Project Report

DH 604

OBSTRUCTIVE SLEEP APNEA

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INTRODUCTION

Background

Problem

Goals

BACKGROUND

- Obstructive sleep apnea (OSA) is a serious medical condition characterized by recurrent partial or complete obstruction of upper airway.
- The current gold standard test for confirming clinical suspicion of OSA is overnight polysomnography (PSG).
- It is a multi-channel monitoring technique that analyses electro-physiological and cardio-respiratory patterns of sleep for a period of 8 hours.

PROBLEM

PSG scoring requires a technician to manually scan through the 8 hours of multi-channel records before the patient can be assigned an apnea-hypopnea index (AHI) which is indicative of the severity of the diseas

GOALS

Develop machine learning-based models that can

- Reduce the time required by technicians to generate a final assessment
- Determine the most optimal channels for classifying the severity of disease

RESEARCH PROCEDURE

Identify relevant channels → Identify critical points → Observe variation in relevant channels at critical points

Step 1

IDENTIFYING RELEVANT CHANNELS

IDENTIFYING RELEVANT CHANNELS

1. Load the entire 8 hour data (utilized mne)
2. Compute mean values for all categories
3. Repeat this process for all patients

IDENTIFYING RELEVANT CHANNELS

1. Tabulate these mean values for all channels across all 4 types of patients- Normal, Mild, Moderate and severe
2. Compute varying coefficient for all categories which is defined as-

$$C = \sigma / \mu$$

σ -standard deviation of means across 4 patients

μ -average of means across 4 patients

IDENTIFYING RELEVANT CHANNELS

$c = \sigma / \mu$

This value describes the change in a category across different patients

category	mild_mean	moderate_m	normal_mear	severe_mea	ovr_mean	std	var_coeff
EEG A1-A2	-0.000366715	9.83E-08	-3.541354326	0.057627076	-0.871023466	1.54189688	1.77021279
Pleth	-0.000979047	-0.001986151	-1.118041035	-0.001893453	-0.280724922	0.48342484	1.722058877
Snore	-0.008972246	-0.008871492	-1.125504066	-0.008969372	-0.288079294	0.48348742	1.678313678
Effort THO	-0.025801552	-0.00749431	-1.125572993	-0.007365651	-0.291558627	0.48157683	1.651732398
Effort ABD	-0.032402993	-0.00727514	-1.132636744	-0.007207205	-0.294880521	0.48378785	1.640623289
Leg 1	-0.098804952	-9.85E-08	-0.968276854	-0.095566214	-0.29066203	0.39322949	1.352875329
EEG F3-A2	-6.141882229	-4.63E-06	-54.65027824	-4.85786656	-16.41250792	22.1951168	1.352329387
EMG Chin	-0.092728525	-9.84E-08	-0.969491112	-0.130632691	-0.298213106	0.39046519	1.309349537
Leg 2	-0.120541456	-1.20E-07	-0.990392752	-0.120162126	-0.307774113	0.39716098	1.290430087
ECG IIHF	-18.81442774	-1.78E-05	-118.8367849	-18.4208072	-39.0180094	46.7061828	1.197041661
ECG II	-20.19902086	-1.88E-05	-120.4720169	-19.45464697	-40.03142587	47.1432136	1.177655119
xPAP IPAP	0.976128472	4.320277778	0	11.38271032	4.169779142	4.46193592	1.070065289
xPAP CPAP	0.976128472	4.320277778	0	11.38271032	4.169779142	4.46193592	1.070065289
Leak Total	4.911848611	20.09667465	-1.479111111	41.74645	16.31896554	16.6412282	1.019747737
xPAP EPAP	0.976128472	4.320277778	0	7.836361111	3.28319184	3.07850563	0.937656336
ECG I	-43.23532238	-4.72E-05	-140.4361856	-41.13936321	-56.20272961	51.5971784	0.918054467
EOG ROC-A2	-4.49002786	-4.95E-06	-8.04688864	-4.971298482	-4.377054984	2.87193899	0.656135004
EEG C4-A1	8.280906891	8.64E-06	5.28574054	8.503809725	5.51761645	3.42968244	0.621587686
EEG C3-A2	-7.003112696	-8.27E-06	-9.114390285	-6.045762951	-5.54081855	3.38615809	0.611129576
EOG LOC-A2	14.1435309	1.51E-05	11.61131064	17.29122088	10.76151937	6.5308331	0.606869056
EEG F4-A1	-12.10329939	-1.27E-05	-15.72098725	-12.84008545	-10.16609619	6.02306076	0.59246545
EEG O1-A2	305.8095819	0.000294037	295.2978968	304.5003879	226.4020402	130.775857	0.577626673
EEG O2-A1	307.6666206	0.000298903	298.4918323	307.4943578	228.4132774	131.926497	0.577578057
PulseRate	69.42645833	66.74993056	75.99243056	65.64174603	69.45264137	4.01861597	0.05786124
SpO2	91.74166667	95.49597222	94.360625	89.61837302	92.80415923	2.28837099	0.024658065
RR	187.8262882	188.7844132	184.9722674	188.6244167	187.5518464	1.53290363	0.008173226
Technical	30799.23824	30803.86311	30464.36277	30812.59149	30720.0139	147.678111	0.004807228

IDENTIFYING RELEVANT CHANNELS

Repeated the same analysis but for hour to hour data and find which channels' varying rate varies a lot across hours

category	hour1_vc	hour2_vc	hour3_vc	hour4_vc	hour5_vc	hour6_vc	hour7_vc	ovr_mean	ovr_std	overall_var_coeff
Leg 2	0.003188	0.002701	0.001849	0.002888	0.002544	0.002544	1.620259	0.23371	0.61141	2.616102083
Snore	0.005896	0.006557	0.007864	0.006981	0.009277	0.009277	1.725168	0.253003	0.649165	2.565840565
EEG C4-A1	0.12851	0.035343	0.071917	0.012041	0.016118	0.016118	8.511762	1.255973	3.199777	2.547647929
Leg 1	0.004278	0.033213	0.007087	0.006334	0.005034	0.005034	1.639401	0.242912	0.615881	2.535411304
Pleth	25.77322	0.424855	0.554179	0.327807	0.430898	0.430898	1.729565	4.238774	9.508296	2.243171134
ECG I	0.280354	0.168375	0.08388	0.089892	0.022947	0.022947	1.387774	0.293738	0.490758	1.670729748
EEG F3-A2	0.731936	0.076356	0.237525	0.026622	0.013231	0.013231	1.515124	0.373432	0.565461	1.514227159
EOG ROC-A2	0.163148	0.083587	0.404792	0.015793	0.017432	0.017432	0.983565	0.240821	0.355845	1.477630845
EEG A1-A2	1.063166	2.046176	1.434556	4.698712	49.74488	49.74488	1.739879	15.78175	23.23123	1.472031449
EOG LOC-A2	0.685461	0.187065	0.13973	0.043242	0.048311	0.048311	1.584722	0.390977	0.573326	1.466391355
EMG Chin	0.127344	0.343448	0.301568	0.122963	0.088316	0.088316	1.641085	0.387577	0.562359	1.45095834
EEG C3-A2	0.618106	0.023334	0.183798	0.018803	0.025511	0.025511	0.893421	0.255498	0.355735	1.392321827
Effort THO	1.446563	0.278313	0.065889	0.183771	0.046207	0.046207	1.724274	0.541603	0.722515	1.334029737
EEG F4-A1	0.316545	0.008941	0.446973	0.007031	0.005023	0.005023	0.578986	0.195503	0.247602	1.266483036
ECG IIHF	0.448122	0.377428	0.212142	0.179984	0.161154	0.161154	1.575917	0.445129	0.511394	1.148867732
ECG II	0.440908	0.380343	0.221162	0.180114	0.160978	0.160978	1.568167	0.444664	0.507823	1.142037492
Effort ABD	2.356978	1.078532	0.060595	0.192147	0.149324	0.149324	1.711131	0.814004	0.921368	1.131895001
SpO2	0.083667	0.043078	0.013914	0.0113	0.011603	0.011603	0.080457	0.036517	0.033129	0.907208605
EEG O2-A1	0.023585	0.00249	0.012138	0.01921	0.031332	0.031332	0.083118	0.029029	0.025987	0.895199702
EEG O1-A2	0.025539	0.004471	0.014438	0.023082	0.03858	0.03858	0.084729	0.032774	0.025981	0.792743016
Leak Total	0	0	1.352482	1.096912	1.104641	1.104641	1.272098	0.847253	0.586835	0.692632144
PulseRate	0.068611	0.066652	0.075775	0.054312	0.103015	0.103015	0.090319	0.080243	0.018934	0.235962744

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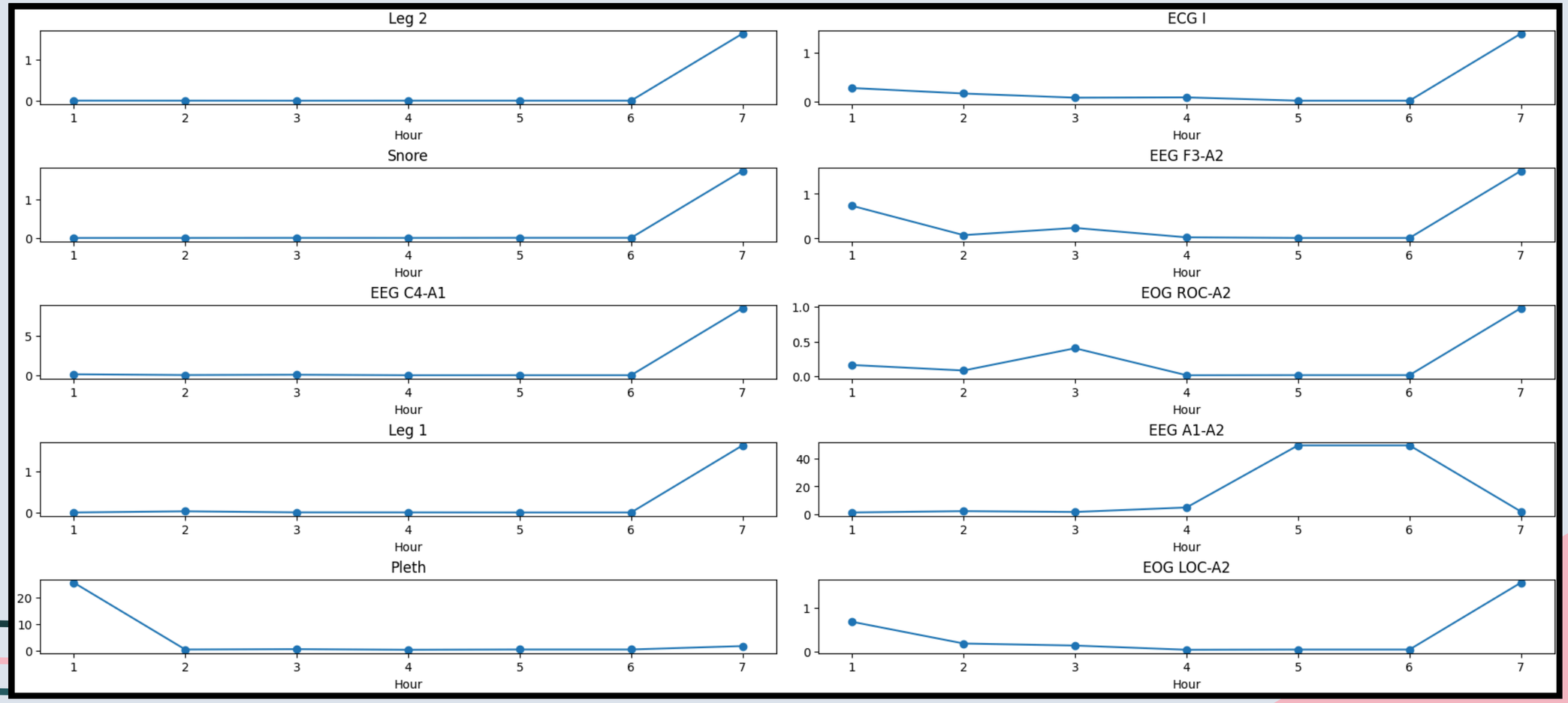

Step 2

IDENTIFYING CRITICAL POINTS

IDENTIFYING CRITICAL POINTS

Background

Apnea Points: ↓ flow ≥ 90% from baseline for at least 10 seconds (Oronasal flow)

Hypoapnea Points: ↓ flow ≥ 30% from baseline for at least 10 seconds (nasal air pressure) with 3% O2 desaturation OR arousal

IDENTIFYING CRITICAL POINTS

Preprocessing

1. Removed outliers (outside 3 x 99 percentile)

2. Replaced NAN values with column mean

3. Utilized Numpy decimate to scale down our dataset from 1 value per 0.001 second to 1 value per 1 second

IDENTIFYING CRITICAL POINTS

Methodology

The function identifies points by iterating through each data point, calculating a running mean. When a value drops to 10% (70% for hypoapnea) or less of the previous mean, it checks the next 9 values to confirm if the low level persists. If all values in the subset are also below this threshold, the index is recorded as an apnea point. The function continues until the value rises above 10% of the previous mean, resuming its scan from the last checked point. The output is a list of indices where these apnea events are detected.

Observed trend matches the actual trend

AHI Index-> Severe > Moderate > Mild > Normal

IDENTIFYING CRITICAL POINTS

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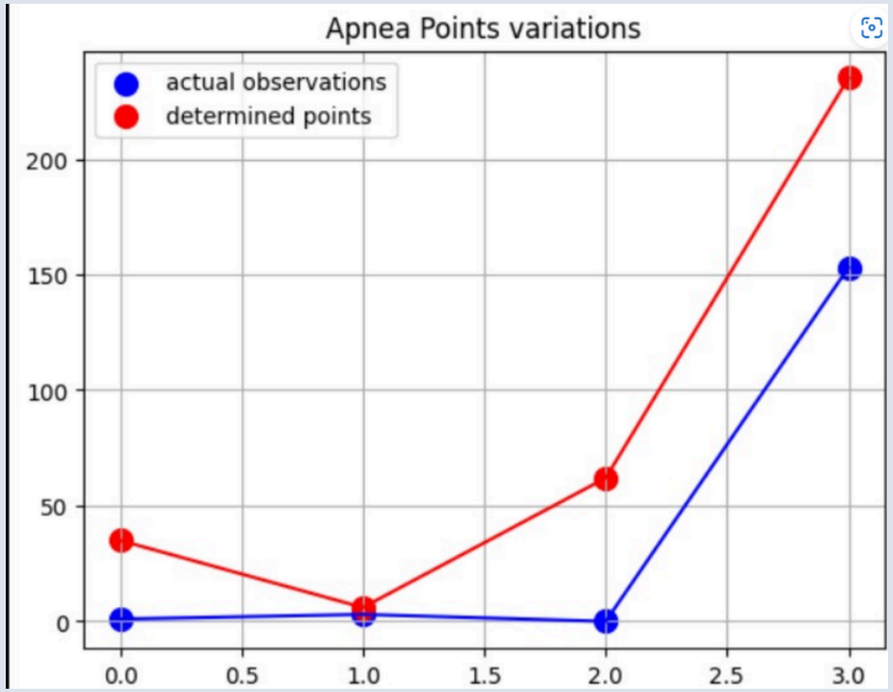
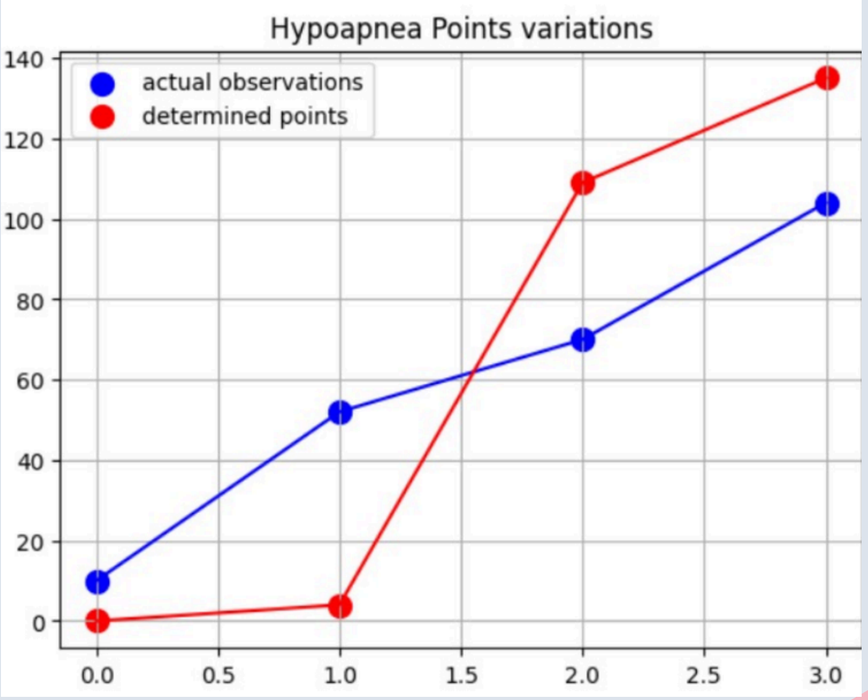


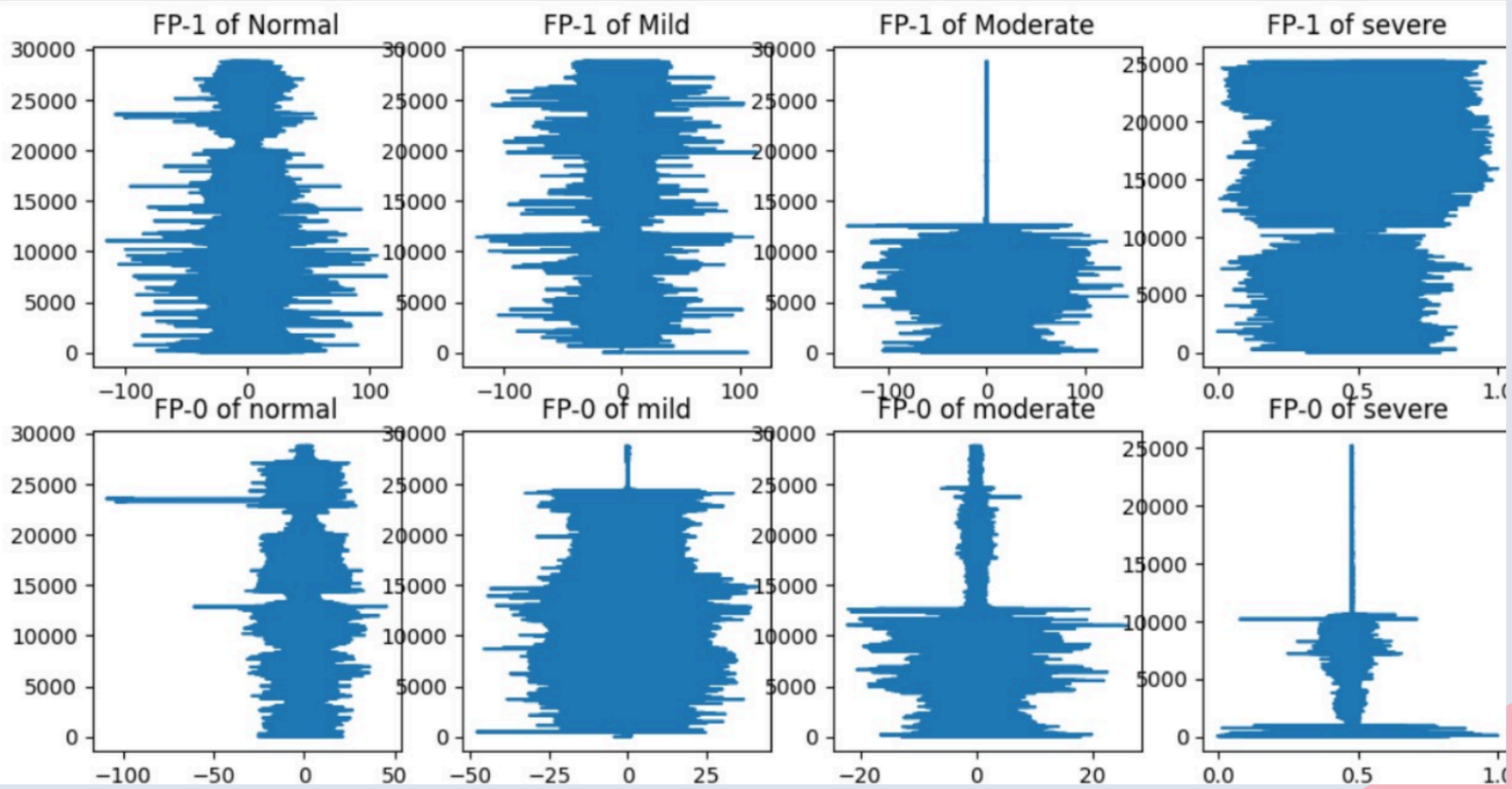


Step 3

OBSERVE VARIATIONS IN RELEVANT CHANNELS AT CRITICAL POINTS

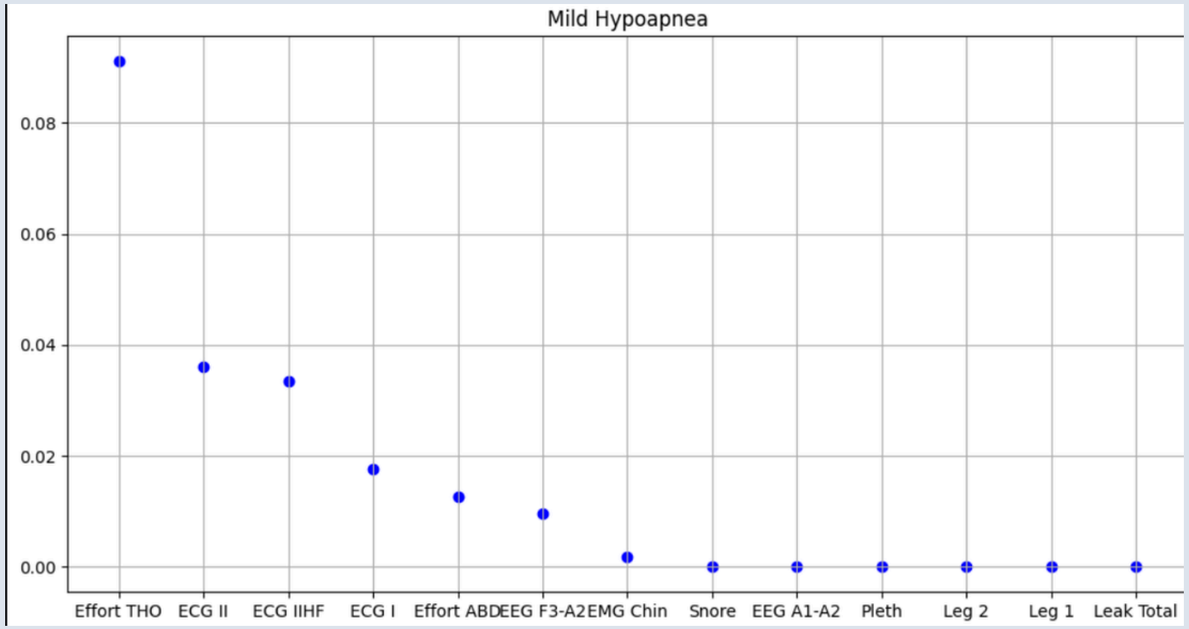
OBSERVE VARIATIONS IN RELEVANT CHANNELS AT CRITICAL POINTS

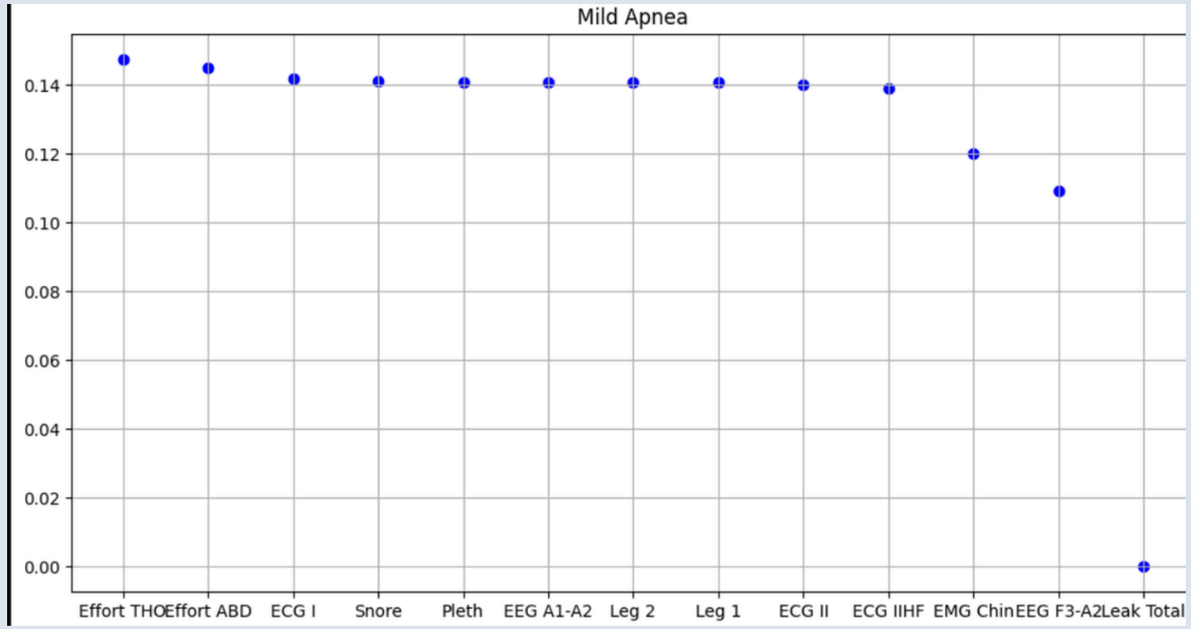
Flow channel variations across the dataset



OBSERVE VARIATIONS IN RELEVANT CHANNELS AT CRITICAL POINTS

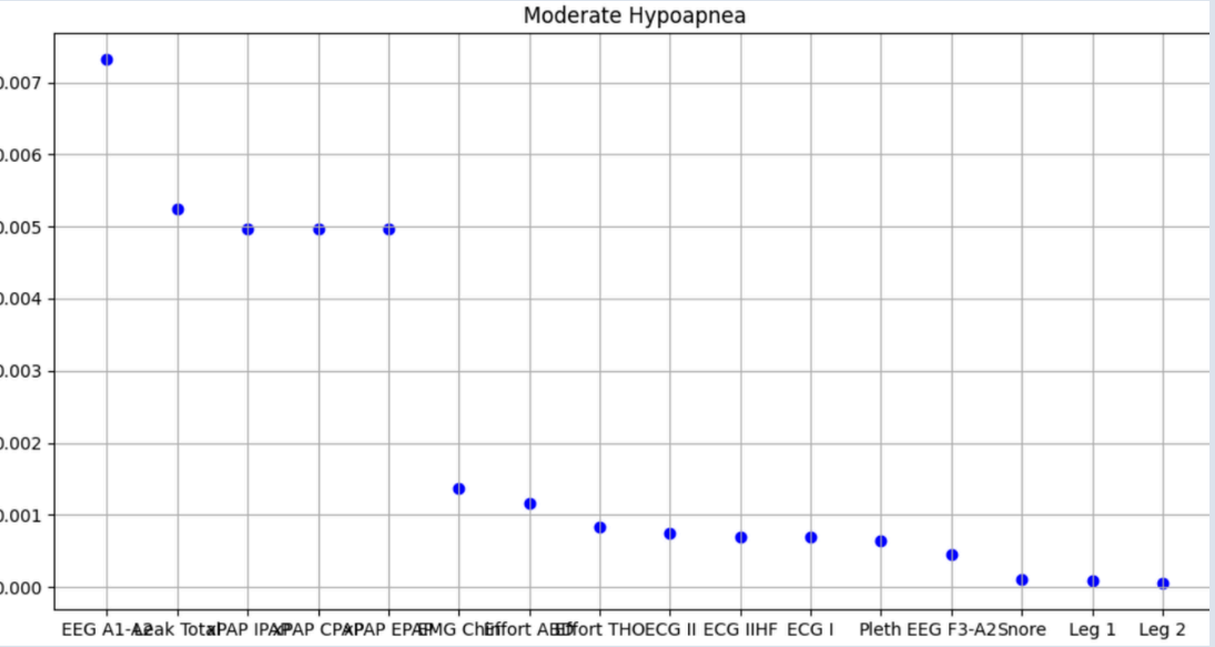
%Variation across other channels

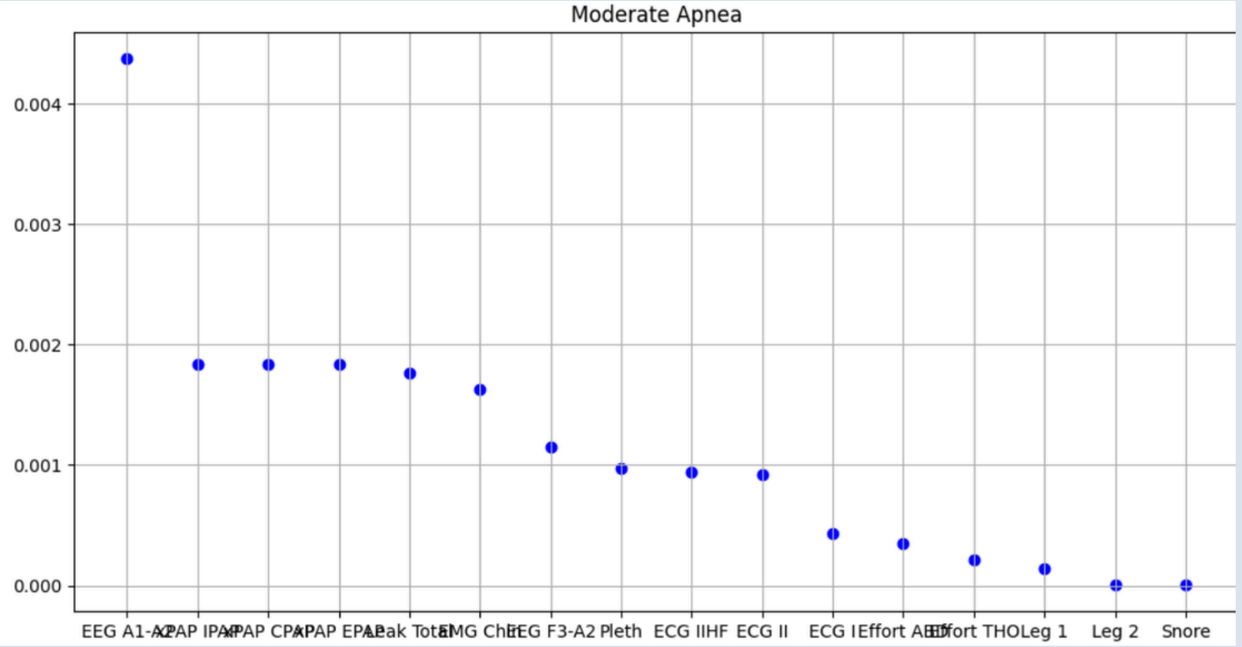




OBSERVE VARIATIONS IN RELEVANT CHANNELS AT CRITICAL POINTS

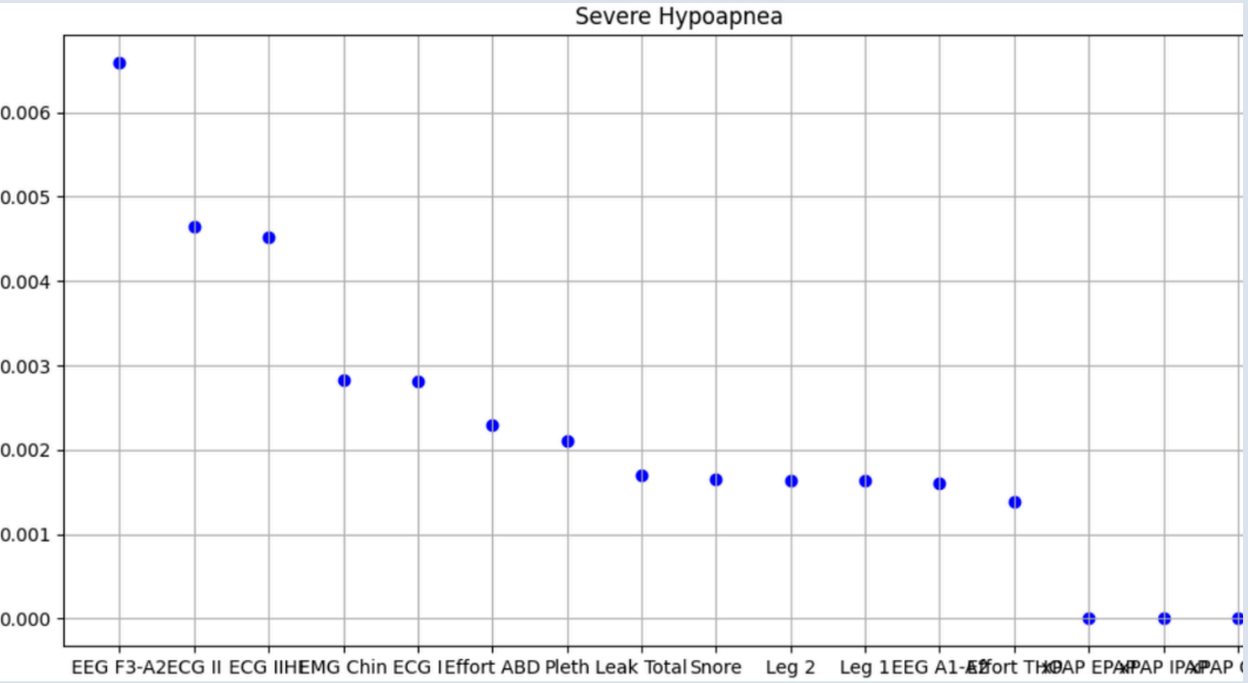
%Variation across other channels

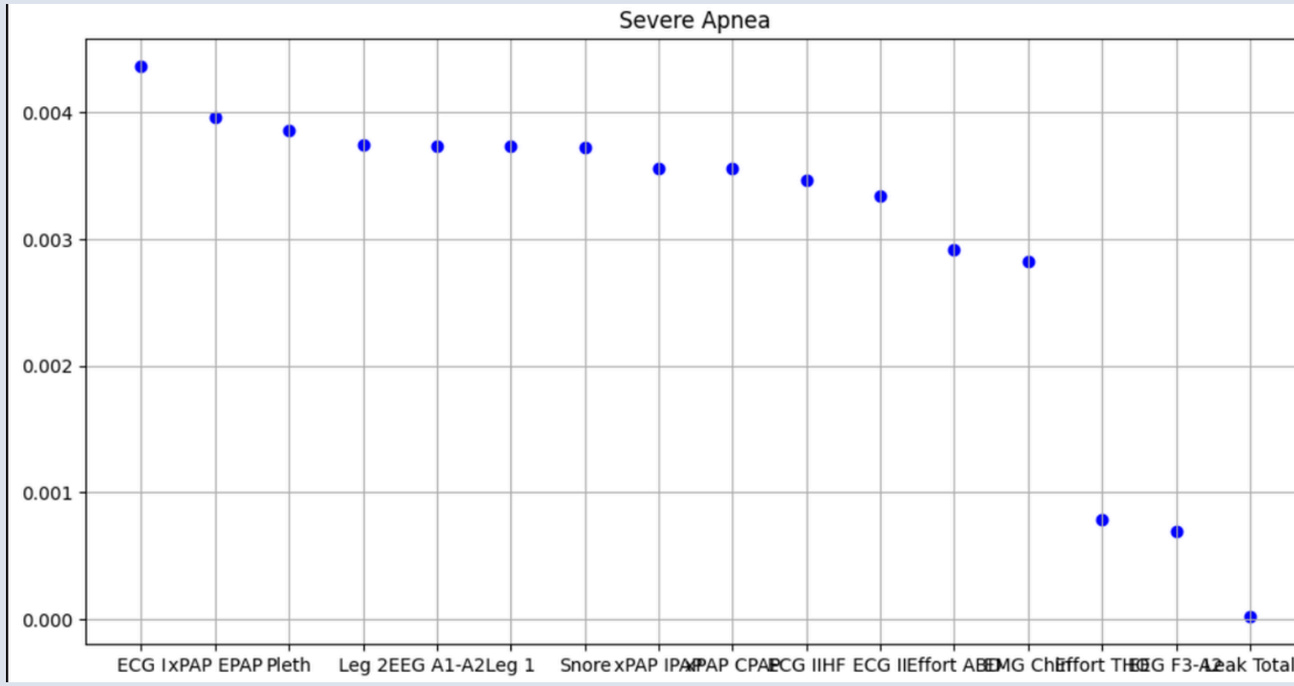




OBSERVE VARIATIONS IN RELEVANT CHANNELS AT CRITICAL POINTS

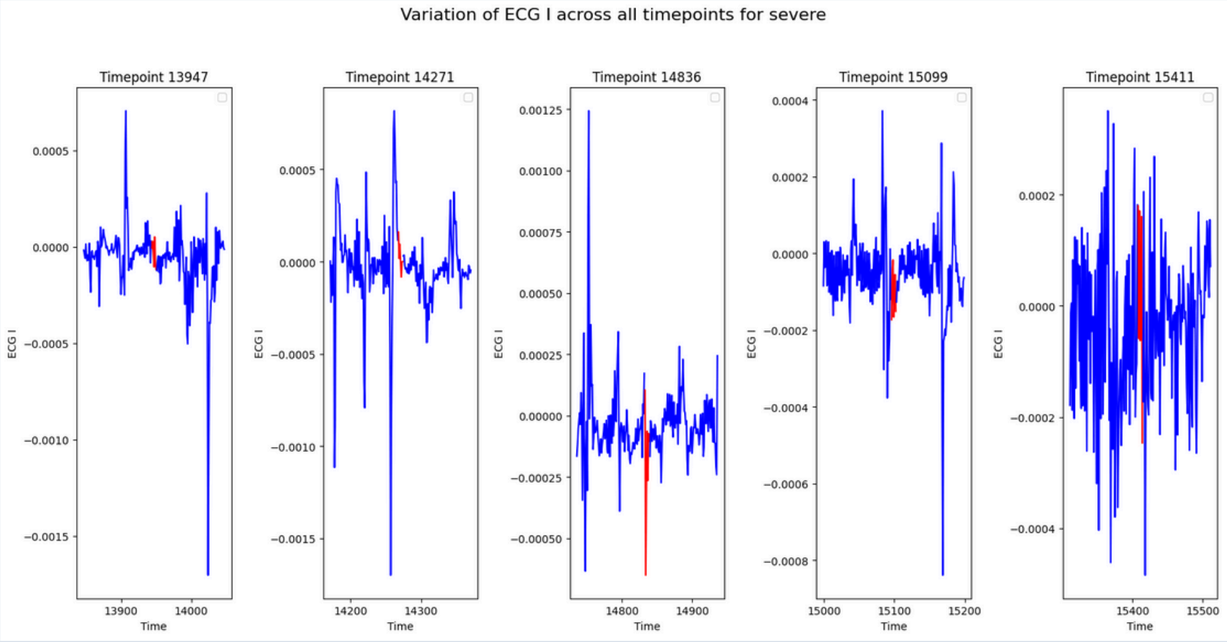
%Variation across other channels



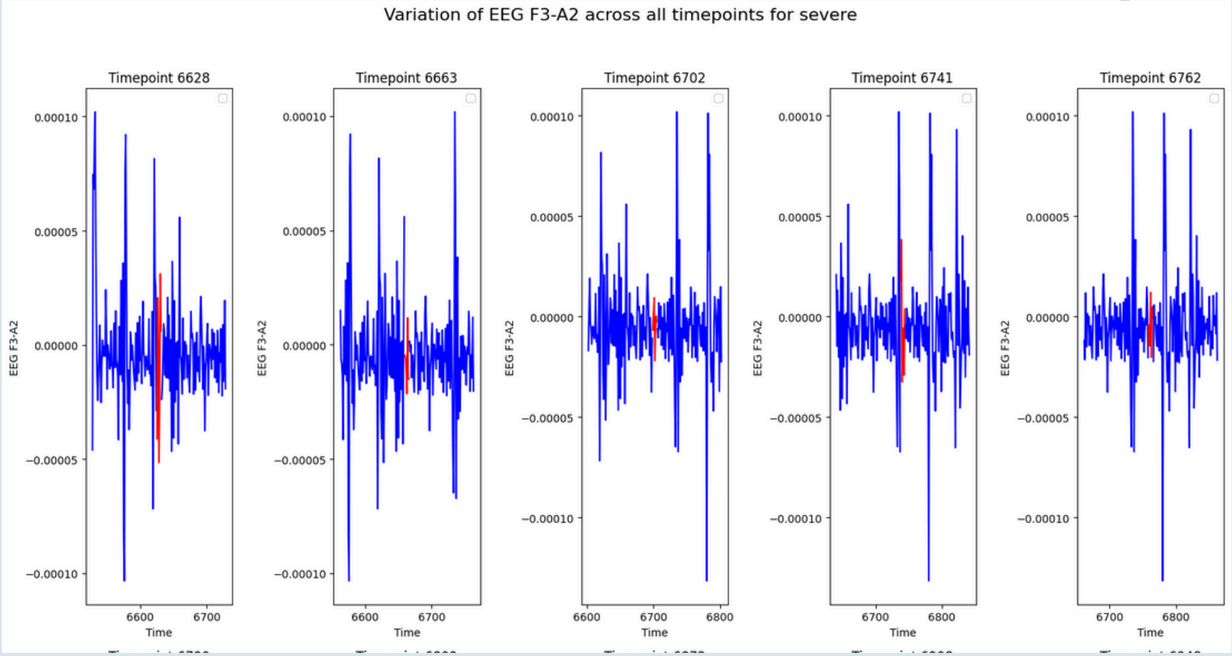


OBSERVE VARIATIONS IN RELEVANT CHANNELS AT CRITICAL POINTS

Concluding some critical observations



ECG1

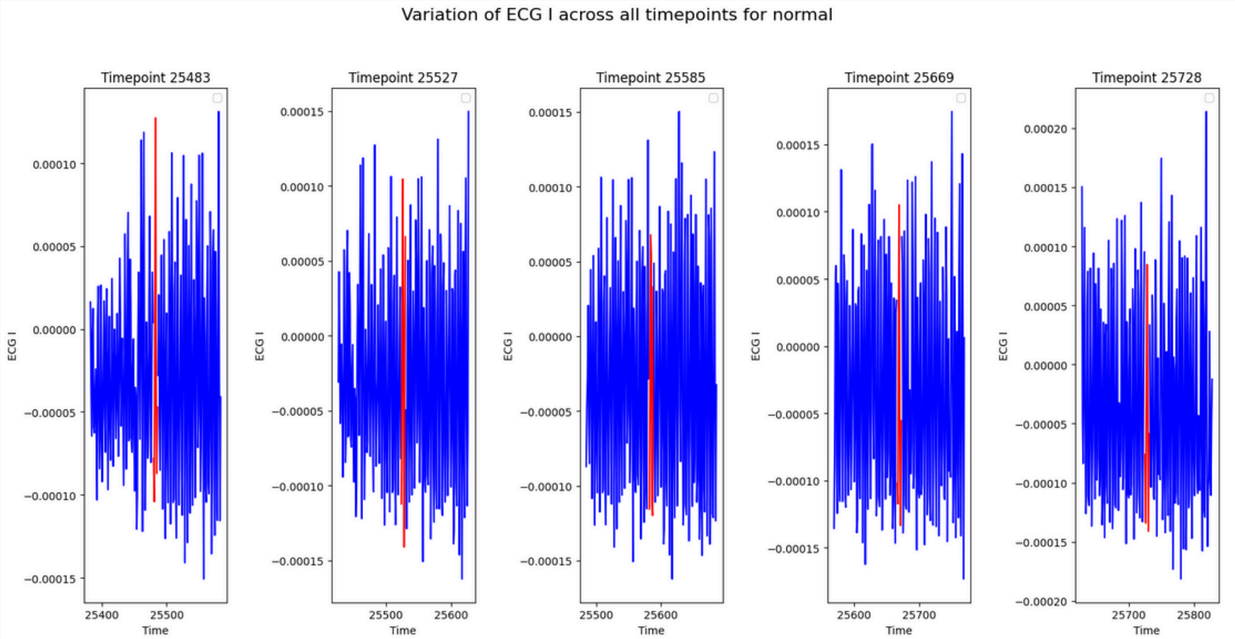


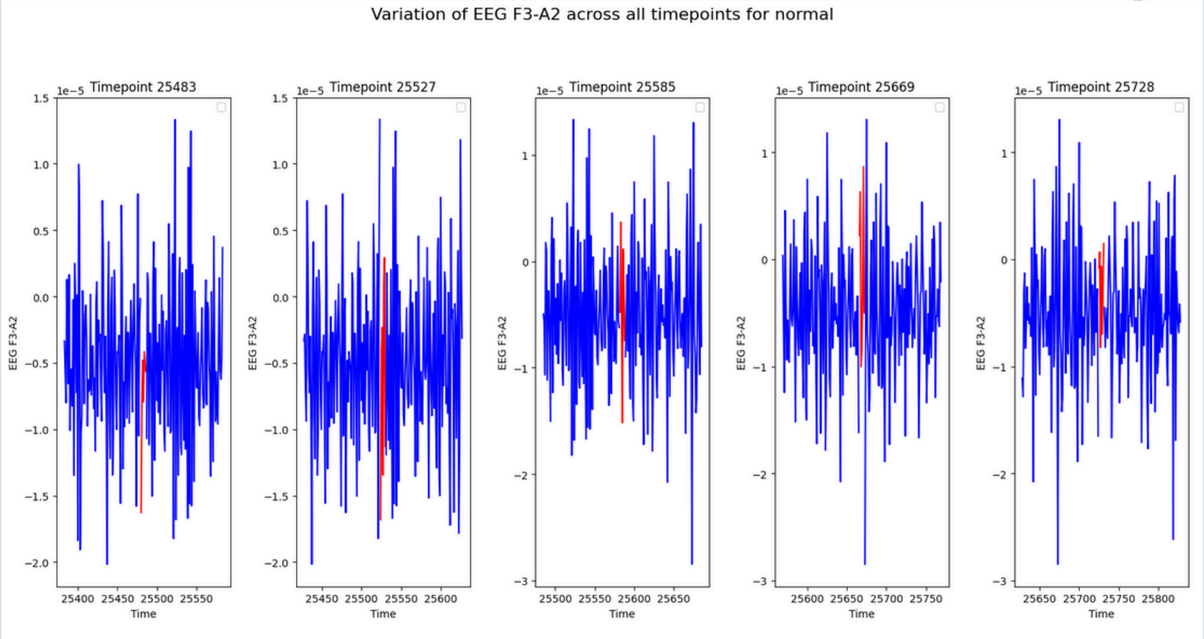
EEG F3-A2

Severe patient

OBSERVE VARIATIONS IN RELEVANT CHANNELS AT CRITICAL POINTS

Concluding some critical observations





ECG1

EEG F3-A2

Normal patient

THANK YOU

By Shahu Patil