SVKM's NMIMS
Mukesh Patel School of Technology Management & Engineering
Computer Engineering Department
Program: B. Tech/MBA Tech EXTC

Course: B. Tech/MBA. Tech (EXTC)
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Program : Btech	*Division:*
Batch:	*Date of Experiment:* 6-01-2022
Date of Submission: 6-01-2022	*Grade :*

AIM: - Feature extraction of EEG Signals-**Time domain feature:** min, max, mean, variance, standard deviation, RMS value, skewness, Kurtosis, Shannon entropy and log entropy

Instructions and Objective:

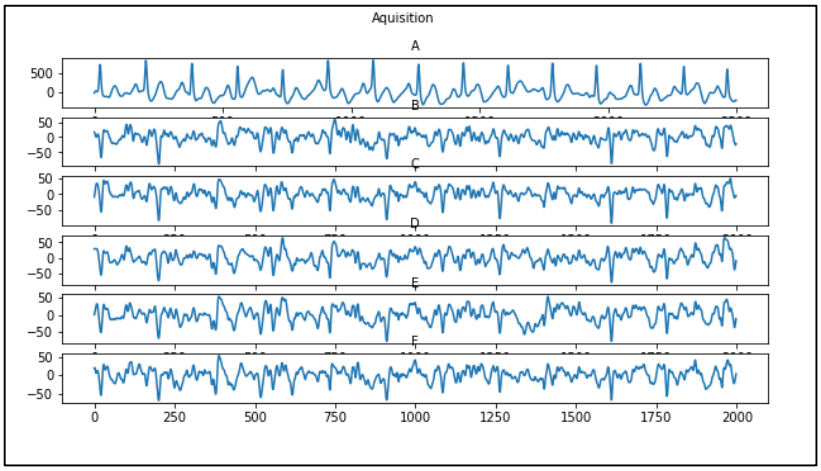
1. Open the data base of Neuromax Select any subjects between 3-9
2. Set the gain 30 µ V/mm, page speed 30 mm/sec, lower freq. 0.5 and higher 99 Hz enable the notch filter 50 HZ and Mont 3
3. Export the data from in excel for 10 secs, samples 2560 (both filtered and unfiltered)
4. Import the CSVs in google collab
5. Remove NaN values if any from the data
6. Perform various statistical analysis (for both dataset)
    a. Plot the graphs of statistical feature for both filtered and unfiltered data
    b. Plot the spectral graphs

Colab Link:

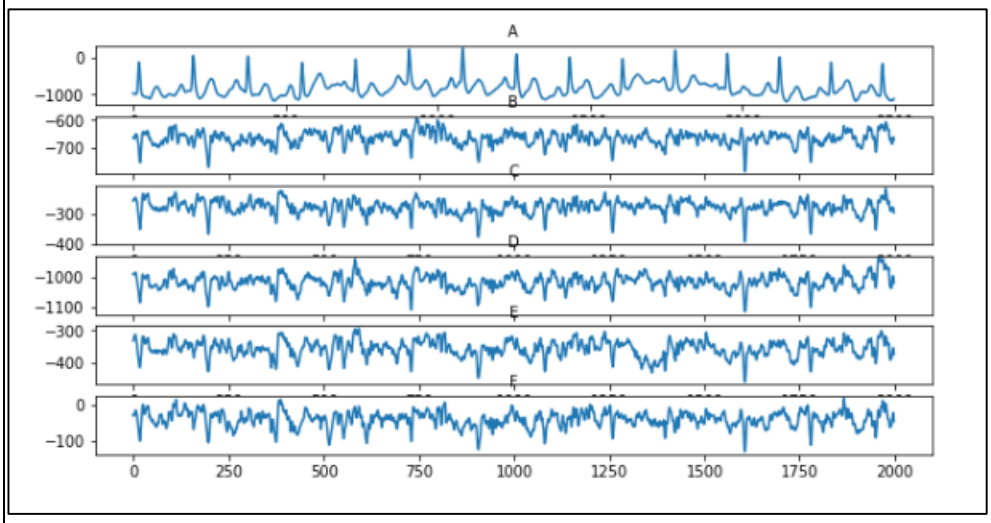
https://colab.research.google.com/drive/1oGmR0ISImnpMawZ_PWAVFOW0PGyOsNQt?usp=sharing

Output

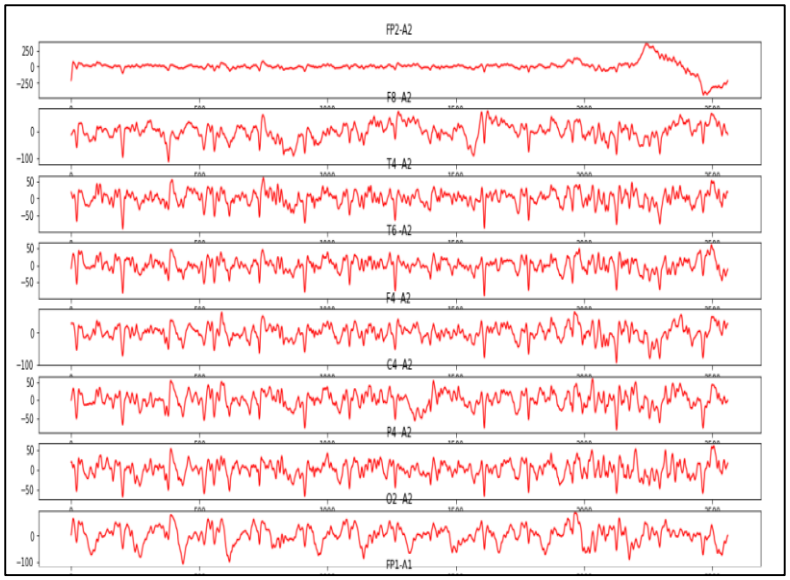
Graphs



Plotting the Graphs for filtered data

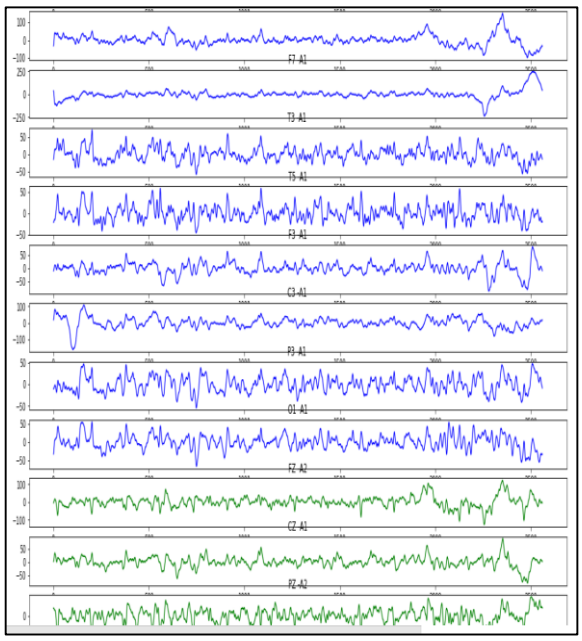


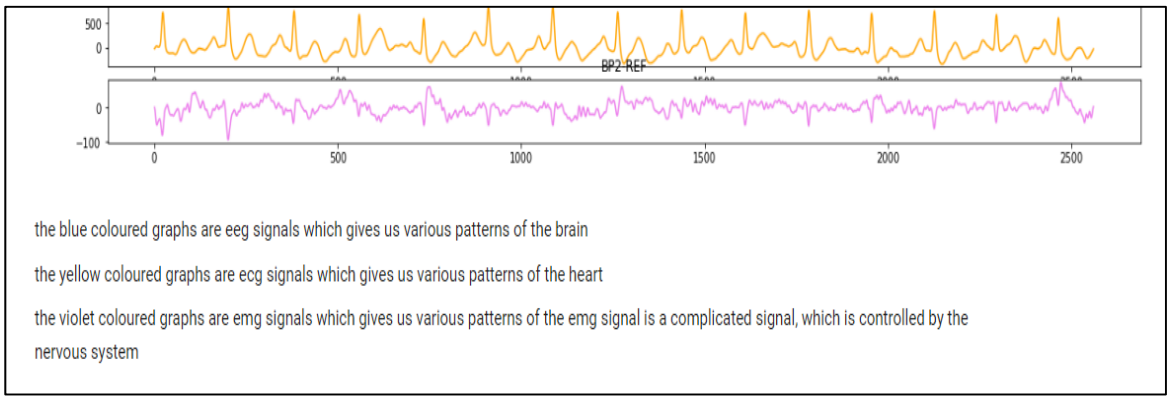
Plotting the Graphs for unfiltered data



Represents all the even signals which is a part of EEG

Blue Represents all the even signals which is a part of EEG and the green signals represented by Z all ground signals are not needed in this survey





the blue coloured graphs are eeg signals which gives us various patterns of the brain

the yellow coloured graphs are ecg signals which gives us various patterns of the heart

the violet coloured graphs are emg signals which gives us various patterns of the emg signal is a complicated signal, which is controlled by the nervous system

```
data.describe()  #filtered
```

	FP2-A2	F8 -A2	T4 -A2	T6 -A2	F4 -A2	C4 -A2	P4 -A2	O2 -A2	FP1-A1	F7 -A1	T3 -A1	T5 -A1	F3 -A
count	2560.000000	2560.000000	2560.000000	2560.000000	2560.000000	2560.000000	2560.000000	2560.000000	2560.000000	2560.000000	2560.000000	2560.000000	2560.00000
mean	-0.070703	-0.023438	-0.039062	-0.022266	-0.014063	-0.032813	-0.041016	-0.054688	0.022656	0.039453	0.018359	0.024219	-0.01601
std	92.849852	31.618912	20.931979	20.792540	23.853938	22.612985	19.979441	34.268965	30.264554	49.732230	18.773679	17.455940	22.02547
min	-433.000000	-114.000000	-89.000000	-90.000000	-95.000000	-82.000000	-69.000000	-107.000000	-99.000000	-236.000000	-57.000000	-46.000000	-85.00000
25%	-15.000000	-18.000000	-12.000000	-12.000000	-14.000000	-13.000000	-13.000000	-19.000000	-13.000000	-19.000000	-12.000000	-12.000000	-11.00000
50%	4.000000	1.000000	2.000000	0.000000	1.000000	1.000000	1.000000	3.000000	0.000000	-1.000000	0.000000	-1.000000	0.00000
75%	24.000000	22.000000	14.000000	14.000000	16.000000	16.000000	13.000000	24.000000	13.000000	13.000000	11.000000	10.250000	11.00000
max	350.000000	78.000000	59.000000	60.000000	66.000000	58.000000	60.000000	86.000000	151.000000	247.000000	69.000000	58.000000	80.00000

Mean, Max, Min Value of Filtered Dataset

```
df = pd.DataFrame(data_z)
df.loc[0:17]
```

	Parameter	Value
0	ECG_Skewness	-0.168100
1	ECG_Kurtoisis	2.998078
2	EMG_Skewness	-0.168610
3	EMG_Kurtoisis	1.921660

Skewness and Kurtosis of ECG AND EMG Signals

Shannon and Log Entropy

	Parameter	Value
0	Shanon Entropy for ECG	-15.484886
1	Log Entropy for ECG	-7.742443
2	Shanon Entropy for EMG	-15.689805
3	Log Entropy for EMG	-7.844903

```
df_11.drop(['FZ -A2 ','CZ -A1 ','PZ -A2 ','BP1-REF','BP2-REF'],axis = 1)
```

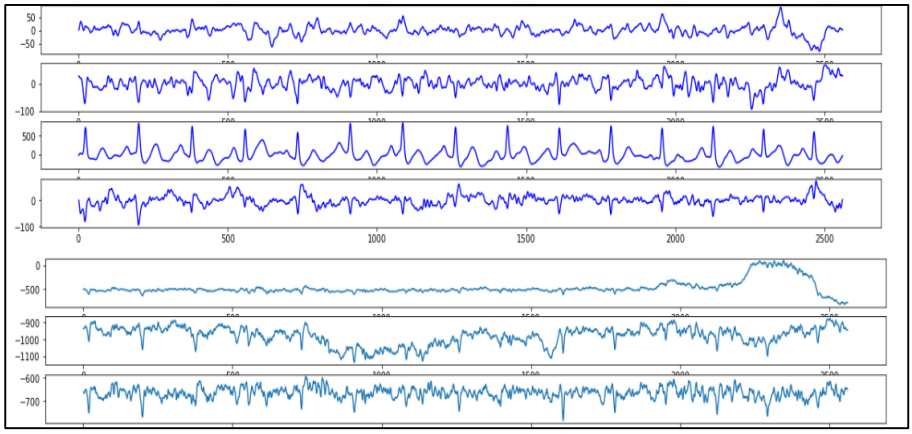
	FP2-A2	F8 -A2	T4 -A2	T6 -A2	F4 -A2	C4 -A2	P4 -A2	O2 -A2	FP1-A1	F7 -A1	T3 -A1	T5 -A1	F3 -A1	C3 -A1	P3 -A1	O1 -A1
0	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
1	-208.0	-11.0	17.0	-9.0	29.0	0.0	19.0	3.0	-32.0	38.0	-14.0	-21.0	-9.0	19.0	-10.0	-32.0
2	-180.0	-11.0	15.0	-3.0	30.0	3.0	20.0	10.0	-24.0	23.0	-11.0	-21.0	-7.0	25.0	-10.0	-28.0
3	-137.0	-10.0	12.0	4.0	30.0	8.0	19.0	19.0	-11.0	1.0	-6.0	-20.0	-4.0	35.0	-9.0	-21.0
4	-84.0	-8.0	8.0	11.0	30.0	12.0	16.0	30.0	4.0	-26.0	0.0	-18.0	0.0	47.0	-8.0	-13.0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
2556	-250.0	-3.0	18.0	-20.0	24.0	-5.0	9.0	-13.0	-36.0	69.0	-7.0	-21.0	0.0	12.0	0.0	-33.0
2557	-241.0	-4.0	19.0	-18.0	26.0	-5.0	10.0	-8.0	-33.0	62.0	-8.0	-20.0	-1.0	14.0	-2.0	-32.0
2558	-232.0	-5.0	19.0	-17.0	27.0	-4.0	12.0	-4.0	-32.0	55.0	-10.0	-20.0	-4.0	15.0	-4.0	-32.0
2559	-225.0	-8.0	18.0	-15.0	28.0	-3.0	13.0	-1.0	-33.0	50.0	-12.0	-19.0	-6.0	16.0	-6.0	-32.0
2560	-220.0	-10.0	18.0	-12.0	28.0	-1.0	16.0	0.0	-34.0	46.0	-13.0	-20.0	-8.0	17.0	-8.0	-33.0

2561 rows × 16 columns

EEG Data created by dropping the remaining columns

	Sknewness 0f EEG	Value of sknewness 0f EEG	Value of kurtoisis 0f EEG
0	FP2-A2	-1.10	7.75
1	F8 -A2	-0.45	0.24
2	T4 -A2	-0.57	1.05
3	T6 -A2	-0.55	1.14
4	F4 -A2	-0.41	0.64
5	C4 -A2	-0.38	0.27
6	P4 -A2	-0.30	0.49
7	O2 -A2	-0.39	-0.13
8	FP1-A1	0.51	3.52
9	F7 -A1	1.21	9.85
10	T3 -A1	0.18	0.28
11	T5 -A1	0.43	0.43
12	F3 -A1	-0.32	2.30
13	C3 -A1	-0.76	4.43
14	P3 -A1	0.14	-0.30
15	O1 -A1	-0.04	0.50

Skewness and Kurtosis of EEG



Dark-Blue consists of Filtered and Light-Blue consists of Unfiltered EEG Signal

	FP2-A2	F8 -A2	T4 -A2	T6 -A2	F4 -A2	C4 -A2	P4 -A2	O2 -A2	FP1-A1	F7 -A1	T3 -A1	T5 -A1
count	2560.000000	2560.000000	2560.000000	2560.000000	2560.000000	2560.000000	2560.000000	2560.000000	2560.000000	2560.000000	2560.000000	2560.000000
mean	-467.612891	-979.899219	-664.623047	-277.748438	-1018.600781	-355.410547	-40.244531	-715.134766	82.114453	138.969531	-254.965625	-146.558203
std	152.551274	51.434969	24.354706	24.541421	27.836681	25.734475	23.091480	37.973884	38.186690	65.227272	22.399696	20.076751
min	-824.000000	-1134.000000	-782.000000	-392.000000	-1136.000000	-456.000000	-131.000000	-823.000000	-32.000000	-167.000000	-324.000000	-197.000000
25%	-530.000000	-1011.000000	-679.000000	-292.000000	-1034.000000	-370.000000	-54.000000	-741.000000	63.000000	124.000000	-270.000000	-160.000000
50%	-508.000000	-969.000000	-663.000000	-276.000000	-1017.000000	-354.000000	-39.000000	-714.000000	77.000000	141.000000	-256.000000	-148.000000
75%	-477.000000	-942.000000	-649.000000	-261.000000	-1001.000000	-338.000000	-25.000000	-687.000000	94.000000	158.250000	-241.000000	-134.000000
max	107.000000	-878.000000	-594.000000	-213.000000	-936.000000	-281.000000	24.000000	-609.000000	262.000000	427.000000	-168.000000	-70.000000

Mean, Max, Min Value of Filtered Dataset EEG Unfiltered Part

BP1-REF	BP2-REF
2560.000000	2560.000000
-827.587109	-644.685938
222.394599	24.406880
-1199.000000	-747.000000
-994.000000	-655.000000
-850.000000	-645.000000
-718.000000	-631.000000
239.000000	-544.000000

Mean, Max, Min Value of Unfiltered Dataset ECG and EMG of Part

	Parameter	Value
0	ECG_Skewness	1.410339
1	ECG_Kurtoisis	3.258239
2	EMG_Skewness	-0.034642
3	EMG_Kurtoisis	1.557795

Unfiltered Dataset Skewness and Kurtosis ECG and EMG of Part

```
df = pd.DataFrame(eeg_data_1)

df.drop(['FZ -A2 ','CZ -A1 ','PZ -A2 ','BP1-REF','BP2-REF'],axis = 1)
```

	FP2-A2	F8 -A2	T4 -A2	T6 -A2	F4 -A2	C4 -A2	P4 -A2	O2 -A2	FP1-A1	F7 -A1	T3 -A1	T5 -A1	F3 -A1	C3 -A1	P3 -A1	O1 -A1
0	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
1	-499.0	-937.0	-661.0	-254.0	-989.0	-331.0	-27.0	-665.0	94.0	153.0	-251.0	-163.0	17.0	-198.0	51.0	355.0
2	-505.0	-938.0	-664.0	-254.0	-990.0	-328.0	-31.0	-666.0	91.0	150.0	-261.0	-168.0	14.0	-201.0	50.0	355.0
3	-502.0	-934.0	-666.0	-249.0	-989.0	-323.0	-30.0	-662.0	83.0	146.0	-259.0	-173.0	11.0	-202.0	48.0	350.0
4	-499.0	-931.0	-664.0	-248.0	-989.0	-318.0	-29.0	-658.0	74.0	144.0	-267.0	-177.0	9.0	-203.0	48.0	352.0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
2556	-786.0	-943.0	-646.0	-300.0	-996.0	-357.0	-19.0	-727.0	6.0	301.0	-288.0	-175.0	-7.0	-269.0	42.0	312.0
2557	-783.0	-944.0	-645.0	-296.0	-994.0	-355.0	-17.0	-725.0	-1.0	297.0	-296.0	-182.0	-11.0	-274.0	41.0	310.0
2558	-778.0	-943.0	-644.0	-288.0	-987.0	-347.0	-11.0	-718.0	2.0	296.0	-295.0	-182.0	-11.0	-269.0	43.0	313.0
2559	-776.0	-944.0	-648.0	-284.0	-984.0	-347.0	-6.0	-717.0	5.0	294.0	-293.0	-181.0	-10.0	-265.0	39.0	314.0
2560	-780.0	-946.0	-649.0	-283.0	-987.0	-347.0	-4.0	-717.0	8.0	292.0	-288.0	-180.0	-10.0	-267.0	39.0	321.0

2561 rows × 16 columns

Dropping the Z, ECG and EMG Values of the Unfiltered Dataset

	Sknewness 0f EEG	Value of sknewness 0f EEG	Value of kurtoisis 0f EEG
0	FP2-A2	2.107398	4.8800
1	F8 -A2	-0.676946	-0.2170
2	T4 -A2	-0.558587	1.2770
3	T6 -A2	-0.691371	1.2690
4	F4 -A2	-0.538441	1.2515
5	C4 -A2	-0.475848	0.4629
6	P4 -A2	-0.367521	0.5497
7	O2 -A2	-0.148263	-0.3300
8	FP1-A1	0.838840	2.7100
9	F7 -A1	0.026736	7.7500
10	T3 -A1	0.223340	0.2110
11	T5 -A1	0.442616	0.4000
12	F3 -A1	-0.397332	1.3600
13	C3 -A1	-0.866406	3.9300
14	P3 -A1	0.133289	-0.5000
15	O1 -A1	0.294989	0.0900

Skewness and Kurtosis of EEG of Unfiltered data

Conclusion:

- Feature extraction is an important step in the process of electroencephalogram (EEG) signal classification. ... Wavelet based feature extraction such as, multi-resolution decompositions into detailed and approximate coefficients as well as relative wavelet energy were computed.

- The electroencephalogram (EEG) is a dynamic non-invasive and relatively inexpensive technique used to monitor the state of the brain. ... An EEG signal recorded with electrodes placed on the scalp consists of many waves with different characteristics. Arrays of electrodes are distributed over the entire scalp

- Statistical features like **mean, median, variance, standard deviation, skewness, kurtosis**, and similar are also used in the frequency domain. Relative powers of the certain frequency bands are the most used frequency-domain features in all fields of analysis of the EEG signals.