

Detection of Rapid Eye Movement Disorder with the Help of Short Time Frequency Applied on EEG Signal

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Abstract: Sleep is a physiological development which performs recuperative functions for the brain and body. It is very necessary to sustain a healthy life status. A sleep disorder is a medical disorder which occurs during sleep. Some disorders are dangerous and harmful. Rapid eye movement behaviour (RBD) is a sleep disorder (also called parasomnia) involves abnormal behaviour during sleep time with rapid eye movement (REM) sleep. REM is the stage in which most vivid dreaming occurs, person unconsciously acts out in his/her dream. These acts can be violent in nature and sometimes cause injury to the patient or to his/her bed partner. This abnormality is measured by a classic non-invasive method known as EEG. This paper shows the use of EEG for the diagnosis of sleep disorder and also aims to promote technology innovation to achieve a reliable and efficient outcome from the diagnosis and to differentiate all the stages of disorder. An interactive MATLAB algorithm is used for processing continuous and event-related EEG waveforms.

Keywords: sleep disorder, REM, EEG, MATLAB algorithm.

I. INTRODUCTION

EEG test is performed when the person is sleeping because when the person is awake no unusual activity is seen. In sleeping condition, change in brainwave patterns occurs which shows more unusual electrical activity [1] The EEG test is performed in hospital using an EEG machine. It takes 1-2 hours for the test and medicine is provided to the patient so that he/she may go to sleep. The EEG (Electroencephalogram) is a recording of the electrical activity of the brain from the scalp. In 1929, Hans Berger was the person by whom first recordings were obtained although similar studies had been carried out in animals in the early 1870s [2]. The recorded waveform hence shows the activity of the brain, which are influenced by electrical activity from the brain structures deep under the cortex. The signals are produced by nerve cells in the brain which are known as action potentials. Synapse is the gap in which these action potentials move across from one cell to other. Neurotransmitter is a special chemical that helps the signals to ram across the gap. Basically these neurotransmitters are of two types one in which it will help the action potentials to move to next cell and the other will stop it from moving to the other nerve cell. The EEG activity is measured in microvolt as it is pretty small with main frequencies of approximately 30 Hz [3]. The waveforms recorder through EEG helps in differentiating between the normal and abnormal signals. The EEG recording is done through electro sensors which are placed on the scalp. This test causes no pain. Certain sleep disorders can be judged using this EEG test.

II. TYPES OF EEG SIGNALS

The signal intensity is quite small and measured in microvolt. The main signal frequencies of the EEG waves are-

DELTA: frequency is of 3 Hz or below. Delta waves are slowest waves and have the highest amplitude. It is normal in infants of one year and in stages 3 and 4 of sleep.

THETA: frequency between 3.5 to 7.5 Hz and activity is slow. It is normal in children of 13 years age and in sleep but abnormal in adults who are not sleeping.

ALPHA: frequency of 7.5 to 13 Hz. Amplitude is higher and usually found on each side in the posterior regions of the head. It appears when the eyes are closed or during relaxing time and vanishes when the eyes are open. It is present in most of life especially after the 13th year or in normal relaxed adults.

BETA: its activity is fast and has a frequency range of 14 Hz and above. It is usually seen on both sides of head and occurs when eyes are open. [4]

III. EEG RECORDING

EEG is recorded with the EEG electrodes placed on the scalp. Electrode gel is applied on the electrodes that are connected through cables and placed on the patient's scalp. These electrodes are made up of stainless steel, tin, gold or silver. Electrodes are like small metal discs which are coated with silver chloride. Every electrode site is specified with a letter and a number. The letters are like for example- F- Frontal Lobe & T-Temporal Lobe. These letters denotes the area of brain on which electrodes are to be placed. Even & odd numbers denotes the right side and left side of the head respectively. Electrode gel increases the skin contact and low-resistance recording can be done through the skin. Smaller the amplitude of the EEG signals, higher the impedance of the electrode. On the EEG machine, EEG signal are recorded with the help of EEG electrodes which are placed on the subject's scalp.[5]

IV. WHAT IS SLEEP DISORDER AND IT'S SYMPTONS?

Sleep is very essential for good physical as well as mental health. A person with good health tends to sleep well while person suffering from sleeping problems might have physical or mental problems. Sleep disorders can cause various other problems like poor health, accidents, impaired job performance, relationship stress and irritation. [6]. Different types of sleep disorders that exist are like Insomnia, Sleep apnea, RLS, Narcolepsy etc. Hence these sleep disorders need to be tracked and should be controlled to improve quality of life.

SYMPTONS:

1. Irritation or sleepy during day.
2. Slowly reacting.
3. Concentrating problem.
4. Tiredness while driving.
5. Trouble in controlling emotions.
6. Take nap almost every day during short interval of time.
7. Feel difficult in staying awake when sitting idle
8. Watching TV or when reading. [7]

V. REM STAGE

This is stage of sleep where most of the dreaming occurs. It is characterised by the random and rapid movement of the eyes. REM sleep is categorised into two: tonic & phasic. REM sleep covers 20-25% of total sleep, which is about 90-120 minutes of a night's sleep. [8] The first REM sleep period occurs 90-120 min after sleep onset & the last REM sleep period occurs during the morning which is also the longest period. During night sleep, person usually experiences about 4 or 5 periods of REM sleep: these are quite short at the starting of the night sleep & longer towards the end. The amount of REM sleep varies with the age. More than 80% of the total sleep of a new born baby spends in REM stage. During REM, the brain's activity is quite same as that during waking period. Hence for this reason, the REM sleep stage is known as paradoxical sleep. REM sleep occurs in all land mammals as well as in birds. There are basically five stages of sleep.[9] Last stage is REM sleep. Most of the dreaming occurs during this last stage. During this stage person move there voluntary muscles such as arms, legs, etc. which sometime becomes dangerous for the partner as well for the person itself.

VI. RESEARCH METHODOLOGY

The EEG signals required for the analysis of these diseases has been acquired from an online source i.e. physionet.org. For the detection of RBD, a comparison of the normal patient and the patient suffering from these problems are required.

GRAPHS

I. For First Normal Patient

REM Stage Graphs

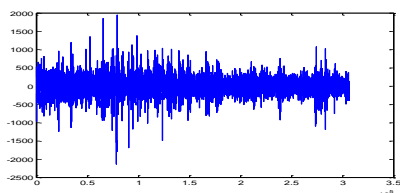


FIG.1. REM SIGNAL

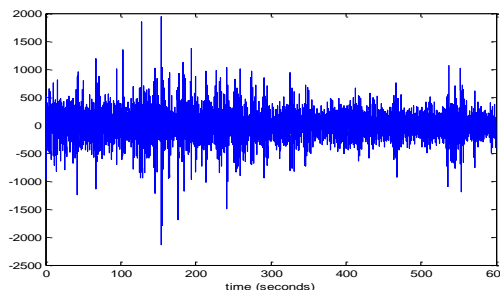


FIG.2. CROPPED SIGNAL

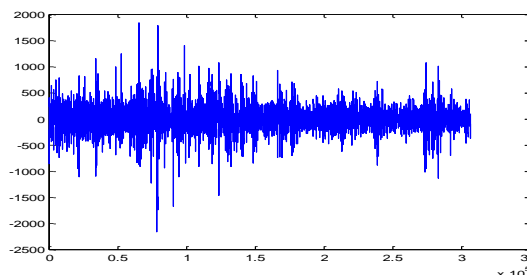


FIG.3. FILTERED SIGNAL

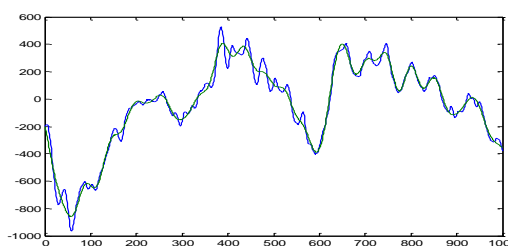


FIG.4. POWER SPECTRAL DENSITY

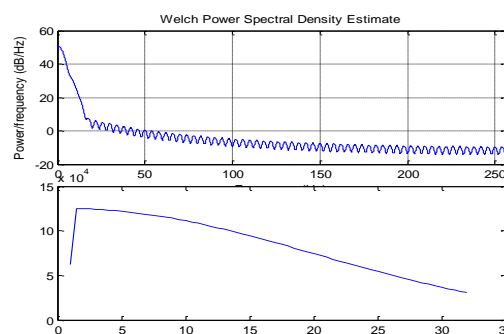


FIG.5. POWER SPECTRUM USING WELCH METHOD

II. For Second Normal Patient

REM Stage Graphs

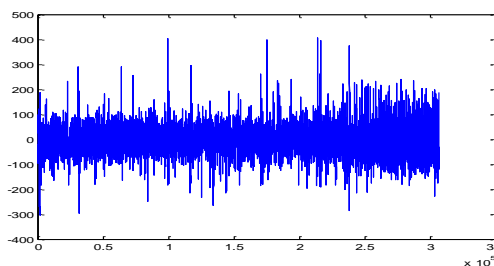


FIG.6. REM SIGNAL

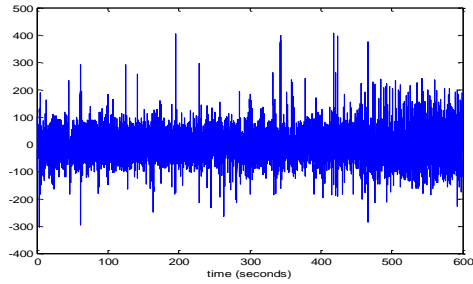


FIG.7. CROPPED SIGNAL

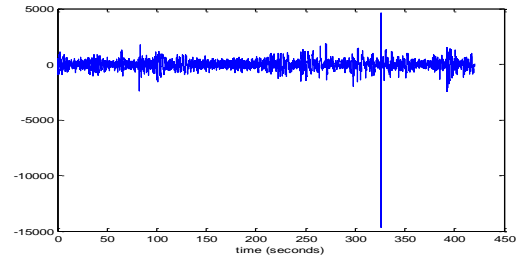


FIG.12. CROPPED SIGNAL

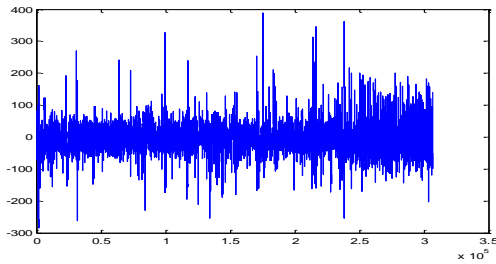


FIG.8. FILTERED SIGNAL

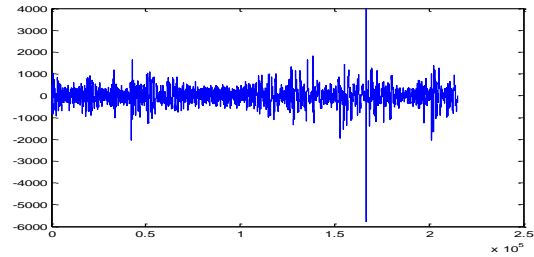


FIG.13. FILTERED SIGNAL

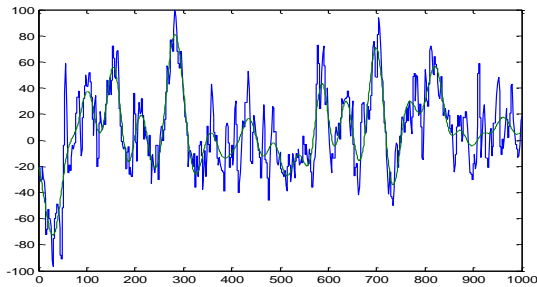


FIG.9. POWER SPECTRAL DENSITY

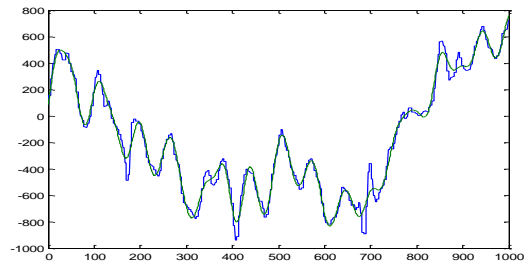


FIG.14. POWER SPECTRAL DENSITY

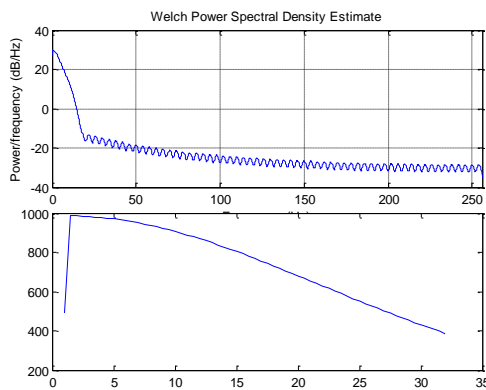


FIG.10. POWER SPECTRUM USING WELCH METHOD

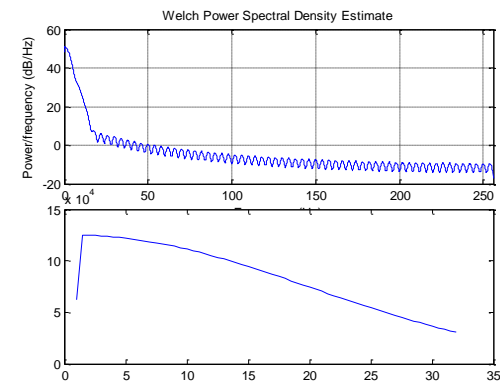


FIG.15. POWER SPECTRUM USING WELCH METHOD

III. For First RBD Patient
 REM Stage Graphs

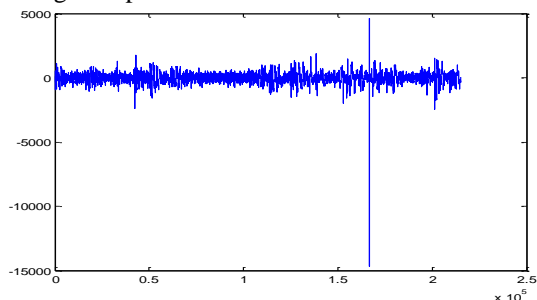


FIG.11. REM SIGNAL

IV. For Second RBD patient

REM stage Graphs

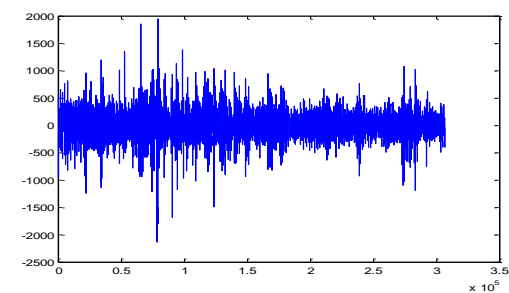


FIG.16. REM SIGNAL

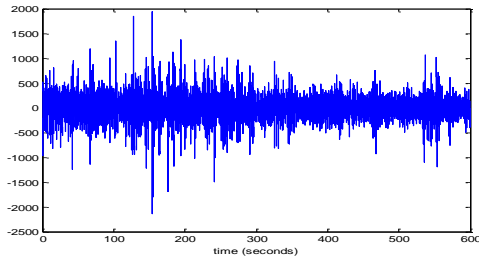


FIG.17. CROPPED SIGNAL

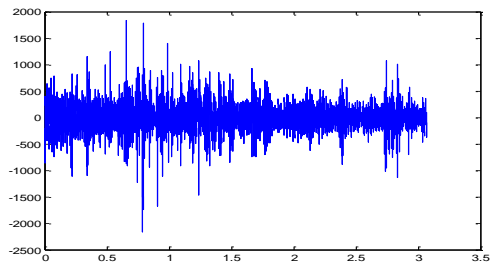


FIG.18. FILTERED SIGNAL

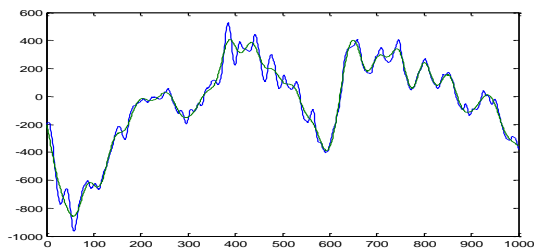


FIG.19. POWER SPECTRAL DENSITY

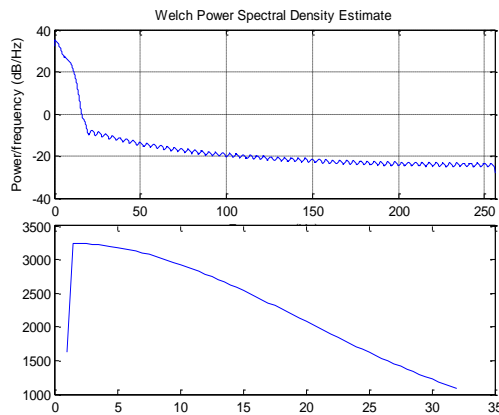


FIG.20. POWER SPECTRUM USING WELCH METHOD

A. RESULTS

1. Normal 1_REM

Average power	Normalised power
3.9138e+005	0.62303
1.5909e+005	0.30037
31176	0.073241
1342	0.0033574

2. Normal 2_REM

Average power	Normalised power
15542	0.54411
0.33222	0.33222
0.11653	0.11653
0.0071339	0.0071339

3. RBD 1_REM

Average power	Normalised power
1.1228e+006	0.67097
2.6246e+005	0.2576
49996	0.068036
2861.2	2861.2

4. RBD 2_REM

Average power	Normalised power
2.4943e+007	0.78883
3.837e+006	0.18455
1.5515e+005	0.025435
10772	0.0011838

The above tables give the average and normalised power of the REM stage of sleep of the normal patient and the RBD patients. The values mentioned in the table are of the DTAB frequency sequence of the EEG waveform, where D stands for delta, T stands for theta, A stands for alpha, and B stands for beta.[10]

B. CONCLUSION

REM Stage

Normal 1	Normal 2	RBD 1	RBD 2
0.30037	0.33222	0.2576	0.18455

The above graph shows the theta frequency normalised power of different patients of their REM stage. As can be seen, the normalised power of the normal patients of REM stage comes in the range of 0.30000-0.35000, and that of the RBD patients comes in the range of 0.18000-0.26000. Hence RBD patients can be easily detected. Thus, with the help of EEG signal, we can detect RBD by the short time frequency analysis of the PSD signal applied on the EEG signal.

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