RESEARCH ARTICLE OPEN ACCESS

Mental Health Diagnosis through EEG Signal Analysis with Deep Learning Models

Rupesh Kumar[1], OnkarNathThakur[2], RakeshKumarTiwari[3], MayankPathak[4]
MTech Scholar[1], Assistant Professor[2&3], Professor[4]
Department of Computer Science & Engineering[1,2,3&4]
Technocrats Institute of Technology & Science, Bhopal. India[1,2,3&4]

ABSTRACT
Mental health disorders pose a serious global challenge due to their complex nature and reliance on subjective diagnostictechnique. This review presents a comprehensive analysis of how Electroencephalography *(*EEG*)*combinedwithdeeplearningtechniques can enhance the accuracy and objectivity of mental health diagnosis. EEG is a non-invasive, low-cost technique that records electrical activity of the brain with high temporal resolution, making it suitable for detecting subtle neural abnormalities. Deep learning models automatically learn temporal, spatial, and frequency-domain features from EEG signals, eliminating the limitations of manual feature extraction. Disorders such as depression, anxiety,attention deficit hyperactivity disorder (ADHD), post-traumatic stress disorder (PTSD), bipolar disorder, and schizophrenia exhibit distinct EEG biomarkers that can be effectively captured using modern neural networks. The reviewed studies demonstrate that EEG-based deep learning frameworks offer reliable, scalable, and clinically valuable diagnostic support.

KEYWORD: EEG signal analysis, deep learning models, mental health diagnosis, neural biomarkers, frequency bands, CNN, GNN.

Date of Submission: 23-01-2026 Date of acceptance: 05-02-2026

I.INTRODUCTION

Mental health disorders present a growing global concern. Traditional diagnostic methods depend heavily on subjective clinical interpretation, often leading to inconsistent diagnosis. EEG provides high temporal resolution brain data that can reflect underlying neural dynamics. Recent advances in deep learning allow automated feature learning from EEG datasets, improving diagnostic accuracy and reliability. This review discusses how EEG signals, frequency bands, and modern deep learning architectures contribute to mental health diagnosis. And according to Ahmed et al. proposed deep learning models to detect multiple psychiatric disorders directly from EEG signals [1]. A hybrid deep neural network incorporating temporal and functional EEG features was introduced for schizophrenia diagnosis, achieving improved classification performance [2]. Robust EEG analysis frameworks are using deep learning have also applied for continuous mental health monitoring [3].

II. LITERATURE REVIEW

A. Previous Approaches

Authors (Year)	Title	Techniques Used	Key Focus/ Contributions
Ahmed et al. (2024)	Psychiatric Disorder Detection	DL	EEG-based disorder classification
Soltani-Nejad et al. (2025)	Schizophrenia Diagnosis	Hybrid DNN	Temporal & functional features
Liu et al. (2025)	Mental Health Monitoring	DL	Robust EEG analysis
Naregalkar et al. (2025)	Depression Detection	ML	EEG-based depression analysis
Elnaggar et al.	Depression Detection	Review	Survey of EEG

(2025)	(Review)		methods
Uyanik et al. (2025)	EEG Disorder Detection (Review)	AI, DL	Overview of EEG-AI systems
Nadella et al. (2025)	Real-Time Mental Monitoring	Unsupervised DL	Real-time EEG monitoring
Yadulla et al. (2025)	EEG Mental Health (Review)	Unsupervised DL	Review of monitoring methods
Ural (2025)	Psychiatric Pre-Diagnosis	Ensemble DL	Non-invasive diagnosis
Modi et al. (2025)	Mental Stress Detection	Hybrid DL	Stress detection using EEG
Angelakis et al. (2024)	EEG Model Comparison	DL	Performance comparison
Vicchietti et al. (2023)	Alzheimer's Classification	ML	EEG-based AD detection
Fouad & Labib (2023)	Alzheimer's Detection	ML, ResNet	Central lobe EEG analysis
Latifoğlu et al. (2025)	Dementia Classification	ANN	AD & FTD classification
Bi et al. (2025)	Alzheimer's EEG Review	Review	Summary of EEG methods

III.RELATED-WORK

Electroencephalogram (EEG) signal analysis is widely used for the automatic detection and monitoring of mental and neurological disorders due to its non-invasive nature and high temporal resolution. According to recent studies have combined EEG signals with deep learning and machine learning techniques to improve diagnostic accuracy and reduce manual feature extraction. Based ondeep learning approaches have shown strong performance in psychiatric disorder classification. Ahmed et al. proposed deep learning models to detect multiple psychiatric disorders directly from EEG signals [1]. A hybrid deep neural network incorporating temporal and functional EEG features was introduced for schizophrenia diagnosis, Achieving improved classification performance [2]. Robust EEG analysis frameworks are using deep learning have also applied for continuousmental health monitoring [3]. Several studies focused on depression and mental stress detection using EEG signals. Based on machine learning depression detection methods demonstrated effective discrimination between healthy and affected individuals [4], while hybrid deep learning models were applied for physiological signal based upon stress detection [10]. These studies confirm that EEG signals carry important biomarkers related to emotional and cognitive states. To reduce dependency on labeled datasets, unsupervised deep learning techniques explored for real-time mental health monitoring and intervention [7], with systematic reviews summarizing recent advances in unsupervised on EEG based approaches [8]. Ensemble deep learning models have further employed for non-invasive pre-diagnosis of psychiatric disorders and improving robustness as well as reliability [9].Based onEEG approaches have also been extensively studied for Alzheimer's diagnosis and dementia classification. Computational EEG analysis methods are proposed for Alzheimer's disease detection [12, 13], while residual neural networks and artificial neural networks had used to enhance classification accuracy [14, 15]. Review studies provided comprehensive summaries of EEG-based Alzheimer's disease identification methods [16].Moreover, EEG analysis has been applied to other neurological conditions, such as pediatric ADHD diagnosis, where wavelet-attention deep learning models demonstrated improved performance [17]. Multiple systematic reviews and highlighted current challenges, including EEG noise, subject variability, and limited real-time deployment, indicating the need for more generalized and robust models [5, 6].Finally, existing research confirms the effectiveness of AI-driven EEG analysis for mental and neurological disorder detection. Finally, issues related to generalization, robustness, and real-time implementation remain open, motivating and further research in this domain.

IV.CHALLENGES

Despite promising results, several challenges remain in EEG-based deep learning systems for mental health diagnosis. Large and well-labeled EEG datasets are limited, which affects model training and performance. EEG signals vary significantly between individuals due to differences in brain activity, age, and mental conditions, making generalization difficult. EEG recordings are also affected by noise and artifacts such as eye blinks and muscle movements, which reduce signal quality. In addition, there is a lack of standardized

EEG acquisition protocols, including differences in electrode placement and recording settings. Most studies are conducted in controlled laboratory environments, which limits real-world and clinical deployment. These challenges highlight the need for more robust, standardized, and generalizable EEG-based diagnostic models.

V.RESEARCH GAP IN PREVIOUS WORK

Most of existing studies show good results using EEG and deep learning for diagnosing mental and neurological disorders. Meanwhile, most of methods use only EEG data and do not combine it with other information such as MRI, fNIRS, or behavioral data, which can limit diagnosis accuracy. Most of studies are also conducted in controlled laboratory settings using clinical EEG systems, with very little focus on wearable EEG devices for real-time and daily-life monitoring. In addition, many deep learning models work like black boxes, making their decisions difficult to understand and reducing trust among clinicians.Issues related to data privacy are not well addressed, as most of models are trained using centralized datasets without privacy-preserving or federated learning methods. Moreover, problems such as high differences between subjects, poor performance across multiple disorders, and the lack of standard EEG recording standards are still unresolved. These gaps show the need for more explainable, multimodal, privacy-aware,and real-world deployable EEG-based diagnostic system.

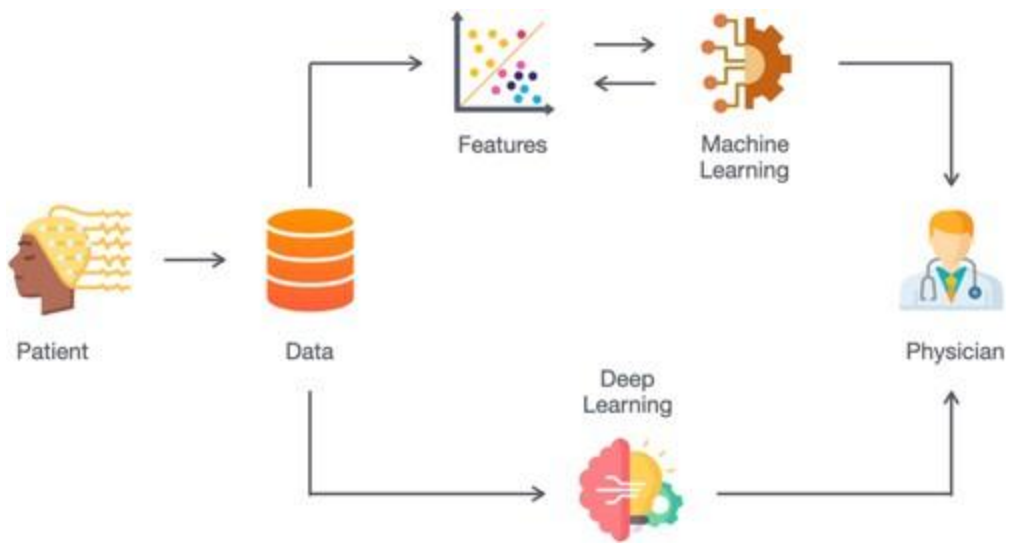

Figure1:Information pathways diagram for the clinical decision support system.

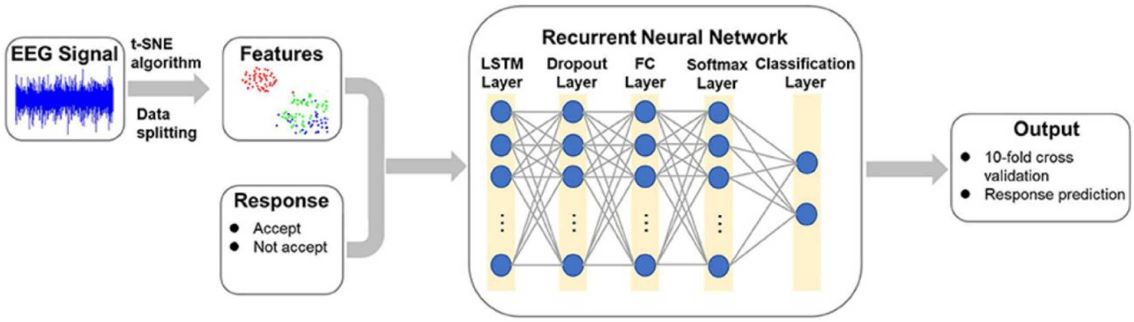

Figure2: RNN-based EEG Feature Classification Workflow

Fig.1 and 2 illustrate the overall based on EEG clinical decision support and classification process. EEG signals are collected from the patient, processed to extract meaningful features, and analyzed using deep learning and machine learning models. Based on RNN architecturelearns temporal patterns from the EEG data and performs classification. The final prediction results are then provided to the physician to support accurate and reliable mental health diagnosis output or result.

VI.CONCLUSION

extensively read and review the mentioned base papers, this review shows that combining EEG signal analysis with deep learning models provides an effective and objective approach for mental health diagnosis. EEG is a non-invasive and low-cost technique that can capture important brain activity patterns related to disorders such as depression, schizophrenia, ADHD, and Alzheimer's disease. Deep learning methods improve diagnostic accuracy by automatically learning meaningful features from EEG signals and reducing the need for manual analysis. However, challenges such as limited datasets,
EEG noise, subject variability, lack of interpretability, and controlled laboratory-based studies still limit real-world use. Future research should focus on multimodal data integration, wearable EEG systems, explainable AI models, and privacy-preserving learning techniques to support reliable, scalable, and clinicallyapplicable mental health diagnosis systems.

REFERENCES:

[1]. Zaeem Ahmed, Aamir Wali, Saman Shahid, Shahid Zikria, Jawad Rasheed, Tunc Asuroglu. Psychiatric disorders from EEG signals through deep learning models [2024]. https://www.sciencedirect.com/science/article/pii/S2667242124000824
[2]. Mahdi Soltani-Nejad, Farnaz Salar-pour, Seyed Ali Rakhshan & Hossein Nezamabadi-pour. Enhanced hybrid deep neural network for EEG-based schizophrenia diagnosis using functional and temporal features [2025]. https://www.nature.com/articles/s41598-025-26627-4
[3]. Zixiang Liu, Juan Zhao, Anhui Vocational College of Grain Engineering, Hefei, China Hefei University, Hefei, China. Leveraging deep learning for robust EEG analysis in mental health monitoring [2025]. https://www.frontiersin.org/journals/neuroinformatics/articles/10.3389/fninf.2024.1494970/full
[4]. Prajakta Naregalkar, Arundhati Shinde and Mangal Patil. A machine learning approach based on EEG signals for detection of depression [2025]. https://iopscience.iop.org/article/10.1088/2631-8695/ae1e6e
[5]. Kholoud Elnaggar, Mostafa M El-Gayar, Mohammed Elmogy. Depression Detection and Diagnosis Based on Electroencephalogram (EEG) Analysis: A Systematic Review [2025]. https://pmc.ncbi.nlm.nih.gov/articles/PMC11765027/
[6]. Hakan Uyanik, Abdulkadir Sengur, Massimo Salvi, Ru-San Tan, Jen Hong Tan, U. Rajendra Acharya. Automated Detection of Neurological and Mental Health Disorders Using EEG Signals and Artificial Intelligence: A Systematic Review [2025]. https://wires.onlinelibrary.wiley.com/doi/full/10.1002/widm.70002
[7]. Geeta Sandeep Nadella, Mohan Harish Maturi, Snehal Satish, Karthik Meduri. Real-Time Mental Health Monitoring and Intervention Using Unsupervised Deep Learning on EEG Data [2025]. https://www.researchgate.net/publication/395371892_Real-Time_Mental_Health_Monitoring_and_Intervention_Using_Unsupervised_Deep_Learning_on_EEG_Data
[8]. Akhila Reddy Yadulla, Guna Sekhar Sajja, Santosh Reddy Addula, Mohan Harish Maturi, Geeta Sandeep Nadella, Elyson De La Cruz, Karthik Meduri, Hari Gonaygunta. A Systematic Review of Mental Health Monitoring and Intervention Using Unsupervised Deep Learning on EEG Data [2025]. https://www.mdpi.com/2813-9844/7/3/61
[9]. Ali Berkan Ural. Non-Invasive Pre-Diagnosis Implementation of Psychiatric Mental Disorders from EEG Bio-Signal Data Using Ensemble Deep Learning: A Comparative Analysis [2025]. https://www.iieta.org/journals/ts/paper/10.18280/ts.420335
[10]. Nandini Modi, Yogesh Kumar, Kapil Mehta & Neelam Chaplot. Physiological signal-based mental stress detection using hybrid deep learning models [2025]. https://link.springer.com/article/10.1007/s44163-025-00412-8
[11]. Dimitris Angelakis, Errikos C. Ventouras, Spiros Kostopoulos and Pantelis Asvestas. Comparative Analysis of Deep Learning Models for Optimal EEG-Based Real-Time Servo Motor Control [2024]. https://www.mdpi.com/2673-4117/5/3/90
[12]. Mário L. Vicchietti, Fernando M. Ramos, Luiz E. Betting and Andriana S. L. O. Campanharo. Computational methods of EEG signals analysis for Alzheimer's disease classification [2023]. https://www.nature.com/articles/s41598-023-32664-8

[13]. Vicchietti ML, Ramos FM, Betting LE, Campanharo ASLO. Computational methods of EEG signals analysis for Alzheimer's disease classification [2023]. https://europepmc.org/article/med/37210397
[14]. Islam A. Fouad, Fatma El-Zahraa M. Labib. Identification of Alzheimer's disease from central lobe EEG signals utilizing machine learning and residual neural network [2023]. https://www.sciencedirect.com/science/article/abs/pii/S1746809423006997
[15]. Fatma Latifoğlu, Fırat Orhanbulucu, Murugappan Murugappan, Sümeyye Nur Gürbüz, Burçin Çayır and Fatma Zehra Avcı. EEG signal analysis for the classification of Alzheimer's and frontotemporal dementia: a novel approach using artificial neural networks and cross-entropy techniques [2025]. https://www.tandfonline.com/doi/full/10.1080/00207454.2025.2529301
[16]. Jinying Bi, Fei Wang, Fangzhou, Shuai Han, Yuting Wang, Zhijian Fu, Xin Zhang. The EEG analysis and identification of Alzheimer's disease: a review [2025]. https://www.frontiersin.org/journals/aging-neuroscience/articles/10.3389/fnagi.2025.1686628/full
[17]. Babak-Masoudi. Wavelet-Attention deep model for pediatric ADHD diagnosis via EEG [2025]. https://www.tandfonline.com/doi/abs/10.1080/21622965.2025.2535017