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# A REVIEW ON EPILEPTIC SEIZURES DETECTION USING DEEP LEARNING

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***Abstract - Epilepsy is a life-threatening chronic disease with repeated seizures. This in effect affects the persons health. Various screening approaches such as EEG (Electroencephalogram) and MRI (Magnetic Resonance Imaging) are employed to detect the seizure patterns based on the chemical variations in the brain. In this approach, EEG is regarded as the primary diagnostic test for diagnosing epilepsy by consistently analyzing and rendering EEG signals. Manual visual diagnosis is highly laborious and cumbersome. Hence novel approaches involving Deep Learning, Machine Learning algorithms are employed for automatic detection. Here various novel approaches of deep learning are reviewed.***

***Key Words: Epilepsy, seizure, EEG, deep learning.***

## 1. INTRODUCTION

The term epilepsy has its roots in the Latin and Greek word 'epilepsia,' signifying 'seizure' or 'to seize upon.' It denotes a significant neurological disorder characterized by recurrent seizures. The concept of epilepsy, documented in Babylonian medical texts over 3000 years ago, transcends human beings, affecting various mammalian species like dogs, cats, and rats. Despite its worldwide prevalence, the term epilepsy does not provide insights into the origin or sternness of seizures, as it is commonplace and evenly distributed globally. The condition involves a disturbance within the brain, possibly originating from aspects like malformations, oxygen deficiency during childbirth, or low blood sugar levels [1].

A protruding distinctive feature of epilepsy is the incidence of numerous seizures in a patient. These seizures lead to sudden disruptions or unusual activities in the brain, causing involuntary changes in behavior, sensations, and temporary loss of consciousness. Seizures usually last for a few seconds to minutes and can happen unexpectedly without any preceding aura, sometimes resulting in significant injuries like fractures, burns, and, in certain instances, fatalities [1].

## 2. BACKGROUND

Electroencephalogram (EEG) signals produced by EEG machines result from ionic currents generated by fluctuations in voltage within the brain's neurons. These signals portray the electrical activity of the brain and find widespread use in the recognition of epileptic seizures.

As depicted in Figure 1, seizures have been classified by neuro-professionals into following primary classes based on symptoms [1,6].

A partial seizure is characterized by its symptoms, primarily resulting from an impact on the cerebral hemisphere. Furthermore, classification into two primary types is possible: simple-partial and complex-partial seizures. Simple-partial seizures involve individuals who remain sensible and can usually connect, whereas complex-partial seizures result in abnormal behavior, confusion, and actions such as chewing and mumbling. Generalized seizures consist of two primary components. Seizures with evident motor signs are classified as nonconclusive, whereas those lacking such signs pose challenges in diagnosis and are termed conclusive seizures. Individuals experiencing conclusive seizures can only gaze without making additional movements or gestures [1,6].

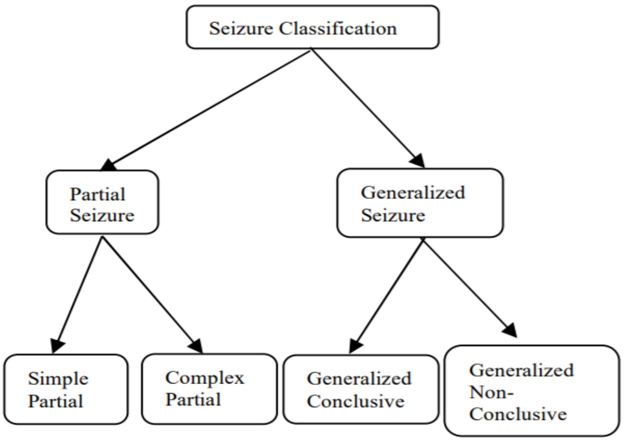


**Fig.1. Classification of Seizure**

## 3. LITERATURE REVIEW

Shoeibi et.al [3] offers a summary of various deep learning methods, including CNNs (Convolution Neural Network). The CNNs are classified as 1D-CNN, 2D-CNN, AlexaNet, VGG, GoogleNet, ResNet, Recurrent Neural Network (RNN), LSTM (Long Short Term Memory), Gated Recurrent Unit (GRU), AutoEncoders (AE), Deep Belief Networks (DBN), CNNRNN, CNN-AE. 1D-CNN with 8 layers gave highest accuracy of 99.28, LSTM with Softmax gave highest accuracy in RNN of 100% and Sparse AE (SpAE) gave highest accuracy with softmax,

Abdelhameed [2] describes various models such as Deep Convolution Autoencoder + multilayer perceptron (DCAE + MLP) , DCAE + Bi-LSTM, Deep Convolutional Neural Network(DCNN) + MLP and DCNN + Bi-LSTM. The DCAE + Bi-LSTM model outperformed other evaluated models, demonstrating the highest performance. Additionally Kruskal– Wallis H test which is non-parametric was steered to measure statistical significance.

Gramacki [5] suggested a framework resembling deep learning (DL) and grounded on convolutional neural networks (CNNs) for the detection of seizure activities. The feasibility of this framework was assessed using an actual neonatal EEG dataset. The implementation was done in Keras, Python and R programming language.

Farooq [11] stated that a thorough review of existing literature was conducted, sourcing information from renowned repositories including MDPI, IEEE Xplore, Wiley, Elsevier, ACM, Springer Link, and others. Additionally, a nomenclature was formulated to summarize the latest solutions employed for addressing this problem. The examination delved into the characteristics of diverse standard and impartial datasets, providing a comprehensive study of classifier performance.

Shoeibi [9] conducted an extensive examination of deep learning (DL) methods applied in the discovery and estimate of epileptic seizures using neuroimaging modalities. Initially, discussed DL-based Computer-Aided Diagnosis Systems (CADS) for detecting and predicting epileptic seizures through neuroimaging modalities. Included details on numerous datasets, preprocessing procedures, and DL models utilized for these purposes. Subsequently, presented research on rehabilitation tools, encompassing technologies such as brain computer interface (BCI), cloud computing, Internet of Things (IoT), and hardware application of DL methods on fieldprogrammable gate array (FPGA), among others.

Zhao [12] adopt the visual diagnostic approach employed by medical specialists, directly processing designed EEG image data, and implement usually applicable algorithms such as LeNet, VGG, deep residual network (ResNet), and vision transformer (ViT) to the task of classifying EEG images. Prior to utilizing these models, introduce a data augmentation technique using random channel ordering (RCO), which alters the frequency order to create novel images. Employ Gradientweighted class activation mapping (Grad-CAM) and attention layer methods for model interpretation. The proposed RCO method effectively balances the dataset between seizure and non-seizure classes, leading to better results by the models in the task to detect seizure.

Mandal [7] suggested a comprehensive comparative analysis of diverse feature selection methods and 23 machine learning approaches aimed at stratifying the hazard of epileptic seizures using EEG. Executed in addition deliberated upon the implementation of deep learning utilizing long shortterm memory networks and time-frequency analysis aimed at the categorization of epileptic EEG signals with various features. The obtained outcomes are equated with previously attained outcomes. Employed a blend of statistical and discrete wavelet transform-based compound characteristics. Assessed dissimilar feature blends to identify the most significant biomarkers for the recognition of epilepsy from EEG signals

## 4. METHODOLOGY

The basic architecture of Seizure Detection is illustrated in Fig 2.

Various popular datasets are available for Seizure detection. These include Epileptic Seizure Recognition [13], Freiburg[3], CHB-MIT, Kaggle, Bonn, Flint-Hills, Bern-Barcelona, Hauz Khas, Zenodo.

Most Commonly datasets are CHB-MIT and Bonn [6]. Deep Learning Tools include Python libraries and MATLAB. It also includes various high-level API such as TensorFlow, Keras, PyTorch, Theano, Caffe. the most commonly employed is the TensorFlow and next is the Keras.

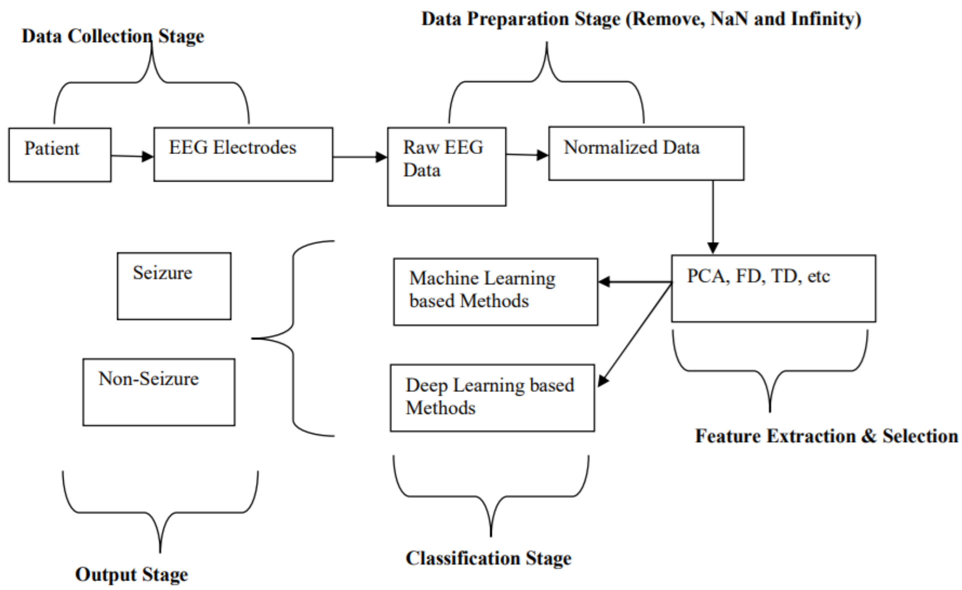


**Fig.2. Model for Deep Learning based Seizure Detection**

Deep Learning Models widely used in research of automatic detection of seizure for epilepsy include the following neural models. Their usage is described in following table 1.

| | |
|---|---|
| 2D-CNN | 34% |
| 1D-CNN | 24% |
| AE | 17% |
| RNN | 15% |
| CNN-RNN | 9% |
| CNN-AE | 5% |
| 3D-CNN | 2% |
| DBN | 2% |

**Table.1. Models based on Deep Learning**

## 5. EVALUATION PARAMETERS

Evaluation metrics are calculated to compare the results of the proposed research with traditional or the existing approaches. These metrics include cross-validation and in specific ten-fold cross-validation [8].

Further the evaluation of most classifiers is evaluated using the metrics as precision, recall, F1-score, Similarity index or DICE and Jaccard or Intersection over Union (IOU).

The basis of above performance measures includes the 4 below mentioned parameters (True Positive, True Negative, False Positive and False Negative) in Table 2.

| | |
|---|---|
| TP | If the person agonizes from a seizure and perceives the same |
| TN | No seizure was perceived, and the person is normal |
| FP | The false perceives and the classifier perceives a seizure where the patient is normal |
| FN | An incorrect decision classifier detected the seizure as normal and predicted no seizure |

**Table.2. Classification metrics**

The parameters are described as:

***Precision & Recall:***

$$P = \frac{TP}{TP + FP} * 100 \qquad R = \frac{TP}{TP + FN} * 100$$

***F1-Score:***

$$F1\_Score = 2 * \frac{P * R}{P + R} * 100$$

***DICE:***

$$Dice = \frac{2 * TP}{2 * [TP + FN + FP]} * 100$$

***IOU (Jaccard-J):***

$$Jaccard = \frac{TP}{TP + FP + FN} \quad \text{OR} \quad Jaccard = \frac{Dice}{2 - Dice}$$

## 5. CONCLUSION

A conclusion can be reached as from the Literature Review conducted various machine learning based methods are suitable for the epileptic seizure detection. Further various evaluation parameters are also discussed.

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