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Detection of Epileptic Seizure using EEG and Machine Learning Algorithms

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ABSTRACT: Detecting epileptic seizures using EEG (Electroencephalogram) has been practiced from early days, although many changes have revolutionized detection which encompassing Machine Learning. Early detection and prediction of the epileptic seizure is important for providing successful immediate treatment and lessen the risk of injury. EEG capturing devices and the fast evolvement of the Machine learning algorithms provides an up-to-date review of the recent epileptic seizures approaches. Special attention is directed towards the feature methods and classification algorithms. With the technological advancement in AI (artificial intelligence) and ML (machine learning) techniques, researchers are trying their best towards employing these techniques for advancing clinical practice. One of the key objectives in health care is the early detection and prediction of disease to timely provide preventive interventions. This is especially the case for epilepsy, which is characterized by repeating and undetermined seizures. Patients could be relieved from the unfortunate outcome of epileptic seizures if it could somehow be foreseen in advance.

The execution of the recommended system holds justified on complete aspects and on a compact set of aspects. The feature extraction has an impact on classifiers performance in terms of accuracy and execution time of classifiers. The proposed machine-learning-based decision support system will assist the doctors to diagnose epilepsy patients efficiently. The datasets are processed in python programming using main Machine Learning Algorithms namely Decision Tree Algorithm, Majority Voting Algorithm and Weighted Average Algorithm which shows the best algorithm among these two in terms of accuracy level of the disease.

KEYWORDS: Epileptic seizures, EEG, Convolution Artificial intelligence, Machine Learning, Feature extraction.

I. INTRODUCTION

Epilepsy is one and only supreme ubiquitous neurological syndromes in human. It is characterized by repeated seizures in which unusual impulsive electrical activity in the brain causes the loss of responsiveness or a whole-body paroxysm. Patients are often ignorant of the phenomenon of seizure due to the random nature of them which may elevate the risk of physical injury. Studies show that 4-5% of the total world population has been suffering from epilepsy. Electroencephalogram is one of the most vital tools for identification and investigation of epilepsy. Electroencephalogram is the chronicled depiction of electrical action created by shots of neuron inside the brain by the scalp. For taping of EEG, electrodes are fixed at particular significant positions on the patient's skull. Electrodes opt for the signals that are chronicled in a footage device done over wires coupled to electrodes. The "10-20" organization is the globally acknowledged system to affect the place of electrodes in EEG footage. The "10-20" indicates the information that reliable distances midst of the electrodes stay one or the other 10% or 20% of front-back or right-left distance of the cranium. As complete visual inspection of EEG signal is very difficult, automatic detection is encouraged. Fourier transform analysis has been most frequently used in early days of processing of EEG signals. However as EEG signal is a non-stationary signal, Fourier Transform analysis does not give accurate results. Extremely operational time-frequency investigation tool for study of ephemeral signal is wavelet transform. The automated diagnosis of epilepsy can be subdivided into pre-processing, feature extraction, and classification. Seizure detection can be organized as either seizure onset detection or seizure event detection. In seizure onset detection the purpose is to acknowledge the starting of seizure with the shortest possible delay.

The purpose of seizure event detection is to recognize seizures with the highest possible accuracy. For treatment of epilepsy, patients take anti-epileptic drugs on daily basis. But about 25% of them again experience frequent seizures. For these patients, surgery is the most vital and generally appropriate treatment method. Surgery can be done only if epileptogenic focus is recognized precisely. For this purpose different types of trackers are used as soon as seizure onset is detected. Hence the seizure onset detection is very vital.

II. RELATED WORK

In a report by Alfaro-Ponce M, Argüelles A and Chairez I, studies that the construction and execution of a pattern recognition algorithm to classify electroencephalographic (EEG) signals focused at Artificial Neural Networks (ANN) depicted via Ordinary Differential Equations (ODEs). [1]

In a research paper by Jirayucharoensak S, Pan-Ngum S and Israsena P, to detect emotion from non-stationary EEG signals, an advanced and futuristic learning algorithm that can represent high-level abstraction is required. This study proposes the use of a Deep Learning Network (DLN) to uncover undetermined feature correlation between input signals that is crucial for the learning task. [2]

Boashash B and Ouelha S in their research work described that Time-frequency (TF) based machine learning methodologies can improve the design of classification systems for non-stationary signals. Using selected TF distributions (TFDs), TF feature extraction is performed on multi-channel recordings using channel fusion and feature fusion approaches.[3]

Tabar Y R and Halici U , in their study investigated convolutional neural networks (CNN) and stacked autoencoders (SAE) to classify EEG Motor Imagery signals. A new form of input is instigated to combine time, frequency and location information extracted from EEG signal and it is used in CNN having one 1D convolutional and one max-pooling layer and also proposed a new deep network by combining CNN and SAE. In this network, the features that are extracted in CNN are classified through the deep network SAE. [4]

Sanjay N Rakhade and Frances E Jensen, in their research studied that, the process of developing epilepsy-a disorder characterized by recurrent seizures-following an initial jibe. Seizure incidence during the human lifespan is at its peak in infancy and childhood. They reviewed the factors responsible for enhanced seizure susceptibility in the developing brain, and considered age-specific mechanisms of epileptogenesis. [5]

III. METHODOLOGY

The database used in this study is the publicly available CHB-MIT Scalp EEG Database . The data was collected at the Children's Hospital Boston and consists of EEG recordings from paediatric subjects with intractable seizures. The participants were overseen for several days following extraction of anti-seizure medication. The recordings were grouped into 23 cases and collected from 22 different subjects. The objects were 5 males between the ages 3-22, and 17 females from the ages 1.5-19. Each case holds unique .edf-files from one individual. In nearly every case, the .edf files contain one hour of digitized EEG signals. Here were 256 samples per second, and most of the files contain 23 channel EEG signals (in some cases, 24 or 26). In total, there are 129 files that contain one or more seizures. The records include 198 seizures in total.

MATLAB was used to interpret all the files. The recordings for subject 12 and 13 were not used in this study, since the data for those patients contained channels that most of the other patients did not have. Some of the records contained other signals than EEG, for example ECG signals. In some cases, the files also contained "dummy" signals, named "-". A script was made in MATLAB to modify the files and make the data more manageable, so the signals that were not useful for the study were ignored. The data set were chosen since it is one of the biggest that is publicly available. It consists of more than 20 patients, while other sets only had around five patients and not as much EEG-data. A study where patient-specific classifiers were investigated used this data set, claiming that it is harder to achieve high accuracy with cross-patient classifiers. This was also a reason for the data set to be chosen as the result from this cross-patient study then could be compared to the patient-specific study.

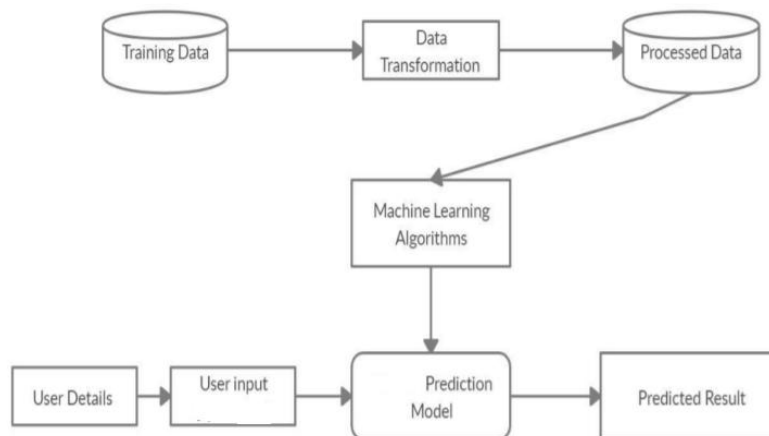
Existing System

- A complete visual analysis of EEG signal is very difficult, automatic detection is preferred.
- Fourier transform analysis has been most commonly used in early days of processing of EEG signals. However, as EEG signal is a non-stationary signal, Fourier Transform analysis does not give accurate results.
- Wavelet transform method and short time Fourier transform method were compared to determine their accuracy to ascertain the epileptic seizures.

Proposed System

- The automated diagnosis of epilepsy can be subdivided into pre-processing, feature extraction, and classification.
- Seizure detection can be classified as either seizure onset detection or seizure event detection using machine learning algorithms. Accuracy check is performed between algorithms.
- In seizure onset detection the purpose is to recognize the starting of seizure with the shortest possible delay for improving the detection of seizure.
- Epileptic Seizure is predicted using Decision Tree - Majority Voting Ensemble and Weighted Average Ensemble.

System Architecture



IV. EXPERIMENTAL RESULTS

Experimental results are shown in the below figures. Figure 1 depicts the plot after dataset processing. Figure 2 depicts the random over-sampling values of the epileptic disease. Figure 3 depicts the Accuracy of the base learners. Figure 4 depicts the Majority Voting algorithm measures. Figure 5 Weighted Average Voting algorithm measures. Figure 6 are the comparison between the different algorithms used for the detection of epileptic seizure with testing and training of data with optimal ratios.

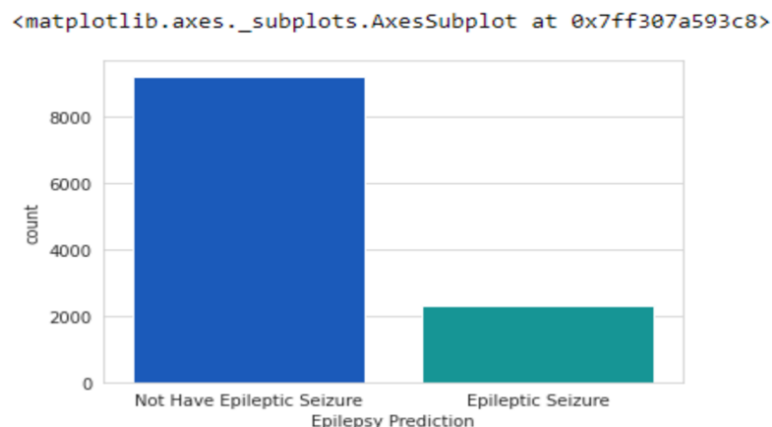


Figure 1 Plot after dataset processing

```
Random over-sampling:
1    9200
0    9200
Name: Epileptic Seizure, dtype: int64
```

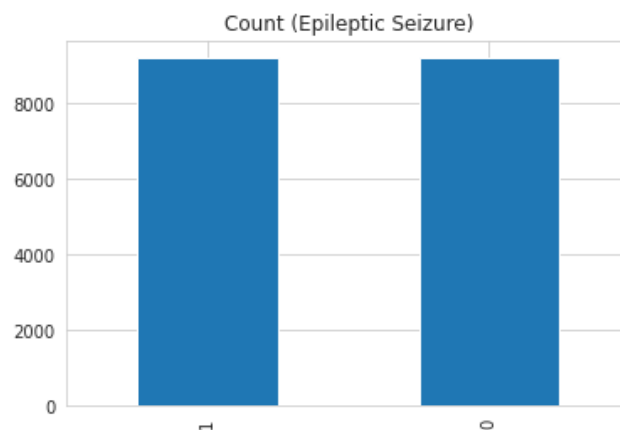


Figure 2 Random over-sampling values

support vector machine: 0.9019927536231884

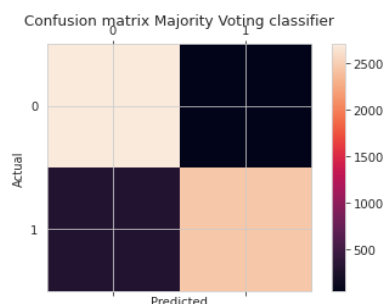
Gaussian NB: 0.9344202898550724

Decision Tree: 0.972463768115942

Figure 3 Accuracy of the base learners

majority voting accuracy: 0.9358695652173913

```
[[2709  57]
 [ 297 2457]]
```



	precision	recall	f1-score	support
0	0.90	0.98	0.94	2766
1	0.98	0.89	0.93	2754
accuracy			0.94	5520
macro avg	0.94	0.94	0.94	5520
weighted avg	0.94	0.94	0.94	5520

Figure 4 Majority Voting Measures

weighted_average_accuracy: 0.9697463768115943

```
[[2631 135]
 [ 32 2722]]
```

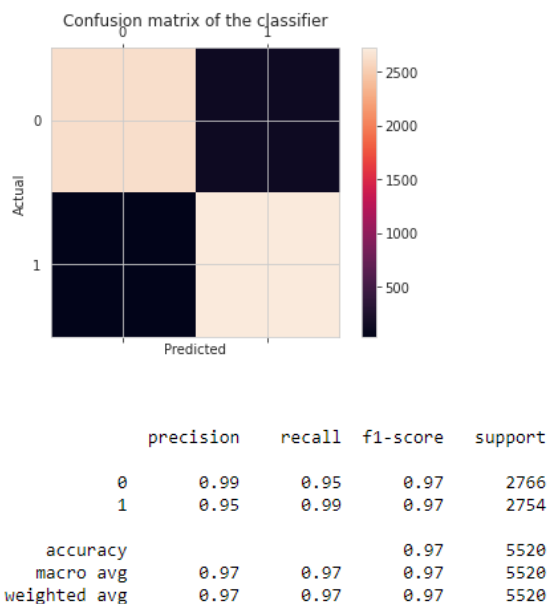


Figure 5 Weighted Average Voting Measures

Table 1. Comparison of the algorithms based on training and testing of data

Percentage	SVM	Naïve Bayes	Decision tree	Majority Voting	Weighted Average
20%training 80%testing	87.4%	94.34%	96.65%	92.73%	97.47%
30%training 70%testing	89.9%	93.2%	97%	93.59%	97.2%
40%training 60%testing	88.27%	90.42%	96.1%	92.44%	96.9%
50%training 50%testing	88.27%	92.12%	95.97%	90.97%	96.1%

V. CONCLUSION

In this paper, two supervised machine learning algorithms were applied on the dataset to predict the possibilities of having epileptic disease of a patient, were analysed with classification model namely Naïve Bayes Classifier and Decision tree classification. These two algorithms are applied to the same dataset in order to analyse the algorithm in terms of accuracy. The accurateness of the structure can be further upgraded by creating various combinations of data

mining techniques and by parameter tuning algorithm. This project presents a new seizure detection method using SVM, Naive Bayes, Decision tree and Majority voting based on the EEG signal, and the method is well applied in the epilepsy detection. The result of experiments shows that the algorithm has a high accuracy, the parameters that might influence the performance of the algorithm are discussed, and the proper parameters are chosen to match the model. We have investigated Machine learning based practical and applied hardware for diagnosing epileptic seizures. It is very heartening that much of the future research and analysis will concentrate on hardware - practical applications to aid this kind of disease. The well-designed hardware is applied to enhance the operation of identification policies.

This menacing neurological syndrome will be gained precautions precisely after in advance identification and medication. Hence the work was aimed at designing an automated classifier. This was achieved using the MATLAB-GUI. The future of this research is to stay ahead in building this system absolutely first, best and tangible.

In this research automated identification approaches designed for epileptic seizure event other than onset has arose recommended. In the case of seizure event detection the data has been decomposed with Daubechies wavelet of order 2 and six features such as maximum, minimum, mean, standard deviation, energy, and entropy were computed over the wavelet coefficients at third and fourth levels. Classification has been done using linear classifier and a total accuracy of 94.2% has been achieved.

In the instance of seizure inception recognition, CHB-MIT database is employed. Along with features used in seizure event detection, interquartile range and mean absolute deviation has been extracted. Latency and sensitivity are manipulated to learn the functioning of the linear classifier. A sensitivity of 98.5% has been achieved with an average latency of 1.76 seconds.

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