Automatic epileptic seizure detection using SVM techniques with EEG signals

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Abstract: Epileptic seizures, the Manifestation of abnormal electrical activity in the brain, represents a significant challenge in neurological health. Epileptic Seizures is unpredictable nature of when they occur, leading to potential injury or danger during this episode and can disrupt daily activities. Available existing methodologies using electroencephalography (EEG) which monitors brain activity through applied of electrodes to the scalp. Most of the researchers developed mechanized technologies for EEG-based system for prediction of epileptical seizure using AI methodologies, limited by high error value, high accuracy, time saving and peak efficiency. Proposed a EEG-based method using SVM classifier for increasing prediction rate of epileptic Seizure. As a result, using SVM algorithm obtained 92% of accuracy.

Keywords :Epileptic seizure, Brain, Eletroencephalogram (EEG), Support Vector Machinne (SVM),

1 Introduction

An epileptic seizure is a sudden electrical disturbance in the brain, leading to various convulsion or loss of consciousness. These seizures can vary widely in their presentation, from subtle alterations in consciousness to dramatic convulsions.

They can arise from various factors different fundamental causes, incorporating brain injury, genetic factors or structural abnormalities. Epilepsy has overlapping symptomatology with other neurological disorders, and hence it can't be diagnosed easily. Moreover, the mechanism causes responsible for epilepsy and seizure progression is not very clear [4]. Despite intensive research into the causes and medical treatment, the little idea of underlying cellular and network properties leads to naturally occurring seizures made the treatment challenging. The uniqueness of the disorder in each patient and understanding of the human brain adds difficulty in epilepsy detection. Nonetheless, to clinically diagnose and treat epileptic patients, it is crucial to diagnose the illness and locate the damaged brain region.

Electroencephalogram (EEG) readings are widely employed in diagnosing brain disorders, offering insights into brain activity's physiological conditions. It serves as a avital tool for identifying conditions like epilepsy and brain tumour and is non-invasive, providing data for analyzing brain behaviour. Approximately 71 million of people effected throughout the world. During Seizure, an excessive number of brain cell become activated in an aberrant manner, a phenomenon scrutinized by EEG signals to identify epileptic episodes. By combining the patient's medical background and the opinions of a skilled neurologist via EEG recordings. The diagnosis of epileptic seizures is analyzed. However, The EEG analysis for forecasting epileptic seizures has advanced more with the emergence of new signal processing techniques.

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In prediction of epilepsy, in accordance to the visual inspection of EEG, the automatic seizure detection system is used, which acts as a second opinion tool by the physician. Proposed a technique, Automatic epileptic seizure detection using SVM techniques with EEG signals for prediction of epileptic seizure detection accurately. The proposed technique complete overview discripts following sections. Section2 deals with available methodologies with different techniques. Section 3 handles with proposed method to overcome the issues in already available systems. Section 4 manages complete process flow of proposed system with SVM classifier. Section 5 holds result obtained by Automatic epileptic seizure detection using SVM techniques with EEG signals. Conclusion of proposed method follows section6.

2 Literature review:

Epileptic seizure detection involves using technology to monitor brain activity and detect abnormal patterns indicative of a seizure, aiming to alert caregivers or trigger interventions to mitigate risk and improve patient safety.

M.Anitha, et al,[2024] introduced a method used Long Short Term Memory (LSTM) and Multi-Scale Atrous-based Deep Convolutional Neural Networks (MSA-DCNN), collectively referred to as Hybrid Deep Scheme (HDS), to predict epileptic seizures using top-rated features for epileptic seizure classification. Ijaz ahmad, et al,[2024]introduced a method for producing best results in alleviating problems and change the average accuracy by 2% when contrast to other machine learning techniques include Bonn and UCI-EEG database. Md Shamshad Alam, et al,[2024] introduced three separate methods for prediction of epileptic Seizure crafted by combining three various features with Quadratic discriminant analysis (QDA) algorithm. A seizure detection system utilizing energy and non-linear energy exhibits superior performance compared to conventional seizure detection methods due to handles with lowest power consumption.

M.V.V. Prasad Kantipudi, et al,[2024] introduced a method merged with FLHF, GBSO, TAENN and FD for enhance accuracy of disease prediction when reducing complexity of system while minimizing time consumption. Zongpeng Zhang, et al,[2024] suggested a data agumentation technique to enhance generalization. And evaluated seizure EEG signal distribution and suggest spatio-temporal EEG agumentaion (STEA) And Patient-adversarial neural network (PANN) to know depiction of patient invariance. Mahrad Poryosef, et al, [2024] proposed a pipeline based on genetic and bat algorithms for decrease the dimensions and construction of features. Mosab A.A Yousif, Mahmut Ozturk, et al, [2024] introduced a classifier to prediction of seizure named as ConceFT is a time frequency technique and transfer learning. Ali H. Abdulwahhab, et al,[2024] introduced deep learning technology having two concurrent methods for predicting the epileptic seizures' activity. EEG time-frequency images and raw waveforms for convolution and recurrent neural networks (RNN and CNN, respectively).

Puja A. Chavan, et al,[2024] introduced an enhanced deep dual adaptive CNN-HMM algorithm is constructed for prediction of epileptic seizures spontaneously both focal and non-focal electroencephalogram signals. Yankun Xu, et al,[2024] suggested a new A deep learning method for anticipating epileptic seizures. pioneers in the switch from binary classification to probabilistic prediction in seizure detection. This innovation involves integrating a transition period from seizure-focused EEG recordings, altering the discourse. Wang et al,[2021] proposed A novel time-varying method using the multi-wavelet Basis function (MWBF) may accurately forecast epileptic episodes from EEG readings.

Ramkumar, et al, [2024] suggested a method for prediction of various state of epileptic Seizure, siamese Convolution fire Hawk Aparse Autoencoder Network (SCFHSAN). EEg signals collected from two datasets incorporating UoB and TUH EEG. Niha Kamal Basha, et al, [2024] choosen Deep learning and machine learning techniques for epileptic seizure prediction.

Data base having a hundred subjects with more sample rate. Nourane Abderrahim, et al, [2024] suggested deep learning methods named as convolution Neural Network (CNNs) for prediction of seizure for analyzing and classification of data. Beula Belk, at al, [2024] introduced convolution Two segment parts of the 1D-CNN network are used by the neural network (CP-CNN).

3 Proposed method

The existing systems for the prediction of epileptic seizures encompass a spectrum of methodologies, each with its unique approach and effectiveness. These systems typically rely on Artificial Neural Networks (ANNs), k-Nearest Neighbors (kNN), and other machine learning algorithms to analyze

Electroencephalogram (EEG) signals and identify patterns indicative of impending seizures. Often, these systems employ feature extraction techniques to transform raw EEG data into informative representations, capturing relevant temporal and spectral characteristics. Additionally, some systems integrate wearable devices or implantable sensors for continuous monitoring, enabling real-time seizure prediction and alerting. Despite advancements, challenges persist, including the need for improved accuracy, reduced false alarms, and seamless integration into clinical workflows. Addressing these challenges requires interdisciplinary collaboration among clinicians, engineers, and data scientists to refine existing methodologies and develop novel approaches for more reliable and efficient epileptic seizure prediction systems.

Proposed a method, Automatic epileptic seizure detection using SVM techniques with EEG signals for prediction of disease with accurate results using Support Vector Machine (SVM) algorithm, that emerged as a promising tool for epileptic seizure prediction. In this method, EEG signals are typically preprocessed to extract relevant features such as frequency domain measures, statistical measures, or time-frequency representations. These features are then used to train the SVM classifier, which learns to distinguish between seizure and non-seizure patterns. During prediction, the SVM algorithm assigns new EEG signals to either the seizure or non-seizure class based on the learned decision boundary. SVMs offer several advantages for seizure detection, including their capacity to manage data with multiple dimensions, robustness to noise, and effectiveness in capturing complex patterns in EEG signals. Furthermore, SVMs can be trained with relatively small datasets and are computationally efficient, making them suitable for real-time applications in epileptic seizure prediction and detection systems.

EEG data acquisition:

The EEG signals were obtained from the online database that was kept up to date at the University of Bonn, Germany's department of epileptology website. Each EEG signal is recorded for 23.6 seconds, which is digitalized at 173.61 Hz with a 12-bit resolution over (0-40) mV range, the total of 4096 samples. The collected data contains 100 epilepsy signals, 100 normal signals. The data that was retrieved is in the ".mat" format, and Matlab software is used to evaluate and handle it.

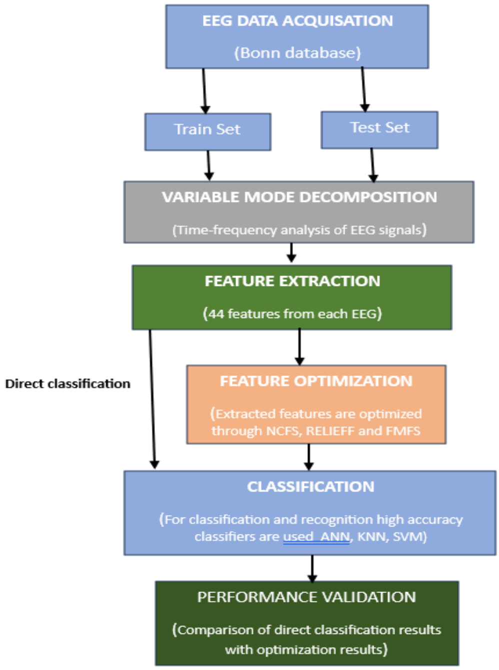

Fig.1 Proposed model for prediction of epileptic Seizure

Feature Extraction:

Features from the EEG are essential for diagnosing epilepsy. For easier analysis, each EEG signal is divided into four segments, each consisting of 1024 samples. The suggested study extracts statistical and spectral data using a support vector machine (SVM) technique. In order to classify the normal and epilepsy signals, a total of 44 features are retrieved from each EEG signal and supplied into the classifiers.

Feature Optimization:

The large feature set could include overfitted, correlated, and irrelevant features that confuse the classification algorithm. To improve the accuracy of predictions, those features ought to be removed from the dataset. Feature selection criteria dictate how feature optimization techniques shrink the feature space. Using a superset of original features, it creates a smaller feature subset to improve computing efficiency and classification accuracy. The proposed methodology uses Neighbourhood component feature selection (NCFS), ReliefF, and Filter method feature selection (FMFS) technique for optimized feature selection.

Classification and Identification:

A classifier utilizes values from a classifying attribute and the training set to categorize data, then applies this classification to new data. The EEG signal can be used to identify epileptic seizures by feeding machine learning classification algorithms with the EEG feature data.
Several classification techniques, including K-Nearest Neighbor, Support Vector Machines, and Artificial Neural Networks, are trained on the optimal feature set that has been generated.

4 Experimental Results

EEG dataset comprises EEG recordings, which are collected fromthe German University of Bonn's Department of Epileptology. In the duration of 23.6 seconds, the EEG signals comprising 100 signal channels were taken. The EEGs of two diverse conditions were selected. The amplifier system of 128-channel using reference, which is averagely common have been used to record the signals extra-cranially and intra-cranially. The signals are digitized and The EEG signals are 200 in total. They are 100 epilepsy signals, 100 normal signals. The slopes at the ending and starting of the series of time having the same sign as chosen for the final segment. N=4096 samples are the final segments which have been given as the difference in amplitude between the last and first data points, which is within the range.The datasets, Set A and Set E, are made up of two distinct sets. The signals in Set A represent the standard state. In Set E, the signals display the ictal activity, or epilepsy. Set A was taken from five healthy participants who had their eyes closed. The Set E was built from the EEG records of five patients with epilepsy who were diagnosed prior to surgery. Set E contains the EEG recordings made by epileptic patients during their seizures. Figure 1 shows one of the signals from each corresponding category. The chart illustrates that in a normal situation, the amplitude of EEG signals is the lowest when compared to the other signals. The amplitude of the signals in micro-volts is represented in Fig. 2

Table 1 Types of EEG states and their features

State	**Amplitude**	**Frequency (Hz)**	**Comment**
Alpha	22-82	10-14	Simultaneous action. Cognitive state.
Beta	2-6	13-26	Rapid de-synchronous activity. Cognitive state.

Gamma	0-0.5	26-41	Brain is highly stimulated and poses a significant risk.
Delta	>85	0.6-4.1	Profound rhymtic activity.typically subconsciou.
Theta	10-15	5-9	Gradual rhythmic activity. subconscious.

Performance analysis:

Accuracy = $\frac{TP+TN}{TP+FP+TN+FN}$ -------(1)

Precision = $\frac{TP}{FP+TP}$ -------------(2)

Recall = $\frac{TP}{FP+TP}$ ------------(3)

F1-Score = $\frac{2*Precision*Recall}{Precision+Recall}$---(4)

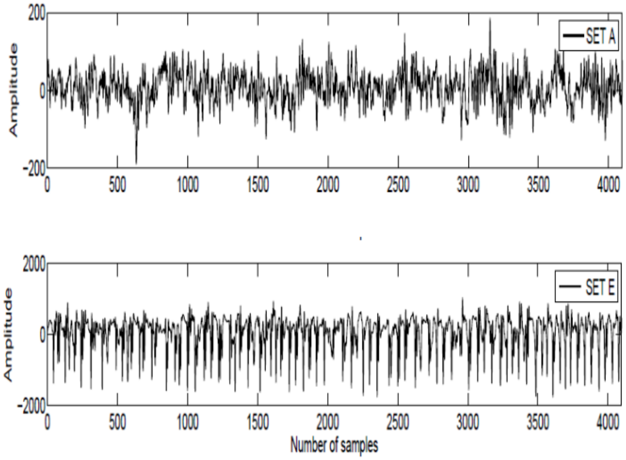

Fig.2 Raw EEG signal of normal and epilepsy

The study aimed to predict epileptic seizures using a Support Vector Machine (SVM) algorithm. The results demonstrated promising outcomes in forecasting seizure occurrences. By leveraging SVM, the model effectively analyzed EEG data, identifying patterns indicative of impending seizures with notable accuracy.

This predictive capability holds significant potential for enhancing seizure management and intervention strategies, offering valuable insights into pre-emptive treatment approaches for individuals with epilepsy.

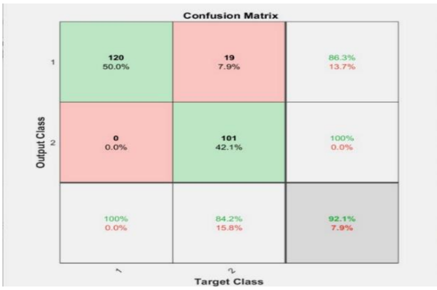

Fig. 3 Results obtained by SVM classifier

In the prediction of epileptic seizures, a confusion matrix serves as a fundamental instrument to assess the performance of predictive models. It offers a structured representation that juxtaposes the model's predictions against the actual classes, or target classes, of the data. True positives (TP), true negatives (TN), false positives (FP), and false negatives (FN) are the four quadrants that commonly make up this matrix. True positives show occurrences where the model correctly predicts a seizure occurrence when one actually happens, while true negatives represent correct predictions of the absence of seizures when none occur. False positives occur when the model erroneously predicts a seizure, leading to false alarms or falseositive forecasts are known as false negatives, and missed detections or false negative predictions are the result of the model's inability to anticipate a seizure that actually occurs. By organizing predictions in this manner, the confusion matrix provides important information about the model's performance that made it possible to compute important metrics including F1-score, specificity, accuracy, recall, and sensitivity. These metrics provide a thorough evaluation of the model's capacity to distinguish between seizure events and non-occurrences, enabling defensible choices about the effectiveness of predictive algorithms in seizure prediction and intervention techniques.

Accuracy performed by various classifiers shown in figure 4, obtained high accuracy by proposed technology Automatic epileptic seizure prediction using SVM techniques with EEG signals as compared to other classifiers

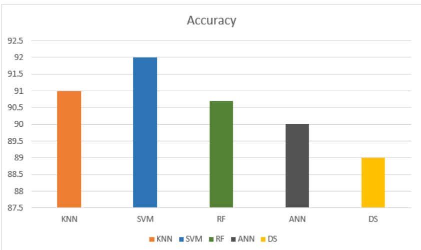

Fig.4 Accuracy performance using various classifiers

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5 Conclusion

Concluded that, the utilization of Support Vector Machine (SVM) techniques for the prediction of epileptic seizures represents a promising avenue in epilepsy management and intervention. Through the analysis of electroencephalogram (EEG) data and the application of sophisticated machine learning algorithms, SVM models have demonstrated impressive capabilities in forecasting seizure occurrences with notable accuracy. By effectively leveraging feature extraction and selection methodologies, these models can discern subtle patterns and anomalies in EEG signals, providing valuable insights into preictal states and enabling timely intervention strategies. The development of SVM-based seizure prediction systems holds significant potential for enhancing patient care and quality of life by offering advanced warning systems to mitigate the impact of seizures and optimize treatment approaches. However, further research and validation studies are warranted to refine and optimize SVM algorithms, address challenges related to data variability and model generalization, and ultimately realize the full potential of predictive analytics in epilepsy management. Overall, the application of SVM techniques in seizure prediction represents a promising frontier in the field of epileptology, with the potential to revolutionize clinical practice and improve outcomes for individuals living with epilepse.

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