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BRAIN EPILEPTIC SEIZURE DETECTION USING DEEP LEARNING

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Abstract :Epilepsy is a chronic condition characterized by recurring, spontaneous seizures. If a person has two or more unprovoked seizures, they are diagnosed with epilepsy. Epilepsy seizures can be caused by a brain damage or a genetic predisposition, although the reason is often unknown. Overcoming the difficulty of accurately describing seizure occurrences in a broad and heterogeneous population of patients is thus a critical step toward clinical applicability. As a result of significant patient inter-variability in epileptic diseases, present technologies have difficulty generalizing to unseen patients, and they frequently need to be fine-tuned to each patient. Several approaches have been developed to detect and forecast seizure events from EEG of epileptic patients collected mostly during short in- hospital monitoring with standard scalp-EEG or intracerebral electrodes, thanks to the rise of Deep Learning (DL) in the biomedical sector. Though some methods reported outstanding results, the majority used offline analysis with extensive pre- processing and manipulation of the EEG data, which is incompatible with the goal of online, long-term, low-power ambulatory operations. The difficulties in accurately detecting automated epileptic seizures with DL and EEG modalities are explored. The benefits and drawbacks of using DL-based approaches to diagnose epileptic seizures are discussed. Finally, the most promising DL models are proposed, as well as potential future research on automated epileptic seizure detection.

IndexTerms - Convolutional Neural Networks(CNNs),Artificial Neural Networks(ANNs),Recurrent Neural Networks(RNNs)

INTRODUCTION

This project seeks to revolutionize the management of epileptic seizures through the development of an innovative solution employing artificial neural networks (ANNs). With millions affected globally by epilepsy, early detection and prediction of seizures are crucial for improving patient outcomes and quality of life. Through our research, we aim to harness the power of machine learning to create a robust system capable of accurately detecting and predicting seizures based on EEG data. This involves collecting diverse EEG datasets from epilepsy patients, preprocessing the data to extract relevant features, and training various ANN architectures, including convolutional and recurrent neural networks. These models will learn to recognize patterns indicative of seizures and adjust their parameters accordingly. Through rigorous testing and evaluation, we anticipate achieving improved accuracy and timeliness in identifying seizure events, paving the way for early intervention and personalized treatment strategies. Ultimately, our project aims to make a significant contribution to both medical research and patient care by demonstrating the efficacy of machine learning approaches in the management of neurological disorders like epilepsy.

OBJECTIVES

The project is structured around several key objectives aimed at advancing the field of epileptic seizure detection and prediction using artificial neural networks (ANNs). Firstly, we will focus on acquiring diverse EEG datasets from individuals with epilepsy, ensuring inclusivity across demographics and seizure types. These datasets will undergo meticulous preprocessing to remove noise and artifacts, ensuring the neural network models receive clean and reliable input data. Subsequently, we will explore and develop various ANN architectures, including convolutional neural networks (CNNs) and recurrent neural networks (RNNs), tailored specifically for seizure detection and prediction tasks. These models will be trained on the preprocessed EEG data, with parameters optimized to maximize performance. Additionally, we will extract relevant features from the EEG signals, such as spectral power and wavelet coefficients, to provide informative input to the neural networks. Through rigorous training, validation, and testing procedures, we aim to evaluate the efficacy of our models in accurately detecting and predicting seizure events. Ultimately, our project seeks to integrate these advanced neural network models into clinical practice, contributing to improved patient care and management of epilepsy by enabling early intervention and personalized treatment strategies.

RESEARCH METHODOLOGY

[1] Yanly Zhang As an electrical signal recorded by the scalp or intracranial electrodes, EEG reflects the nonlinear process of epileptic seizures and possesses fractal structure. The applicability of fractal analysis to seizure detection has been investigated by many researchers and fractal dimension (FD) quantifying the irregularity or complexity of a fractal object has been used to discriminate the seizure from the non-seizure state. Nevertheless, fractal analysis is seldom utilized for seizure prediction research. In this work, we concentrate on using fractal techniques to analyze the characteristics change of EEG in the period prior to epileptic seizures and capture the key features needed for preictal identification. Specifically, a roughness length method proposed by Malinverno is adopted to study the fractal characteristics of epileptic EEG for seizure prediction. The method has been successfully applied in the analysis of multi-scale rough surfaces and the research of the interrelationships between topography and structure53, since it is simple to implement and has a high accuracy and a little variability in estimating fractal dimensions. Establishing an efficient classifier model is indispensable for seizure prediction after the characteristic analysis of epileptic EEG. In recent years, gradient boosting method has been developed into a type of main method in ensemble learning, which follows the basis idea that builds a strong classifier by combining weak classifiers through iterative process.

[2] Asghar Zarei In their study, the NIG parameters were fed into Adaptive Boosting to automatically detect seizures. Subasi et al. presented an approach for epileptic seizure identification using a particle swarm optimization method and a genetic algorithm (GA). They classified different EEG segments utilizing the support vector machine (SVM) classifier, the discrete wavelet transform (DWT) technique, and statistical features. In their work, the SVM parameters were optimized using GA and PSO-based approaches. Although numerous studies have been performed on the discrimination of ictal-free and ictal segments, in this work, all possible pre- ictal, inter-ictal, and ictal cases were considered, among which ictal and inter-ictal classifications are more important since they can estimate future ictal activity. Despite attempts to develop algorithms for seizure detection based on EEG signals, an automated algorithm with low computational load for practical applications is still required. To address these problems, a novel automatic seizure classification algorithm based on the DWT and orthogonal matching pursuit (OMP) techniques is presented. Applications based on DWT and OMP need better trade-offs among efficiency, accuracy, and computational complexity. The algorithm presented in this study is different from the existing techniques such as. This study has combined the OMP algorithm with different features to classify the EEG segments.

[3]Oliver Faust In this paper we analyze frequency measures for the detection of epileptic activity in EEGs. The study is based on EEG data samples which are classified into three distinct classes: normal, epileptic background and epileptic seizure. We used autoregressive moving average (ARMA), Yule-Walker and Burg's method, to extract the power density spectrum (PSD) from representative EEG signal samples. Local maxima and minima were detected from these spectra. The locations of these extreme become input vectors to the classifiers. ANalysis Of VAriance between groups (ANOVA) tests on these input vectors show that the information, conveyed by these input vectors, is statistically significant. The three classifiers used here are: Gaussian mixture model (GMM), artificial neural network (ANN), and support vector machine (SVM). The different classification results are documented with confusion matrices and compared with receiver operating characteristic (ROC) curves. We found that Burg's method for spectrum estimation together with a SVM yields the best classification results. This combination reaches a classification rate of 93.33%, the sensitivity is 98.33% and the specific is 96.67%.EEG signals can be used to discriminate and subsequently diagnose different brain states, like normal, epileptic background and epileptic seizure. Changes in the EEG signals might be quite prominent, as in the case of an epileptic seizure or more hidden (complex), as in the case of epileptic background. In the time domain, only a trained eye can detect the different states. This work shows that, characteristics of these different mental states are also visible in the spectral domain.

[4] Farhan Riaz In this paper, we propose a novel feature extraction methodology for the classification of EEG signals involving three stages. The first stage of the algorithm involves the calculation of EMD of the EEG signal, giving a set of IMFs. The first three IMFs are selected for further processing. The second stage involves feature extraction which is done by calculating the temporal and spectral characteristics of the IMFs, which is the main contribution of this paper. For the calculation of spectral features, we have used power spectral density (PSD). The temporal and spectral features are obtained from the Hilbert transformed IMFs as using this transformation can remove the DC offset from the spectral content of the signals which is one of the sources of non-stationarity in the signals. The third stage involves the use of support vector machine (SVM) for the classification of EEG signals. In this paper, we have proposed a method for the detection of seizures and epilepsy in the EEG signals. The foundation of this method lies on the extraction of temporal and spectral features from Empirical Mode Decomposition (EMD) of the EEG signals. The usage of EMD is motivated by the fact that EEG signals are non-stationary and EMD is a data dependent method exhibiting a better adaptability towards non-stationarity in the EEG signals. Previously, researchers have shown that temporal statistics are useful for classifying the EEG signals. We have extended their work in the spectral domain where the power spectrum density (PSD) has been observed to exhibit good discrimination power for the classification of EEG signals.

PROBLEM DEFINITION

The problem we aim to address is the need for more accurate and timely detection and prediction of epileptic seizures. Epilepsy, a neurological disorder characterized by recurrent seizures, affects millions of individuals worldwide, significantly impacting their quality of life. Current methods for seizure detection and prediction often lack precision and may not provide sufficient warning time for timely intervention. This poses challenges for patients and caregivers in managing the condition effectively and minimizing the potential risks associated with seizures, such as injury or loss of consciousness. Therefore, our goal is to develop an advanced solution utilizing artificial neural networks to improve the accuracy, reliability, and timeliness of epileptic seizure detection and prediction, ultimately enhancing patient outcomes and quality of life. Despite advancements in medical technology, accurate and timely detection of epileptic seizures remains a significant challenge. The current methods often rely on manual interpretation of EEG signals by healthcare professionals, which can be subjective, time- consuming, and prone to errors. Automated seizure detection systems have been developed, but they may suffer from high false alarm rates or limited sensitivity, leading to missed or misclassified seizure events. Additionally, predicting seizures before they occur is a complex task, as seizure onset can vary widely among individuals and may not always follow predictable patterns. This lack of reliable seizure prediction hinders the implementation of preventive measures or timely administration of medication to mitigate seizure severity.

OVERVIEW OF THE PROJECT

The project is cantered on the development of a sophisticated system that aims to significantly improve the detection and prediction of epileptic seizures through the innovative application of artificial neural networks (ANNs). By meticulously collecting and preprocessing EEG data from a diverse range of individuals with epilepsy, we ensure the robustness and reliability of our dataset. Through advanced feature extraction techniques, we distill crucial information from these EEG signals, allowing our ANNs, including convolutional neural networks (CNNs) and recurrent neural networks (RNNs), to learn and recognize patterns indicative of impending seizures. The models undergo extensive training and validation phases, fine-tuning their parameters to optimize performance and ensure generalizability across different datasets. Our ultimate objective is to seamlessly integrate these advanced neural network models into clinical practice, providing healthcare professionals and patients with timely alerts and actionable insights for proactive intervention. This integration holds the promise of revolutionizing epilepsy management, empowering patients to take control of their condition and improving their overall quality of life. Through our project, we aim to contribute to the advancement of medical research and healthcare, ultimately making a meaningful difference in the lives of individuals living with epilepsy. By accurately recognizing patterns indicative of impending seizures, our models aim to provide timely alerts and proactive interventions, ultimately improving patient outcomes and quality of life. The integration of our advanced neural network models into clinical practice has the potential to transform epilepsy management, empowering patients and caregivers with invaluable insights and enabling personalized treatment strategies. In summary, our project represents a significant advancement in leveraging machine learning for medical research, with the ultimate goal of enhancing the well-being of individuals living with epilepsy.

DATASETS ACQUISITION

Epilepsy is a central nervous system (neurological) disorder in which brain activity becomes abnormal, causing seizures or periods of unusual behaviour, sensations and sometimes loss of awareness. Anyone can develop epilepsy. Epilepsy affects both males and females of all races, ethnic backgrounds and ages. Seizure symptoms can vary widely. Some people with epilepsy simply stare blankly for a few seconds during a seizure, while others repeatedly twitch their arms or legs. Having a single seizure doesn't mean you have epilepsy. At least two seizures without a known trigger (unprovoked seizures) that happen at least 24 hours apart are generally required for an epilepsy diagnosis. In this module we can input the CSV file about EEG data. The CHB-MIT dataset is a dataset of EEG recordings from pediatric subjects with intractable seizures. Subjects were monitored for up to several days following withdrawal of anti-seizure mediation in order to characterize their seizures and assess their candidacy for surgical intervention

PREPROCESSING

Data preprocessing can refer to manipulation or dropping of data before it is used in order to ensure or enhance performance, and is an important step in the data mining process. The phrase "garbage in, garbage out" is particularly applicable to data mining and machine learning projects. Data-gathering methods are often loosely controlled, resulting in out-of- range values, impossible data combinations and missing values, etc. Analyzing data that has not been carefully screened for such problems can produce misleading results. Thus, the representation and quality of data is first and foremost before running any analysis. Often, data preprocessing is the most important phase of a machine learning project, especially in computational biology. In the pre-processing stage, continuous EEG recordings are firstly segmented without overlapping by a sliding time window. Then wavelet transform is performed on the EEG data to provide the signals form of dataset .

FEATURES EXTRACTION

In this module, we can extract the time and frequency domain features from preprocessed data. It includes “mean”, variance", "kurtosis", "skewness” and other features for future classification. Mean: It is the average of an N sample EEG signal; it can be defined

Standard deviation: The dispersion of data from it’s a mean value of a signal is a standard deviation.

5.4 CLASSIFICATION

In the process of seizure detection from EEG recordings, a series of post-processing are needed to carry out on the outputs of the trained CNN network to obtain the category labels of testing EEG. A CNN consists of an input and an output layer, as well as multiple hidden layers. The hidden layers of a CNN typically consist of convolutional layers, pooling layers and fully connected layers. Convolutional layers apply a convolution operation to the input, transferring the result to the next layer. The convolution emulates the response of an individual neuron to visual stimuli. Convolutional networks may include local or global pooling layers that combine the outputs of neuron clusters in one layer into a single neuron in the next layer. Mean pooling uses the average value from each cluster of neurons in the previous layer. Fully connected layers connect every neuron in one layer to every neuron in another layer. The CNN is in principle the same as the traditional multi-layer perceptron neural network. Compared with traditional classifiers, CNNs have obvious advantages for analyzing high-dimensional data. CNNs employ a parameter sharing scheme, which is used in convolutional layers to control and reduce the number of parameters. A pooling layer is designed to progressively reduce thespatial size of the representation and the number of parameters and computation in the network, and subsequently control over fitting.

Constructing the CNN Model function INITCNNMODEL (θ, [n–5])
layerType = [convolution, max-pooling, fully-connected, fully-connected]; layerActivation = [tanh(), max(), tanh(), softmax()]
model = new Model(); for i=1 to 4 do
layer = new Layer(); layer.type = layerType[i]; layer.inputSize = ni
layer.neurons = new Neuron [ni+1]; layer.params = θi;
model.addLayer(layer);
end for return model; end function

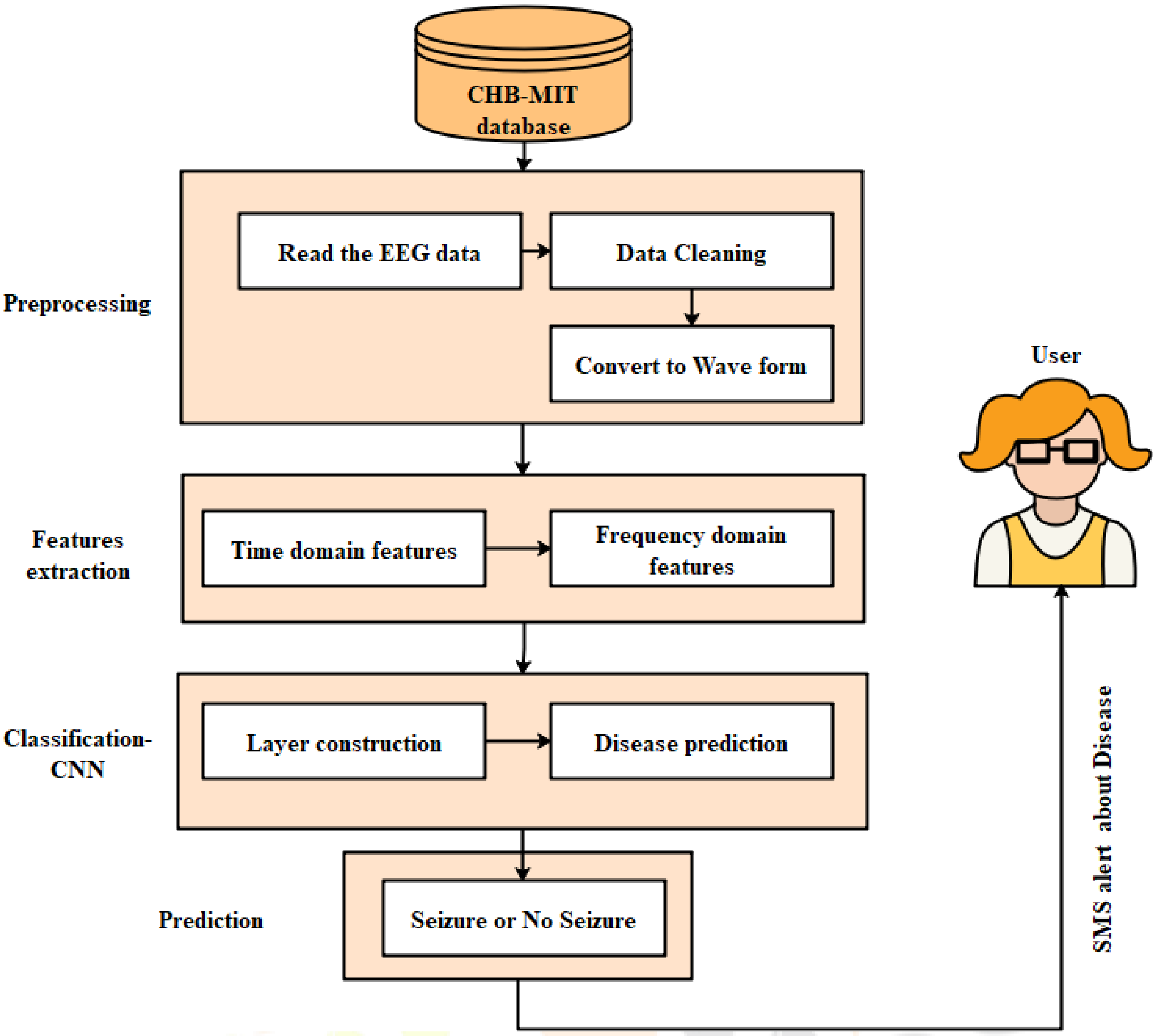
Training the CNN Model

Initialize learning rate α, number of max iterationITERmax, min error ERRmin, training batchsBATCHEStraining, bach size SIZEbatch, and so on;
Compute $n2$, $n3$, $n4$, $k1$, $k2$, according to $n1$ and $n5$; Generate random weights θ of the CNN;
cnnModel = InitCNNModel(θ, [$n1$–5]); iter = 0; err = +inf;
while err >ERRmin and iter<ITERmax do err = 0;
for bach = 1 to BATCHEStraining do
[$\nabla\theta J(\theta)$, $J(\theta)$] = cnnModel.train (TrainingDatas, TrainingLabels),
Update θ
err = err + mean($J(\theta)$);
end for err = err/BATCHEStraining; iter++;
end while
Save parameters θ of the CNN

So our proposed work overcomes outlier’s separation in EEG data classification with features extraction. Based on classification we can predict the seizure and non-seizure data and predict the Epilepsy with SMS alert

SYSTEM ARCHITECTURE

A system architecture or systems architecture is the conceptual model that defines the structure, behaviour, and more views of a system. An architecture description is a formal description and representation of a system, organized in a way that supports reasoning about the structures and behaviours of the system. System architecture can comprise system components, the externally visible properties of those components, the relationships (e.g. the behaviour) between them. It can provide a plan from which products can be procured, and systems developed, that will work together to implement the overall system. There have been efforts to formalize languages to describe system architecture; collectively these are called architecture description languages (ADLs).



CONCLUSION

Every electrode on the skull produces different numerical measurements; it is very important and difficult to choose the most effective and good characteristics, because it is worthnoting that previous researchers have put in a lot of effort to locate the most beneficial featuresfor accurate categorization. Some researchers, on the other hand, have combined two or more criteria to achieve excellent seizure classification accuracy. Energy, skewness, and entropy arefrequently recognised as the most widely utilised features; nonetheless, optimising the featurevector is necessary to lower the classifier's workload while maintaining accurate results. It isreally difficult to determine which classifier is the most optimal, so to sum up, classifiers are tested and assessed using numerous datasets. Earlier research scientists used a variety ofmethodologies, including SVM, KNN, and ANN, according to the literature. The fundamentaldrawback of these classifiers is that they are unable to provide adequate explanations for hiddenmodel patterns and logic principles. According to the literature, CNN algorithm produces high accuracy results for seizure detection. In future, we can extend the framework to implementother deep learning algorithm to improve the accuracy in seizure prediction and also includeEEG sensors with real time implementation.

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