://nhahealth.com/can-eeg-diagnose-adhd/
- https://www.ncbi.nlm.nih.gov/books/NBK539805/
- https://thewolfsound.com/what-is-aliasing-what-causes-it-how-to-avoid-it/
- https://xiengineering.com/sampling-frequency-audio-aliasing/
- http://stresstherapysolutions.com/uploads/STSCheatSheetoftheBrain.pdf
- https://www.researchgate.net/publication/236602395_Prediction_of_Treatment_Response_and_the_Effect_of_Independent_Component_Neurofeedback_in_Obsessive-Compulsive_Disorder_A_Randomized_Sham-Controlled_Double-Blind_Study