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Wavelet Based EEG Signal Analysis for Detection of Small Abnormalities

A.K.M. Fazlul Haque*
Md. Habibullah Pappu
Kabir Hossain Tutul
Mahim Bin Firoz
Syed Nazmus Sakib

Department of Electronics and Telecommunication Engineering, Daffodil International University

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***Corresponding author:**

A.K.M. Fazlul Haque

Department of Electronics and Telecommunication Engineering
Daffodil International University
Email: akmfhaque@daffodilvarsity.edu.bd

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ABSTRACT

This paper correspond to Wavelet based Electroencephalogram (EEG) signal analysis to become aware of small abnormalities to endure any emergency medical application. The EEG is a very decisive and effectual tool for brain monitoring system. This work aspires to be evidence for an improved and more effective way of monitoring the brain and its disruptions. It also provides an enormous opportunity to analyze the brain signal more intensely considering the different environments. As the current analyzing technologies are not sufficient enough to deal with the sudden abnormalities or even very small abnormalities, the proposed method offers an effective way of analyzing the data more precisely. Because of the availability of statistical information of the EEG data, extracting various statistical parameters along with the other processing techniques including filtering, the proposed method can monitor the brain as well as detect the smallest possible abnormalities even in the harsh conditions in a more accurate and operative way.

KEYWORDS

EEG signal, Medical application, Signal analysis, Wavelet, Abnormalities

INTRODUCTION

Brain diseases are one of the burning issues and new concerns in worldwide, and the importance of the EEG, which helps to monitor as well detect the small abnormalities in the brain is remarkable since epilepsy or other seizure disorders, head injuries, brain tumors, stroke, dementia, sleep disorders, encephalitis, encephalopathy diseases constitute one of the real reasons for mortality on the world. Brain diseases are now growing as a serious health threat in the third world countries like Bangladesh.

EEG signal analysis is the process adapted to detect the small electrical movement of the brain. The brain cells are communicating through electrical impulses. And the EEG signal analysis here to be used to detect influential difficulties associated with this action in each time of arising [1]. EEG traces and notes the brain wave arrangements. The small flats of metal discs are known as electrodes and those are appended to the human scalp through cables. The electronic movements (impulses) are considered by the electrodes and sends the signs to a computer which stored the outcomes [2].

The recorded electrical movements looks near a wavy channels. Those channels enable specialists to rapidly survey if there finds any irregular examples. Any irregularities might be an indication of seizures either auxiliary issues in brain or various other reasons [3]. In most of the cases, small changes of the signal that come from the brain cannot find out and that's why in crucial moments proper treatment cannot be made, which could lead into even more critical situation. EEG signal analysis is the area where we can study about the smallest changes of the signal and implement into emergency medication. But it's not very easy to find the smallest changes or abnormalities in brain and we cannot take the necessary steps in proper time. By using wavelet, it can be possible to detect the smallest abnormalities or changes which will give a great advantage to take the proper treatments in case of heart attack, cardiac arrest and brain strokes.

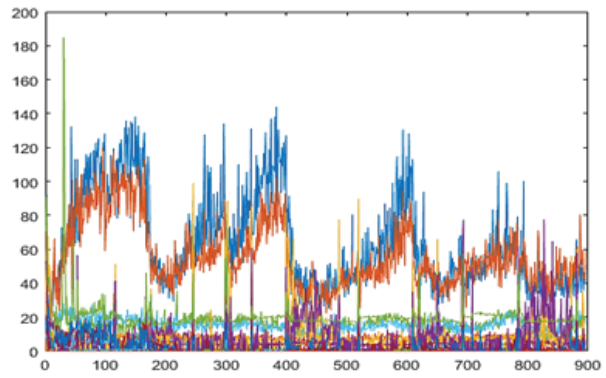

Figure 1: Recorded EEG Signal of Subject (A)

The various statistical parameters of the wavelet tool in MATLAB helps in monitoring the brain signals and also offers the detection of small abnormalities in brain in emergency conditions. Figure 1 is the presentation of brain signal of subject (A). It carries the brain signal information as for time (x-axis) as well as voltage (y-axis).

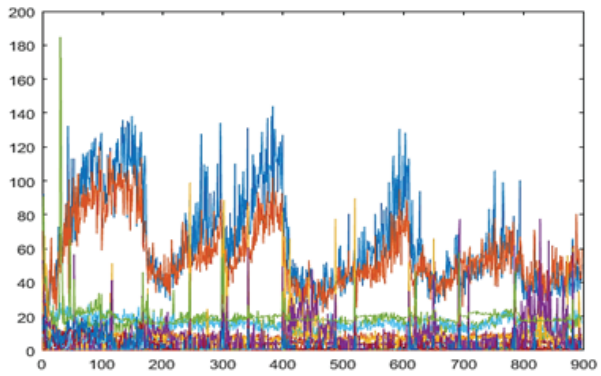

Figure 2: Recorded EEG Signal with Noise of Subject (A)

Figure 2 represents the same subject (patient), but in this case, Figure 2 have some small abnormalities or changes compared with figure 1 due to noise or other brain problems. But normally these small abnormalities cannot be detected, eventually by using the First Fourier Transform (FFT) or other popular methods, it cannot be possible to detect the changes. And this project will clarify that by using wavelet, it can easily differentiate the smallest changes in the brain signal [4]. And which will surely help to take immediate action at the crucial moments

LITERATURE REVIEW

Brain signal analysis is a great concern in the area of biomedical and signal processing. In last 30 years, many researchers are worked in this field and added a good numbers of information about the EEG signal but considering the importance of the brain signal in the case of emergency medication and small abnormalities detection, the information are not still good enough. In a research paper, Berdakh *et al* discussed about the brain activities, but it did not seems to clear to all about the brain functionalities and behavior of the brain in hash conditions [5]. Sheik *et al* clarified the classification of the EEG signal and its feature extractions [6], but the brief discussion about the EEG did not focused on the small abnormality monitoring or detection. M. Akin's deep research based on the EEG signal on the wavelet transform and FFT also over loop the importance of the small abnormalities [7]. Subasi also dealing with the classification stage based on wavelet spectral [8]. Irijanti *et al*., paper was focusing on the neural network [9], the spotlight of the research also not touch the small abnormality issue. But Lee *et al*'s narration was slightly touch the brain activity monitoring issue, but abnormality monitoring or detecting related such important issues were also disgusted in that paper [10].

Comparing with other research papers, which are dealing with the EEG signal, Thakur *et al*'s paper focused the time-scale based signal analysis which gave a better idea about the signal variation during difficult condition of the brain [11]. Saadat *et al* saw in headache patients appear to propose a conceivable physiological association between rest, hyperventilation and headache [12]. The investigation of such relationship may reveal new insight into headache psychopathology. And most of the recent research on EEG did not consider the brain signal monitoring in emergency conditions and did not tell about the small abnormalities on the brain signals which causes various serious brain diseases. The aim of this project is to monitor the brain activity and detect the smallest abnormalities of the brain signal based on wavelet transform in regular basis or in the case of emergency medication [13-18].

EEG SIGNAL ANALYSIS

The power line noise eradicated by the software implemented of the MATLAB code and the high frequency components noise also removed by processing in the same technique. The original information carrying signal of the recorded EEG data is shown in Figure 5, which also carrying the error signal. And extracting various statistical parameters along with the other processing techniques including filtering, the proposed method of wavelet based EEG signal analysis can monitor the brain as well as detect any type of abnormalities in a more accurate and effective way [15-18].

Figure 3 is the Basic EEG signal where background noises such as power line noise and high frequency components noise when the EEG circuitry was interfaced to the sound port of the PC.

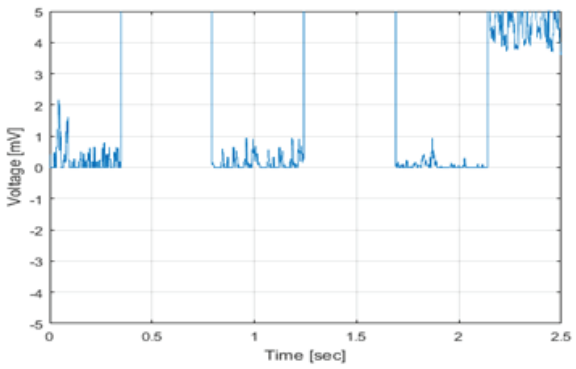

Figure 3: Basic EEG Signal

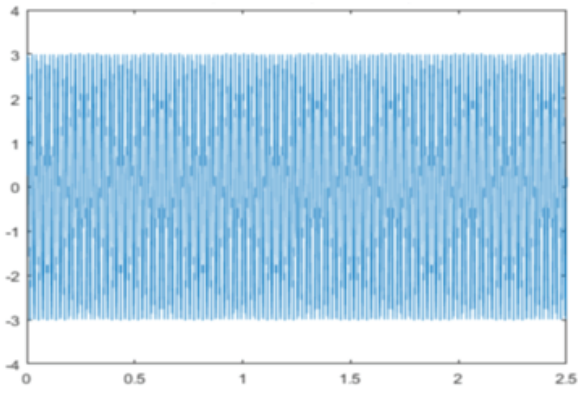

Figure 4: Noisy time domain signal

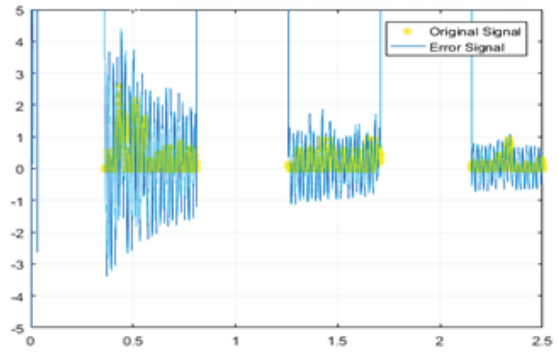

Figure 5: Original information carrying signal

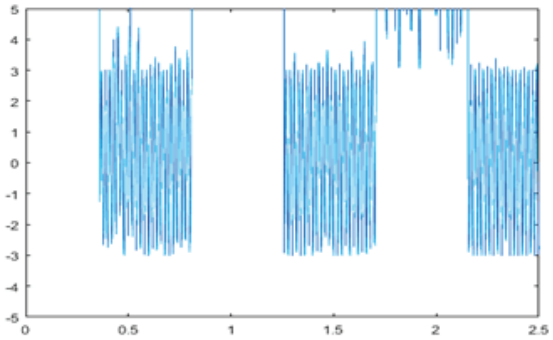

Figure 6: Signal with Noise

After realization of the fact of back ground noise, the EEG signal has filtered for removing the power line and high frequency noises. Figure 6 shows the signal before filtering. The EEG signal Power Spectrum Density (PSD) is shown in Figures 7 and 8. It signifies the power sharing of EEG in frequency dominion to assess the abnormalities from the norm of the brain. In 'x' axis it signifies frequency in hertz whereas y axis signifies voltage in mv.

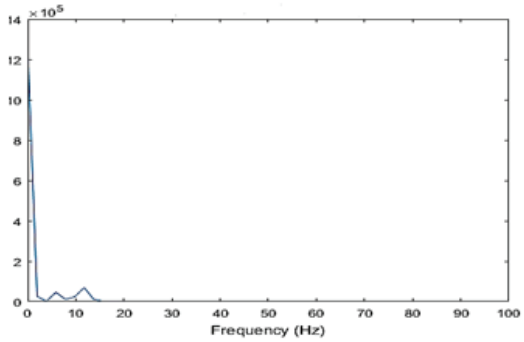

Figure 7: Power Spectral Density (a)

RESULTS ANS DISCUSSION

Wavelet transform gives a complete three dimensional information about any Brain signal i.e. what distinguish between frequency components are present in any signal and what their respective amplitudes are and at time axis where the different frequency component exits. For this project analysis, we using the wavelet tool in MATLAB and generating the signal.

Wavelet Transform has high time determination and also high frequency determination as well as frequency and time resolution can also be changed. Decomposition of EEG signal in wavelet tool is shown in Figure 11.

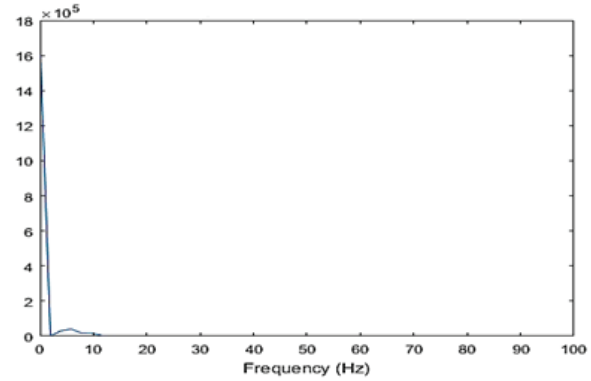

Figure 8: Power Spectral Density (a)

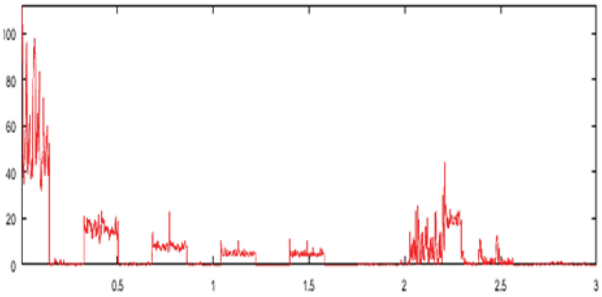

Figure 9: EEG signal by using Wavelet Transform

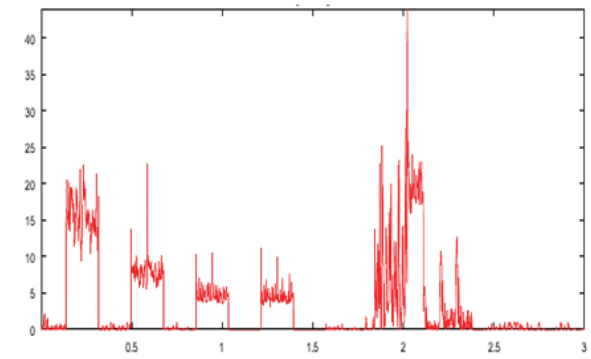

Figure 10: Statistical EEG signal analysis in wavelet

The investigation of this project clarify that the 3D representation of the signals in wavelet based analysis, statistical information of the parameters and spectral analysis helps to fulfill the aim of this work.

And the wavelet transform is suitable for stationary and non-stationary signal. It helps to study the local signal's behavior, for example discontinuity or spikes. The statistical analysis through the wavelet tool helps to detect the changes. It shows the smallest values of each parameters.

Table 1 is the summery of the statistical values of brain signal based on the wavelet spectral analysis. From this table, it seems very clear to all that the smallest changes or any kind of abnormality in the brain can effortlessly be identified and with the help of this monitoring, any emergency medication of the subject (Patient) might be provided.

The small changes or abnormality detection is very much important issue in neuroscience and proper detection of the abnormality helps for proper medication. Figure 13 is the

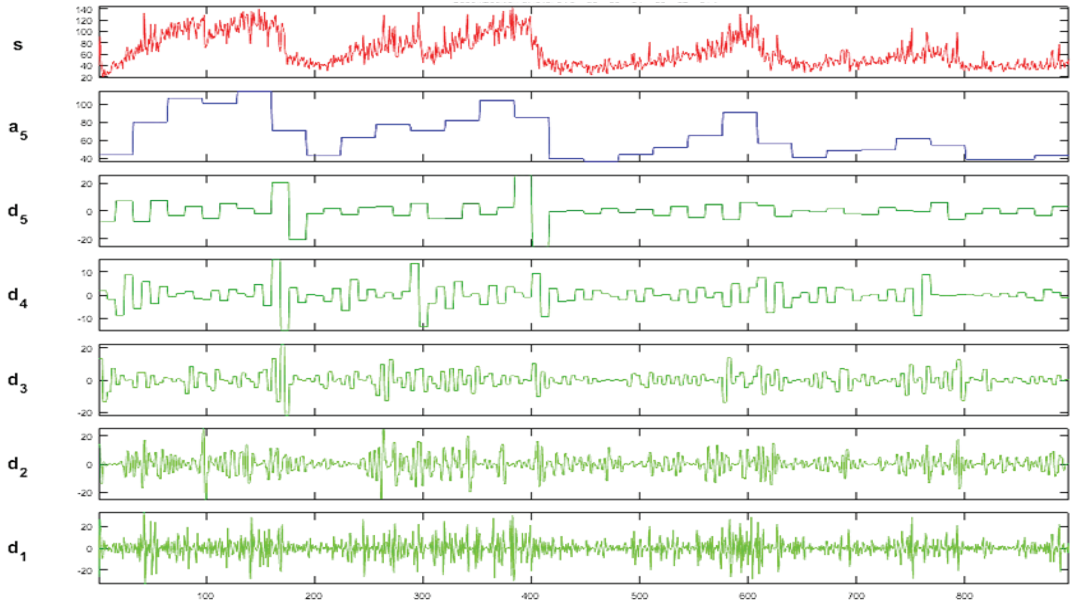

Figure 11: Decomposition of the EEG signal in wavelet

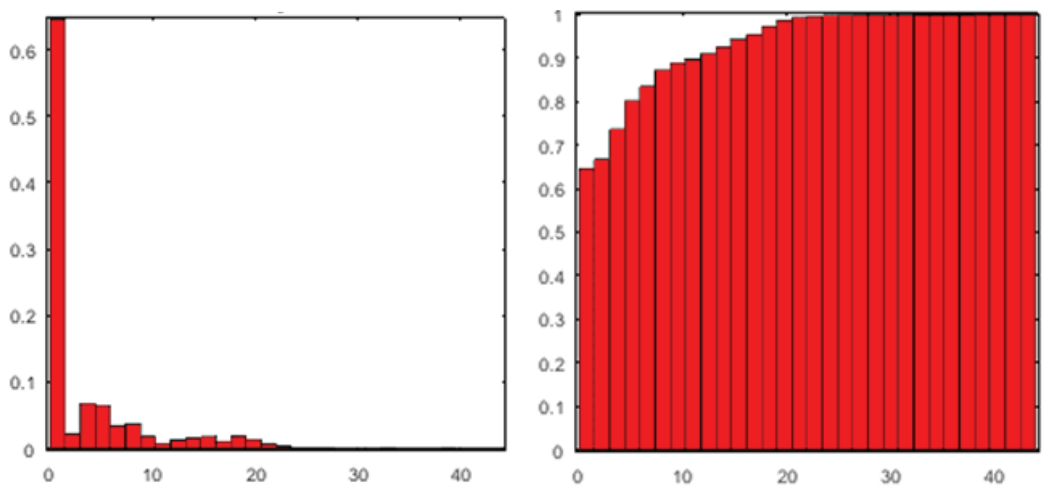

Figure 12: Statistical EEG signal analysis in wavelet (Histogram & Cumulative)

Table 1: Statistical Analysis of the Original EEG Signal in Wavelet

Parameter	Value
Mean voltage	3.275
Median frequency	0.1933
Mean frequency	0.7734
Maximum	44.01
Minimum	00
Range	44.01
Standard Dev.	5.515
Median Abs. Dev.	0.1933
Mean Abs. Dev.	4.086
L1 norm	9.826e+4
L2 norm	1111
Max norm	44.01

demonstration of an EEG signal where noise or abnormality is detected.

Wavelet transformation is one of the best possible way to find the smallest changes in the brain as discussed earlier, the statistical properties in the MATLAB Wavelet tool helps to identify the small changes and parameter basis analyzing facility which makes the detection familiar in EEG analysis. Figure 14 is the representation of the noisy EEG signal in wavelet. By this figure, the signal decomposition can be clarifies and can be observed without any problems.

In wavelet analysis the signal is converted into scaled and translated form of mother wavelet which is very irregular and helps to detect smallest changes. The mother wavelets are more suitable for predicting the local characteristic of the signal such as irregularities and spikes such as histogram presentation and cumulative which are shown in Figure 15, which helps to detect the small abnormalities. The statistical table of the EEG signal where noise or small changes are noticed will helps a doctor or technician to detect the abnormalities. It could help the patient to take proper treatment or further steps.

First of all, FFT converts signal of time sphere into frequency

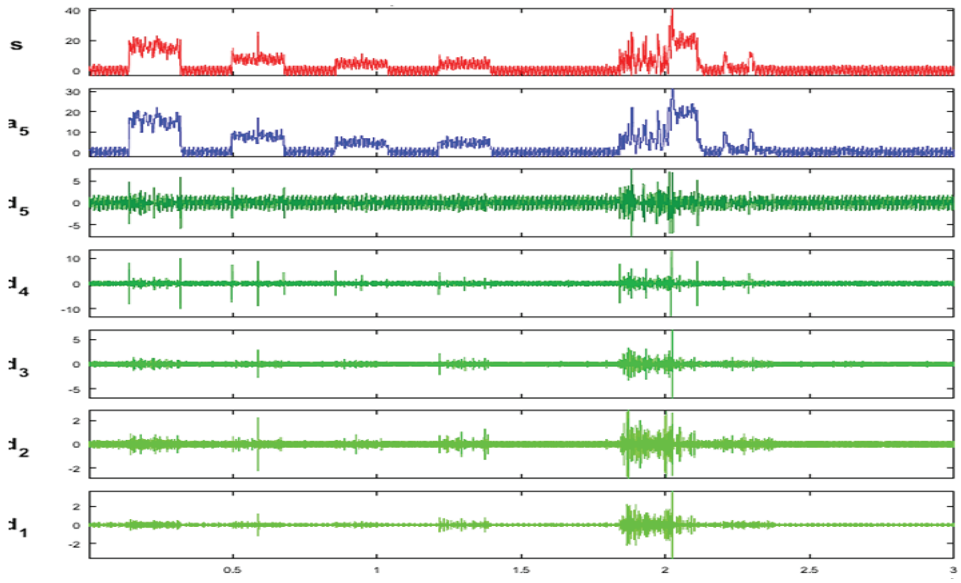

Figure 13: Decomposition of the noisy EEG signal in wavelet

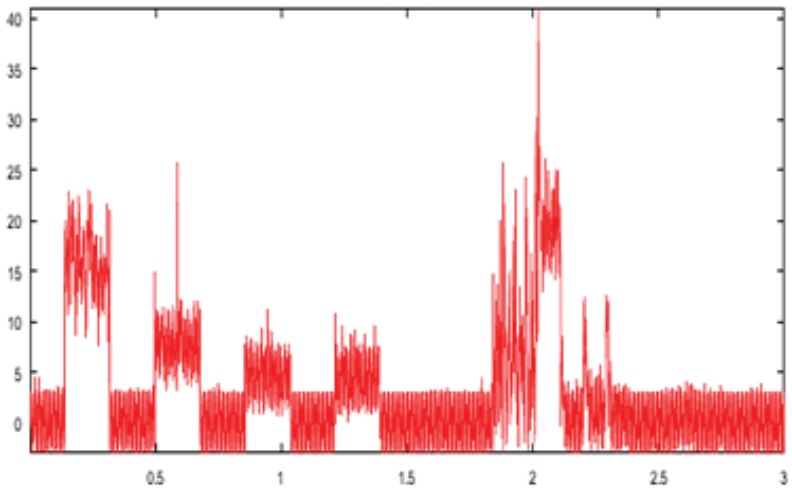

Figure 14: Statistical noisy EEG signal analysis in wavelet

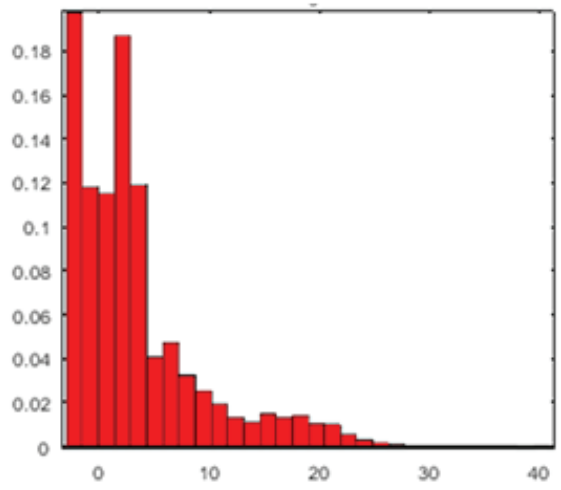

Figure 15: Statistical noisy EEG signal analysis in wavelet (Histogram & Cumulative)

sphere signal. It provides two dimensional information regards to any signal that what different frequency component present in a signal and what are their respective amplitude. Whereas Wavelet transform gives a complete three 3D about any signal i.e. what different frequency components has created any signal and what are their respective amplitudes and at time axis where the different frequency component exits.

And from the data comparison, it seems clear that wavelet can detect the smallest changes in EEG signal what is a great advantage that have not exist in FFT or other methods. It helps to anyone to observe the abnormalities of the brain signal through the wavelet properties.

CONCLUSION

Brain disease affected patients will be benefited most when EEG signal will offer the best analyzing report. There is no doubt that FFT and other popular methods have a great feature in frequency division signal analysis but it cannot ensure the detection of small abnormalities in the EEG signal data. In this work, a method is proposed to monitor and detect the smallest changes or abnormalities in the brain signals with the help of wavelet based EEG signal analysis. It can be served as an innovative tool for both regular and emergency issues. In wavelet

Table 2: Statistical Analysis of the Noisy EEG Signal in Wavelet Tool

Parameter	Value
Mean voltage	3.276
Median frequency	2.039
Mean frequency	-2.268
Maximum	41.04
Minimum	-3.002
Range	44.04
Standard Dev.	5.919
Median Abs. Dev.	2.887
Mean Abs. Dev.	4.248
L1 norm	1.328e+5
L2 norm	1172
Max norm	41.04

Table 3: Comparison between The Original and Noisy EEG Signal in Wavelet tool

Parameter	Original Signal	Noisy Signal
Mean voltage	3.275	3.276
Median frequency	0.1933	2.039
Mean frequency	0.7734	-2.268
Maximum	44.01	41.04
Minimum	00	-3.002
Range	44.01	44.04
Standard Dev.	5.515	5.919
Median Abs. Dev.	0.1933	2.887
Mean Abs. Dev.	4.086	4.248
L1 norm	9.826e+04	1.328e+05
L2 norm	1111	1172
Max norm	44.01	41.04

based signal analysis, this proposed method determines smallest changes or abnormalities of brain signals that helps for emergency medication as well as future risk factors. The graphical analysis and statistical presentation have shown that wavelet based EEG signal analysis associated with better error detection feature will help in any kind of medical application.

CONFLICT OF INTEREST: Not mentioned

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