Spectral Analysis of Polysomnograph

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Abstract*: The Polysomnography (PSG) is the most commonly used test in the diagnosis of OSAS – Obstructive Sleep Apnea Syndrome. PSG signals consist of simultaneous recording of multiple physiological parameters related to sleep and wakefulness. PSG is used to evaluate abnor-malities of sleep and or wakefulness and other physiological disorders that have an impact on or related to sleep and or wakefulness. In this paper, we propped an idea of detection of insomnia based on frequency spectral analysis of PSG signals. The PSG signals consist of EMG of the chin, EEG taken from various lobes, respiratory signal, EOG signals, Temporary rectal signal and ECG signal. From all these physiological parameters, the Spectral analysis of EOG (horizontal), EEG FPZ-CZ and PZ-OZ [EEG 10-20 electrodes paced on midline FPZ,CZ,OZ channels]signals are analyzed and the mean, variance, standard deviation, RMS value and SNR features of the signal are extracted. The proposed methodology is applied to the male as well as female subjects at the age group of 30-40 years. The difference of the frequency range taken at respective intervals of time is noted and compared.

***Keywords* : OSAS-Obstructive Sleep Apnea; PSG-Polysomnography; RMS-Rootmeansquare; SNR-Signaltonoise Ratio.**

I. INTRODUCTION

This Polysomnography is the medical procedure that is useful in diagnosing sleep disorders. The monitoring parameters that are involved in PSG are EEG , ECG ,EOG ,EMG, Pulse oximeter ,nasal cannula and others .PSGs are used in diagnosis of sleep apnoea, narcolepsy ,idiopathic hypersomnia ,sleep paralysis .Insomnia is a disorder of sleep ,insomnia may be caused by cardiac rhythm disruption, arthritis , bipolar disorders, and also may be due to hormonal problems. It is caused by physical and psychological factors. The types of insomnia are chronic, transient, and acute. Insomnia is detected using PSG by estimating the parameters of the signals taken from the EEG[FPZ-OZ-CZ], EOG[Vertical], EMG [Surface chin], Temp rectal, Respiratory Oro Nasal. In this paper we are detecting the power spectral density of PSG signal taken from data-base (physio net) and detecting the insomnia condition and comparing abnormal condition in male and female subjects.

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II. REVIEW CRITERIA

4]PK Stein1 ,et all.., determines the bed and wake times from con-tinuous ECG recordings in the elderly, PSG (polysomnogram), ECG channels were extracted and scanned on a Holter analyzer for N=56 participants (age 76±3) in the Sleep Heart Health Study who had 2 PSGs 5 years apart. Bed and wake times were determined from a combination of 5-min averaged HR and HRV patterns and from HR tachograms of normal-to-normal intervals. Bed and wake times were also extracted from the PSGs. PSG- and HRV bed and wake times were compared via paired t-tests and correlation analy-sis. Correlations between PSG- and HRV-determined bed and wake times were ≤0.95. HRV-derived bed and wake times were slightly (4±7 min) earlier for and 5±11 min earlier the 2 PSGs, p≤0.001.

Mean PSG and ECG-based wake times were closer (12±20s earlier, p=0.069 and 2±8 min later, p=0.049 for the [2] PSGs). Therefore, determination of bedtime and wake time patterns in large Holter cohorts without activity diaries is feasible.

[5]Jacqueline Fairley, ET all, investigates the application of an au-tomated approach, using the generalized singular value decomposi-tion algorithm, to compensate for specific PSG artifacts. They im-plemented analysis of Manual/visual polysomnogram (PSG) and the procedure utilized in the diagnosis and treatment of sleep related human pathologies. Current technological trends in PSG analysis focus upon translating manual PSG analysis into automated/computerized approaches. A necessary first step in establishing efficient automated human sleep analysis systems is the development of re-liable pre-processing tools to discriminate between outlier/artifact instances and data of interest. This paper investigates the application of an automated approach, using the generalized singular value decomposition algorithm, to compensate for specific PSG artifacts. [3] Sana Tmar-Ben Hamida, et all. proposed an simplified efficient insomnia detection algorithm of polysomnography based on central single electroencephalographic(EEG) channel(C3) using only deep sleep. Also analyzed several spectral and statistical EEG features of good sleeper controls and subjects suffering from insomnia in different sleep stages to identify the features that offered the best dis-crimination between the two groups. The proposed algorithm was evaluated using EEG recordings from 19 patients diagnosed with primary insomnia (11females,8males) and 16 matched control sub-jects (11 feamles,5 males). The sensitivity of the algorithm is 92%, the specificity is 89.9%,the Cohen’s kappa is 0.81 and the agreement is 91%,indicating the effectiveness of the proposed method.

[1] Smruthy A, ET all, introduced a novel method for classification of healthy and apnea subjects using variational mode decomposition. The proposed method distinguishes the apnea and normal sub-jects with the help of an Electrocardiogram (ECG) signal. Polysomnogram is the gold standard used for identification of apnea subjects. The process is complex, expensive and time consuming. In that paper both online and offline based feature extraction and classification methods are explored. The proper extraction of suitable features from the signal was done by applying variational mode decomposition. Two features are extracted from the variational mode functions (VMFs) namely energy and RR interval of ECG signal. These features are fed in to a support vector machine classi-fier where they are classified as healthy and apnea. The accuracy obtained for both online and offline processes are 97.5% and 95% respectively.

[2] Stephen J. Bethel, et all.., developed a simpler sleep apnea re-cording system that restricts the electrodes and sensors to the area of a shirt. Electrocardiogram signals are recorded by three electrodes, and electromyogram of the intercostal muscles are recorded to monitor respiratory activity. A prototype has been made from an athletic shirt which houses all electronics. Custom made LabView programs analyze and plot the signals for assessment of variability of the heart rate and respiration rate, which may be used to identify possible episodes of sleep apnea. Further development and testing were necessary toward wider application

III. METHODOLOGY

In this paper, the polysomnographic signals of a [4] female and 4 males (volunteered subject) are analyzed from the physio net data-base that contains 61 PSG signals. The PSG signal consists of EEG (taken from FPZ-CZ and PZ-OZ electrode location), EOG (horizontal), EMG (sub mental chin) and event marker that contains ORO nasal respiration and rectal body temperature. The PSG signals is taken 20 hrs. of time period during 2 subsequent period at the subjects home, the EOG AND EEG signals sampled at 100hz. The power spectral density of the PSG signals is analyzed using mat lab to diagnose the insomnia condition in subjects. the mean, variance, SNR, RMS, S.D are the features extracted from the signals acts as analyzing parameters

FILTERING EOG (HORIZONTAL)

In this paper first, we tested digital low pass filter of cut off frequency 100 Hz that are passed and other signals are attenuated. Differentiation of an EOG signal is necessary to determine threshold or event . Differentiation is the linear time invariant process it can be viewed as LTI system as convolution. The main problem with differentiation in practice is that any noise become amplified. Therefore, we implemented low pass filter at first and then followed by differentiator. The output of the differentiator signal is sampled at 150 Hz and the 1D FFT is applied.

EEG (FPZ –CZ)

The polysomnography signal analyzed in this paper consists of 2 types of EEG signals (i) FPZ-CZ (ii)PZ-OZ . The EEG acquired from various temporal regions exhibit different sleeping pattern waves with different frequencies . The EEG signal is filtered using bandpass filter of cut off frequency 40hz and applied moving aver-age filter to smooth the signal at an order of 20dB. The power spec-tral density (1D FFT) applied to the signal, the mean, frequency, variance, SNR, RMS, standard deviation is calculated.

POWER SPECTRAL DENSITY

The power spectral density is the average of the magnitude squared Fourier transform, at large time duration. PSD is the frequency re-sponse of the random or the periodic signals. Power spectral density function (PSD) shows the energy strength as the frequency function It shows the strong and weak frequency variations. The unit of PSD is energy (variance) per frequency (width) by the integration of PSD within the frequency range the energy can be obtained within the specific frequency range.

IV. RESULTS AND DISCUSSION

The database consists of sleep-hypnogram signals of 62 subjects. The signal is been monitored and recorded during continuous sleeping hours of the subjects. In this paper we have analysed 8 PSG signals that contains EEG FPZ-CZ,EEG PZ-OZ, EOG horizontal ,ECG ,TEMP RECTAL ,EMG submental chin .In that 8 PSG signal we have taken 4 female and 4 male subjects at the age group of 26-35.The EOG horizontal signal and EEG FPZ-CZ ,EEG PZ-OZ signals are analyzed in this paper. Initially the raw signal of EOG is low pass filtered at the frequency of 100Hz and then the signal is differentiated .The moving average signal is applied to smooth the signal and the DC offset noise is been removed .The 1D FFT is applied and peak frequency of the signal is measured and various features like mean ,variance ,standard deviation , SNR ,RMS. The same methodology is applied for EEG FPZ-CZ and EEG PZ-OZ signals but the filtering characteristics is changed to band pass filter of cut off frequency of 40Hz is applied. The regression of frequency(EEG,EOG) and subject is plotted.

V. CONCLUSION

From the values tabulated in the table [4-6], we conclude that female subjects exhibits more delta wave frequency than the male subjects do. Likewise comparing EOG signal of male and female subjects, females exhibits more frequency. On analyzing the dataset taken from the physionet (sleep EDF signal) the female subjects are found to be sleepless (light off condition-10hrs of recording) com-paring to the male subjects. In future all the PSG signals will be analyzed and classified to diagnose the insomnia condition in the subject

Table 1: Peak Frequency of EOG

Subject	Frequency(Hz)
1	2
2	2
3	1.8
4	2.5
5	4
6	2.5
7	3.2
8	3.2

Table 2: Peak Frequency of EEG FPZ-CZ

Subject	Frequency(Hz)
1	1.2
2	0.7
3	1.2
4	1.3
5	1.2
6	0.8
7	0.9
8	0.7

Table 3: Peak Frequency of EEG PZ-OZ

Subject	Frequency(Hz)
1	0.8
2	0.4
3	0.6
4	0.5
5	0.5
6	0.8
7	0.5
8	0.9

Table 4: EEG FPZ-CZ Features

Subject	Gender	Age	Mean	Variance	S.D	RMS	SNR
1	F	33	0.0150225	0.00502877	0.079138	0.0724876	59.4232dB
2	M	27	0.012764	0.00332372	0.0576517	0.0590478	59.0808dB
3	F	33	0.0149992	0.0050272	0.70903	0.072722	62.4834dB
4	F	33	0.130166	0.00373122	0.0610837	0.0624552	61.86dB
5	F	33	0.0125585	0.00348958	0.0590727	0.0603929	61.8666dB
6	M	26	0.00828992	0.00159656	0.039957	0.0408079	62.1813dB
7	M	26	0.0126989	0.003566	0.059716	0.0610513	59.148dB
8	M	26	0.00847482	0.00155977	0.039494	0.040393	62.0842dB

Table 5: EEG PZ-OZ Features

Subject	Gender	Age	Mean	Variance	S.D	RMS	SNR
1	F	33	0.00779022	0.00146081	0.0382205	0.0390064	60.5428dB
2	M	27	0.00574467	0.000700415	0.0264654	0.0270817	59.2405dB
3	F	33	0.00839661	0.00166435	0.407964	0.0416515	64.6158dB
4	F	33	0.0052509	0.00061384	0.0247758	0.0253261	63.5546dB
5	F	33	0.00668244	0.000985766	0.0313969	0.021002	63.3607dB
6	M	26	0.00766369	0.00143014	0.0378171	0.0385859	63.5234dB
7	M	26	0.00566619	0.000783896	0.0279981	0.0285657	59.081dB
8	M	26	0.0100535	0.00227754	0.0477236	0.048771	63.4206dB

Table 6: EOG Features

Subject	Gender	Age	Mean	Variance	S.D	RMS	SNR
1	F	33	0.0260369	0.0160019	0.126499	0.12915	60.1647dB
2	M	27	0.0302593	0.0210081	0.144942	0.148067	60.8934dB
3	F	33	0.0199831	0.00941547	0.0970333	0.0990696	61.0398dB
4	F	33	0.0316099	0.0257428	0.160446	0.16353	62.4707dB
5	F	33	0.399327	0.0410849	0.202694	0.20659	63.2059dB
6	M	26	0.0303154	0.0222337	0.14911	0.15216	62.1692dB
7	M	26	0.0394047	0.0372604	0.19303	0.197011	60.3543dB
8	M	26	0.0369702	0.032663	0.180729	0.184472	61.5519dB

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