

EEG DATA ANALYSIS BY WAVELET POWER SPECTRUM & GLOBAL WAVELET SPECTRUM

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Abstract

To investigate about the electrical activity of human brain, electroencephalography (EEG) is the eminent technique. It is the non-invasive way to examine brain indications which assist to locate that either signals are appearing normal or abnormal scheme of the brain for instance epilepsy furthermore other neurological disorder. The frequency of signals alters time is meant by the signals of EEG are inconsistent. By analyze these inconsistent signals, Wavelet transform is handed-down to categorize EEG segment for epileptic patient conversely distinct intellectual positions. Wavelet power spectrum (WPS) furthermore global wavelet spectrum (GWS) having three dimensions are enforced in the presented work on four datasets to contrast the conclusion of peculiar mental cases of individuals.

Keywords: EEG, wavelet transform, wavelet power spectrum(WPS), global power spectrum(GWS)

Introduction

This study is the extension of the work present in reference no [5]. There are extraordinary consequences regarding brain in human growth. Thousands of nerve cells are affiliated with each other in brain. Our all behaviors, attentions furthermore exercises are executed by electrical impulses that move onward neurons inside body to main organ of body which is brain. Five waveform are categorized by these electrical signals on the basis frequency range which coincide to different actions carried out by the substrate. The frequency limits of brain waves are generalized as: Delta wave contain the frequency range of 0-4Hz, Theta wave range having 4-8Hz, Alpha wave range is 8-12Hz, whereas Beta have the range within 13-30Hz and Gamma wave contain 30-60Hz.[1]

Throughout the time, the abnormality in variations of electrical signs display condition of brain illness likewise epilepsy, autism spectral disorder (ASD) also other diseases of neurology.[2]

The interpretation of deformity is a significant affair, For this, various methods have been approached to estimate brain activity for the reorganization of epilepsy or many other neuro diseases for instance electroencephalography (EEG), positron emission tomography (PET) etc.[5]

The widely common techniques among all is EEG which is the main concern of this paper. EEG signals maintain consequential instruction about the operation of the brain conquering brain's electrical signals.[1]

Naturally, EEG signals are not stationary and a lot of data standards are included in EEG evaluations that is ambitious to survey physically.[2]

That is why time modifying calculation is necessary to abstract the useful illumination from EEG signals. A variety of mathematical methods are available for the purpose to debate the time set to enclose the capacities that are not stationary having different frequencies. **Wavelet Transform** is the convenient method to resolve localized variations of power within a time series.[5]

Materials and Proposed Methodology

Method 1

Dataset Collection

The data handed-down in this study is collected from "Epilepsy centre in Bonn, Germany compiled by Dr. Ralph Andrzejak" which is mutually available accessible on <http://epilptogiebonn.de/> Andrzejak et al.(2001).

The datasets (A-D) consist of 100 individual channels. A,B,C,and D are the sets that are selected.

Set A shows Z001

Set B serve as O001

Set C having N001

Set D represents S001

Healthy subject is represented by Class Z with eye open state, Class O is eyes closed situation while N Class is display interictal execution furthermore illness bustle is showed by Class S. Time series plots are given in the figure 1. [10]

Wavelet Transform

For the purpose of estimating signals in time-domain, there are immense manners in wavelet transform. It is mechanism for time-scale inquiries, signal confining and signal disintegrations. Discrete Wavelet transform and Continuous wavelet transform are two types of wavelet transform.

In this paper, we used Continuous wavelet transform (CWT) to differentiate healthy person and epileptic person with the assistance of global wavelet spectrum and wavelet power spectrum.

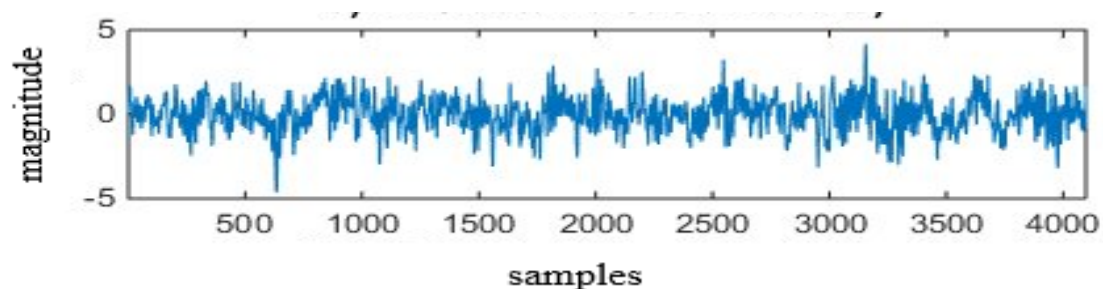
With reference to Torrence(2001), Morlet wavelet function has been used with wavelet power spectrum in this paper.

$$\psi_0(\eta) = \pi^{-\frac{1}{4}} e^{i\omega_0\eta} e^{-\frac{\eta^2}{2}}$$

where ω_0 and η represents frequency and time which has no dimension respectively. Illustration of CWT of discrete sequence of EEG signal 'Sign' as a convolution of data sequence is given by Torrence(2001). It is the translated version of the mother wavelet. In Mathematical terms:

$$W(s) = \frac{\delta t}{\sqrt{s}} \sum_{n=0}^{N-1} \text{Sig}_n \psi^* \left[\frac{(n-m)\delta t}{s} \right]$$

$m = 0, 1, \dots, N-1$. s, m are dilation and translation parameters used to change the scale and slide in time with the order of wavelet function. [10]



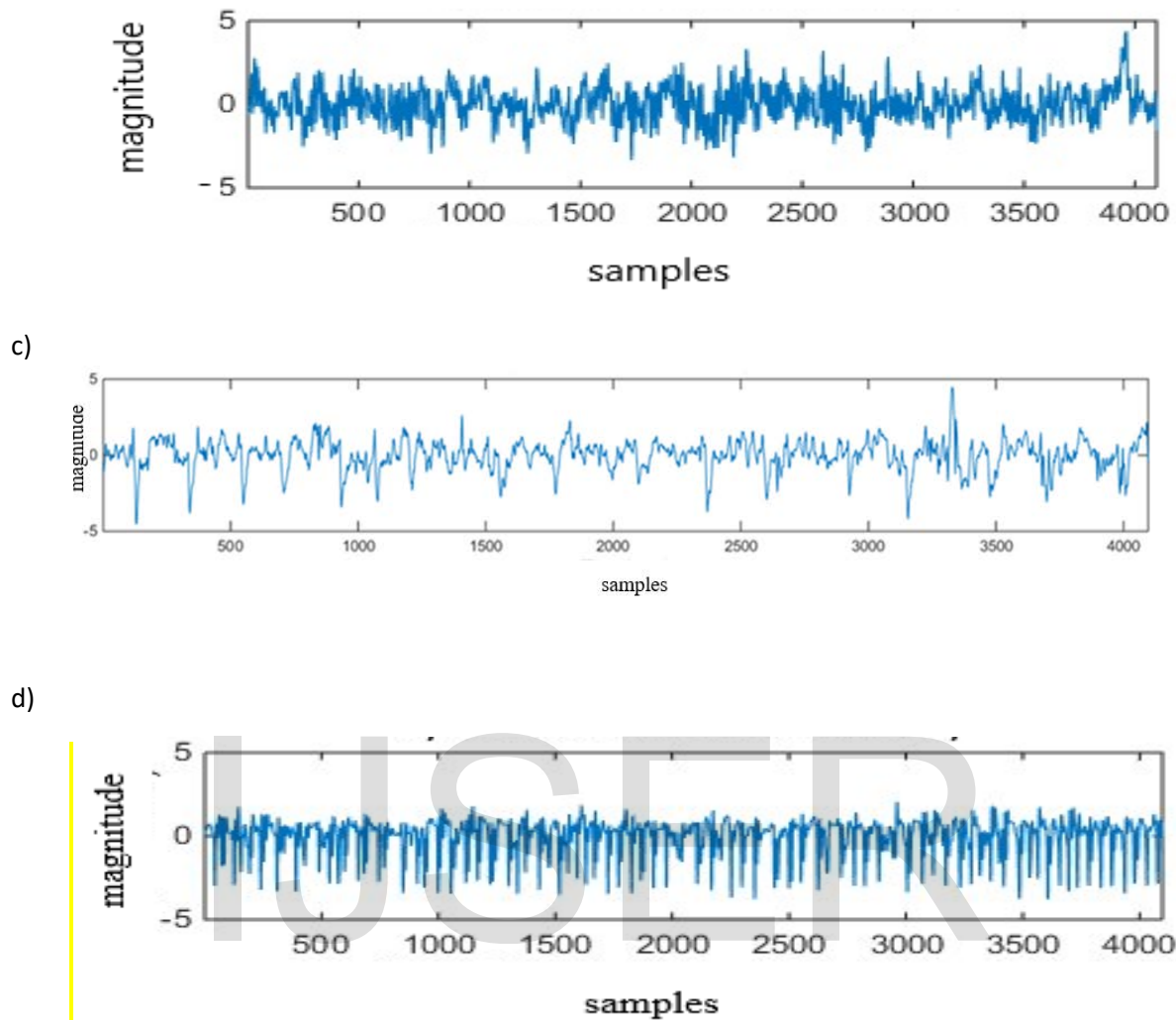


Figure 1: EEG signals a) Z001, b) O001, c) N001, d) S001

a) Wavelet power spectrum

It grants permission to find out the energy handling within the data array where large power in WPS represents whether value in whether the signal factors are necessary to figure out or not. In Mathematical terms, It is the doubled of Eq. 2 which is symbolized as:

$$|W(s)^2|$$

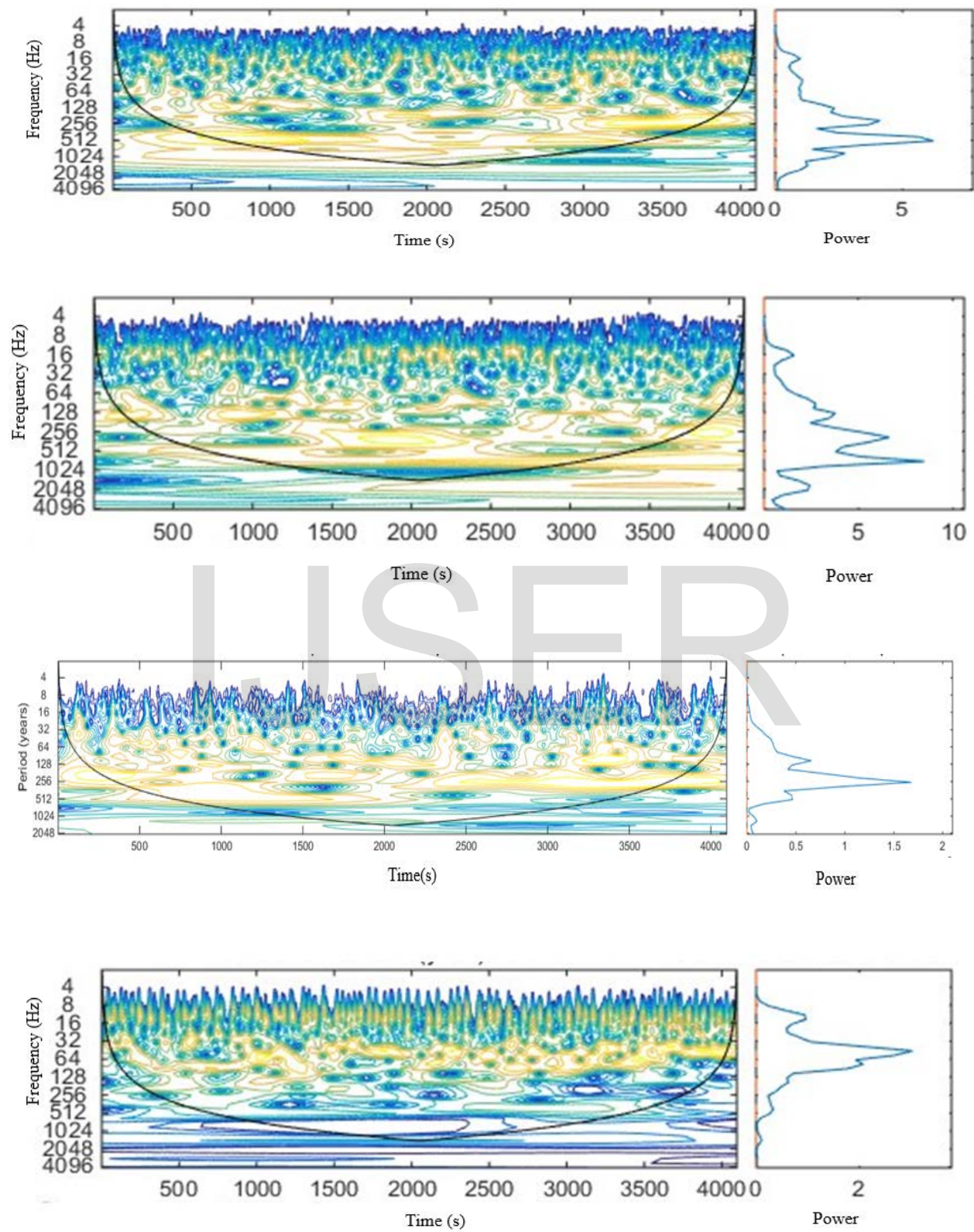


Figure 2: Wavelet power spectrum of signals Z001, O001, N001 and S001 are shown in left panel of a, b, c and d respectively with cone of influence indicated by black curve. Below this curve, values are not statistically significant. Global wavelet spectrum of signals Z001, O001, N001 and S001 are showing in right panel of a, b, c and d respectively. Wavelet power decreases according to the color order as: red, orange, yellow, blue and white

b) Global wavelet spectrum

A fair arrangements and persistent appraisal of accurate spectrum of time series has been provided by Global wavelet spectrum. In order to contrast the regions of temporal fluctuation to other regions that is not display long term changes, GWS is very convenient: [5]

$$\bar{W}^2(s) = \frac{1}{N} \sum_{n=0}^N |W(s)|^2$$

Results And Discussions

Figure 2 is plotted by utilizing programming apparatus accessible at: <http://paos.colorado.edu/inquire/about/wavelets/> in which the wavelet control range and worldwide wavelet range of four EEG signals are analyzed. It is obvious from Figure 2 that the distinction in the size of the EEG flag S001 and N001 part in the recurrence time frame around 4-8 Hz (theta wave) and 8-16 Hz (alpha wave) are huge unique in relation to a similar segment of the EEG signals Z001 and O001.

The primary outcomes are thought about in Figure 3, Figure 4 ,Figure 5 and Figure 6. In Figure 3, recurrence groups of two EEG signals are thought about which are N and S. Consequences of 0-100 are identified with class N, 100-200 are for class S. The thing that matters is plainly appeared between these two datasets. The GWS estimations of 0-100 flags in the zone up to 2-4, 4-8 and 8-16 Hz for example the recurrence scope of delta, theta and alpha exercises are predominantly communicated.[5]

In Figure 4, contrasts between eyes open and eyes closed conditions are inspected for healthy phases of the person. The powers of the Alpha which is deciphered as unwinding waves are higher amid eyes shut when contrasted with eyes open.

In Figure 5, comparison of 200 signs for example 0-100 and 100-200 of two EEG datasets is demonstrated which are Z and S individually. Seizure movement is determined around period 4-8 Hz which is fundamentally unique in relation to different signs.

To measure the distinction among each of the four flags, the factual element (change) of these signs is determined in Table 1 which unmistakably demonstrates the distinction in epileptic patient when assault, sound individual with eyes open and eyes shut.

In Figure 6, comparison of 400 signals i.e. 0-100, 101-200, 201-300,301-400 of four EEG datasets is shown which are N,O,Z and S respectively. Seizure activity is specified around period 4-8 Hz which is significantly different from other signals.

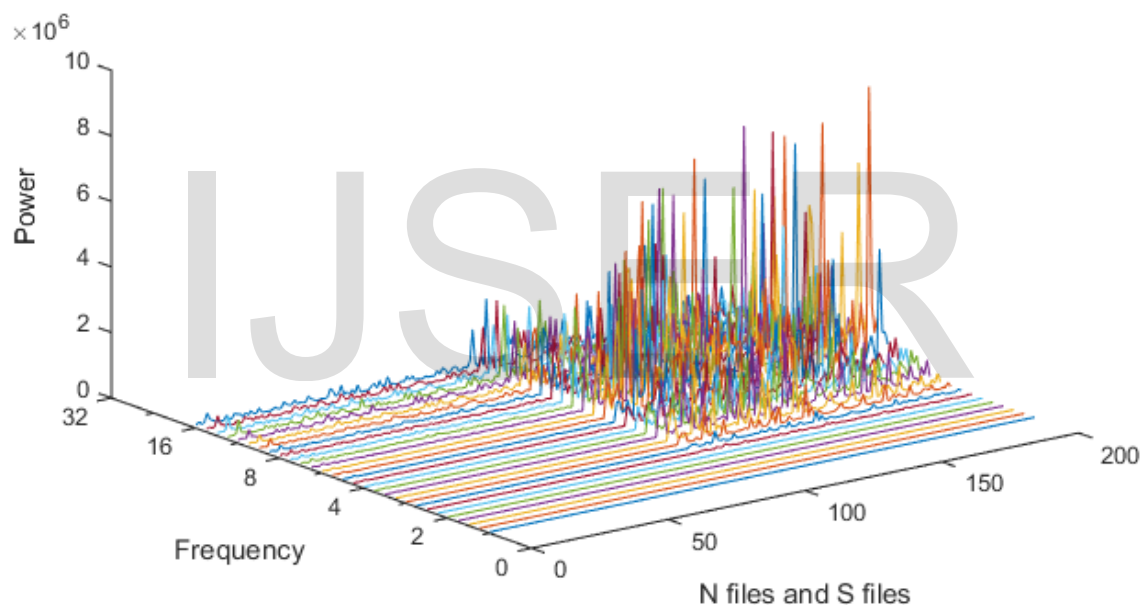


Figure 3: GWS of 100 EEG signals of two datasets: N and S

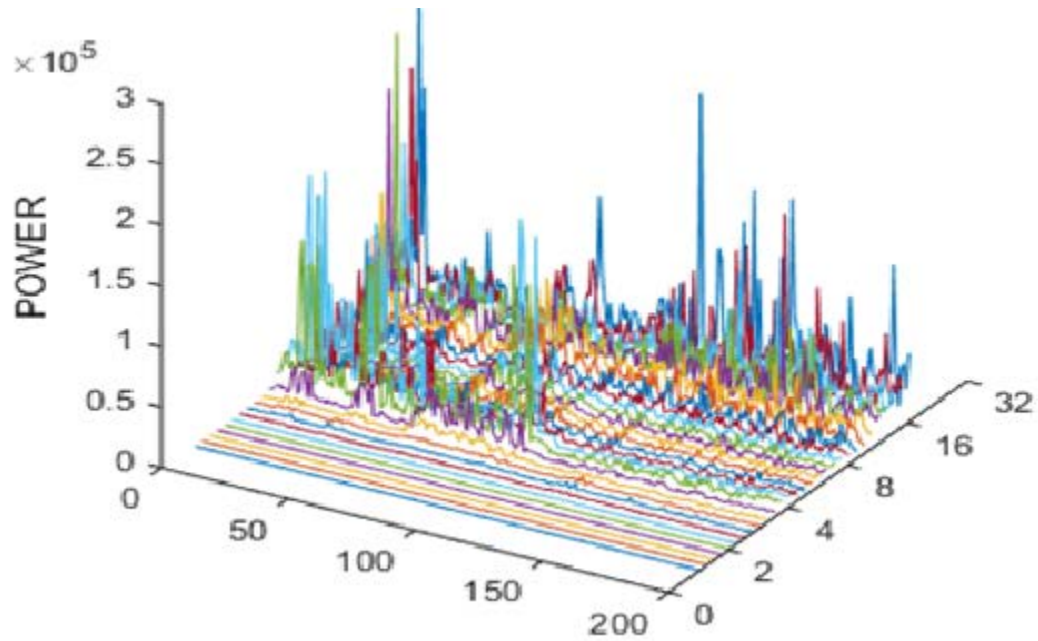


Figure 4: GWS of 100 EEG signals of two datasets: O and Z

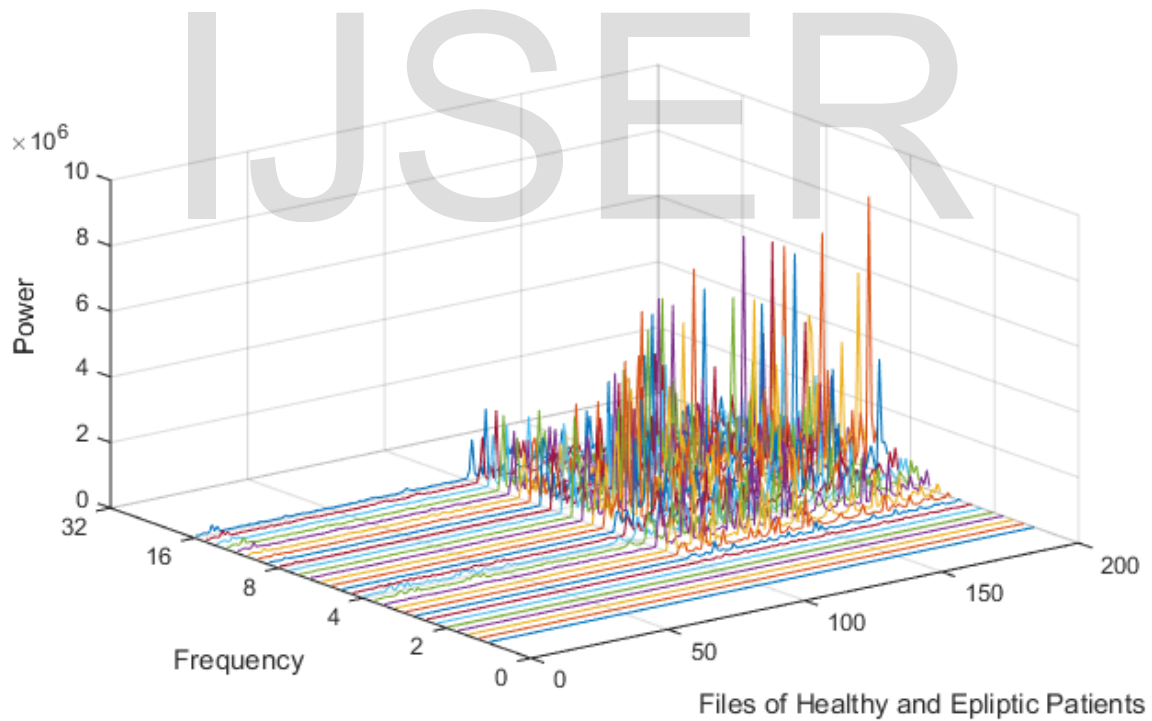


Figure 5: GWS of 100 signals of two EEG datasets: Z and S

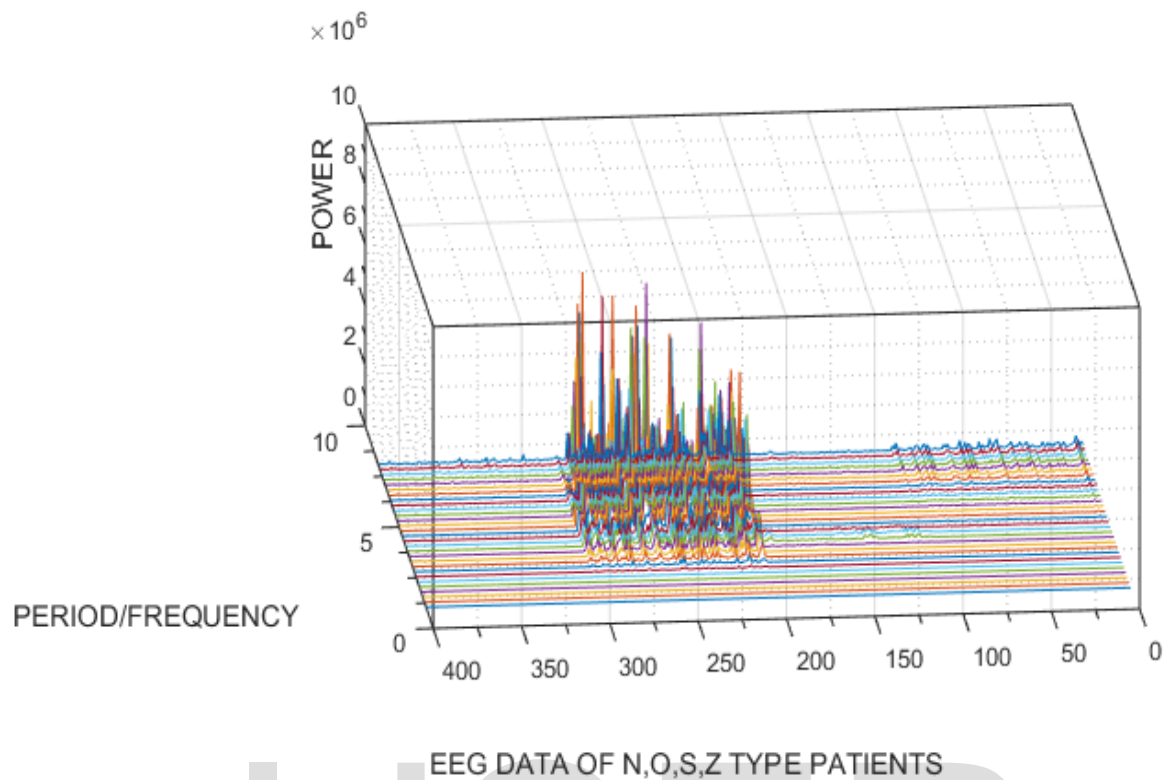


Figure 6: GWS of 100 signals of four EEG datasets: N,O,S and Z

Table 1: Variance of EEG signals S001, Z001, N001 and O001

Brain waves	S001	N001	Z001	O001
Alpha	4.1656e+003	321.5280	157.6744	328.8349
Theta	1.1900e+003	148.0828	151.0412	174.5409

Conclusion

In this study, healthy and epileptic persons, eyes open and eyes closed conditions, and ictal and interictal spikes are distinguished using EEG data based on wavelet analysis. Wavelet analysis is applied to characterize EEG signal frequency component along with time localization on four EEG datasets. WPS and GWS clearly indicated the difference in activities of examined groups within the specific components.

Conflict of interest

The authors declare that they have no conflict of interest.

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