Zachodniopomorski
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BIOMEDICAL SIGNAL PROCESSING

Classification & Analysis of EEG Signals

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INTRODUCTION

Firstly let s look for abstract about introduction;
the electroencephalogram (EEG) is a highly noninvasive diagnostic tool which provides information on the different physiological and psychological states of the brain and helps in studying its complex dynamics. EEG signals are highly nonlinearand nonstationary, with great variability from patient to patient in terms of their amplitudes. It is also an important clinical tool for diagnosing major neurologicaldisorders.

EEG is useful for the analysis of the functional activity of the brain and a detailed assessment ofthis non-stationary waveform can provide crucial parameters indicative of the mental state ofpatients. The complex nature of EEG signals calls for automated analysis using various signalprocessing methods. This paper attempts to classify the EEG signals of normal using well-established signal processing techniques involving relative wavelet energy (RWE) and articial feed Forward neural network. High frequency noise present in the recordedsignal is removed using total variation filtering (TVF). Classification of the frequency bands of EEG signals into appropriate detail levels and approximation level is carried out using an eight-level multiresolution decomposition method of discrete wavelet transform.

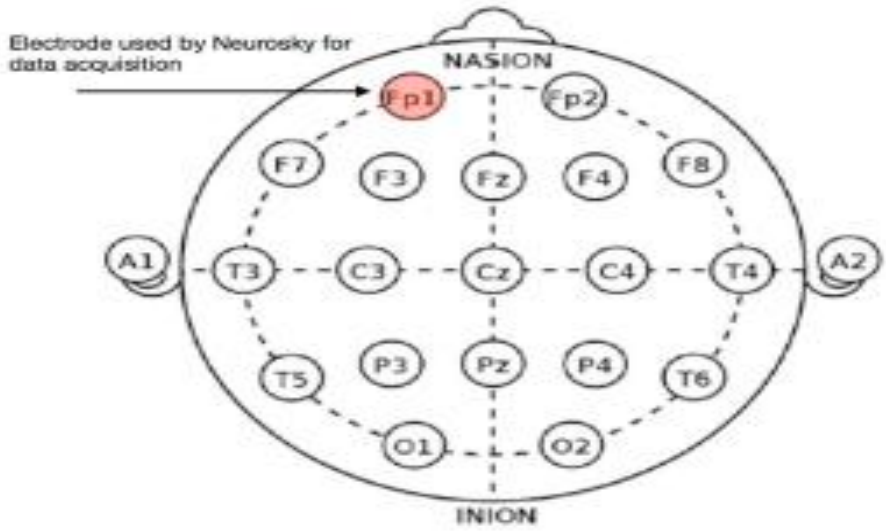


Fig. 4. Neurosky Electrode position

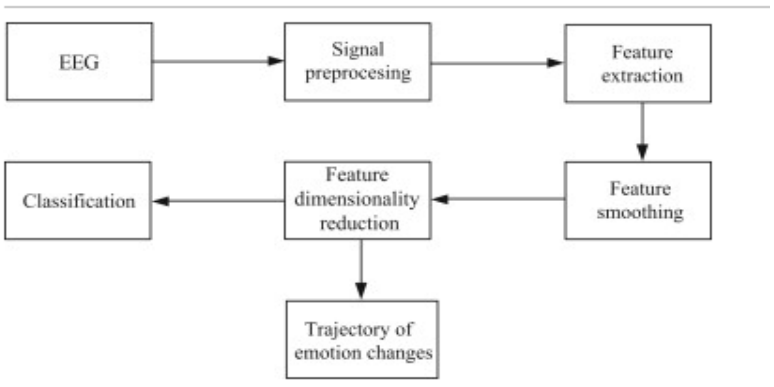
MATERIALS AND METHODS

First of all I used the software version of MATLAB R2019b when editing these codes. I used code to plot the results directly without a GUI design. When processing and compiling code I used a lot of MATLAB toolbox which is ‘’Deep Learning Toolbox’’, ‘’Signal Processing Toolbox’’, ‘’EEGlab developers Toolbox’’, ‘’ Machine Learning Toolbox’’, ‘’ Wavelet Toolbox’’. I took some of EEG databases from Stanford University Library (Publicy sources) and also contacted some officials and asked for help from same university. I plotted power spectrum with the FFT method and Pwelch method. There is a some different activities of brain alpha, theta, beta, delta. Lets talk about FFT method;
the **Fast Fourier Transform** (FFT) algorithm to compute a Discrete Fourier Transform (DFT). The FFT can be used to simply characterize the magnitude and phase of a signal, or it can be used in combination with other operations to perform more involved computations such as convolution or correlation.
Welch's method, named after P.D. Welch, is an approach for spectral density estimation. It is used in physics, engineering, and applied mathematics for estimating the power of a signal at different frequencies. The method is based on the concept of using periodogram spectrum estimates, which are the result of converting a signal from the time domain to the frequency domain. Welch's method is an improvement on the standard periodogram spectrum estimating method and on Bartlett's method, in that it reduces noise in the estimated power spectra in exchange for reducing the frequency resolution. Due to the noise caused by imperfect and finite data, the noise reduction from Welch's method is often desired.

Theta waves (3 to 8 Hz)
Theta brainwaves occur most often in sleep but are also dominant in deep meditation. **Theta** is our gateway to learning, memory, and intuition. In **theta**, our senses are withdrawn from the external world and focused on signals originating from within.

Beta waves (12 to 38 Hz)
Beta brainwaves dominate our normal waking state of consciousness when attention is directed towards cognitive tasks and the outside world. **Beta** is a 'fast' **activity**, present when we are alert, attentive, engaged in problem solving, judgment, decision making, or focused mental **activity**.
Alpha waves are neural oscillations in the frequency range of 8–12 Hz arising from the synchronous and coherent (in phase or constructive) electrical activity of thalamic pacemaker cells in humans. They are also called Berger's waves after the founder of EEG.

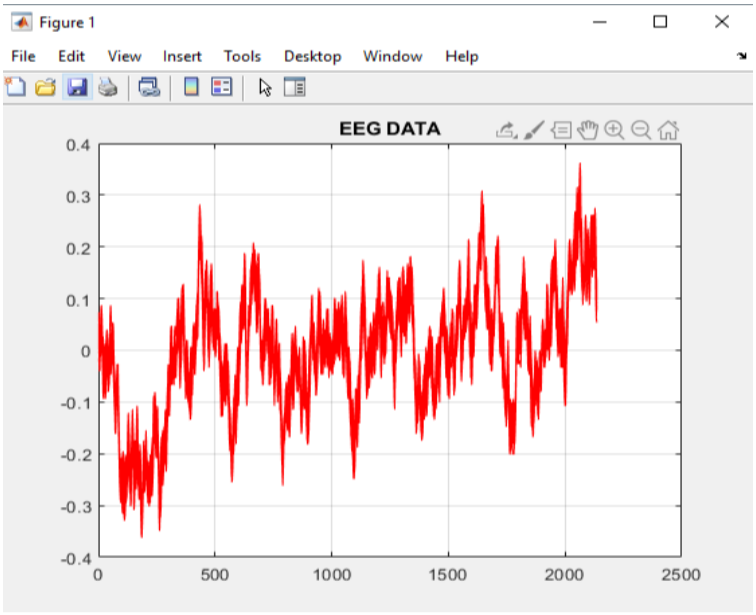
Alpha waves (8-12 Hz) are one type of brain waves detected either by electroencephalography (EEG) or magnetoencephalography (MEG), and can be quantified using quantitative electroencephalography (qEEG). They predominantly originate from the occipital lobe during wakeful relaxation with closed eyes. Alpha waves are reduced with open eyes, drowsiness and sleep. Historically, they were thought to represent the activity of the visual cortex in an idle state. More recent papers have argued that they inhibit areas of the cortex not in use, or alternatively that they play an active role in network coordination and communication. Occipital alpha waves during periods of eyes closed are the strongest EEG brain signals.
A **delta wave (0.5 – 4 Hz)** is a type of high amplitude **brain wave** found in humans. **Delta waves** have a frequency from one to four hertz and are measured using an electroencephalogram (EEG). These **brain waves** are thought to emerge from the thalamus and are generally associated with slow-**wave** sleep (during the third stage of sleep.)

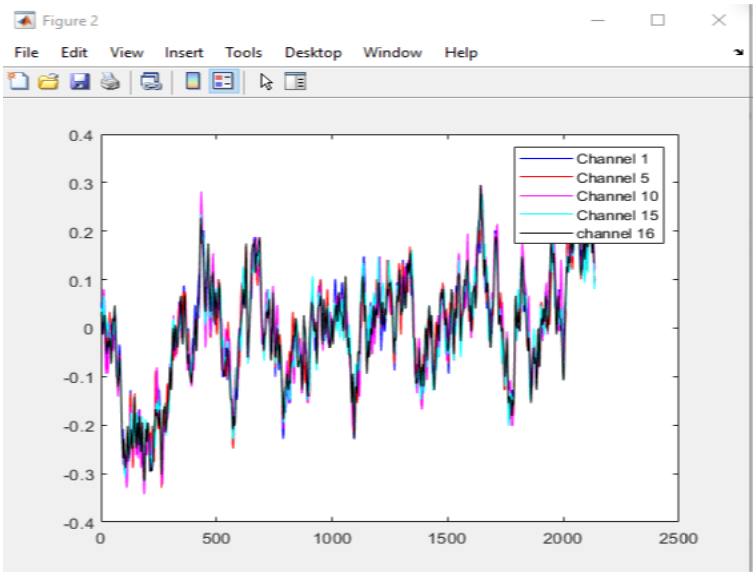


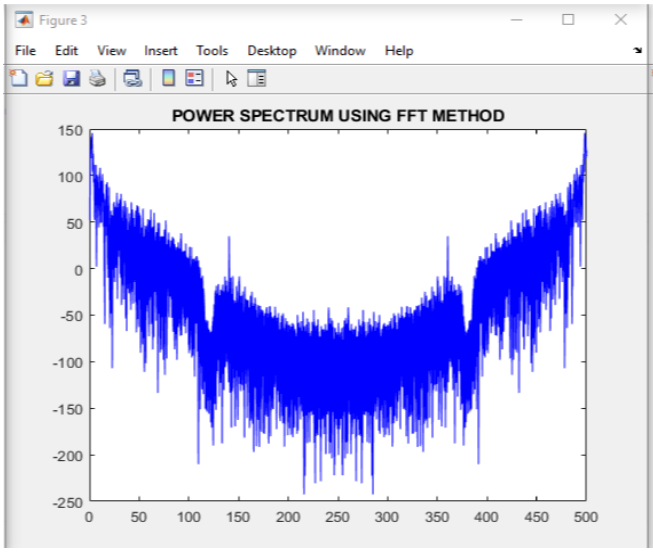
RESULTS

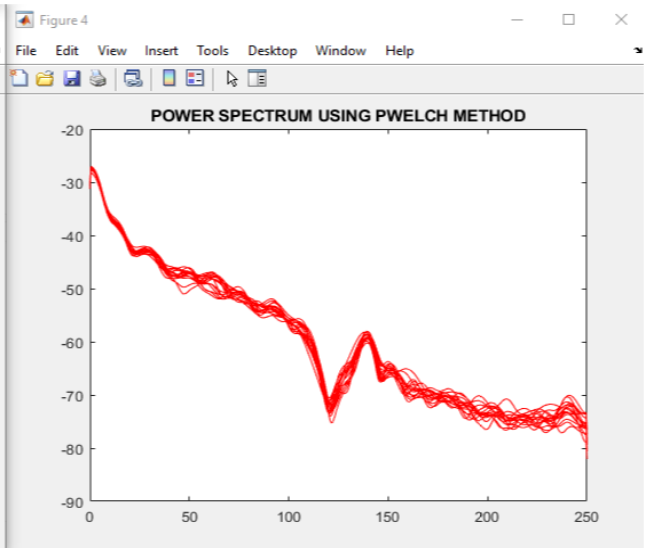
I used different EEG data in most of my studies, but I had the chance to test the patient's EEG data from Mrs. Gorecka while trying my codes. However, I used data from different sources for the codes to work in more detail. Due to the protection of personal rights in the data I collected, I could not provide information such as name, age, check-up-date.

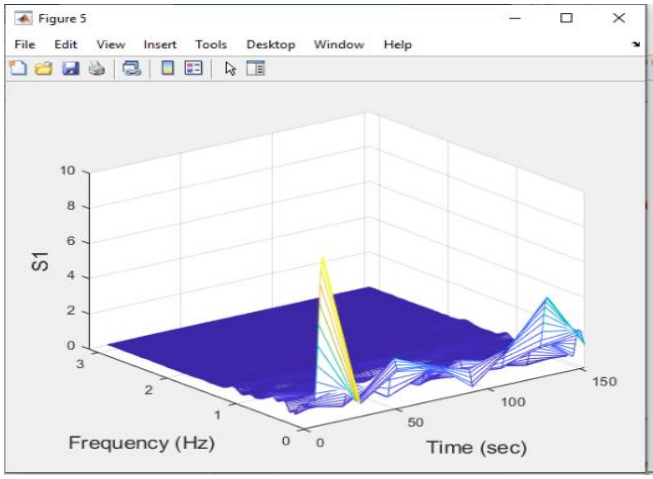
Results from classification of EEG databases;

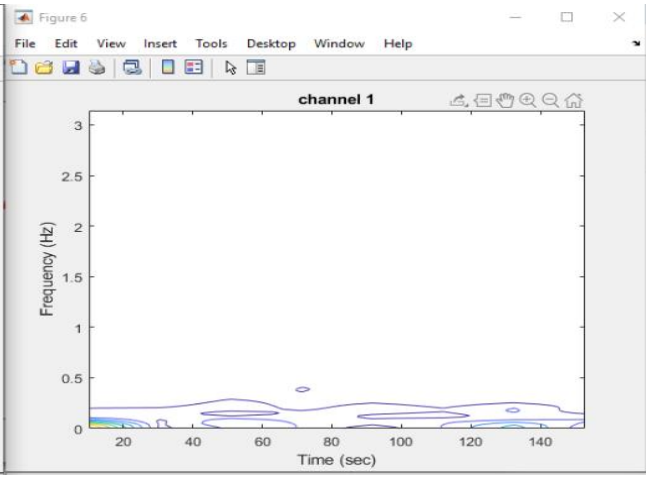












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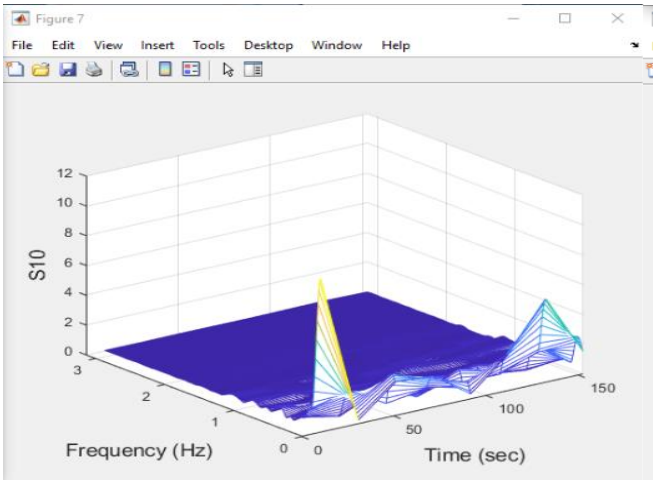
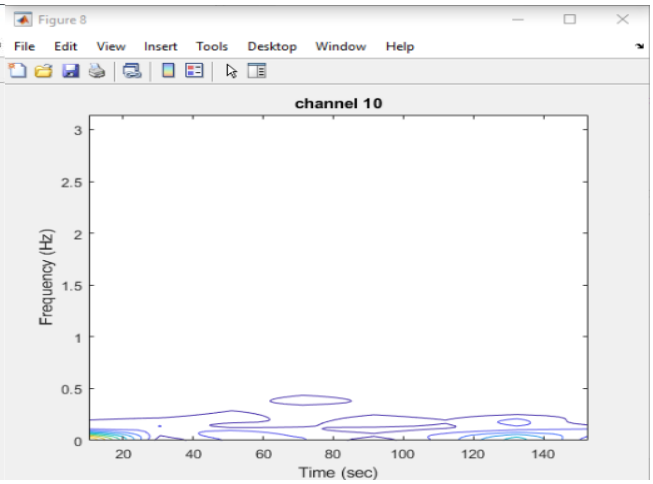




FROM CHANNEL 10

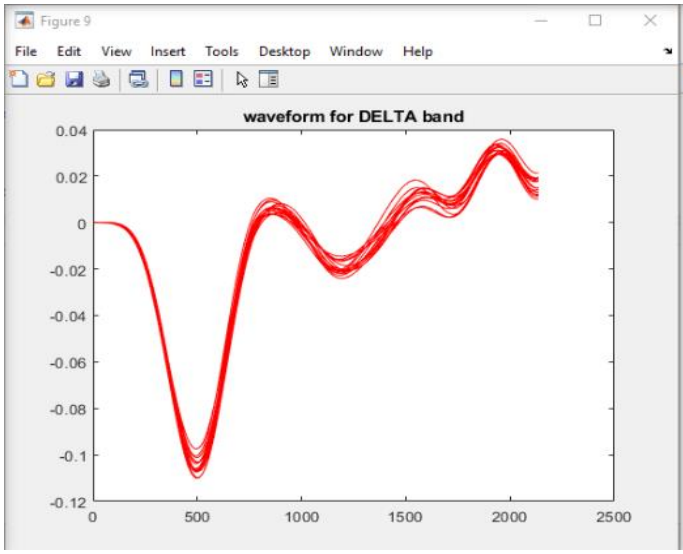


Figure 9
File Edit View Insert Tools Desktop Window Help
waveform for DELTA band
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
0
500
1000
1500
2000
2500

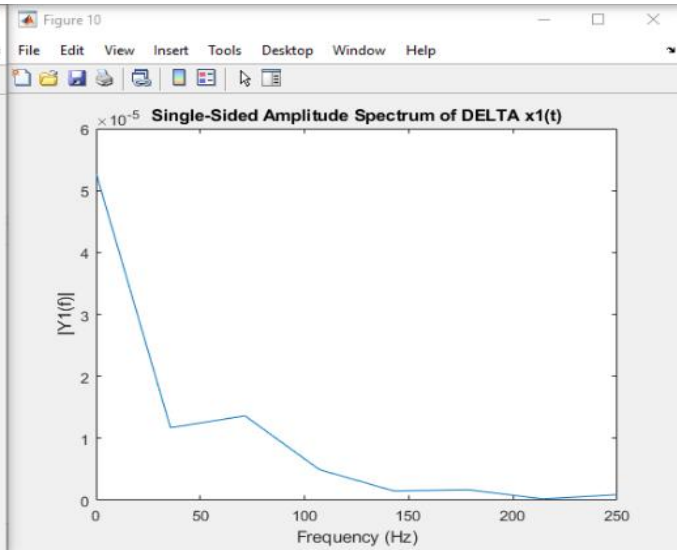


Figure 10
File Edit View Insert Tools Desktop Window Help
×10^-5
Single-Sided Amplitude Spectrum of DELTA x1(t)
|Y1(f)|
6
5
4
3
2
1
0
0
50
100
150
200
250
Frequency (Hz)

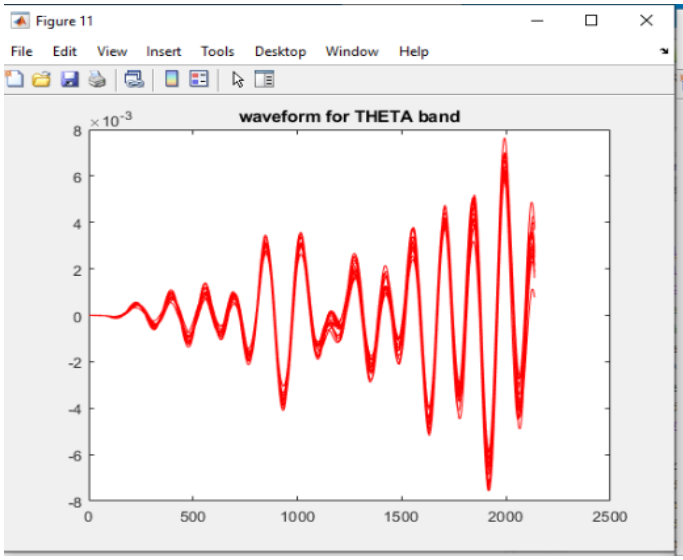


Figure 11
File Edit View Insert Tools Desktop Window Help
×10^-3
waveform for THETA band
8
6
4
2
0
-2
-4
-6
-8
0
500
1000
1500
2000
2500

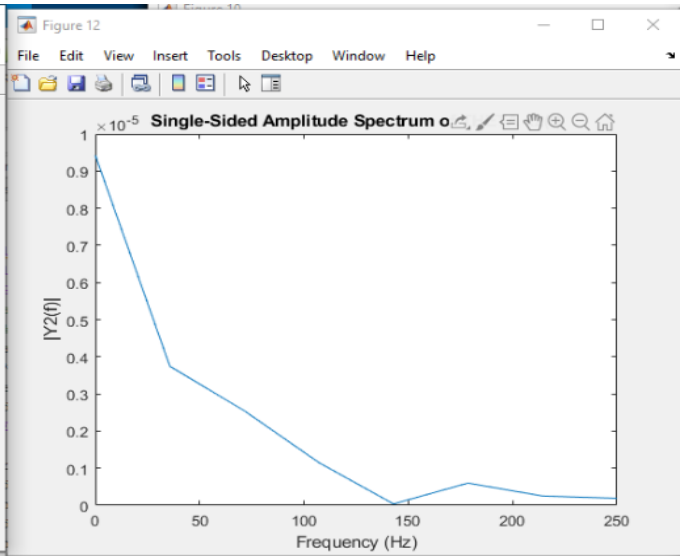


Figure 12
File Edit View Insert Tools Desktop Window Help
×10^-5
Single-Sided Amplitude Spectrum o
|Y2(f)|
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
50
100
150
200
250
Frequency (Hz)

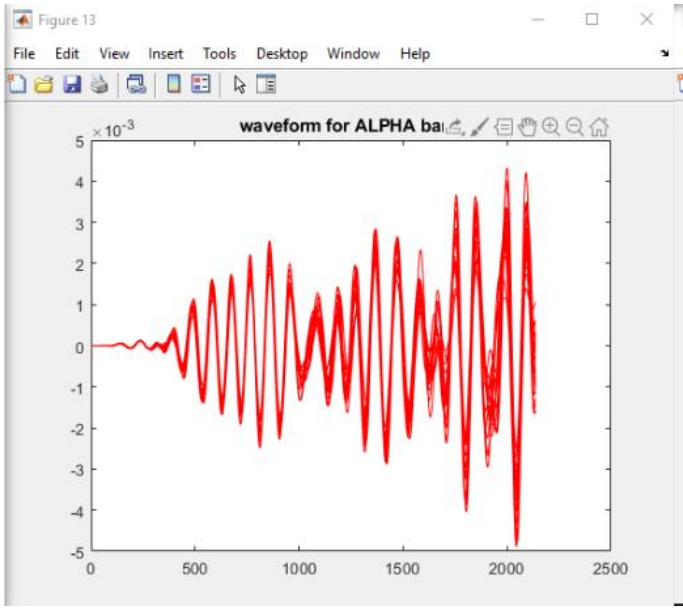


Figure 13
File Edit View Insert Tools Desktop Window Help
×10^-3
waveform for ALPHA ba
5
4
3
2
1
0
-1
-2
-3
-4
-5
0
500
1000
1500
2000
2500

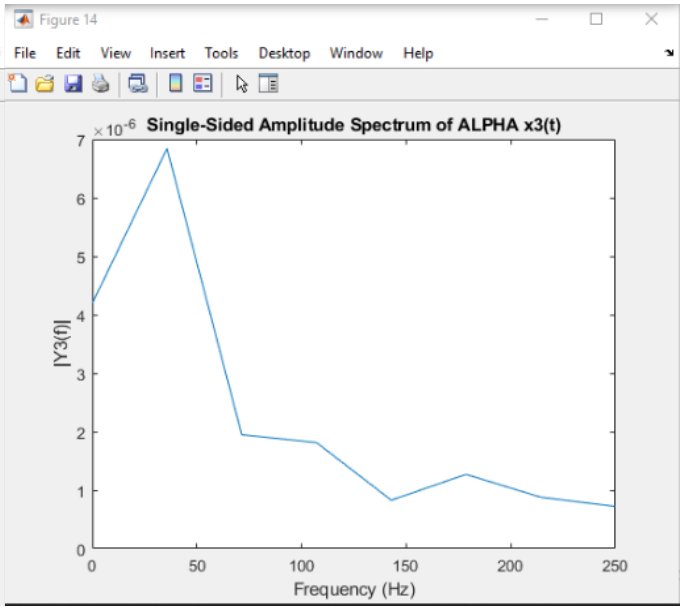
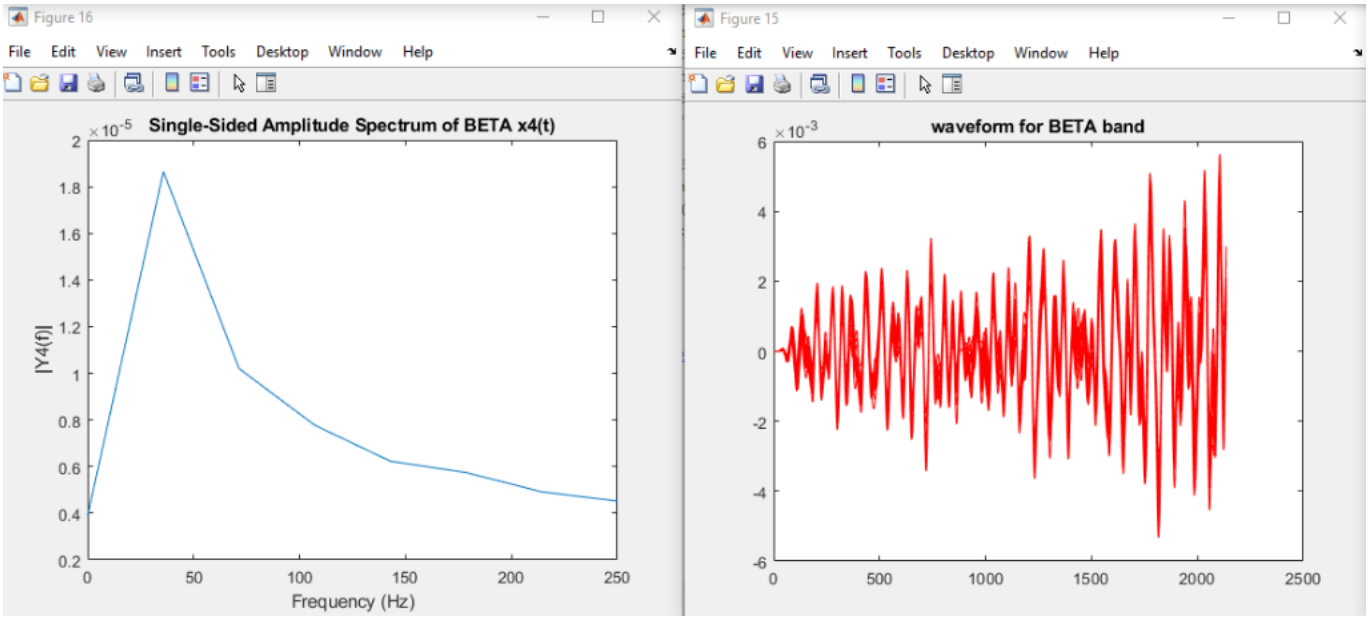


Figure 14
File Edit View Insert Tools Desktop Window Help
×10^-6
Single-Sided Amplitude Spectrum of ALPHA x3(t)
|Y3(f)|
7
6
5
4
3
2
1
0
0
50
100
150
200
250
Frequency (Hz)



CONCLUSIONS

In this paper I have processed the techniques to be used when classifying EEG data. In this project, I made use of EEG data of a normal person who is not under stress to interpret the brain activities. Through the interpretation of alpha, beta, theta, delta waves, I have seen what problems the patient has with her through the signals coming from her brain. Also when I m researching on the web found some disease (Alzheimer, migraine, Parkinson etc.) which is can detectable by analysis EEG data.

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