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Analyzing of EEG Using Discrete Wavelet Transform Method with (KNN & ANN) Algorithms for Detection of Epileptic Seizures

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Abstract

An epileptic seizure is a type of seizure that occurs Because of the disruption of electrical signals in brain cells, it is a neurological ailment or problem that happens in brain cells. Epilepsy may be evaluated using electrical impulses from the brain (electroencephalogram), which are indicated by EEG, and the number of people with these disorders is roughly 1% worldwide [1]. Epilepsy can be studied using electrical impulses in the brain (electroencephalogram). Following the acquisition of EEG data, they are evaluated and divided into two categories: normal and abnormal (indicating an epileptic seizure). The EEG signals provided by the MIT BIH Dataset will be used in this work. The features will be extracted from the signals using the DWT method on the input EEG signals, and two separate algorithms (KNN and ANN) will be used to categorize the derived features into two different groups, depending on whether the input signal contains an epileptic seizure or not. Following the above method, two types of EEG are expected to be obtained using classification, either Normal (refers to normal brain activity) or Abnormal (refers to the active of brain is non-normal, maybe contain the epilepsy. The method will be evaluated using four matrices (precision, recall, and accuracy), as well as the implementation time. In this study, two methods were used: the first was DWT with KNN, and the second was DWT with ANN. Depending on the values of the three parameters and the time required for implementation. The second method proved to be superior that first method because the obtained results of second method were more accurate.

Keywords: *EEG Signal*, *Epilepsy*, *DWT*, *KNN*, *ANN*, epileptic seizure.

Introduction

Seizures caused by epilepsy are abnormal symptoms caused by excessive activity in the neurons in the brain, and this seizure has negative consequences for those who are affected, such as loss of consciousness or temporary disability [2]. Seizures caused by epilepsy are sudden and unexpected. Furthermore, conventional detection is time-consuming and necessitates long-term monitoring by specialized physicians in order to decompose EEG signals. EEG stands for electroencephalogram, and it measures the activity of the patient's brain. With the advancement of technology, it is much easier; by feeding digital EEG signal data to the computer, an epileptic seizure can be detected automatically by a special software system. The use of computer programming will shorten the time it takes to detect epilepsy. Because of automation, the accuracy of the results will improve, and the analysis time will be significantly reduced, allowing doctors to treat more patients in less time. Automatic detection of epileptic seizures is possible using classification algorithms. The EEG classification techniques for epilepsy have two parts: the extracting features method and methods of classifier design [3], during epilepsy seizures, there is a clear distinction between normal brain activity and active brain activity, which refers to electrical signals that originate in the patient's brain. As a result, the artificial intelligence technique has been proposed. In this paper, the classification algorithms (ANN & KNN) proposed a classifiers with the feature extraction method, DWT, to detect epileptic seizures from signals. The work is as follows: To begin, take the EEG signal, reduce the noise, and process it using the extraction method (DWT) to extract the features. Second, divide the extracted features into normal and abnormal categories.

- **Methods**:

  Figure 1, is a diagram that explains the steps of research:

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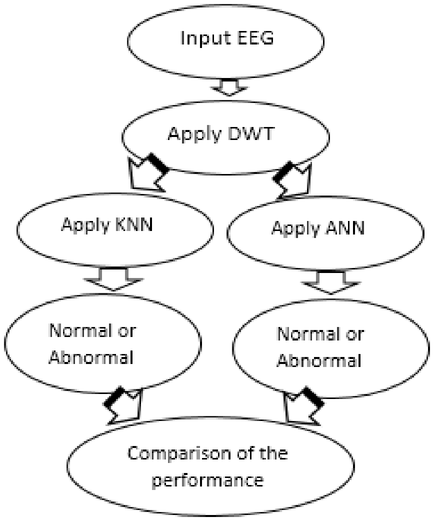

Figure 1. Flow Diagram of work

Feature Extraction Method:

The extraction of features is required to determine the brain case. Depending on the method of feature extraction, useful features can be obtained. (DWT) is used in this work to extract features from EEG. DWT is regarded as one of the most important methods for extracting features from electrical signals. DWT is used to analyze EEG signals at various frequencies (Figure 2). EEG signals are frequently unstable because they are highly dependent on the subject condition. In this study, we will use (Daubechies 6 DWT) to analyze brain signals at four levels, where we will find a sufficient amount of information. While keeping the basic information, the implementation time will be a little longer in this case. When applied to an EEG signal, DWT removes the noise while also obtaining the necessary features to classify the signals. DWT has four filters; we get each filter on one feature, as follows:

i. Low low pass filter: used to extract a specific signal approximation coefficient.

ii. Low high pass filter: used to extract specific detailed coefficients from the received signal.

iii. High Low pass filter: used to extract a specific signal's vertical coefficient.

iv. High high pass filter: used to extract a specific signal's diagonal coefficient.

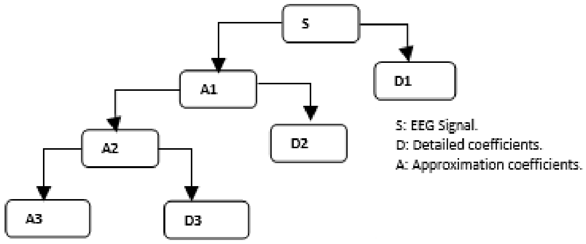

Figure 2. The EEG signals are decomposed using DWT.

The wavelet expansion in each EEG signal is:

It is used to extract characteristics (coefficients). Then, use the following functions:

1. Mean Function:
2. Standard deviation Function:

Features Classification

When the DWT is applied to EEG brain signals, the features will be ready to use classification techniques to determine the patient's condition while taking the signal and determining whether he was in an epileptic state.
To classify signals, the following classification techniques will be used. The best of the results will then be compared:

KNN:

K-Nearest neighbor among the features entered, is one of the techniques used in the classification process [10][11]. Its operation is based on comparing the features of the input signals with the features of the training signals, and then calculating the distance between them using the measure of similarity technique (one of the methods used to calculate the distance between cases of data to identify the similar ones). KNN works to find samples that are similar to the input data and closer to their selection during classification processes. The following equation is used to calculate the distance between two points:

$$X1=(x11,x12,\ldots,x1n),Y2=(y21,y22,\ldots,y2n).$$

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ANN:

Is used to categorize EEG signals as normal or abnormal [12][13]. ANN is a biologically inspired algorithm composed of a large number of neuron processing units organized into multiple interconnected layers. Every unit in this layer is connected to every unit in the previous layer. Because each connection has a different weight, not all links between units (neurons) are equal. The weights on the connections represent network knowledge. The ANN input layers in this work are made up of 90 neurons (node). In a neural network, there are five hidden layers. The back propagation algorithm is used to train the neural network. The output layer is responsible for defining the various types of EEG signals (Normal or Abnormal).

Ensemble classifiers:

Using classifiers (KNN, ANN) on the input signal features, we can obtain classification results for the signal to detect the epileptic seizure, which are divided into two categories: normal or abnormal. (As in Figure 3a & 3b).

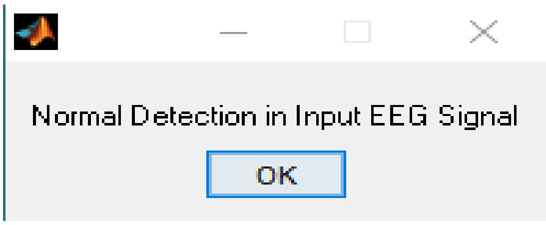

Fig. 3, a: It means it is normal result

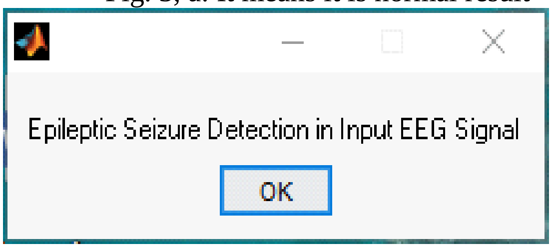

Fig. 3, b: It means it is epileptic seizure result

Results of Work:

Two different algorithms (KNN and ANN) are proposed to classification and then applied individually to determine which one the best, is based on which

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is in parentheses brackets below (Precision, Recall, Time, and Accuracy) [11]:

Precision: indicates positive predictive value, which is calculated in the following way:

$$P = t_p / (t_p + f_p)$$

Recall (sensitivity): Means true positive rate, as determined by:

$$R = t_p / (t_p + f_n)$$

Accuracy: is a measure of how accurate the recognition to samples is, which is calculated in the following way:

$$Ac = (t_p + t_n) / (t_p + t_n + f_p + f_n)$$

Time: time required to complete operations, as calculated by:

$$T = \text{end } T - \text{start } T$$

Where: tp means true positive, fpmeans false positive, tnmeans true negative, fn means false negative, T means time

The results obtained from applying the two classification algorithms to the extracted features are as follows:

DWT and KNN:

Each EEG signal is processed by DWT to extract four features. The classification algorithm (KNN) is then applied to the features, allowing the epileptic seizure to be detected from the inputted EEG. The following outcomes were obtained using KNN. (As in Table 1):

Table 1: Results of (DWT with KNN)

KNN	Parameters
84.6	Precision %
40.9	Recall %
0.41	Time %
73	Accuracy %

DWT and ANN:

Each signal is processed by DWT to extract four features. The classification algorithm (ANN) is then applied to features in order to detect epileptic seizures from the inputted EEG. ANN produced the following results. (As in Table 2):

Table 2: Results of (DWT with ANN)

ANN	Parameters
84	Precision %
95	Recall %
0.022	Time %
90	Accuracy %

Analysis of Results:

Figure 4 depicts the results of the analysis for both classification algorithms. Explaining the results for each individual classification algorithm and displaying the classification accuracy for each algorithm:

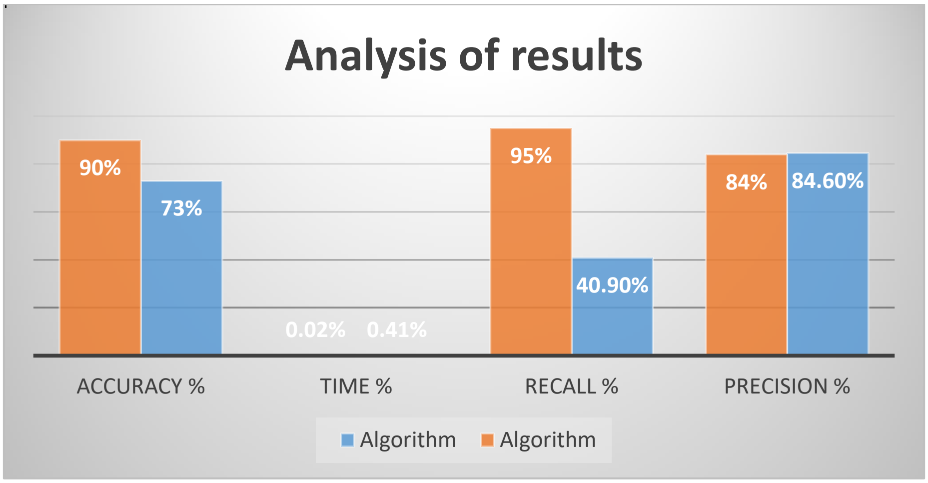

Figure 5. Results analysis for Algorithms

Conclusion:

In this research, two different classifiers (KNN, ANN) were addressed to detect epilepsy, where the DWT method was used on input EEG signals to extract features, and then the above classifiers were applied individually (the work was done using MATLAB). The ANN algorithm was discovered to be more efficient; the detection accuracy of epilepsy with ANN is 90%. While the detection accuracy of KNN is only 73%.

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