Journal of Engineering Science 13(2), 2022, 69-81
DOI: https://doi.org/10.3329/jes.v13i2.63727

JES
an international Journal

AUTISM DETECTION FROM BRAIN SIGNALS: SOUTH ASIA PERSPECTIVE

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Received: 18 August 2022 Accepted: 28 November 2022

ABSTRACT

Autism Spectrum Disorder (ASD), simply autism, is a complex neurodevelopmental disorder that leads to serious social, communication, and behavioral challenges. The impact of ASD on the family, general well-being, society, and economy is becoming increasingly important due to its high prevalence and the extensive range of clinical treatments required for affected children. Early ASD detection is important because it could help improve access to intervention measures and may help improve developmental outcomes. Autism exposes a critical issue for developing countries, especially in South Asian countries. In the South Asia region, a few institutes are available in the capital or a few big metropolitan cities for diagnosing ASD. Generally, ASD is diagnosed through some conventional methods (e.g., screening). As a neurodevelopmental condition, ASD can be detected through brain signals. On account of easy operation and to maintain low-risk factors, only noninvasive neuroimaging methods, such as electroencephalography (EEG) are considered to measure a child's neural behaviors for classifying ASD. Machine learning methods are used with EEG signals for classifying ASD subjects in different studies than conventional methods. The main concern of this study is to provide some guidelines for machine learning-based automatic ASD detection through EEG signals which might be a prospectus for South Asian countries. Through the advanced system, people from all areas of the country will get proper ASD diagnosis and treatment facilities. Therefore, it is a timely approach of employing brain signals (especially EEG signals) and machine learning-based effective techniques for ASD detection in South Asian countries.

Keywords: *Autism Spectrum Disorder; Brain Signals; Electroencephalography; Machine Learning*

1. INTRODUCTION

Autism Spectrum Disorder (ASD) (Tonge et al., 2011), or simply autism, is a complicated disorder that is diagnosed based on social indications. Early autism detection is a major concern worldwide. Early diagnosis (Yang, 2019) of ASD is significant because it can help to reduce difficulties associated with ASD. The successful application of early intervention approaches can not only enhance the personal satisfaction of people with ASD but also reduce the country's financial costs.

In the past few decades, numerous studies have stated that one out of every 68 children has an ASD diagnosis, but more recent research indicates that one out of every 59 children has an ASD diagnosis (Yolanda de Diego-Otero and Salgado-Cacho, 2019). According to other international studies, there are more ASD incidences worldwide (Hossain, 2018). It is a social issue worldwide but the prevalence of ASD is still unknown in many developing countries such as South Asian countries. In India and Sri Lanka, up to 1 in 93 children is suffering from ASD (Hossain et al., 2017). In Bangladesh, around 10.5 million people may have ASD according to a study by the Centers for Disease Control (CDC) of Bangladesh in 2012, and 1 in 88 children are affected in 2015 (Jahan et al., 2015). In Nepal, the estimated prevalence of ASD is 3 in 1000 (Heys et al., 2018). Around 400,000 children in Pakistan (Tribune, 2021) have ASD, according to the Pakistan Autism Society. Although due to under-reporting, misdiagnosis, and social stigma this number is in reality much higher.

This study describes autism and the importance of early detection. Several ASD detection techniques are analyzed in this study. The main objective of the study is to propose Machine Learning (ML) based automatic ASD detection method through brain signals by which it is possible to diagnose autistic children in rural areas easily. Several ASD detection studies of South Asian countries, as well as other countries, are reviewed and some barriers to ASD diagnosis are also mentioned. Finally, the paper gives some important prospects for ML-based ASD detection in South Asian countries.

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ISSN 2075-4914 (print); ISSN 2706-6835 (online)

Figure 1: Autistic children playing at school. (WBPC, n.d.)

The rest of the paper is structured as follows. Section 2 describes autism, several autism detection techniques, and ML-based automatic ASD detection. Section 3 explores ASD detection scenarios in South Asian countries and brain signal prospects for its detection. Finally, the paper concludes with a few remarks in Section 4.

2. AUTISM: CAUSES, EFFECTS AND DETECTION TECHNIQUES

Autism is a complicated developmental disease with a wide range of phenotypes that are characterized by ongoing difficulties with speech, social interaction, and nonverbal communication. Numerous causes of autism have been suggested, but the hypothesis of autism and other autism spectrum disorders (ASD) causation is still poorly understood. This section describes some causes and effects of autism as well as several ASD detection techniques.

2.1 Autism Causes and Effects

ASD is defined by impairments in social communication, as well as constrained interests and repetitive activities (Johnson and Myers, 2007). The emotional expression of an autistic child is difficult to understand, and empathy is rarely developed at an age-appropriate level. Some social-related skills may improve with time, although they are usually limited or abnormal. The child may immediately repeat words and phrases, as well as favorite phrases previously heard, and engage in repetitive questioning and rituals (Tonge and Brereton, 2011). Figure 1 shows the image of children with ASD playing at school.

ASD is not proven to have a single established cause; however, it is generally accepted that anomalies in the structure or function of the brain are responsible for it. According to brain scans, children with autism have distinct brain shapes and architectures than a neurotypical children. Regarding the complexity of the condition and the wide range of symptoms and severity, there are probably many causes (Ha et al., 2015). As per the National Institute of Neurological Disorders and Stroke (NINDS), ASD can be caused by both inherited traits and environmental factors (Cherney, n.d.). The effects of ASD vary from one another. Individuals with ASD may experience issues with correspondence and social cooperation, limited interests and dull practices, and powerlessness to work viably in school, work, and different everyday issues. Children with autism are approximately eight times more likely than typical children to experience one or more chronic digestive problems (Dawson and Rosanoff, 2013).

2.2 Importance of Early ASD Detection

ASD cannot be prevented, however, there are treatments available to improve situations. Any autism intervention or treatment is more effective the earlier it begins and the more consistently it is implemented. There is significant evidence that ASD is not a deep-seated condition. More research is now revealing that a significant number of children who were diagnosed with ASD never meet the analytic criteria again. This has led to increased interest in the early detection of ASD which can help in a better life. Early findings and intercession are generally useful and can improve behavior and communication abilities and language advancement (ASDF, 2019; Mayo Clinic, 2018). In any case, intercession is useful at any age.

2.3 ASD Detection Techniques

There are several techniques for diagnosing ASD. Generally, ASD is diagnosed using a questionnaire-based screening procedure that just makes recommendations for further investigation. Some strategies are used in conjunction with a multidisciplinary team that interacts with patients to diagnose ASD. Since ASD is a neurodevelopmental problem, it is now also diagnosed based on brain activity through various brain signals. Some other techniques are developed based on visual gaze or eye gaze. Autism detection techniques may categorize into three groups: questionnaire-based, from brain signals, and others.

2.3.1 Questionnaire-Based ASD Detection

There are several questionnaire-based autism detection techniques. The methods are briefly described below.

Questionnaire-Based Screening

Questionnaire-based screening (CDC, 2018) works by asking questions to the child or parents about the child's development including language, movement, thinking, behavior, and emotions. Formal questionnaires or checklists based on research are the screening instruments employed. Screening doesn't give a conclusion; it assists with deciding if extra examination (e.g., an analytic assessment) by clinicians with exceptional aptitude in pediatric improvement is essential. The effects of screening for ASD and subsequent therapies are usually negligible, but they could involve the stress and financial expenses caused by misdiagnosis, additional testing, and prospective treatments. Besides screening does not work after a certain age. ASD is diagnosed through a cell phone application (ET, 2016) that monitors a child's eye development to see if they are showing signs of the disorder. The application can be introduced in phones, tablets, or PCs giving discovery of the neurodegenerative issue in kids as youthful as two years of age, and can drastically improve the advantages of treatment. The application tracks a child's eye development while they look at images of social scenes, revealing the most significant differences in eye development between children with and without ASD.

Assessment through a Multidisciplinary Team

The multidisciplinary team (Huerta and Lord, 2012) has regularly been utilized to diagnose ASD consisting of parents, therapists, psychologists, special educators, and medical specialists. The team brings together their skills and know-how for a joint effort in planning, managing, and coordinating a treatment route and care services. At certain facilities, this has implied that ASD assessment is performed by multi-part demonstrative groups. However, this isn't always possible, and it can be overwhelming for guardians at times. Rather, "multidisciplinary" should be used to mean that during an indicative evaluation, several different areas of work should be evaluated. These multi-faceted evaluations must be completed by clinicians who have extensive experience with government-sanctioned testing of children and who are experts in the evaluation of ASD.

2.3.2 ASD Detection from Brain Signals

As a neurodevelopmental condition, ASD can be detected exclusively by brain signals. Brain signal-based ASD detection has been started in many countries all over the world now. Several brain signals and ASD detection using those are briefly described below:

EEG Signal

The EEG is a signal that records electrical brain activity from a human's scalp over a while. It measures the fluctuation of voltage generated from the ionic current flowing through the neurons of the brain (Robert Clancy MD, 1988). The activity of this type of signal is very small in the range of microvolt. A sample of the EEG signal is shown in Figure 2. EEG signal (Bosl et al., 2018) has been described as a relatively simple, low-cost brain monitoring system and is increasingly being explored as a possible clinical tool for observing abnormal mental health.

Recurrence Quantification Analysis (RQA) as a potential biomarker for ASD was investigated (Heunis et al., 2018). On continuous 5 seconds segments of resting-state EEG data, RQA feature extraction was accomplished. The authors performed classification through a leave-one-out protocol with a nonlinear Support Vector Machine (SVM), Linear Discriminant analysis (LDA), and Multi-Layer perceptron (MLP) classifier obtaining 92.9% accuracy. EEG signal was used for ASD detection through Multi-Scale Ranked Organizing Map/Implicit Function As Squashing Time (MS-ROM/I-FAST) and Artificial Neural Network (ANN) (Grossi et al., 2017). The proposed I-FAST

algorithm comprises precisely three distinct stages or parts. The raw EEG signals were converted into vectors in the first stage, also known as the Squashing stage. The presence of ASD was measured through EEG signals of kids during face

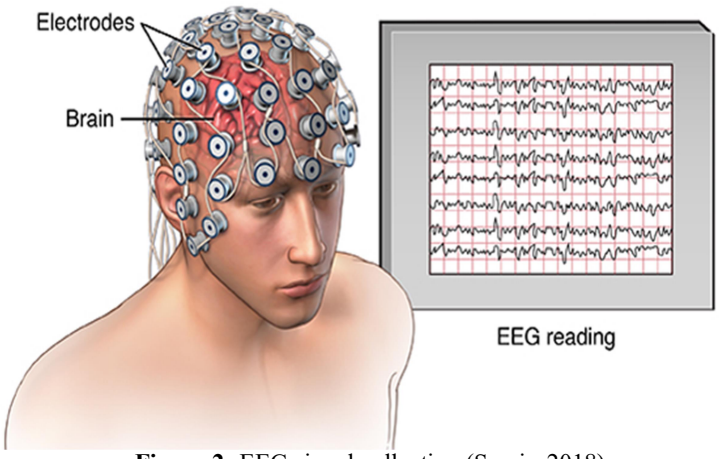

Figure 2: EEG signal collection (Samir, 2018).

observation tasks researched by (Jamal et al., 2014). They used leave one out cross-validation with classification algorithms for classifying autistic and typical children using Continuous Wavelet Transform (CWT), LDA, and SVM. EEG signal to characterize children with ASD and normal children through ANN was used (Raja and Priya, 2017). For the study, a real-time dataset that was obtained from ASD children of various special schools in Coimbatore has been used.

MEG Signal

MEG is a useful neuroimaging tool for mapping cerebral movement by utilizing sensitive magnetometers to record the attractive fields produced by electrical flows that occur naturally in the brain. The most well-known magnetometers are SQUIDs (superconducting quantum impedance devices), but researchers are also looking into the SERF (turn trade unwinding free) magnetometer for future products (Hämäläinen et al., 1993). MEG is used for a variety of purposes, including essential analysis of perceptual and subjective mental forms, determining the capacity of distinct parts of the brain, and neuroticism.

Takahashi et al. (2016) examined MEG signal changeability while unrestricted watching of soundless recordings using Multi-Scale Entropy (MSE) in 43 children with ASD and 72 typically developing (TD), highlighting the transition from childhood to adolescence as a critical period for brain system development. In TD children, there was an age-related increase in mind signal changeability in a certain timeline, whereas, in the ASD group, there was an abnormal age-related adjustment. A story-based neural system (MNet) was created by (Aoe et al., 2019) to characterize the variety of neurological diseases utilizing resting-state MEG signals.

F-MRI

Functional magnetic resonance imaging (FMRI) (Wikipedia Contributors, n.d.) assesses brain movement which distinguishes changes in the circulation. This approach is based on the relationship between cerebral circulation and neuronal initiation. When a part of the brain is utilized, the blood flow to that part increases as well. F-MRI is a useful method for measuring the atypical neurobiological capabilities of ASD and other disabilities. F-MRI isolates metabolic connections between brain function and essential neurocognitive procedures using specific heartbeat groupings. Furthermore, unlike positron emission tomography (PET) and single-photon emanation registered tomography (SPECT), fMRI is non-invasive and does not rely on radiotracers. Plitt et al. (2015) investigated whether resting-state functional MRI (rs-fMRI) network gauges are suitable as demonstrative biomarkers for ASD and whether specific availability highlights are predictive of a diagnosis. Zou et al. (2017) developed a deep learning-based ADHD classification technique using 3-D Convolutional Neural Network systems (CNNs) applied to MRI filters. A Deep Neural Network (DNN) was created using a component evaluation technique (Cheng and Liu, 2017) for the high-dimensional entire brain resting-state FC design order of ASD patients against typical development (TD) controls. To categorize ASD and controls using ABIDE (Autism Brain Imaging Data Exchange) deep learning was successfully applied (Sólon et al., 2018). They investigated examples of practical availability that

impartially distinguishes ASD members from relevant brain imaging data and tried to reveal the neural examples that emerged from the identification. The classification was performed through DNN and AutoEncoder (AE).

Table 1: Brain Signal-Based ASD Detection.

Brain Signal	Work Ref.	Sample Size	Age	Scenarios	Data Source	Number of Channels	Machine Learning Method
EEG	(Heunis et al., 2018)	62	0-18y	Resting State	Boston Hospital, Harvard Medical School, etc.	19	RQA, LDA, SVM, MLP
	(Grossi et al., 2017)	25	7-14y	Resting State	Vila Santa Maria, Italy	19	MS-ROM/I-FAST, ANN
	(Jamal et al., 2014)	24	6-13y	Fearful, happy, and neutral faces	Real Data	128	CWT, LDA, SVM
	(Raja and Priya, 2017)	10	6-12	Relax, Flashcards read and spell,	ASD schools of Coimbatore, India	10	AR-Burg, Pattern Net, LRN
MEG	(Takahashi et al., 2016)	115	3-9y	Watching videos without sound	Kanazawa Univ. Hospital and Prefectural Hospitals in Toyama	151	MSE
F-MRI	(Zou et al., 2017)	776	7-21y	Resting - State	ADHD-200 consortium	-	3D CNN
	(Sólon et al., 2018)	1035	10-35y	Resting - State	ABIDE	-	DNN, AE
f-NIR	(Zhang and Roeyers, 2019)	429	12m-18y	-	-	-	-

f-NIR

An optical spectroscopy system called functional near-infrared spectroscopy (f-NIRS) was created to monitor brain function continuously and non-invasively by measuring blood oxygen levels (Ferrari and Quaresima, 2012). This system is a type of useful neuroimaging technology that provides a non-intrusive, safe, convenient, and simple method for indirect and synchronized brain movement observation. It allows analysts to scan the bloodstream in the forward area of the brain by estimating changes in close infrared light. It is as yet another strategy, so it isn't yet broadly utilized in exploration, however, it shows promising outcomes in contemplates done to date. Zhang and Roeyers, (2019) proposed that f-NIRS is a promising instrument to investigate neurodevelopment in ASD from the beginning.

2.3.3 ASD Detection Methods Other Than Brain Signals

There are several other methods for ASD detection such as visual gaze and eye gaze which are briefly described below.

Visual Gaze

Visual gaze (MDN, 2019) is used to diagnose ASD by observing the visual look of kids. According to previous research, children with ASD filter people's faces differently than neurotypical children. The conventional methods for determining whether someone has ASD are not particularly child-friendly. The strategy takes into consideration the analysis to be made all the more effectively and with less chance of missteps.

Eye Gaze

Eye gaze (Liu et al., 2015) is also an important feature for ASD detection. A gathering of subjects (either ASD or non-ASD) appeared with a lot of adjusted human face pictures, with eye stare areas on each picture recorded successively. The recorded eye gaze areas on each face photo are then extracted as a picture-level element. To catch discriminative eye development designs identified with ASD, such a component extraction approach is required.

3. AUTISM DETECTION IN SOUTH ASIA AND BRAIN SIGNAL PROSPECTS

Though autism is a growing health and social problem globally, it highlights a significant challenge for developing countries, particularly in South Asian nations. The scenario of autism detection in countries with advanced medical facilities is analyzed in this section. ASD detection in South Asian countries is also described. Finally, some prospects for brain signal-based ASD detection are proposed.

3.1 Autism Detection in Countries with Advanced Medical Systems

Autism detection is a great concern worldwide since the number of children who are affected is rising day by day. According to the most recent large-scale surveys, the prevalence of ASD has risen over the past 20 years and is currently between 1% and 2% worldwide (Kim, YS, Leventhal BL, Koh YJ, and Al., 2011). Generally, autism is diagnosed through screening, observation of behavior, and developmental history. Actually, for diagnosis purposes, these methods are used all over the world. But recently brain signals are considered as a potential biomarker for autism detection for both research and diagnosis purposes.

In western countries for example in Australia (L. Bartaka, 2020) importance has been given to early intervention of autism but the diagnostic process is mainly a questionnaire-based screening method and multidisciplinary team. Some other methods related to a screening method for ASD diagnosis are reported by (Taylor et al., 2016). The techniques include wait lists, durations of assessment sessions, multidisciplinary assessments, and assessments conducted in many settings. For diagnostic practices, they used hearing tests, medical investigations, and assessment measures.

In the UK (Hayes et al., 2018), multidisciplinary assessment is identified as the 'ideal' assessment for diagnosing autism. The Diagnostic and Statistical Manual of Mental Disorders (DSM-5) and the International Classification of Mental and Behavioral Disorders (ICD-10), both in their fifth editions, are also used in the UK to diagnose ASD. According to another research in the UK(Act, 2020), autism is identified through clinical observation of behavior, and developmental history. All these methods are questionnaire-based.

In Italy (Muglia et al., 2018) autism is primarily diagnosed through DSM-IV criteria, but additional evaluations, included language assessment, the Krug Asperger's Disorder Index, and instrumental examination such as EEG and structural MRI. Recently, some studies have shown the effectiveness of brain signals (fMRI, EEG, MEG) (Aoe et al., 2019; Bosl et al., 2018; Sherkatghanad et al., 2020) with ML methods to detect ASD in several countries. Grossi et al. (2017) proposed an algorithm named MS-ROM/I-FAST for detecting ASD from EEG signals using ANN. Bosl et al. (2018) used EEG signals as a potential method for classifying ASD and control subjects through SVM.

3.2 Autism Detection in South Asian Countries

In South Asian countries, very little support is available in assessing ASD in rural or urban areas outside big metropolitan cities because of constrained assets, creating well-being frameworks, and little information on ASD. Only very few institutes like the Institute of Paediatric Neuro disorder and Autism (IPNA) in Bangabandhu Sheikh Mujib Medical University (BSMMU), National Institute of Mental Health (NIMH), Dhaka Children Hospital, Shuchona Foundation (SF, 2014), Hope autism center (HAC, n.d.) are available in the capital or few big metropolitan cities (Mannan, 2017) in Bangladesh. Moreover, most of the assessment is done by medical professionals in Bangladesh (Hossain, 2018). There are a few expensive private hospitals in Pakistan, including (Nadeem et al., 2019) Aga Khan University Hospital (Stadium Road Campus), Ziauddin Hospital in Clifton, and a few smaller private institutes that offer therapy. An autism program is offered at discounted prices by the Institute of Physical Medicine and Rehabilitation (IPM&R) at Dow University of Health Sciences (DUHS), Karachi. A Center for autism rehabilitation and training has also been opened by the Sind government in Karachi, though it is not yet fully operational. In India there are some ASD treatment centers such as Academy for Severe Handicaps and Autism (ASHA), Darpan Autism, Assam Autism Foundation, Care 4 Autism etc. situated mainly in urban areas(Pareek, n.d.). In the centers ASD is diagnosed through several training, music therapy, dance therapy, yoga etc. The number of institutes for ASD diagnosis is inadequate in other South Asian countries.

Among South-Asian countries, in India, EEG signal-based autism detection is established mainly for research purposes (Arunkumar et al., 2020; Sinha et al., 2019). There are few and expensive services accessible in Pakistan for people with autism and their families (Imran and Azeem, 2014; Nadeem et al., 2019). Only a few private schools in the nation are willing to be included, and the government schools in the nation are not equipped to handle autistic children (Khan, 2009). ASD diagnosis system is mainly screening and therapy-based (Farooq and Ahmed, 2020). In Sri Lanka, autism is poorly understood and there is little cooperation among them (Perera et al., 2016). People with ASD are stigmatized in Sri Lankan society due to a general lack of awareness and deep-seated stigma. There are not enough screening tools and therapy facilities for diagnosing ASD in Sri Lanka. In Nepal, ASD

detection is extremely difficult because of the low level of understanding about autism, detecting, diagnosing, and managing autism in children (Shrestha and Santangelo, 2014). There are some screening tools for diagnosing ASD in Nepal (Heys et al., 2018). In Bangladesh, although autism is diagnosed mainly through a questionnaire-based screening method, brain signal (especially EEG) based ASD detection has got much attention (IPNA, n.d.).

Table 2 summarizes several recent studies of ASD detection in South – Asian countries. From the table, it is observed that ASD is diagnosed through several methods like DSM-IV, MCHAT, ADOS, etc. EEG signal is also used as a diagnostic criterion in some studies. From the table, it is notable that Akhter et al.(2018) performed a rigorous study among 5286 children in the Sirajganj district of Bangladesh. Finally, 66 children were selected through primary screening in the study.

There is a general tendency to stigmatize individuals (Akhter et al., 2018) with neurodevelopmental diseases in developing countries. Having a child with ASD causes social stigma for the parents. This erroneous notion and stigma operate as a deterrent to scientific care of diseases. So necessary steps should be taken at an appropriate level for removing the stigma as well as proper diagnosis of ASD all over South Asia. There are multiple barriers to ASD diagnosis in several South Asian countries. Some of them are mentioned below. (Table 2)

Limited Diagnostic Facilities

Though there is a high prevalence of ASD in South Asian countries, limited diagnosis facility is available at the primary health care (PHC) level (Hossain et al., 2014). In Bangladesh, the number of children with autism who received a diagnosis in the urban hospital increased from 12 in 2001 to 105 in 2009 (Theoharides and Tsilioni, 2016).

Table 2: Overview of recent studies for ASD detection in South Asian countries.

Work Ref	Geographical Remit	Age Range	Sample size	Study Period	Range of Diagnosis	Diagnostic Criteria	Remarks
(Islam et al., 2018)	Bangladesh	73-84 months	50	6m	ASD, Rett Syndrome	Predesigned questionnaire	Despite the rising prevalence, Dhaka has few facilities for diagnosing ASD.
(Mullick et al., 2016)	Bangladesh	2-12 years	42	1y	ASD, Mental illness	ICD-10 (DCR) criteria, EEG, MRI	There are 35.7% abnormalities in MRI and 42.9% in EEG among studied children.
(Akhter et al., 2018)	Bangladesh	18-36 months	66	3m	ASD	MCHAT[1], DSM-IV, ADOS	Age-specific ASD is present in Rural communities.
(Farooq and Ahmed, 2020)	Pakistan	16-30 months	163	10m	ASD	Urdu Translated M-Chat, M-CHAT-R/F^{TM}, CARS 2[2], DSM-5	3% of the children coming to the hospital for any purpose were found to have ASD.
(Anwar et al., 2018)	Pakistan	50.6±10.3 years	339	3m	ASD	Pre-tested questionnaire	There is a lack of awareness and knowledge regarding autism among parents.
(Perera et al., 2016)	Sri Lanka	18-40 months	62	1y	ASD	DSM-IV TR[3] criteria, CARS	the improvement between preintervention and postintervention of ASD.
(Arunkumar et al., 2020)	India	-	10		ASD	EEG	EEG signals with spectral analysis may be used to diagnose ASD.
(Daley, 2004)	India	2-27y	35	-	PDD[4]	Symptom recognition	Environmental, cultural, and socioeconomic factors influence ASD

[1] Modified Checklist for Autism in Toddlers
[2] Childhood Autism Rating Scale 2nd edition
[3] Diagnostic and Statistical manual, 4th edition, Text Revision
[4] Pervasive Developmental Disorder

diagnosis.

In Sri Lanka, there are currently no population-based screening programs for autism, and autism screening is not a mandatory part of PHC(Dennis Mombauer, 2018). The facility is also poor in other countries.

Lack of Expert Professionals

Due to a shortage of qualified personnel, both district and upazilla health institutions frequently fail to provide the necessary services. There is a limited number of doctors and the trained people are not adequate. Primary health care physicians are not properly trained to handle (screening, diagnosis, and management) autism and are referred to the next level, when necessary, in several South Asian countries.

Social Stigma

Autism is still considered a curse and people have a negative attitude to autistic children and their mothers. Since autism has previously been recognized as a disease burden, it is widely believed that the prevalence is significant and that the majority of cases are undiagnosed. Autism is a disorder that has been discovered to be ignored, particularly in rural areas. The majority of the disease's treatment is provided at government facilities or locally, and the parents in the rural community are still largely unaware of the condition. Children haven't, however, received care from specialized centers where ASD treatment counseling is offered. One of the major issues is social stigma and barriers in rural Bangladesh(Rahman et al., 2016), Sri Lanka (Dennis Mombauer, 2021), Nepal (Shrestha and Santangelo, 2014), and other developing countries of South Asia.

Limited Number of Autistic Schools

In South Asian countries number of autism schools and therapy centers with all facilities is not adequate. Most autism schools are very expensive compared to other regular schools. So, a major percentage of autistic children are deprived of treatment, therapies, and special schools. Recently several autism schools are established by the government and NGOs in the Urban area.

Lack of Advanced Facility

Though EEG test for autism detection has been started in some hospitals and clinics but the signal collection process is lengthy. Their system is wired and the patient should be fixed in bed during the test. The total time taken for the test is also long.

3.3 Brain Signal Prospects for Automatic ASD Detection in South Asian Countries

Since the cause of ASD is neurodevelopmental disorders, early detection is thought to be most successful with a diagnosis based on brain activity. EEG is being increasingly examined as a promising medical tool for detecting abnormal mental health among the currently available brain imaging techniques since it is often easy to use and requires little effort.

3.3.1 Framework for ML-Based Automatic ASD Detection for Rural Areas

People with ASD in rural areas encounter significant challenges regarding the sufficient accessibility of diagnostic, treatment, and technical support. This study proposes a framework for automatic ASD detection in patients of rural areas. Automatic ASD detection means digital standardized tests that automatically diagnose ASD and provide a widely accessible time-efficient and cost-efficient diagnosis. Through an automatic ASD detection system, it is possible to diagnose patients in any area easily. Figure 3 shows the framework for ML-based automatic ASD detection. The steps are described below.

EEG Data Collection from Rural Areas

In the proposed framework raw EEG data is collected from children of rural areas who have the possibility of ASD. This is possible with only a limited number of low-cost EEG devices. The patient in the rural area (e.g., Upazilla) does not need to go to the doctor. If there is an EEG device in an area then the signals of the autistic children are collected. The data can be collected easily without the help of experts or doctors as there is a lack of doctors in rural areas of South Asian countries. After collecting the raw data, it is processed through several techniques such as ICA, FFT, DWT, etc.

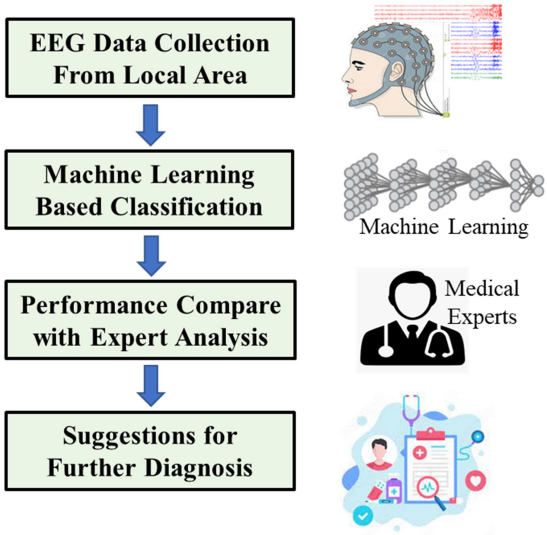

Figure 3: Framework of ML-Based Automatic ASD Detection for Rural Areas.

ML-Based Classification

After completion of data collection and preprocessing, the data is classified through several ML algorithms such as CNN, SVM, ANN. The output of this step is then saved on the computer. ASD and normal participants are classified into two groups through ML-based analysis. Several studies are available in the literature about ML-based ASD detection through brain signals. In 2020, Peya et al. (2020) uses Pearson's Correlation Coefficient (PCC) to translate individual EEG channel data into two-dimensional images. They were then divided into two groups using the Convolutional Neural Network (CNN) of Deep Learning, i.e., ASD and control participants. In 2022 (Peya et al., 2022), investigated two CNN models namely the deep CNN model and Residual Network (ResNet) for classifying EEG data of ASD patients. In 2021 (Grossi et al., 2021) observed that only two EEG channels namely C3 and C4 contain such a valuable piece of information that powerful ML systems may use to recognize ASD. They performed feature selection using the TWIST algorithm and classification using ANN.

Expert Analysis

After ML-based classification, the output along with the dataset is sent to specialist doctors in the hospitals of the Metropolitan area. So, the doctor in the metropolitan area received the EEG data without visiting the site for analyzing and verifying the result. The expert then suggests further diagnosis if necessary.

3.3.2 Prospects for Automatic ASD Detection

Some prospects have been suggested for brain signal-based ASD detection in South Asian countries. The prospects are described below:

Increasing awareness about ASD

As autism is a lifelong developmental condition that affects the interaction ability of a person with the outside world, awareness about autism is an important aspect. Most parents are unsure of the main indications and characteristics of autism. In some cases, children have general developmental delays but it is necessary to check the child's development of cognitive, language, and social skills concerning age. Parents need special training for increasing awareness about autism.

Use of brain signal-based methods for ASD detection

Brain signals are promising ways for ASD detection since its cause is neurodevelopmental disorders. EEG is a low-cost technology among other brain signal-based techniques, and preparation for collecting EEG signal environment is very easy. An EEG test is needed to record the EEG signals of the brain. On the website of IPNA, BSMMU of Bangladesh mentions that depending on the autistic child's situation, an EEG test may be suggested. In India (Sinha et al., 2019), some research has been done on EEG signal-based ASD detection. So, in Bangladesh as well as in other

South Asian countries, it is necessary to well establish the EEG signal-based ASD detection method in both rural and urban hospitals.

Availability of devices for recording brain signals

Technology has a great deal of promise to help with early diagnosis and enhance intervention strategies. If we want to start an EEG signal-based ASD detection system in our country, EEG devices are necessary to collect the signal. Though EEG signal−collecting devices are usually very expensive nowadays, some devices at comparatively low cost (Farnsworth, 2017) are available in the market. Simple EEG readings may give significant clinical biomarkers for early risk assessment due to the EEG test's dependability and affordability. EEG devices are of various categories such as devices with different channels, stationary or portable device, wired or wireless devices, etc. Wireless portable devices are more flexible than other devices. All hospitals in our country need this service for collecting brain signals from autistic children.

Training of health professionals for collecting brain signals

Training of health professionals is essential to ensure accurate results of brain signal collection. There should be specialized training about the concept of autism, brain signal-based ASD detection, and then the appropriate system of brain signal collection. In the training health professionals must have an opportunity to learn the system of brain signal collection practically. At the end of the training, there should be a system for issuing certificates to health professionals.

More research needs to be done in South Asia

For establishing new systems, it is necessary to do more research on that topic through real data. But unfortunately, in South Asian countries, there is a limited number of research papers based on ASD detection from brain signals. No research has been found on EEG signal-based ASD detection through clinical data from patients in South Asian countries. So, more research should be done to establish an efficient ASD detection system using brain signals.

4. CONCLUSIONS

ASD is not a disease but a neurodevelopment disorder. Early detection is helpful for children to improve their learning ability to minimize life-long problems. But the parents, as well as the government had a negative and stigmatized view of ASD and they think there is no cure for it and there is no need for investing in this sector. For this reason, the prevalence of ASD is approximate 1 in 60 children, which is alarming for us. It is necessary to increase awareness about the timely diagnosis of ASD among parents and health professionals involved in autism diagnosis. In South Asian countries, most of the methods of ASD diagnosis are questionnaire-based but children with ASD generally suffer from speech problems, intellectual disability, and other problems. Accurate diagnosis is not possible through these conventional methods. Recently brain signals are used as a potential biomarker for ASD detection with machine learning methods. So, the employment of modern ML techniques with brain signals (especially EEG signals) might be a novel approach for automatic ASD detection in South Asia.

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