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Epileptic seizure detection and Prediction using Deep learning

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Abstract*:* Numerous methods, including electroencephalography (EEG) and magnetic resonance imaging (MRI), have been proposed to diagnose epileptic seizures. Deep knowledge (DL) is one of the many subfields of artificial intelligence. Conventional machine learning algorithms involving point birth were used prior to the emergence of DL. As a result, their performance was restricted to what the people creating the features by hand could do. However, in DL, the creation of features and type is completely automated. Similar to how the theory of epileptic seizures has advanced significantly, these methods have appeared in numerous medical fields. This study presents a thorough overview of a factory focused on automated epileptic seizure discovery using neuroimaging modalities and DL methods. Different approaches have been suggested to diagnose epilepsy.

Keywords: LSTM, EEG modalities, MRI modalities.

I. INTRODUCTION

Millions of people worldwide suffer from epilepsy, a neurological condition marked by frequent, unprovoked seizures. The frequency, duration, and severity of seizures, which are caused by aberrant electrical activity in the brain, can vary greatly. Because seizures can happen suddenly and without warning, epilepsy is still a difficult condition to manage. For this reason, early seizure detection and prediction are essential for efficient treatment and averting possible harm.Although there are conventional techniques for seizure detection, their efficiency, timeliness, and accuracy are frequently limited. Both seizure prediction and detection have advanced significantly in recent years with the introduction of deep learning techniques. These techniques, which provide more reliable, automated, and real-time solutions, are revolutionizing the way we monitor epilepsy. Unusual electrical discharges cause seizures.

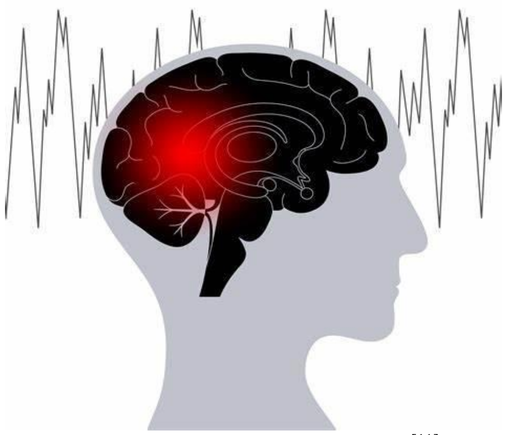

Fig1.Nueral System of Epileptic [11]

II. BACKGROUND AND CONTEXT

Data collection, preprocessing, model selection, training, and evaluation are some of the crucial steps in deep learning-based epileptic seizure detection and prediction. In order to capture past and future dependencies in EEG signals and improve the model's capacity to identify intricate temporal patterns for increased accuracy and early seizure prediction,

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epileptic seizure detection and prediction employ Bidirectional Long Short-Term Memory (BiLSTM) networks. Patients' EEG signals are first gathered, and noise and artifacts are eliminated through processing. After that, these signals are converted into formats that are appropriate for deep learning models, like spectrogram images or time-series data. While recurrent neural networks (RNNs) or long short-term memory (LSTM) networks capture temporal dependencies in seizure patterns, convolutional neural networks (CNNs) are frequently used for feature extraction. Models use pre-seizure data to make predictions.

III. RELATED WORKS

[1] The paper "" Deep Learning Framework for Epileptic Seizure Discovery Grounded on Neonatal EEG Signals" focuses on developing an effective system for detecting epileptic seizures in babes(babe) using Electroencephalography(EEG) signals. Neonatal seizures are delicate to identify, especially because they can be subtle and the EEG patterns are frequently less distinct compared to adult seizures. The main thing of the study is to use deep literacy(DL) ways to automatically descry these seizures with high delicacy.

[2] The paper "Epileptic Seizure Prediction Using Big Data and Deep Learning: Toward a Mobile System Epileptic Seizure vaticination Using Big Data and Deep Learning Toward a Mobile System" explores the use of big data and deep literacy ways for prognosticating epileptic seizures, with a particular focus on developing mobile systems for real- time vaticination. This exploration aims to enhance the delicacy and punctuality of seizure vaticination to ameliorate patient issues by using advanced data processing styles and mobile technologies.

[3] A Novel Epilepsy Seizure Prediction Model Using Deep Learning and Classification" proposes a new approach for prognosticating epileptic seizures by combining deep literacy ways with bracket models. The end is to ameliorate the delicacy and punctuality of seizure vaticination to enhance patient care and allow for early intervention..

[4] The paper "EEG-Based Epileptic Seizure Detection via Machine/Deep Learning Approaches: A Systematic Review" provides a comprehensive review of the colorful machine literacy(ML) and deep literacy(DL) ways employed for epileptic seizure discovery using EEG signals. The study aims to punctuate the strengths, challenges, and advancements in applying these ways to enhance the delicacy and effectiveness of seizure discovery systems. Epileptic seizures are neurological events that bear timely discovery for proper operation and intervention. EEG signals are generally used to descry seizures, as they give anon-invasive, real- time system to cover brain exertion. Traditional seizure discovery styles frequently calculate on homemade analysis, which is time- consuming and prone to error. Machine literacy and deep literacy styles have surfaced as effective druthers by automating the point birth and bracket processes.

[5] The paper "Epileptic Seizure Detection: A Deep Learning Approach" explores the operation of deep literacy ways to the discovery of epileptic seizures from EEG signals. The thing is to ameliorate the delicacy, effectiveness, and robotization of seizure discovery to help in early intervention and better operation of epilepsy. This deep literacy approach aims to overcome the limitations of traditional styles in directly relating seizures in EEG data.

[6] The paper "EEG-Based Epileptic Seizure Detection via Machine/Deep Learning Approaches: A Systematic Review provides a comprehensive review of colorful machine literacy(ML) and deep literacy(DL) ways used for the discovery of epileptic seizures from electroencephalogram(EEG) signals. It emphasizes the significance of automated seizure discovery for early intervention and better operation of epilepsy.

[7] The paper "Advanced Framework for Epilepsy Detection through Image-Based EEG Signal Analysis presents a new frame for detecting epileptic seizures by assaying EEG signals through image- grounded ways. The study explores the metamorphosis of EEG data into images and applies advanced image processing styles to ameliorate seizure discovery. This approach aims to overcome the limitations of traditional styles that directly process raw EEG signals. Epileptic seizures are caused by abnormal brain exertion and can be detected using EEG signals, which give real- time information about the electrical exertion of the brain

[8] The Paper “The novel deep learning framework for the detection of epileptic seizures using EEG signals” involves the operation of advanced machine literacy models to directly identify seizure events from electroencephalogram(EEG) data.

[9] This paper presents a new approach to prognosticating epileptic seizures by combining Multidimensional Mills and intermittent Neural Networks(RNNs). The thing is to ameliorate the delicacy of seizure vaticination, which is pivotal for furnishing timely interventions for individualities with epilepsy.

[10] This paper focuses on detecting epileptic seizures in EEG(electroencephalogram) signals using a variety of machine literacy(ML) and deep literacy(DL) ways. Since seizures frequently do unpredictably, early discovery through automated systems is pivotal for timely intervention and bettered patient care. The paper provides an overview of colorful approaches for seizure discovery and their effectiveness. EEG signals are a primary individual tool for relating brain exertion

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[11] This explores the use of machine knowledge(ML) ways for the prophecy of epileptic seizures from EEG signals, with the end of furnishing early discovery for cases with epilepsy. The paper highlights several ML styles, their operations, and the challenges involved in predicting seizures directly. Epileptic seizures are unlooked-for bursts of electrical exertion in the brain. Seizure prophecy involves relating early warning signs in EEG signals that precede a seizure, allowing for timely intervention. EEG(electroencephalogram) is a primary tool used to record the electrical exertion of the brain. The complexity and noise in EEG signals make seizure prophecy a challenging task. The paper explores several machine knowledge ways applied to seizure prophecy .

[12] This paper introduces an effective crossbred model for case-independent seizure prophecy using deep knowledge ways. The primary thing of the study is to develop a robust system that can predict epileptic seizures from EEG data without taking individual case-specific training, thus making the model adaptable to new cases without demanding large amounts of labelled data for each new case. Case-independent prophecy refers to a model's capability to generalize across different cases without retraining or taking case-specific data. This is vital for wide clinical handover since training models on individual cases can be labour-ferocious and inoperable. The challenge is to produce a model that can descry seizure patterns in EEG signals that are harmonious across various individualities, indeed though each case's EEG signal might differ. CNNs are employed to capture spatial features from the raw EEG signals.

[13] The paper proposes a new crossbred deep knowledge model called ResNeXt- Lenet, designed for predicting epileptic seizures using EEG(electroencephalogram) data. The model combines two established neural network architectures ResNeXt and LeNet. ResNeXt is a deep residual knowledge architecture known for its capability to learn further effective representations using a cardinality- predicated design. It enhances point birth by incorporating farther pathways in the network, which improves performance, particularly with high- dimensional data like EEG signals. LeNet is a classical convolutional neural network(CNN) model.

[14] The paper focuses on the operation of deep knowledge(DL) ways for predicting epileptic seizures predicated on EEG(electroencephalogram) signals. Epilepsy prophecy using deep knowledge aims to identify seizure events before they do, furnishing critical time for medical intervention and perfecting the quality of life for cases. Traditional styles for seizure prophecy , analogous as statistical or signal processing ways, are limited in their capability to handle complex, high- dimensional data like EEG. Deep knowledge models, particularly Convolutional Neural Networks(CNNs) and intermittent Neural Networks(RNNs), have shown superior performance in lodging spatial and temporal features from EEG signals, which are essential for accurate prophecy

[15] The paper "Supervised and Unsupervised Deep Learning Approaches for EEG Seizure Prediction" provides a comprehensive overview of how deep knowledge ways are applied to the task of predicting seizures using Electroencephalography(EEG) signals. Seizure prophecy is a critical area of disquisition for perfecting the lives of people with epilepsy, and the paper compares supervised and unsupervised styles for achieving high delicacy in this task. Electroencephalography(EEG) is a considerably used fashion for covering electrical exertion in the brain. In the terrain of epilepsy, EEG can be used to predict seizures, allowing for timely intervention and bettered operation of the condition

[16] The paper "Epileptic Seizure Detection Using Deep Learning Through Min-Max Scaler Normalization" explores a method for detecting epileptic seizures from EEG (electroencephalogram) data using deep learning techniques. The key focus is on the application of Min-Max Scaler Normalization as a preprocessing step to enhance the performance of deep learning models. Epilepsy is a neurological disorder that causes recurrent seizures. Early detection and prediction of seizures can significantly improve the quality of life for individuals with epilepsy. Electroencephalography (EEG) is commonly used to monitor the electrical activity in the brain and is crucial for detecting seizures. However, raw EEG signals are noisy and contain a lot of irrelevant information, making the detection task challenging.

[17] The paper "Two-Layer LSTM Network-Based Prediction of Epileptic Seizures Using EEG Spectral Features" explores a deep knowledge approach to predicting epileptic seizures by using EEG spectral features and a Two- Subcaste Long Short- Term Memory(LSTM) network It The paper proposes the use of a Two- Subcaste LSTM Network to predict epileptic seizures from EEG data. This approach combines spectral features of EEG signals and a deep knowledge model(LSTM) designed to capture temporal dependences, which is essential for understanding the successive nature of brain exertion

[18] The paper "Epileptic Seizure Detection: A Comparative Study Between Deep and Traditional Machine Learning Techniques" presents a comprehensive comparison of deep knowledge and traditional machine learning approaches for detecting epileptic seizures from EEG(electroencephalogram) signals. The study highlights the strengths and sins of both types of styles, fastening on their performance, interpretability, and real- world connection in seizure discovery. Deep knowledge styles, especially Convolutional Neural Networks(CNNs) and intermittent Neural Networks(RNNs)(analogous as LSTMs), have gained popularity for EEG seizure discovery due to their capability to automatically learn hierarchical features from raw data, barring the need for unambiguous point birth.

[19] The paper "Detection and Classification of Adult Epilepsy Using Hybrid Deep Learning Approach" proposes a crossbred deep knowledge model for the discovery and type of adult epilepsy from EEG(electroencephalogram) signals.

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The study aims to enhance the delicacy and effectiveness of epileptic seizure discovery and type by integrating multiple deep knowledge ways into a unified frame. The paper presents a crossbred deep knowledge model that combines the strengths of multiple neural network architectures to meliorate both discovery(relating when a seizure occurs) and type(classifying the type or stage of seizure).

[20] The paper "Epilepsy Seizure Detection and Prediction Using an Approximate Spiking Convolutional Transformer" introduces a novel model that combines spiking neural networks, convolutional layers, and transformers for the detection and prediction of epileptic seizures using EEG (electroencephalogram) data. The approach leverages the unique characteristics of spiking neurons along with the power of convolutional and transformer architectures to improve seizure detection accuracy and prediction. Spiking neural networks are biologically inspired models that simulate the way neurons in the brain communicate through discrete spikes. Unlike traditional neural networks, which use continuous values, SNNs process information in the form of spikes that occur at specific times, making them more efficient for processing temporal data like EEG signals.

[21] [21] The paper "Automatic Seizure Detection Based on Imaged-EEG Signals Through Fully Convolutional Networks" explores a new system for detecting epileptic seizures by transubstantiating EEG signals(electroencephalograms) into images and using Completely Convolutional Networks(FCNs) for bracket. This approach combines the strengths of image- grounded processing and deep literacy models for real- time, accurate seizure discovery. The raw EEG signals are converted into spectrograms(time- frequence representations) or scalograms(time- scale representations), which are basically 2D images representing the signal's power diapason over time.

[22] This study proposes a patient-independent approach for seizure prediction, where a single deep literacy model is trained on data from multiple cases to make prognostications without counting on any specific case's data during the vaticination phase. The paper investigates multiple deep literacy models for prognosticating seizures, Convolutional Neural Networks(CNNs) are used to automatically prize spatial features from the EEG data, which can help identify patterns that are reflective of brewing seizures. intermittent Neural Networks(RNNs), particularly Long Short- Term Memory(LSTM) networks, are employed to capture the temporal dependences in the EEG signals. Since seizures have a temporal element.

[23] The paper "An End-to-End Deep Learning Approach for Epileptic Seizure Prediction" presents a new end- to-end deep literacy frame for prognosticating epileptic seizures from EEG(electroencephalogram) data. The proposed approach aims to automate the entire process of seizure vaticination — from raw EEG data accession to seizure vaticination — by employing deep literacy models that can prize applicable features and make prognostications without taking homemade intervention. The model is trained using labelled EEG data from cases who have recorded both seizure andnon-seizure events. The model learns to distinguish between seizure andnon-seizure events grounded on the input EEG parts.

[24] The paper "Interpreting Deep Learning Models for Epileptic Seizure Detection on EEG Signals" focuses on perfecting the interpretability and understanding of deep literacy models used for epileptic seizure discovery from EEG signals. While deep literacy models, similar as Convolutional Neural Networks(CNNs) and Long Short- Term Memory(LSTM) networks, have achieved high performance in seizure discovery, they're frequently viewed as black- box models delicate to interpret and understand. This lack of translucency can hamper trust in medical operations.

[25] The paper "Epileptic Seizure Detection Based on EEG Signals and CNN" focuses on perfecting the interpretability and understanding of deep literacy models used for epileptic seizure discovery from EEG signals. While deep literacy models, similar as Convolutional Neural Networks(CNNs) and Long Short- Term Memory(LSTM) networks, have achieved high performance in seizure discovery, they're frequently viewed as black- box models delicate to interpret and understand. This lack of translucency can hamper trust in medical operations.

[26] The paper "Brain Epileptic Seizure Detection Using Deep Learning" explores the use of deep literacy ways to descry epileptic seizures from EEG(electroencephalogram) signals. The study highlights the eventuality of deep literacy models to ameliorate the delicacy and effectiveness of seizure discovery systems, which are pivotal for real- time monitoring and intervention in cases with epilepsy. The paper primarily focuses on deep literacy models, similar as Convolutional Neural Networks(CNNs), for seizure discovery from EEG data. Seizure events are fairly rare compared tonon-seizure events, leading to imbalanced datasets

[27] The paper "Patient-Specific Preictal Pattern-Aware Epileptic Seizure Prediction with Federated Learning" introduces an innovative approach to prognosticating epileptic seizures using case-specific models and allied literacy. The focus of the study is on perfecting seizure vaticination by using substantiated patterns in EEG signals, combined with the cooperative power of allied literacy. The proposed model uses a deep literacy armature, probably a combination of Convolutional Neural Networks(CNNs) for point birth and intermittent Neural Networks(RNNs) or Long Short-Term Memory(LSTM) networks for landing temporal dependences in the EEG signals

[28] The paper "Deep Learning of Simultaneous Intracranial and Scalp EEG for Prediction, Detection, and Lateralization of Mesial Temporal Lobe Seizures" focuses on the use of deep literacy ways to ameliorate the vaticination,

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discovery, and lateralization(localization of seizure onset) of mesial temporal lobe seizures(MTLS) using intracranial and crown EEG data. MTLS are frequently associated with temporal lobe epilepsy(TLE) and can be delicate to diagnose and treat without precise localization of seizure onset. This study investigates how deep literacy models can handle the complexity of EEG data from both intracranial(IC- EEG) and crown(SC- EEG) electrodes to ameliorate clinical issues.

[29] The paper titled "A Model for Epileptic Seizure Diagnosis Using the Combination of Ensemble Learning and Deep Learning"presents a new approach to enhancing the delicacy of epileptic seizure discovery through the integration of ensemble and deep literacy ways. exercising EEG signals from the intimately available Bonn University dataset, the study employs an ensemble system that combines algorithms similar as Extreme Gradient Boosting(XGB), Support Vector Machine(SVM), Random Forest(RF), and Bidirectional Long Short- Term Memory(BiLSTM) networks.

[30] This study focuses on detecting epileptic seizures using a pretrained deep convolutional neural network(CNN) and transfer literacy ways. EEG signals are converted into images(similar as spectrograms or time frequence representations), which are also fed into a CNN model pretrained on large image datasets(e.g., VGG16, ResNet, or Inception). Transfer literacy allows the model to acclimatize snappily to EEG- grounded seizure bracket with limited data. The approach enhances discovery delicacy, reduces computational costs, and eliminates the need for handcrafted point birth, making it an effective tool for automated seizure opinion.

IV. SYSTEMATICANALYSIS

Ref. Nos.	Method Used	Dataset	Merits	Demerits	Inference
Artur gramacki Et.al [1]	CNN, RNN, LSTM	Neonatal EEG Dataset	\High accuracy for neonatal cases	Limited generalization to adults	Effective for neonatal seizure detection
Afshin Shoeibi Et.al [2]	CNN	Multiple datasets	analysis of DL techniques	No experimental validation	Provides insights into different DL models
Isabell kirak kornek Et.al [3]	CNN, LSTM, Big Data Processing	CHB-MIT, TUH-EEG	Mobile friendly model,	Computationally expensive	Demonstrates feasibility of mobile seizure prediction
B. Jaishankar Et.al. [4]	CNN, BiLSTM, SVM	CHB-MIT	Improved seizure prediction accuracy	High false positive rate	BiLSTM enhances temporal feature extraction
Ijaz Ahmad Et.al. [5]	CNN	Various EEG datasets	Covers both ML and DL approaches	No implementation	Highlights the need for patient-specific models
Ramy Hussein Et.al. [6]	CNN, Deep Belief Networks	Bonn University EEG	High accuracy in seizure classification	Requires large labelled datasets	CNNs are effective for feature extraction
Thanaraj Krishnan Et.al. [7]	CNN, Image Processing	CHB-MIT, TUH-EEG	Converts EEG to images for better analysis	Loss of raw temporal features	Image based EEG analysis is promising
Sayani Mallick . Et.al. [8]	CNN, LSTM	CHB-MIT	High detection accuracy, low latency	Requires large training data	CNN-LSTM improves detection rates

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Syed Muhammad Usman Et.al. [9]	SVM, Random Forest, KNN	Bonn, CHB-MIT	Traditional ML performs well on structured data	Limited deep learning integration	ML models can still be useful
Ref.Nos.	**Method Used**	**Dataset**	**Merits**	**Demerits**	**Inference**
Rong Zhu Et.al. [10]	Transformer, RNN	CHB-MIT	Captures long term dependencies well	High computational cost	Transformer models improve EEG sequence modeling
Ratnaprabha Ravindra Borhade Et.al. [11]	ResNeXt, Lenet	CHB-MIT, TUH-EEG	Hybrid model improves prediction	Complex architecture	Hybrid approaches enhance accuracy
Y. Sai Chand Et.al. [12]	LSTM, CNN	CHBMIT	Good temporal feature extraction	Needs Patient specific tuning	LSTM works well for sequential data
Zakary Georgis-Yap Et.al. [13]	CNN, Autoencoder	TUH-EEG	Works for both labelled and unlabelled data	High false alarm rate	Unsupervised learning is useful for prediction
Deepa B Research Et.al. [14]	CNN, Data Normalization	CHB-MIT	Improved accuracy through normalization	Sensitive to noise	Data preprocessing enhances model performance
Kuldeep Singh Et.al. [15]	Two-layer LSTM	CHB-MIT	Better long-term dependency handling	Training complexity	LSTM layers boost seizure prediction accuracy
Rekha Sahu Et.al. [16]	CNN, ML(SVM, RF)	CHB-MIT, TUH-EEG	Deep learning outperforms ML	DL models need large datasets	Deep learning is superior for EEG analysis
Saravanan Srinivasan. Et.al. [17]	CNN-LSTM	Bonn University EEG	Good for adult epilepsy cases	Limited to a specific age group	Hybrid models improve detection rates
Qinyu Chen Et.al. [18]	Spiking Neural Networks, Transformer	CHB-MIT	Low power consumption	Difficult to train	Spiking models reduce computational cost
Ref.Nos.	**Method Used**	**Dataset**	**Merits**	**Demerits**	**Inference**
CatalinaGómez Et.al. [19]	FCN, Image Processing	CHB-MIT	Effective for image-based EEG	Loss of raw EEG information	Loss of raw EEG information

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Ref.Nos.	Method Used	Dataset	Merits	Demerits	Inference
Theekshana Dissanayake, Et.al. [20]	CNN, Transfer Learning	CHB-MIT, TUH-EEG	Generalizes across patients	Lower accuracy than patient specific models	Transfer learning helps with patient variability
Yankun Xu Et.al. [21]	CNN	International Affective Picture System (IAPS)	Non-contact method for emotion recognition, potential for assistive communication devices	Lower accuracy for complex emotions like joy, indifference, and disgust	Eye-tracking features can be used for monitoring mental well-being and emotion recognition
Valentin Gabeff Et.al. [22]	Explainable AI (XAI), CNN	CHB-MIT	Improves model interpretability	Lacks Realtime implementation	XAI enhances clinical trust in DL models
Mengni zhou Et.al. [23]	CNN	CHB-MIT, TUH-EEG	Simple yet effective model	Needs large labelled datasets	CNNs are useful for seizure detection
Anitha V Et.al. [24]	CNN, BiLSTM	CHB-MIT	Improved accuracy using hybrid methods	Requires high computational power	Hybrid models combine spatial and temporal features
Raghdah Et.al. [25]	Federated Learning, CNN	CHB-MIT, TUH-EEGs	Enhances privacy, personalized models	Requires distributed computing	Federated learning benefits patient-specific modelling
Zan Li Et.al. [26]	CNN, LSTM	CHBMIT, iEEG	Captures both intracranial and scalp EEG.	Needs invasive electrodes for iEEG	Multi-modal approaches improve seizure localization.
Mehdi Hosseinzadeh Et.al.[27]	Ensemble Learning, CNN	CHB-MIT, TUHEEG	Robust model performance	High computational demand	Ensemble models increase reliability
Syed Muhammed Usman Et.al. [28]	CNN, LSTM	CHB-MIT, Bonn EEG	Effective in predicting seizures	High training complexity	Deep learning is promising for seizure prediction
Yankun Xu Et.al. [29]	CNN-LSTM, End-to-End Deep Learning	CHB-MIT, TUH-EEG	Eliminates manual feature extraction, improves automation	High computational cost, requires large training data	End-to-end deep learning enhances seizure prediction by automatically learning features

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					from raw EEG signals
Nogay, H. SEt.al. [30]	2D convolutional neural network (CNN)	CHB-MIT Scalp EEG Database	High Accuracy, efficiency	Dataset Specificity, Generalizability	CNNs with transfer learning on spectrogram images of EEG signals can effectively detect epileptic seizures

V. CONCLUSION

Epileptic seizure detection and prediction using deep learning has shown significant potential in improving the accuracy and timeliness of seizure diagnosis and forecasting. Deep learning models, particularly convolutional neural networks (CNNs), recurrent neural networks (RNNs), long short-term memory (LSTM) networks, and transformer-based architectures, have demonstrated superior performance in analysing electroencephalogram (EEG) signals. These models effectively capture spatial and temporal dependencies in EEG data, enhancing seizure detection and prediction capabilities. Despite their success, challenges remain, including data scarcity, variability in EEG patterns across individuals, and the need for real-time implementation in clinical settings. Addressing these issues requires improved dataset quality, advanced model architectures, and integration with edge computing for real-time applications. Future research should focus on explainability, robustness, and personalized seizure prediction to enhance patient outcomes. In conclusion, deep learning-based epileptic seizure detection and prediction systems offer promising advancements in epilepsy management, potentially leading to earlier interventions and improved quality of life for patients.

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