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Literature Survey Paper on Epilepsy and Autism Spectrum Disorder Detection and Analysis Using Machine Learning

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Abstract*: The detection and cure of epilepsy and autism spectrum disorder (ASD) are significantly complicated by their co-occurrence. This survey research investigates an integrated method for identifying ASD using behavioural characteristic questionnaires and epilepsy using EEG corpus inside a single system. We provide an overview of all the relevant research, emphasizing the difficulties in diagnosing each of these disorders separately and in combination. Our suggested approach combines behavioural questionnaire assessments for ASD with EEG-based analysis for epilepsy detection in an effort to improve diagnostic accuracy and expedite the evaluation process. This study examines the approaches, difficulties, and developments in both domains, providing perspectives on possible overlaps and prospects for further investigation. So, an attempt has been made to review on the pattern detection methods for epilepsy seizure detection from EEG signals. More than 150 research papers have been discussed to determine the techniques for detecting epileptic seizures. Further, the literature review confirms that the pattern recognition techniques required to detect epileptic seizures varies across the electroencephalogram (EEG) datasets of different conditions. This is mostly owing to the fact that EEG detected under different conditions have different characteristics.*

Keywords: Autism Disorder, Machine Learning, Epilepsy, EEG corpus.

I. INTRODUCTION

Both autism disorder (ASD) and epilepsy are complicated neurological disorders that can have a major negative effect on a person's quality of life. Recurrent seizures are the hallmark of epilepsy, which need prompt diagnosis and treatment to properly control symptoms. Electroencephalography (EEG) is a vital diagnostic tool for epilepsy because it captures electrical activity in the brain. Thanks to the development of techniques for analysing EEG signals, researchers and physicians can now identify precise patterns linked to epileptic seizures. Through the utilization of machine learning techniques like deep learning and signal processing algorithms, researchers hope to improve seizure detection accuracy and efficiency, which will accelerate exceptional patient results. However, Autism Spectrum disease (ASD) is a developmental disease that impacts behaviour, social interaction, and communication. Typically, a thorough evaluation of a person's behaviour and developmental history is required to diagnose ASD. It's normal practice to collect data on a person's social skills, communication abilities, and repetitive behaviours using questionnaires and organized interviews. These evaluations offer insightful information on the prevalence and intensity of ASD symptoms, assisting medical professionals in accurately diagnosing patients and creating specialized treatment programs.

The annual economic burden of epilepsy is enormous in developing nations like India where it is estimated to be 88.2% of gross national product (GNP) per capita and 0.5% of the overall GNP [24]. Hence, early diagnosis through recent technologies like Artificial technology(AI), feature engineering, data analytics is vital and can aid in Quality of Life (QOF) of patients and their associated caretakers. Secured, reproducible AI algorithm, good quality data and efficient computing horse power are the major elements for development of early treatment of epileptic wave forms through EEG signals. There are several types of EEGs such as intracranial, scalp, ambulatory, etc. They are recorded in video, image and signal format depending on their use and application in hospitals. There is a high demand of real-time biomedical tools for data analytics, and pattern identification. Bonn EEG time series database [25] was the first EEG dataset to be publicly available for research applications in this field. It remains as the benchmark dataset for most research works due to its availability. Several datasets discussed in this paper encourage scientific advances in this field. The data quality of biomedical datasets is measured through different factors such as presence of artefacts and noise, missing values, descriptive information, annotations by health experts, pre-fined data structure, processing and robustness to outliers etc.

II. LITERATURE SURVEY

2.1 Detection of epileptic seizure in EEG signals using machine learning and deep learning techniques

In this paper, the authors aim to address the challenge of detecting programmed epileptic seizures using machine learning (ML) and deep learning (DL) algorithms. They conduct a study that involves a comparative analysis of these algorithms and utilize the UCI-Epileptic Seizure Recognition dataset for training and validation purposes[1]. The authors begin by explaining the importance of accurately detecting epileptic seizures, as it can significantly improve the quality of life for individuals with epilepsy. To conduct their study, the authors first gather the UCI-Epileptic Seizure Recognition dataset, which contains EEG recordings from patients with. The authors propose a model that incorporates LSTM, a type of recurrent neural network known for its ability to capture long-term dependencies in sequential data. They train this model on the dataset and evaluate its performance using the validation set. The results of the study indicate that the proposed LSTM model achieves a validation accuracy of 97%, surpassing the performance of the other algorithms mentioned in this study. The authors provide valuable insights into the effectiveness of different approaches and propose an LSTM model that outperforms the other algorithms. This research contributes to the ongoing efforts to improve the detection and management of epilepsy using advanced computational techniques.

2.2 EEG seizure detection: concepts, techniques, challenges, and future trends

The research paper, it heavily relies on electroencephalography (EEG) signals as the primary means to assess brain activity during seizures. However, manually determining the location of seizures in EEG signals can be both troublesome and time-consuming[2]. To address this issue, the automatic detection framework has emerged as a crucial tool in assisting doctors and patients in taking appropriate precautions. This research paper aims to review the mental disorder associated with epilepsy and the various types of seizures, as well as the preprocessing operations conducted on EEG data. Additionally, it explores the commonly extracted features from the EEG signals and provides a comprehensive overview of the classification procedures employed in tackling this problem. Furthermore, the paper offers insights into the challenges faced and future research directions in this innovative field. Consequently, this study presents a comprehensive review of recent methodologies for the epileptic seizure process, while also presenting perspectives and concepts to researchers for the development of an automated EEG-based epileptic seizure detection system. This system utilizes IoT and machine learning classifiers to enable remote patient monitoring within the context of smart healthcare.

Interior Artifacts	Exterior Artifacts
Blinking of the eye (EOG)	Power line
Heartbeat (ECG)	Machine fault
Muscle movements (EMG)	Faulty electrode/poor placement
Skin resistance	ventilation
Subject's movement	Digital artifacts (loose wiring, etc.)

Table 1 Types of Artifacts in EEG Signals

2.3 Detection of autism spectrum disorder (ASD) in children and adults using machine learning

This paper[3] is characterized by repetitive behaviour, restricted interests, communication problems, and difficulties in social interaction. Detecting ASD at an early stage is crucial in order to mitigate its severity and long-term effects. Federated learning (FL) is a recently developed technique that can be utilized for accurate ASD diagnosis in the early stages or for the prevention of its long-term effects. This article explores the unique application of FL in autism detection by training two different machine learning classifiers, namely logistic regression and support vector machine, locally. These classifiers are trained to classify ASD factors and detect ASD in both children and adults. Through the use of FL, the results obtained from these classifiers are transmitted to a central server, where a meta classifier is trained to determine the most accurate approach for detecting ASD in children and adults. Four different datasets, each containing over 600 records of affected children and adults, were obtained from various repositories for feature extraction. The proposed model achieved a prediction accuracy of 98% for ASD in children and 81% for ASD in adults.

2.4 Rebalancing Techniques for Asynchronously Distributed EEG Data to Improve Automatic Seizure Type Classification

The main objective of this research paper[4] is to evaluate the effectiveness of various rebalancing techniques in addressing the challenge of dealing with asynchronously distributed data. Specifically, the study focuses on the application of random resampling, synthetic minority oversampling technique (SMOTE), and adaptive synthetic sampling approach for imbalanced learning (ADASYN) in the classification of different types of seizures. The dataset used in this study is the Temple University Hospital EEG Seizure Corpus (TUSZ) v1.5.2, which consists of EEG signals recorded from 19 common channels. To classify the seizure types, the proposed model utilizes both frequency information obtained through variational mode decomposition (VMD) and phase information extracted using the phase locking value (PLV). The random subspace k-nearest neighbour (RSkNN) ensemble classifier is employed for the classification task, considering five classes of seizures: complex partial seizures (CPSZ), simple partial seizures (SPSZ), absence seizures (ABSZ), tonic clonic seizures (TCSZ), and tonic seizures (TNSZ). The performance of each rebalancing technique is evaluated based on accuracy and weighted F1 score, with SMOTE using two nearest neighbours achieving the highest accuracy of 96.28% and a weighted F1 score of 0.964.

2.5 A systematic study of intelligent autism spectrum disorder detector

This paper[5] talks about multifaceted developmental condition that primarily affects the nervous system, resulting in impairments in communication, social behaviour, and underlying social knowledge. This disorder is not limited to a specific age group but has been increasingly prevalent across all age groups. Early identification and prediction of this developmental disorder can significantly contribute to the overall well-being of individuals, both physically and mentally. Recent advancements in technology have made it possible to detect certain neurological disorders at an earlier stage. Machine-learning methods, predominantly, have been employed for the analysis of ASD. This research paper aims to provide a comprehensive review of existing artificial intelligence (AI) models used for ASD detection, focusing on screening methods, eye movements, and MRI data. By critically examining the limitations of previous studies, the authors propose the development of an ASD MRI model for the early detection of autism. This proposed model combines eye gaze data and MRI data, offering a promising avenue for future implementation. The integration of these two data sources holds great potential in enhancing the accuracy and efficiency of ASD detection. By leveraging the power of AI and utilizing multiple data modalities, this model can contribute to the timely identification and intervention of autism spectrum disorder.

2.6 Review on Epileptic Seizure Prediction: Machine Learning and Deep Learning Approaches

This review paper talks about the modern computational tools, machine learning, and deep learning techniques have been extensively utilized in the field of epilepsy research to forecast seizures using electroencephalogram (EEG) data[6]. However, the accuracy of these predictions can be compromised due to the presence of background noise and artifacts, such as eye blinks and muscle movements, which can introduce irregularities in the EEG signal. These irregularities, commonly referred to as "pops," result in electrical interference that is arduous to identify through manual visual inspection, especially for long-duration recordings. Consequently, the automatic detection of interictal spikes and epileptic seizures, which is crucial for a comprehensive analysis of EEG recordings, faces significant challenges. Given these limitations, it becomes imperative to explore automated approaches that can aid neurologists in effectively categorizing epileptic and non-epileptic signals. In light of this, a comprehensive review paper is presented, focusing on various schemes that have been developed to address this issue. Notably, the main hurdles encountered in the

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development of epilepsy prediction algorithms are feature selection and classification. This paper aims to address these challenges by presenting a range of techniques that have been proposed in recent years, employing diverse features and classifiers.

2.7 Multimodal detection of epilepsy with deep neural networks

The first method involves the application of the short-time Fourier transform (STFT) to the single-channel electroencephalogram (EEG) signals. By doing so, an image comprising three channels is constructed. This image is then subjected to pretrained models such as AlexNet, DenseNet201, EfficientNet, ResNet18, and others. Through this approach, the authors aim to leverage the power of deep learning models to accurately classify the different cases.

The second method proposed in this paper[7] is a multimodal deep neural network. In this approach, each single-channel EEG signal is passed through two branches of convolutional neural networks (CNNs). These CNNs are capable of extracting both low and high frequency features from the signals. Additionally, the short-time Fourier transform (STFT) is applied to the EEG signals, resulting in the creation of an image with three channels. This image is then fed into a pretrained EfficientNet-B7 model. To control the importance of each modality, a gated multimodal unit is employed.

2.8 A review on the pattern detection methods for epilepsy seizure detection from EEG signals

Numerous research papers have been published to gain a better understanding of epileptic seizures, necessitating a thorough review of these papers. Consequently, an examination has been undertaken to analyse the methods used for pattern detection in the context of epilepsy seizure detection from EEG signals. This review[8] encompasses more than 150 research papers, with the goal of determining the most effective techniques for detecting epileptic seizures. The literature review confirms that the pattern recognition techniques required for detecting epileptic seizures vary depending on the specific electroencephalogram (EEG) datasets and their associated conditions. This variation arises from the fact that EEG data obtained under different conditions exhibit distinct characteristics. Therefore, it is crucial to identify the appropriate pattern recognition technique that can accurately differentiate between EEG data related to epileptic seizures and EEG data associated with various other conditions.

2.9 Autistic Spectrum Disorder Screening Data for Children - UCI Machine Learning Repository

The UCI dataset serves as an invaluable resource for this study, as it provides a large amount of data that can be used to train and test machine learning models. By analysing this data, the researchers can identify patterns and trends that may be indicative of ASD. This information can then be used to develop algorithms and models that can accurately screen and diagnose ASD in children.By improving the accuracy and efficiency of ASD screening processes, this study has the potential to make a significant impact on the lives of children with ASD. Early diagnosis and intervention are crucial for improving outcomes for individuals with ASD, and by enhancing the screening process, more children can receive the support and interventions they need at an earlier stage.Overall, this study aims to utilize machine learning techniques and the UCI dataset to enhance the understanding and screening of ASD in children. By improving the accuracy and efficiency of screening processes, the researchers hope to contribute to the development of more effective early diagnosis and intervention strategies, ultimately improving outcomes for children with ASD.

2.10 Detection and classification of adult epilepsy using hybrid deep learning approach

This article[10] presents a novel approach to classifying minimally pre-processed, raw multichannel EEG signal recordings for the purpose of identifying seizures in pre-adult patients. The method utilizes a three-dimensional deep convolution auto-encoder (3D-DCAE) with automatic feature learning capabilities, combined with a neural network-based classifier. This integrated framework is trained in a supervised manner to achieve the highest level of classification precision for both ictal and interictal brain state signals. To evaluate the effectiveness of the method, two models were developed and tested using three different lengths of EEG data sections. A tenfold cross-validation procedure was employed to ensure robustness. The labelled hybrid convolutional auto-encoder (LHCAE) model, which

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incorporates a bidirectional long short-term memory (Bi-LSTM) classifier and an EEG segment length of 4 seconds, demonstrated the best performance based on five evaluation criteria.

2.11 Automated Detection Approaches to Autism Spectrum Disorder Based on Human Activity Analysis: A Review

This study presents a systematic review that follows the PRISMA guidelines, focusing on the potential of an automated autism detection system utilizing Human Activity Analysis (HAA). The objective is to identify distinctive characteristics of autism disorder (ASD), such as repetitive behaviour, abnormal gait, and visual saliency. The review encompasses literature published from 2011 onwards and employs both qualitative and quantitative analysis to investigate the capability of HAA in recognizing ASD features, its classification accuracy, the extent of human intervention required, and the screening time involved.

Based on the findings of this review, the paper[11] delves into various aspects including the different approaches utilized, the challenges encountered, the resources utilized, and the future directions in this field. Furthermore, a quantitative assessment of the dataset by Zunino et al. (IEEE: 3421–3426, 2018) reveals that Inception v3 and LSTM Zunino et al. (IEEE: 3421–3426, 2018) exhibit the highest accuracy of 89% in detecting repetitive behaviour. In the case of abnormal gait-based approaches, the multilayer perceptron achieves an impressive accuracy of 98% by utilizing 18 features from the dataset provided by Abdulrahman et al.

2.12 Spatial Attentional Bilinear 3D Convolutional Network for Video-Based Autism Spectrum Disorder Detection

In this study, we propose a novel approach called spatial attentional bilinear pooling to enhance the extraction of spatial information without introducing a significant increase in parameters. By incorporating spatial attention, our method allows for a more focused and accurate perception of discriminative regions within the video frames. To further improve the performance of video-based ASD detection, we introduce a fine-grained action recognition network named SA-B3D, which utilizes a Long Short-Term Memory (LSTM) model.Our proposed model[12], SA-B3D, dynamically and effectively focuses on the most discriminative regions within the video frames, leading to a significant improvement in performance compared to existing state-of-the-art models. Through extensive experimentation on a video-based ASD dataset, our model demonstrates its superiority in accurately detecting ASD, showcasing its potential for practical applications in the field.

2.13 Applications of Supervised Machine Learning in Autism Spectrum Disorder Research: A Review

This study presents an extensive examination of 45 research papers that have employed supervised machine learning techniques in the field of Autism Spectrum Disorder (ASD). These papers encompass various algorithms used for classification and text analysis. The primary objective of this paper is to identify and elucidate the prevailing trends in supervised machine learning within the ASD literature. Additionally, it aims to provide valuable insights and guidance to researchers who are keen on advancing the repertoire of clinically, computationally, and statistically robust methodologies for extracting meaningful information from ASD data.The scope of this paper[13] encompasses a thorough analysis of 45 scholarly articles that have employed supervised machine learning methods in the context of Autism Spectrum Disorder (ASD). These articles encompass a wide range of algorithms utilized for classification and text analysis purposes. The central aim of this research is to discern and explicate the prevailing patterns and tendencies observed in the application of supervised machine learning techniques within the ASD literature. Furthermore, it endeavours to offer valuable information and direction to researchers who are interested in expanding the collection of reliable and rigorous approaches for extracting and analysing ASD data, encompassing clinical, computational, and statistical aspects.

2.14 Indications of nonlinear deterministic and finite-dimensional structures in time series of brain electrical activity: Dependence on recording region and brain state

This study aims to compare the dynamical properties of brain electrical activity across different recording regions and various physiological and pathological brain states. To achieve this, the researchers employed several analytical

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techniques. Firstly, they utilized the nonlinear prediction error and estimated the effective correlation dimension. Additionally, they employed the method of iterative amplitude adjusted surrogate data. These methods[14] were applied to sets of electroencephalographic (EEG) time series.The EEG time series consisted of surface EEG recordings obtained from healthy volunteers in two conditions: eyes closed and eyes open. Furthermore, intracranial EEG recordings were obtained from epilepsy patients during the seizure-free interval. These recordings were taken from both within and outside the seizure generating area. Moreover, intracranial EEG recordings of epileptic seizures were also included in the analysis.Before conducting the main analysis, a pre-analysis step was performed, which involved applying an inclusion criterion of weak stationarity. The results indicated that surface EEG recordings with eyes open were consistent with the null hypothesis of a Gaussian linear stochastic process, as suggested by the surrogates.

III. CONCLUSION

A thorough examination of the literature on the detection of epilepsy using EEG data and autism spectrum disorders (ASD) reveals several significant findings. Existing research demonstrates notable progress in both fields, highlighting the potential of EEG-based methods for diagnosing epilepsy and identifying patterns associated with ASD. However, challenges remain, such as the need for more robust algorithms capable of accurately distinguishing between epileptic seizures and ASD-related behaviours. Furthermore, there is a lack of integrated systems that address both disorders simultaneously. Based on this analysis, our review emphasizes the importance of developing a comprehensive framework that combines advanced EEG processing techniques with machine learning algorithms to create a unified system for detecting and differentiating epilepsy and ASD. Our project aims to contribute to this interdisciplinary field by providing a novel solution that improves diagnostic accuracy and enables early intervention for individuals affected by these neurological conditions.

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