CORE
Metadata, citation and similar papers at core.ac.uk
Provided by UB ScholarWorks

Using Signal Processing Techniques to Detect Sleep Apnea Events

Kai Chen, Kareem Saleh, Advisor: Navarun Gupta
School of Engineering, University of Bridgeport, Bridgeport, CT 06604

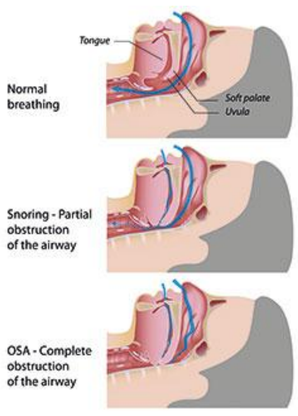
Abstract

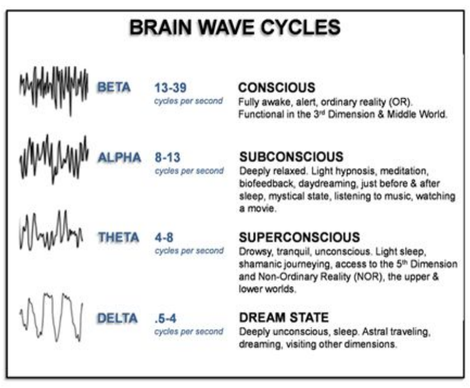
Nowadays, with the development of modern technology, we can detect sleep apnea by using Electroencephalography (EEG), Electrocardiography (ECG), blood pressure (BP), and Respiration rates (RR). These signals are recorded in time domain, however for us to extract vital information we must analyze them in frequency domain. This research will examine sleep apnea; how to understand it and in doing so determine the best methods of detection using several different signal processing techniques. By doing so we hope to help physicians further improve their detection methods as well as their accuracy.

Introduction

Sleep apnea is a sleep disorder characterized by pauses in breathing or periods of shallow breathing during sleep. Each pause can last for a few seconds to a few minutes and they happen many times a night. In the most common form, this follows loud snoring. There may be a choking or snorting sound as breathing resumes. As the disorder disrupts normal sleep, those affected may experience sleepiness or feel tired during the day. In children it may cause problems in school, or hyperactivity.
There are three forms of sleep apnea: obstructive (OSA), central (CSA), and a combination of the two called mixed. OSA is the most common form. Risk factors for OSA include being overweight, a family history of the condition, allergies, a small airway, and enlarged tonsils. In OSA, breathing is interrupted by a blockage of airflow, while in CSA breathing stops due to a lack of effort to breathe. People with sleep apnea may not be aware they have it. In many cases, it is first observed by a family member. Sleep apnea is often diagnosed with an overnight sleep study. For a diagnosis of sleep apnea, more than five episodes an hour must occur.

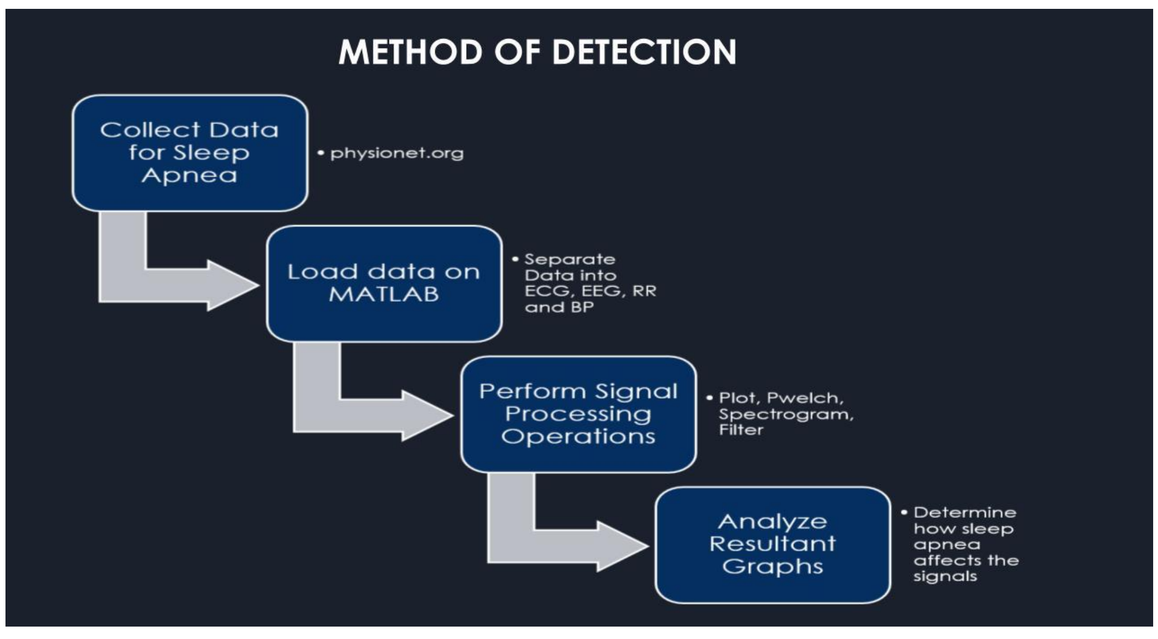
The EEG is an inexpensive and non-invasive instrument used to track and record brain activity by applying small flat metal discs, called electrodes, to the scalp of the subject. Similarly, ECG's are used the same way with the exception of the electrodes being placed on the chest of the subject and recording the heart rate. Respiration rate may also be measured by wrapping a respiration recording belt that measures the rate at which a person is breathing. Finally BP may be measured with several sensors available in the market. All of these tools are used while the subject is asleep. By recording the data and observing the graphs of the abovementioned measurements using a MATLAB program, we can study sleep apnea. We can also further study the effects of sleep apnea on various parts of the body through the obtained graphs.





Signal Processing Commands

MATLAB is a practical software that can be used to analyze different types of signals. Key MATLAB commands to note:
Plot: Allows user to plot data points on a graph.
Fft: Fast Fourier Transform; allows user to view signals in frequency domain instead of time domain.
Pwelch: Allows us to view the power spectral density of the signals in frequency domain.
Spectrogram: Offers visual representation of frequencies as they vary with time. Generated by the use of fft.
Filter Design: A tool that removes unwanted components from a signal, namely frequencies in our research.



Percent Power	Normal Sleep (0-4 Hz)	Sleep Apnea (8-14 Hz)
Delta Waves	93%	14.9%
Alpha Waves	-	78.1%
Other	7%	7%

Results

As seen in figure 6, the subject takes deep breaths after stopping breathing for a few seconds.In the figure 8, the subject's EEG shows conspicuous changes in EEG during sleep apnea events (around 4.7 and 4.9). The EEG changes are seen at the same time as the RR changes are observed (figure 6).Sleep apnea results in higher frequencies in ECG spectrogram

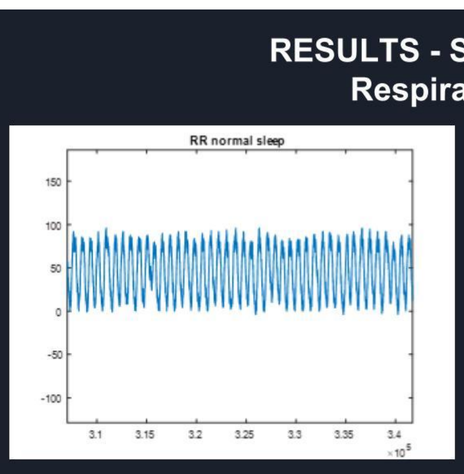


Figure 5

Figure 6

The subject's breathing is affected during sleep apnea. As seen in figure 6, the subject takes deep breaths after stopping breathing for a few seconds.

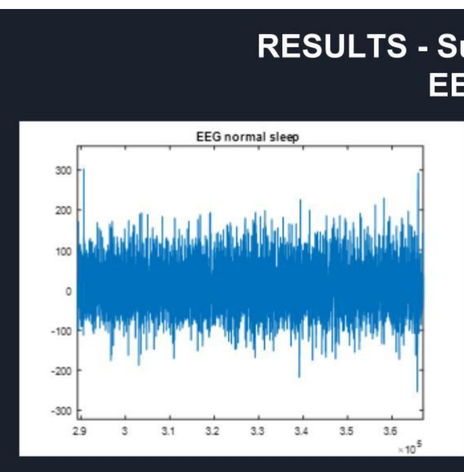


Figure 7

Figure 8

As seen in the figure 8, the subject's EEG shows conspicuous changes in EEG during sleep apnea events (around 4.7 and 4.9). The EEG changes are seen at the same time as the RR changes are observed (figure 6).

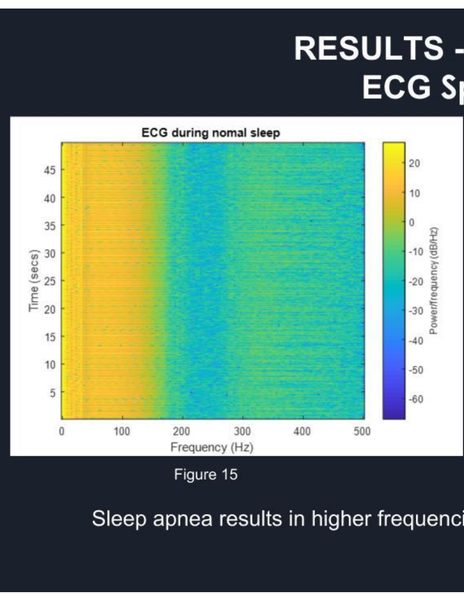
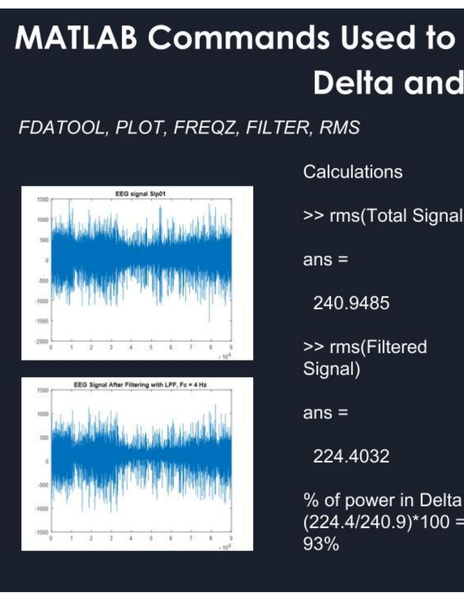


Figure 15

Figure 16

Sleep apnea results in higher frequencies in ECG spectrogram (Figure 16).



Conclusions and Further Work

According to the results we can clearly see that sleep apnea episodes cause significant changes in the RR, EEG, and ECG. Preliminary analysis on the RR acted as our main indicator for sleep apnea. Then by performing signal processing techniques along with detailed analysis on the EEG and ECG we were able to determine and explain major deviations in these signals. Sleep apnea caused rapid fluctuations in the RR, the spectrogram showed an increase in power concentration in alpha waves on the EEG as well as an increase in power and frequency deviations on the ECG. We did not see much change on the spectrogram for the RR, however for the EEG and ECG were very definitive. Overall we can prove that sleep apnea directly causes many problems to the body, and if unchecked can cause serious hard. We hope our work will help physicians better detect sleep apnea with more accuracy.