Epileptic Seizure Prediction using EEG data

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Abstract - This review of the literature examines recent advances in the prediction of epileptic seizures using machine learning and EEG data. The review looks at different techniques and emphasizes the significance of feature extraction, dataset properties, and model architectures in improving patient quality of life. Difficulties are discussed, such as inter-subject variability and moral issues. This study provides academics and clinicians with a succinct resource to help them develop seizure prediction models that are more reliable and useful in clinical settings.

Index Terms - Epilepsy Seizure Prediction, EEG, Machine Learning

I. INTRODUCTION

Epilepsy is known as a neurological condition in which a person's brain experiences uncontrolled electrical activity between the neurons [1]. This results in sudden and recurrent seizures which causes temporary abnormalities in muscle movements or behavior of a patient. Ancient records of this condition are found but it was associated with superstitions like supernatural forces. With advancements in the medical field, this condition was recognized as a neurological disorder rather than divine punishment.
Nearly 50 million people in the world are suffering from epilepsy [1]. Early detection of epilepsy is needed to provide proper medication and reduce the risk of upcoming seizures. Electroencephalogram(EEG) is the most common technique used to diagnose epilepsy. The patient's EEG is recorded by placing electrodes on the scalp. This may contain hours and days of EEG data. This data is observed by neurologists to differentiate between normal and epileptic EEG. However, manual observation of such huge data can cause errors. Recently, various machine learning techniques have been developed that can automate the process of EEG detection. The machine learning algorithms can differentiate between ictal(during seizure), pre-ictal(before seizure) and inter-ictal (between seizures) stages.
The study focuses on various machine learning approaches to detect and classify epilepsy.

II. LITERATURE SURVEY

U. Rajendra Acharya, in 2018, implemented a 13-layer deep CNN algorithm for automated EEG analysis [1] to detect ictal, pre-ictal and inter-ictal classes with an accuracy of 88.67%. The algorithm achieved a specificity and sensitivity of 90% and 95%.

In 2019**, Muhammad U. Abbasi** [2] proposed a Long Short-Term Memory classifier that classified The EEG signals in three categories- pre-ictal, inter-ictal (seizure-free epileptic) and ictal (epileptic with seizure). This model achieved 95% accuracy whereas it increases to 98% in case of binary classification such as detection of inter-ictal or ictal only.

Wang, Y et al. researchers addressed the prediction of the pre-ictal stage in a multi-class classification setup[3]. They utilized the Random Forest classifier and feature extraction based on wavelet packet decomposition. Their model achieved an accuracy of 84% on the CHB-MIT dataset.

Syed Muhammad Usman et al.'s 2020 study[4], focused on specificity and sensitivity in order to forecast seizures that would occur during the pre-ictal period. They used a variety of classification methods, such as CNN, FT, EMD, WT, SVM, deep learning, and EMD. Using the CHB-MIT dataset, the study's combination of feature extraction and handmade feature approaches produced a sensitivity of 92.7% and specificity of 90.8%.

In **Rabcan, J. et al**. [5] proposed a study in 2020 to categorize epileptic seizures using time-frequency characteristics and quadratic discriminant analysis (QDA), decision trees (DT), and k-nearest neighbors (KNN). Their precision was just 85% and their sensitivity was low.

Another study in the same year by **Subasi, A. et al**. [6] Artificial Neural Networks (ANN) with line length features on the CHB-MIT dataset but achieved low accuracy, only reaching 52%.

In 2021, **S. Poorani** [7] focuses on using a specific type of artificial neural network called an Asymmetric Back Propagation Neural Network (ABPN) to analyze EEG signals and classify them as either non-seizure or seizure activity with an accuracy of 93.6%. The study suggests that in the future, other advanced deep learning approaches like Recurrent Networks or Long Short Term Memory (LSTM) could be explored to further improve the results.

In the study conducted by **Chaosong Li et.al.**,in 2021 [8] they introduced a novel seizure onset detection system that combines empirical mode decomposition (EMD) and common spatial pattern (CSP) analysis. The method achieved high accuracy, with sensitivities of 97.34% in one database and 93.67% in another, alongside strong specificity. CSP was used to automatically identify the EEG channels related to seizure onset.

In 2023, **Muhammad Shoaib Farooq et al**.[9] implemented a deep learning approach using a 13-layer convolutional neural network (CNN) that was proposed to automatically classify EEG signals into normal, preictal (before a seizure), and seizure categories. The authors obtained an accuracy of 88.7%, a sensitivity of 95%, and a specificity of 90%. However, using a larger dataset would likely increase the model's performance.

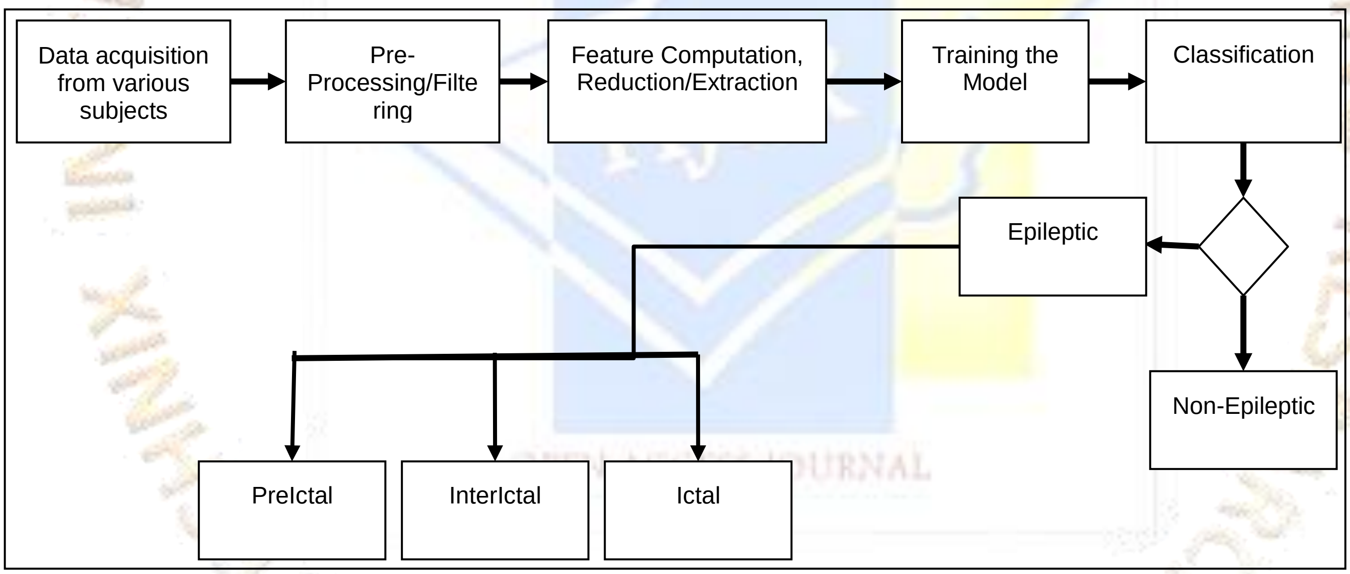
In 2023, **Xiong and Dong** proposed a method at[10] for automated epileptic seizure detection, achieving high accuracy (97.26% and 98.88% on two datasets). However, it mainly focuses on short seizure segments and binary classification, limiting generalizability. Additional research is needed to explore diverse segment lengths and multiple seizure classifications. The paper lacks discussion on computational resource requirements, a potential limitation for practical use.

Muhammad U. Abbasi et.al. proposed a Long Short-Term Memory (LSTM) method for epilepsy detection in EEG signals in their paper [11]. This approach effectively distinguishes between different states, such as pre-seizure, seizure, and seizure-free, achieving high accuracy rates—up to 95% for multiple states and 98% for two states. However, the method's applicability to diverse EEG datasets and real-world conditions requires further investigation.

III. System Design

In the proposed methodology for epilepsy seizure prediction using EEG, the system is designed with a sequential flow encompassing key stages: Signal Acquisition, Preprocessing, Feature Extraction, Training, Classification and Evaluation.

Training Block Diagram



Real-Time Application Block Diagram

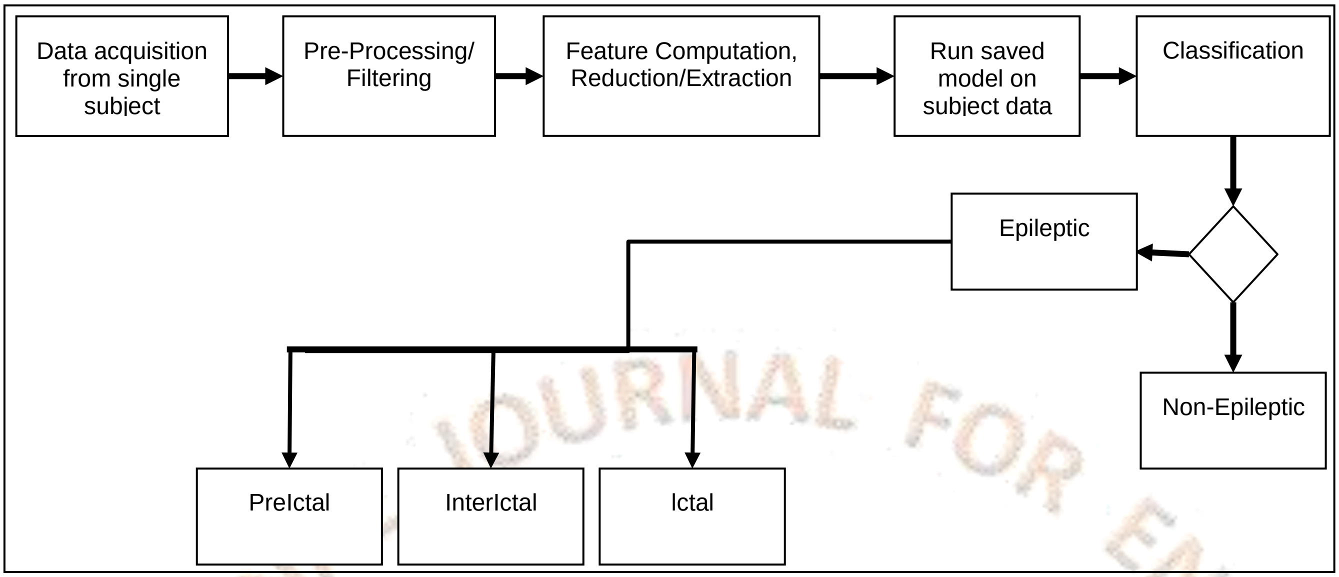


Fig. Block diagram

The first step of the system is Signal Acquisition, which involves employing specialized sensors to collect EEG data from the patient. After that, the obtained signals go through preprocessing, which includes signal augmentation and noise reduction to guarantee the quality of the data. Next comes feature extraction, which involves taking pertinent characteristics out of the preprocessed EEG signals to identify key patterns that point to seizure activity.

Using the features that were retrieved, a machine-learning model is developed during the training phase to identify the distinctive patterns connected to various seizure states.

Next, testing is done with fresh EEG data to assess how well the model predicts outcomes. The EEG signals are divided into many types by the model, such as preictal and non-preictal.

After classification, the system proceeds to the prediction phase, where it uses the trained model to predict the probability of a seizure. The model's accuracy, sensitivity, and specificity are evaluated throughout the evaluation phase to make sure it is reliable in practical situations. Lastly, the Display of Results helps with prompt response by giving physicians or caregivers feedback by showing the anticipated seizure episodes.

With the integration of machine learning, signal processing, and assessment components for reliable performance, this methodical approach guarantees a comprehensive and effective solution for epilepsy seizure prediction.

IV. CONCLUSIONS

Automated epilepsy detection and seizure prediction can be a revolutionary change in the medical field and ultimately aid in the diagnosis and treatment of epilepsy. In this paper, we have presented a few existing researches and models with their various approaches. The automated process of detecting epilepsy has the potential to enhance the accuracy and efficiency of epilepsy diagnosis, thus providing valuable support to healthcare professionals in managing this neurological condition.

V. REFERENCES

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