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Review of Machine Learning Algorithms for Autism Spectrum Disorder Prediction

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Abstract **-** Autism is a disorder of the brain caused by language and severe social difficulties in people. It is the most common of the many pervasive developmental disorders (PDD), which begin in childhood and continue throughout life, affecting almost all aspects of life. Autistic people (cognitive and linguistic) and social skills are delayed compared to their classmates, but their motor skills are higher than usual. The nature of ASD varies from person to person and is a condition for the development of the brain or nervous system. In the first 12 months, most children with autism seem to develop normally. Symptoms of autism appear between eighteen and thirty-six months. Up to 3 years, 40% of cases were detected. The aim of the study was to detect ASD at an early stage to improve brain development and increase the awareness of parents and caregivers about ASD. Machine learning methods are now used to predict the spectrum of autism. This study provides a comprehensive assessment of documents that use machine learning to predict ASD, as well as data analysis and classification algorithms. This work aims to classify and study the different methods of Machine Learning, as well as to explain the nature of ASD and to evaluate performance and demonstrate research potential using different criteria. This publication serves as a roadmap for imminent researchers who want to work on the topic of ASD prediction using machine learning.

Keywords: Autism Spectrum Disorder, Machine Learning, Support Vector Machine, Random Forest, Artificial Neural Network

1. INTRODUCTION

Early diagnosis of autism spectrum disorder is challenging because people without ASD exhibit comparable behaviors to those with ASD, which is why cognitive tests are appropriate for diagnosing ASD. According to the World Health Organization, autism can cause social, communication, and behavioral difficulties. The AIIMS in New Delhi reports that, in India one in 100 children under the age of 10 has autism, and about one in eight has at least one neurological disorder.

There are many ways in which autism affects people. There are some people with autism who can live independently, others face significant challenges that require lifelong support and care. People with autism face stigma, discrimination and human rights abuses.

Based on research from the National Institute of Mental and Mental Health (NIMHANS), Autism rates are reported by the new CDC (Centers for Disease Control and Prevention). In 1993, six cases of ASD were diagnosed in 160 patients (3.8 percent). In 1997, six cases of ASD were diagnosed in 143 patients (4.2 percent). ASD was diagnosed in 2002 in 94 of 309 patients (30.4 percent). Since 2015, the number of people with autism in India has increased by 10-17 % per year. Autism rates are based on research from the National Institute of Mental Health and Neuro Sciences (NIMHANS) reported by the new CDC (Centers for Disease Control and Prevention). The occurrence of an autism spectrum disorder (ASD) has been identified, as shown in Figure 1.

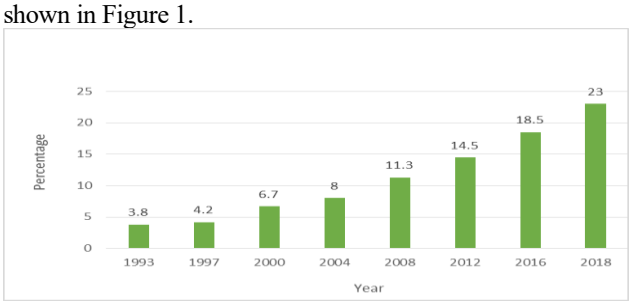

Figure 1. Identified Occurrence of Autism Spectrum Disorder

The Autism Spectrum Disorder (ASD) is a neurological disorder that is accompanied by a variety of symptoms. There are some issues with social media and communication such as

- Improper play with toys
- Unable to connect with others
- Inactive or inactive
- Wrong laughing and crying
- Sensitive to sound or poor
- Changes in habits are difficult to deal with
- Cannot express their emotions through gestures.
- Strange attachments to objects
- Poor speech or lack of speech
- Want to live alone
- Do not feel dangerous

Limited interests and repetitive activities are often a problem for people with ASD. The following list includes specific cases of different types of behavior [12].

- Repeat specific actions, such as repeating the same words or phrases over and over again
- The person gets upset when a habits change

- Interested in specific aspects of the topic, such as numbers and facts
- In some cases, such as light and sound, you may feel less sensitive than the other person

Children 12 to 36 months of age are screened for autism spectrum disorders. There are a variety of tools commonly used for autism screening, including:

- Modified Checklist for Autism in Toddlers
- Ages and Stages Questionnaire
- Screening Tool for Autism in Toddlers and Young Children
- The Childhood Autism Rating Scale

It affects the way people interact with each other, as well as their behavior and learning. When the child is very young, clinical signs appear. It is a chronic, incurable disease [1]. There have been different types of autism discussed until recently by scientists.

1. Asperger's syndrome
2. Symptoms of Rett
3. Childhood Disintegrative Depression (CHD)
4. Kanner's Syndrome
5. Pervasive Developmental Disorders - Not otherwise Specified (PDD-NOS)

1.1. Asperger's syndrome

Technically, Asperger's syndrome is no longer a stand-alone diagnosis. The DSM-5 investigative manual classified it as level one autism. However, Asperger's syndrome is more common in societies with autism and is more common than level one spectrum disorders.

Children with Level one spectrum have special intelligence and excellent speaking skills, but having trouble communicating in society. A child with moderate autism has the following symptoms [2].

- Lack of mental and behavioral flexibility
- Difficulty switching between activities(Often focus on one subject or passion or only want to pursue a limited range of activities)
- Problems related to the function to be performed
- It is not possible to change the volume to respond to normal voices, speech difficulties, or others.
- Difficulties in communicating with classmates or family members at school or at home.

1.2. Symptoms of Rett

Rett is a neurological developmental disorder seen in childhood. Although it is more common in girls, it can also be found in boys. Rett syndrome affects almost all aspects of a child's development. The good news is that with proper care, your baby can still live a happy and successful life. You can spend quality time with your family and help your children do what they love [2].

General symptoms of Rett syndrome:

- Loss of coordination and normal movement
- Difficulty communicating and speaking
- In some cases, breathing problems

1.3. Childhood Disintegrative Depression (CHD)

Childhood schizophrenia (CDD), also known as Heller's syndrome or schizophrenia, is a developmental problem characterized by the onset of a partial impairment of language, mobility, or subsequent social function. The development of children in these areas is normal until they are 3 years old when they collide. For ignorant parents, their children have autism, and cognitive loss can be devastating. The origin of CDD is unknown, as it is associated with neurodegenerative studies. Boys are more prone to rashes in childhood. Nine out of ten cases of the disease are boys, only one girl. By the time the situation begins, the baby will grow normally, regressing, taking into account more than two assessments of life. Children may lose the following abilities and skills: [2]

- Hygienic skills, if they have been performed before.
- Derived dictionary or language
- Flexible attitude and social skills
- Some engine capacity

1.4. Kanner's Syndrome

Canner was first identified in 1943 by Leo Canner, a psychiatrist at Johns Hopkins University, who classified him as autistic. According to doctors, this condition is also called classic autism. Canner syndrome, regardless of the nature of the disease, makes children beautiful, alert and intelligent, which includes: [2]

- An inability to form emotional connections with people
- Issues related to communication and interaction
- The uncontrolled use of language.
- Training issues

1.5. Pervasive Developmental Disorders -Not Otherwise Specified (PDD-NOS)

PDD-NOS, or metastatic disease, is an intermediate form of autism that is not otherwise expressed and reveals itself in a variety of ways. Social and language difficulties are the most common symptoms. The language development of your child, as well as the development of movements and other body functions, may be delayed. An observation of the child and identification of the child's suffering, such as interacting with other children, can reveal this type of autism. PDD-NOS, also known as "subthreshold autism", is a term used to describe someone who exhibits some, but not all, autism symptoms [2].

2. LITERATURE REVIEW

Clay et al. [3] to classify newborns NT and ASD, the researchers used cross-border machine-controlled learning systems and performed a series of statistical tests. False-positive ASD was detected with 96 % NT and reduced to 41% of newborns with a good accuracy of 77%. During the third trimester, the legs are measured, the white blood cells are counted, and the fetal heart rate is monitored at birth. As well, 38 percent of children at risk of ASD have a larger fetal circumference than infants of normal development, which indicates that the brain is larger in infants. There is uterine ASD.

Ming Zhao et al. [4] suggested a work of HC - SZ discrimination, the integration of multiple sites achieved a classification accuracy of 85.1 and 81.0 percent, respectively. In addition, 72.4% of the multi-site classifications between HC and ASD ACC were achieved using the publicly available ABIDE data set.

Karunakaran, P et al. [5] demonstrated early prediction using Mullen is added, and it is analyzed by utilizing a machine learning method with an adaptive functional classifier and a computational approach to fMRI analysis.

It is a superior strategy for dealing with the circumstance when the quantity of training data samples out numbers the quantity of characteristics for each data point.

Vivekanandam, B, et al. [6] the classification of Alzheimer's disease using a hybrid technique is more accurate than using other conventional methods. Furthermore, compared to other algorithms, CNN offers more minute details of subtle alterations in MRI scan images. The Mild Cognitive Impairments (MCI) region of the sagittal, coronal, and axial brain segments can be classified with high accuracy using the CNN algorithm.

Table 1 show summary of the advantages and disadvantages of data collection modules and algorithms used in the diagnosis of ASD.

Table 1: Methods for diagnosing autism spectrum disorder (ASD)

Ref. No.	Author/Year	Advantages	Disadvantages	Applicable tools / applications / algorithms	Data Collection / Accuracy
[7]	Zhong Zhao et al (2021)	ASD and Typical Development (TD) in children with normal development.	The number of functions obtained is limited. No integrated function found.	SVM, LDA, DT, RF	Accuracy - 92.11%
[8]	Victoria Yaneva et al (2020)	It tested a hypothesis that changes in visual function in adults with and without high function, such as eye observation measurements, could be used to automatically detect autism.	This is not acceptable for very young children and the number of participants is small.	VIPS	Accuracy -74%
[9]	Abdul Rahman Aslam et al (2020)	The classification process using the emotions used was 72.96 % of the time and 73.14 % of the time.	Classification accuracy 72.96% - DEAP data set 70.71% Classification accuracy - SEED data set	EEG, LSVM	DEAP-72.96% SEED -70.71%
[10]	Tania Akter , Md et al (2019)	For the toddler dataset, SVM showed the best performance, while Adaboost showed the best results for the children dataset, Glmboost for the adolescent dataset, and Adaboost for the adult dataset. A feature transformation method that includes sine functions will produce the best classification for toddlers using SVM.	These issues cannot be addressed fully due to the lack of ASD data available. Increase the amount of data to be analyzed to improve the detection of ASD.	FDA, LDA, MDA	Accuracy - 97.10%
[11]	Fadi Tabtah et al (2020)	It not only improves the sensitivity, accuracy and predictability of ASD testing processes, but also offers a new method called RML that improves sensitivity, accuracy and precision to predict the ASD screening process.	Except in the case of young children Using RML makes it difficult to improve predictive performance	RML, Bagging, Boosting and DT	Use of the Kaggle ASD database was estimated in 92.26% of children, 93.78% of adolescents and 93.78 % of adults.
[12]	Zeinab et al (2020)	Using the ABIDE I and CC400 data sets, the proposed atlas parcellation function of the future model brain was able to accurately predict ASD with 70.22 % accuracy.	Use only a few pictures in each class. Additional data is needed to create a robust model Gender and average age are not taken into account. Difficulties in improving performance with unbalanced data	SVM, KNN and RF classifiers	ABIDEI-70.22%
[13]	Chalin Grossard et al (2020)	A special method of analyzing the dynamics of facial expressions (FD) in children with autism can be developed using computerized visual acuity and human narration (ASD).	It is difficult to describe FE production disorders in children with autism spectrum disorders.	RF classifier	-
[14]	Maria Laya et al(2020)	In order to develop a classification model for ASD, a machine-learning methodology was used to analyze retinal images using ARIA.	The sample size is small No other clinical information Family history and information are difficult to access	ARIA method	Accuracy - 95.7%

Ref. No	Author/Year	Advantages	Disadvantages	Applicable tools / applications / algorithms	Data Collection / Accuracy
[15]	Rim Haweel et al(2019)	This paper proposes an approach to assessing the severity of autism spectrum disorder using machine learning.	More experiments and different brain methods are needed Do not offer an individual diagnosis and timely treatment plan	RF, SVM, MLP	NDAR Accuracy -78%
[16]	Kaushik Vakadkar et al(2021)	We developed automated ASD prediction models using a minimal set of behaviors in each diagnostic data set. Of the five models we used for the data set, maximum accuracy was observed using logistic regression.	Identify open source and large ASD data sets. Accurate modeling based on large data sets. There are not enough cases in the data set.	SVM, RFC, NB, LR, KNN	Kaggle Accuracy -92.15%
[18]	Zhong Zhao et al(2021)	By combining visual information and session duration, the SVM classifier achieves a maximum estimate accuracy of 92.31 %. The accuracy of the classification of the combined marks is higher only than the visual capabilities (maximum rating accuracy 84.62 percent) or the time of the study (maximum rating accuracy 84.62 percent).	Used only small sample	SVM, LDA, DT, RF	Figshare Accuracy - 90%
[17]	Ping-I Lin et al(2021)	Classification accuracy can be improved up to 90% by using RF algorithm and SVM algorithms.	Due to the lack of other individual templates to test, it may be difficult to find additional features from the limited templates within the SVM.	RF, SVM	Figshare Accuracy - 90%
[19]	Munirul et al (2021)	Assuring that parents and guardians provide their children with a comprehensive method of informing them about important events.	Three controllable machine research models with KNN and ANN logistic regression reach only 85% accuracy.	DT, LR, KNN, ANN	UCI storage -95% accuracy
[20]	Chaitra et al (2020)	With a combined feature set of 70.1 percent accuracy, a diagnosis may be made.	Larger datasets were not used. Psychiatric and neurologic disorders features were not examined	Recursive-Cluster-Elimination SVM.	ABIDE Accuracy - 67.3%

3. METHODS

This literature review was done to examine how machine learning methods are used in autism spectrum disorder prediction. Some of the most commonly used algorithms were DT, NB, LR, SVM, RF, K-NN, RFC. Among this by combining features, the SVM classifier was capable of achieving an accuracy of 92.31% [18].

Figure 2 shows the basic block diagram of ASD Prediction. The workflow for Autism Spectrum Disorder (ASD) consists of 2 basic steps which involves Data Preprocessing, ASD classification. Preprocessing is the process of preparing raw data for further processing by performing any type of processing on it. The data includes both individuals with and without ASD. Features are typically collected from an ASD and TD person. After selecting the features, the resulting features are sent to the classification section. The

Classification section classifies ASD using various techniques. Machine learning has more predictive models, the proposed method will use the best predictive model.

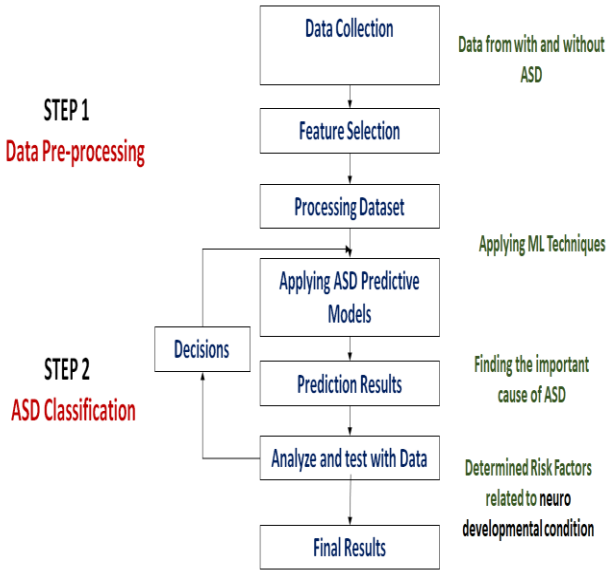

Figure 2. Basic block diagram of Autism Spectrum Disorder Prediction

3.1 DATASET

To Diagnose ASD, several datasets are available. Generally, Autism dataset is collected from ABIDE-I, ABIDE-II, UCI Machine Learning Repository, NDAR, Kaggle, Deep, Seed, figshare data repository.

In UCI Repository, there are three types of datasets: Autism Screening Adult, Autistic Spectrum Disorder Screening Data for Children, and Autistic Spectrum Disorder Screening Data for Adolescent.

4. DISCUSSION

The goal of this review paper is to combine works that have examined ASD utilising machine learning concepts. According to the study, some ML and DL algorithms used for autism include ANN, SVM, and deep neural network, Decision tree, linear regression, random forest, Naïve Bayes and more included. Some algorithms are combined with feature extraction or feature selection methods to improve results. The next phase is in implementing machine learning for the diagnosis of ASD is to reduce processing time and increase diagnostic accuracy while increasing complexity.

The performance of the sample was calculated using evaluation values. Table 2 shows the image classification evaluation metrics.

Table 2 Evaluation criteria for classification

Accuracy(ACC)	$ACC = \frac{TP + TN}{TP + TN + FP + FN}$
Precision(PRC)	$PRC = \frac{TP}{TP + FP}$
Sensitivity(SNS)	$SNS = \frac{TP}{TP + FN}$
Specificity(SPC)	$SPC = \frac{TN}{TN + FP}$
Geometric mean(GM)	$GM = \sqrt{SNS * SPC}$
Bottom zone (ROC) curve	$AUC = \int_0^t SNS * dSPC$

5. CONCLUSION

Autism can be detected at an initial stage, which increases the chances of recovery and lifelong care and support. In this study, we considered several machine learning methods for the autism. As a result, model machine learning and in-depth training methods, as well as fMRI and EEG signals for the detection of ASD can be provided. The in-depth study model includes several types of neural networks that simultaneously improve classification accuracy. However, the Deep Learning approach has the disadvantage that it requires a larger set of data for training to produce successful models. In conclusion, this document discusses several methods for diagnosing ASD, as well as practical measures for each model / algorithm.

ABBREVIATIONS

SVM-Support Vector Machine
LDA-Linear Discriminant Analysis
DT-Decision Tree
RF-Random Forest
VIPS-Vision Based Page Segmentation
EEG-Electroencephalogram
LSVM-Lagrangian Support Vector Machine
FDA- Flexible Discriminant Analysis
MDA- Multiple Discriminant Analysis
RML-Rules-based Machine Learning
KNN-K-nearest neighbour
ARIA-Automatic Retinal Image Analysis
NB-Naïve Bayes
ANN-Artificial Neural Network
RFC- Random Forest Classifier
LR-Linear Regression
CNN-Convolutional Neural Network
TP-True Positive
TN-True Negative
FP-False Positive
FN-False Negative
AUC-Area under Curve
UCI-University of California Irvine Machine Learning Repository
ABIDE I and II-Autism Brain Imaging Data Exchange I and II
NDAR-National Database for Autism Research

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