Detection and Prediction of Autism Spectrum Disorder Using AI Techniques: A Review

Sara Yasmin[1], Sana Jamshed[1], Iqra Hussain[1], Dania Tahreem[1], Hamid Ghous[2]

[1]Machine Vision and Linguistic Research Lab, Multan, Pakistan

[2]Department of Computer Science, Australian Scientific and Engineering Solutions, Sydney, NSW Australia

Abstract: Typical designations for autism include a developmental disability that lasts a lifetime. The traits associated with autism spectrum disorder (ASD) are repetitive behavior, nonverbal communication, and difficulty focusing. ASD needs to be diagnosed early because it has been growing more quickly in recent years. It costs a lot of money and time to figure out autism utilizing several testing methods. Predictive analytics, another name for various AI models, has gained prominence recently. In medical science, machine learning, deep learning, and pattern recognition are the main examples of multidisciplinary research areas that offer efficient methods for diagnosing ASD. This paper aims to analyze various algorithms for deep learning (DL) and machine learning (ML) and compare the outcomes focusing on precision and effectiveness.

Keywords: Machine Learning, Deep Learning, Autism Deduction, Childhood.

Email: sarayasmin114@outlook.com

1. Introduction

Genetic components are a strong reason for people suffering from autism. Parents with one child having autism have a great chance to have other children suffering from the same disorder. The research shows that the chances are 3 to 7 percent and the risk is very high if the affected child is female (more than 7 percent) than male (3 percent) [1].

Autism is found all over the world. Roughly, 1 percent of the world's population is affected by it and most people don’t have the awareness that they are suffering from mental illness. The Centers for disease Control and Prevention (CDC) estimates that 1 in 44 US children will suffer from ASD in 2025. Autism may be rooted in other mental disorders like Anxiety, Obsessive-compulsive disorder, depression, panic disorder, eating disorder, etc. People don’t even know that they are facing these conditions because they have ASD. They may get treatment for their disorder, but it will be a temporary relief because the root cause is still there.[2]

People with ASD have communication and interaction difficulties. Some don’t speak at all while

others speak fluently with repetition and in a monotone voice. They are indifferent and remote, and they struggle to connect with people and form emotional bonds.

Among the typical signs of autism in adults are:

- Having difficulty understanding what other people are feeling or thinking.
- Having trouble reading gestures, facial expressions, or social signals.
- Inability to control emotions.
- Difficulty maintaining a discussion Unreflective tone of voice.
- Difficulty sustaining a conversation's natural reciprocation, prone to monologues on a favorite topic, and the tendency to participate in regular or repetitive actions.
- Only engages in a small number of Tasks.
- Strict adherence to exact schedules fits aggression when things alter manifesting passionate, specialized interest [3].

During the conversation, autistic people prefer to look at the walls and roofs, or their shoes, anywhere but directly into the eyes of the person they are talking to. They act like robots. They talk to their colleagues in a similar way they talk to their family. During meetings, they are involved in involuntary actions like repeatedly cleaning the throat. Autistic individuals have extraordinary talents in math, music, art, and visual skills. 40% of autistic individuals have above-average intelligence.

Marital relationships with autistic people are also somehow complicated and need a lot of patience. Partners of autistic persons may find that there is a lack of communication, misinterpretation, or feeling that their partner is indifferent. An autistic partner needs time to pursue their hobbies and routines. Instead of focusing on a shared objective, they would rather spend their free time by themselves, playing solitary games or individual sports like golf Zauderer et al [4].

More insight into the composition and operation of the brain is now possible because of recent neuroscience and brain imaging. To diagnose and identify Adult ASD and its symptoms, artificial intelligence, machine learning, and deep learning models are used. Various machine learning techniques, such as SVM, Decision trees, Linear Regression, Logistic Regression, and Random Forest, provide superior outcomes and accuracy.

2. Literature Review

We researched to detect and predict ASD using machine learning models. A study carried out by [5] concludes that ASD is a chronic illness that affects people differently and can range in extent from mild to severe. Multiple approaches to machine learning are employed to identify autism

spectrum conditions. These techniques give different results on pre-processed data.

The results show that Random Forest gives the best accuracy, precision, and prediction. The proposed model and technique give 81.49% results on the classification of autism spectrum disorder. [6] Claimed that a lot of diseases, including ASD, have been noticed around the world but cannot be evaluated clinically. With machine learning-based models, it is somehow easy to diagnose and predict A S D traits in toddlers, children, Adolescents, and adults. They worked on four age groups to predict ASD using machine learning techniques Decision trees, linear regression, and random forest techniques perform best in all age groups and give 100% accuracy on pre-processed datasets.

[7] Concluded that the prevalence of ASD has been rapidly increasing among all ages in recent years. Machine learning techniques are widely used in treating and diagnosing various ailments including ASD. The main purpose is to determine ASD in early stages in adults. The adult dataset that was employed with 21 attributes like age, gender, ethnicity, genetics, etc, and pre-processing techniques were applied. ML techniques are used to check specificity, accuracy, sensitivity, and F1 score. Random forest shows the accuracy of 99%, 99%, 99%, and 98% respectively. [8] researched that Children's learning and social development are impacted by autism. The approach is based on a dynamic process combining activity design, technology benchmarking, and concept generation into constantly improving actions. The research literature on difficult behaviors in children and youth with developmental disabilities and autism spectrum disorders isomerized the study.

A study carried out by [9] predicted that there is some evidence that individuals dealing with autism spectrum disorder (ASD) are more willing to commit suicide; the studies that have been conducted have produced contradicting results. The purpose of the research is to examine the incidence, risk factors, and comorbid aspects of suicidality in individuals with ASD. Using PRISMA guidelines. There were 12 papers in the final review, totaling 2,651 samples. Suicidal ideation was reported in as many as 72% of cases, while the prevalence of suicide attempts ranged from 7% to 47%. The factors of gender and a history of depression and self-harm were mentioned. [10] Researched to detect early ASD. It is very difficult to find high-functioning autism in adults. Logistic regression is applied to datasets from web pages with two tasks the search task and the browse task. The result shows 81% and 80.5% accuracy in both tasks respectively and made it a promising tool for detecting ASD. [11] Concluded that anxiety disorders are common in adults with ASD. This could have an impact on their social interactions, communication, and behavior. Phobias and OCD are more common in ASD sufferers than in non-autistic individuals. Whether or not they have autism, their siblings and half-siblings exhibit anxiety disorder symptoms as well. The result depicted that 20.18% of adults with

ASD suffer from anxiety disorders of multiple types compared to non-autistic people which is 8.7%. Anxiety disorders are more common in full siblings and half-siblings of autistic patients which somehow show the genetic impact.

According to [11]. The degree of risk, treatment response, and severity of ASD vary widely. Autism Spectrum Disorder (ASD) begins in early childhood and extends into adulthood. There were thirty articles in all that used approaches, 2000 videos were used as a dataset, and classification and evaluation techniques were applied. The results show maximum accuracy. It is critical to develop a prediction model that can be applied to patients having ASD throughout all age groups. [12] Used the 3Di- Adult model which was based on interviews and is used to assess autism spectrum conditions in adults. 3 diverse groups are selected which consist of normal health people and non-autistic groups. The second one shows ASD and the 3rd group doesn't have symptoms of ASD. These 3 groups are evaluated based on interview questions with different time administrations. The 3Di-Adult model shows excellent sensitivity which is95% and specificity of 92%. This model can be used to assess patients with ASD in research and clinical practice.

Research by [13] has shown that handwritten tasks are very helpful in diagnosing the early symptoms of ASD. So, by using the Google Net transforming algorithm, a total of 104 people were tested according to tasks like writing and drawing. With a high accuracy of 90.48%, the suggested method accurately predicts ASD. Additional variables include F1 score accuracy, which is 100%, 100%, and 80%, respectively. There is a lot of promise in using handwritten tasks to diagnose ASD early. The study by [14] Showed Social identities affect social interactions and how we feel about ourselves. An online survey with free response text spaces about disclosure was conducted and people showed mixed responses. This indicates the social pressure to accept mental diseases and to get help. This behavior will lead to severe mental illnesses which are difficult to cure. The ML approaches Random Forest, a machine learning classification model technique including three categories. This worked excellently in diagnosing autism in adults, adolescents, and children. The methodology used here is mix-test-data. As the amount of data increases, the model remains stable. The model's accuracy is 96 percent. [15] Conducted research on autism during COVID-19 instructions to teach patients to wash hands, wear masks, and take precautions while going out. The system is designed for parents of autistic children to train them how to continue daily life during corvid-days. The achieved accuracy is 78.5%.

[16] Labored with data comprising, at the age of ten, the Autism Diagnostic Interview-Revised (ADI-R) and Social Responsiveness Scale (SRS) scores of 1,264 verbal people with ASD and 462

verbal people with developmental or psychiatric disorders who were not ASD. Should prioritize the most precise clinical diagnosis of ASD over non-ASD. Support vector machines, a powerful machine learning classifier, are used to develop algorithms. The cross-validation process involved several levels of parameter tuning. The created algorithms outperformed the existing ones in terms of efficiency findings from the ML-based combination of SRS and ADI-R revealed and provided a screening algorithm that, using only five behavioral codes, achieved 89.2% accuracy (86.7%) sensitivity and 59.0% (53.4%) specificity.

[17], [18] found that Adults having ASD are increasing with every passing day. Apart from ASD, adults suffer anxiety disorders that increase with ASD. To find cost-effective and evidence-based models for diagnosing this condition in adults, more research is needed. By using a basic ML random forest classifier 98% accuracy is achieved. The focus of the research is the knowledge of the aging process in older adults with ASD and a better transition in healthcare from young adults to older adults.

[19] Concluded that Children with ASD frequently experience anxiety, but not much is understood regarding the predominance of anxiety disorders in adults. The diagnosis of anxiousness disorders in ASD adults with or without intellectual disability is complicated. Research carried out more analyses of the siblings. Compared to 8.7% of controls, 20.1% of the adults with ASD were diagnosed with anxiety-related disorders. Autistic individuals without intellectual disability are most at risk. Nearly every individual suffering from anxiety disorders was more common, most notably phobias and obsessive-compulsive disorders (OCD). **Error! Reference source not found.** Reviewed various strategies for identifying autism and provided a visual representation of each model's accuracy. Kids with ASD diagnoses differ from typically developing (TD) little ones in that they have distinct facial landmarks. The creation of a system based on social media and face recognition for the identification of autism spectrum disorders is an innovative component of the research. High classification accuracy was attained for both the Browse (80.50 percent) and Search (81 percent) tasks, indicating that our approach has high potential in automatic ASD detection.

Table: Results of the ML techniques used for the Prediction and detection of ASD

[5]	Kaggle	Data visualization, data scaling, label encoding	KNN SGD Confusion matrices, Random Forest Decision tree	KNN84% SGD80% CM88% Random forest 88%Decision Tree 81.5%
[6]	Kaggle and UCI machine library	Data normalization data encoding,	Decision Tree Naive Bayes KNN Support Vector Machine Logistic Regression	SVM{Children100%} LR {Toddlers 100%, Adolescents100%, Children 100%, Adults100%}
[7]	A small cohort of children	Classification, Missing values were replaced with imputation	Random forest classifier, Extra tree classifier	Using RF, the two classifiers giveanaccuracyof82%ona small dataset
[8]	Kaggle and UCI machine library	Data normalization data encoding,	Decision Tree Naive Bayes KNN Support Vector Machine Logistic Regression	SVM{Children100%} LR {Toddlers 100%, Adolescents100%, Children 100%, Adults100%}
[9]	The author created a datasetof20kidswith ASD and 20 kids who are normally developed	Feature Extraction using the FFmpeg library of Python, Dividing the data set into groups	Pre-trained CNN model RASNET-50InceptionV3 LSTM (long short-term memory) LSTM(2layer)	**TEST** {Rasnet50+LSTM 0.52, Inception V3 + LSTM 0.70, InceptionV3+2LSTM 0.78
[10]	High-functioning ASD adults from webpages.	Classification algorithms	Eye tracking with gaze features like AOI ID, MEDICAID Transfer learning algorithm with MATLAB	With the LR classifier ASD participants show 83.3% in the **browse task** By using the LR classifier ASD participants show82.3 % in **Search task**
[11]	**Stockholm** youth cohort and medical insurance database from **California**	the dataset is sorted with patients' history and less than 5% are missing or ambiguous values	comparison techniques are applied to detect anxiety disorders in siblings with distinct genetic histories, half-siblings, full-siblings, etc.	people having ASD show 20% more symptoms to develop anxiety disorders of different types as compared to ton on-autistic people is 8%
[12]	2000 videos dataset	Classification and Evaluation	the two-phase method with an image model	82% accuracy in ASD diagnosis
[13]	Pictures, videos facial images of people affected with ASD. Most of the data is collected online and From Health websites	Classification techniques, handling missing values, mean, median, and mode. All the data is then saved. CSV format	ML and DL techniques along with CNN	Most of the ML techniques like the random forest, decision tree, andSVMgive80%and more accuracy
[14]	Patients registered for UK psychiatric services Mental Health National Health Service.	Observations and information collected from patients having ASD can help to formulate questions for interviews.	This interview is known asthe3Di-Adult, or the Developmental, Dimensional, and Diagnostic Interview-Adult version.	Sensitivity95% Specificity92%
[15]	The data set is collected through a tablet computer INTUOS WACOM PROFESSIONAL, Efficient in capturing both right-handed and left-handed written tasks.	Captured images are then cropped, and extra spaces are removed. The output images are again rescaled by 224 by 224. The aspect is maintained by Google	CNN Transfer learning Google Net Cross-validation	CNN models squeeze Net Google Net accuracy of 90%, sensitivity of 80%, and specificityof1%.
[16]	An online survey	Quantitative and qualitative responses in the form of checkboxes to validate the participants	online survey Questionnaire on Autism, self-esteem-based questionnaire	willing well as not to show that they are suffering due to factors, challenges in treatment, etc.
[17]	Kaggle	Image processing techniques like image scaling, and removing colors, and unnecessary data.	Inception-RasnetV2	The achieved accuracy of 78.56%
[18]	Dataset from Kaggle	Image processing techniques like image scaling, and removing color sand unnecessary data.	Random forest	Accuracy98%
[19]	Facial pictures of people both autistic and non-autistic.	cleaning noisy data colors pace changes to grey color space	SVM Decision tree k-nearest neighbors	SVM0.19 DT0.9 KNN0.11
[20]	Real social metadata	Data cleaning and classification	Deep learning techniques And Machine learning algorithms	Accuracyincreasedby8% and test accuracy is 94%
[21]	Dataset from health cancerous	Classification	CNN, Random forest	Prediction accuracy=78.5%
[22]	dataset from the Shanghai Public Health Center	Data analysis and processed	RF, K-fold cross-validation	Kfold92% RF93%
[23]	Emirate of Abu Dhabi Mental Health and Fitness Center	Classification and screening of Data	Questionnaire technique to diagnose ASD	sensitivity (0.77) specificity (0.29)
[24]	High-functioning ASD adults from webpages.	Labeling, classification	Eye tracking with gaze features like AOI ID, MEDIA ID Transfer learning algorithm with MATLAB	With the LR classifier, ASD participantsshow83.3%in **browse tasks** By using the LR classifier ASD participants show 82.3 %in **Search task**

2.1 Using Deep Learning Algorithms

To improve risk detection, deep learning (DL) has become a popular method of analyzing huge data sets. When it comes to identifying factors that may raise the chances of depression, such as certain personality features Clinical files and social media information can be combed through by DL, which can sort through large data sets. Low self-esteem being unduly dependent, self-critical or pessimistic,

having experienced some trauma or stress, or having relatives with a history of mental illnesses are a few examples of these.

The three primary layers of the convolution, pooling, and fully connected layers make up a CNN model. Further into the network, the convolution and pooling layers help generate new feature maps in each subsequent layer, which makes it possible to obtain more complex features from the data that was entered. The output is generated by the fully connected layers of the classification. Auto encoders consist of two primary parts: the encoder, which is responsible for reducing the size of features and presenting the input data in an encoded representation. The other part is the decoder, which reconstructs the data from the encoded version to closely resemble the original data. The input, forget, and output gates of the LSTM are primarily responsible for controlling the stored information.

Over fitting, which is a CNN issue based on comparatively little data, reduces the algorithm's accuracy and performance. The machine learning method for resolving the problem of little data used in CNN is transfer learning. It operates by enabling the reuse of an already trained model from a big data set in a different by applying the acquired parameters to a fresh network task. Through transfer learning, the amount of computation needed to train the new model is significantly reduced. The last few layers of the newly trained networks are replaced, and the new networks are trained using the weights of the formerly trained network. Because it has analyzed and processed a sizable amount of data on its own, the previously trained network is now able to offer novel network feature extraction capabilities.

To detect and identify ASD, pictures of the patient's facial expressions, emotions, and eye movements are used. If the model work is task-based the pictures of handwritten tasks are used to observe patterns in processing abilities, thinking patterns, etc. The information is extracted by using image processing techniques like image enhancement, compression, encoding, restoration, etc.

2.2 Literature Review

[21] Studied four openly accessible, distinct, non-clinically Inspection datasets to identify ASD using a variety of DL models. Four age groups are associated with these datasets toddlers, kids, teens, and adults. The models developed for ASD identification were evaluated using several performance assessment criteria. After making changes Models outperform all employed classifiers and tracking values in the comparison of the toddler's autism spectrum, according to comparison results with other recent studies on this topic. [22] Worked on three parameters which are accuracy, precision, and

recall these three performance measurement metrics are used to validate the suggested models. The study examined and compared the prediction of autism spectrum disorders using typical parameters like input data, simulation method, application type, and comparison methodology. Giving researchers who are working on the prediction of autism spectrum disorders a centralized framework. An accuracy of 89.23% was achieved [23] investigated the AQ questionnaire's potential to predict the presence of ASD in a sizable sample of adults who may have ASD and are referred to a diagnostic clinic. The main focus was to ascertain whether the AQ would function as a useful tool for "gating" clinical recommendations, per the UK NICE guidelines. It was not evident that the AQ could predict who would be clinically diagnosed with ASD. The short AQ10 questionnaire had a high sensitivity (0.77) but a low specificity (0.29), making it less accurate than chance in predicting the diagnosis of ASD patient's score fell below the cut-off points of 6, approximately two-thirds of them were considered "false negatives," meaning they were later diagnosed with ASD**.** This predicted that the diagnosis of adult high-functioning autism is considerably harder than that of early stages (ASD) with severe symptoms. Modern methods for early evaluation are suggested by the research, such as the Internet of Things (IoT), ML, eye-tracking devices, and other assessment tools. Identifying adults with well-functioning ASD through transfer learning. Transfer learning, logistic regression, and decision trees were used to analyze a dataset of adults with highly functional ASD and those in charge who appeared online for details. High classification accuracy was attained indicating that our approach has high potential in automatic ASD detection. Regarding the early diagnosis of ASD also suggested the framework of two recently adopted methods, namely DL and XAI. The accurate diagnosis of ASD in toddlers and the features that are most helpful in predicting this diagnosis are the main topics of the research. The toddler screening test data set has been used to apply the 4-layer deep learning model to predict ASD. Three case studies and two datasets have been used to evaluate this model. It has been noted that the maximum accuracy for Case Study II is 98%. With an F1-score of 98 percent, a recall metric of 97 percent, and a precision parameter of 99 percent. The SHAP architecture is used in conjunction with the XAI to prioritize the key characteristics on which the medical specialists helped make accurate predictions.

[24] Introduced a multisite resting-state fMRI deep learning approach for ASD prediction. The research suggested that ASD detection is a difficult task because there is currently a wide range of current practices and no standard modeling choice has been recognized. The CPAC pipeline provided the pre-processed fMRI data used in the work. Using brain atlases means BOLD signals are extracted from pre-processed data. Consequently, ROIs were extracted using four distinct standard

and predefined atlases. Tangent embedding was used to prepare the connectivity matrices, which were flattened to create a feature vector that eliminated redundant data. The suggested model received this feature vector as input. The impact of altering the model's hidden layer configuration on detection was also noted. The 122 ROI BASC atlases are thought to be more accurate in diagnosing ASD than the AAL, CC200, or Power atlases due to their higher predictive power, as demonstrated by multiple tests. It obtained a 96% 87 percent F1-score, 90 percent sensitivity, as well as the area under the receiver operating characteristic curve, with an accuracy of 88%. A study evaluated the effectiveness of NASNET Mobile, Xception, and VGG19 deep learning models in identifying ASD using facial features. A publicly accessible dataset from the Internet was used to train each The Xception model generated the best classification accuracy result (91 percent). The results of the classification model indicated that these deep learning and computer vision-based models can be used as automatic tools to help families and specialists diagnose autism more quickly and accurately.

[25] Research work is based on early ASD detection. The study employed PCA to lower the number of characteristics and then trained the data using ten-fold cross-validation. DL is employed to detect ASD in all categories of people with age groups corresponding to infants, kids, teenagers, and adults. The attributes are condensed in the data set based on their minimally beneficial contribution. Using DNN, the various evaluation parameters including accuracy, sensitivity, specificity, and F-measure produced clinically acceptable results.

The approach adopted by [26] suggested that several deep learning applications should be employed in addition to the available clinical tests, which has improved the accuracy of this disorder's diagnosis. It has been demonstrated that the Deep Neural Network (DNN) architecture increases classification accuracy. The goal of the study is to check the DNN model's efficacy in terms of classification accuracy for ASD diagnosis. On the first dataset, the DNN model's precision in categorizing diagnoses for ASD was 99.40%, and on the second dataset, it was 96.08%. Using the first and second sets of data, the SVM model obtained an accuracy of 95.24% and 95.08%, respectively. The findings demonstrate that employing ASD adult screening data in combination with the DNN approach to classification enables a precise determination of ASD cases. [27] suggested a DL system, a deep feature map is extracted and classified by fully connected layers using the CNN models GoogleNet and ResNet-18, which were employed based on the transfer-learning technique. Promising outcomes were obtained by both models. Based on two blocks in the hybrid approach, a CNN and SVM hybrid was used called GoogleNet + SVM and ResNet-18 +

SVM. The first block extracted deep feature maps using CNN models (GoogleNet and ResNet-18). In contrast, these can block classified data using an SVM classifier. In the second block, an SVM classifier was used for classification and better extraction of deep feature maps techniques (ResNet-18 and Google Net). The research outcomes depicted that the hybrid model produced better results. The third method referred to as Google Net + SVM and ResNet-18 + SVM, combined ML (SVM) and deep learning (Google Net and ResNet-18) in a hybrid fashion. The approach relies on two fundamental elements. The first block extracted deep feature maps using CNN, while the second block classified the features extracted from the first block using SVM. This technique's high diagnostic ability is demonstrated by its accuracy of 94.5% for Res Net-18+ SV Mand and 95.5% for Google Net + SVM. Research on ASD, a developmental disability may result in serious problems with behavior, social interaction, and communication. Early intervention can help children with ASD become more intellectually capable and reduce their symptoms of autism. There may be facial phenotypic differences between typically developing (TD) and ASD children, according to several clinical studies. In this research, VGG16 applies deep learning based on studying an exclusive ASD dataset of kids who have been clinically diagnosed, and a workable face-based ASD screening solution. The model yielded an F1-score of 0.95 and a classification accuracy of 95%. [28] Investigated the identification of people with complex psychiatric disorders like ASD using models made up of deep neural networks. The model is based on CNN and RNN with different architectures, mainly using them as tools for analysis and diagnosis. Every individual's performance is checked using a different MRI dataset for every classification task when applying the model. The difference in structure rather than employing conventional techniques that extract morphological features using conventional algorithms, a difference between the autism and control groups was found by directly applying neural networks to the original MRI voxel data. The research by [30] offered a technique by directly measuring changes in first-order statistical properties from the fNIRS time series, one can estimate the global time-varying behavior of brain activity. A DL model combining long-short term memory (LSTM) and convolutional neural network (CNN) was then constructed to investigate possible temporal variation patterns based on the integration strategy with an enhanced bagging algorithm for the identification of ASD. Analysis of the global time-varying behavior of hemodynamic fluctuations in ox hemoglobin (HbO2) and deoxy hemoglobin (Hb) revealed that children with ASD showed weaker internal logic, but they also showed stronger memory and resilience to random shocks. The stationary theory served as the foundation for this analysis. With a sensitivity of 97.1% and specificity of 94.3%, the recommended DL technique provides a highly

accurate classification of children with ASD from normal children. Normal children's highly precise categorization with sensitivity of 97.1%and specificity of 94.3%. In research conducted by [29], a novel approach Deep ASD Pred ASD risk gene identification. RNA nucleotide sequences and gene expression levels are the only benchmark datasets used by Deep ASD Pred, which has no prior biological knowledge. CNN and LSTM form its foundation. LR and the chi-square test to determine the ideal feature subset following the encoding of the data features can reduce redundant data and speed up training. Furthermore, the contrast Deep ASD Pred with three single classifiers and cutting-edge techniques is used. The comparison results demonstrate that Deep ASD Pred performed the best and validated its effective performance in identifying the ASD risk gene. In the study, limited source sample data is a challenge for the gene expression values utilized in the characterization data. With the conclusion that an individual's capacity for interaction and communication may be impacted by ASD, a neurobehavioral disorder. There isn't a single solution that works for everyone. Pre-trained CNN models are used to detect autism by using video data. Feature extraction with Python libraries is used on pre-processed data, which is separated into datasets for testing and training. CNN models like Rasnet-50 and InceptionV3 are used with LSTM and 2-layer LSTM. The result shows that InceptionV3 + 2layer LSTM gives the best accuracy which is 91%. Based on video communication, models can be developed in the future to forecast autism. The aim of the study conducted by [31] is to develop a system that by using deep learning techniques can identify these kinds of actions and alert parents or other caregivers so they can quickly get the situation under control. The study concluded that, in contrast to all ML algorithms, deep learning Compared to other neural networks, RCNNs are more effective and offer more room for growth, to train the system more quickly while maintaining reliability. By using images from reputable websites and videos that feature the most predictive gestures, a trained classifier is used to identify meltdowns more accurately. A classifier that uses loss/train with a minimum of 0.4% is included with the trained model, which validated the accuracy by approximately 93%. Functional testing involved feeding the deep neural network selected instants from four different people. This yielded an accuracy of approximately 92% in every case, ensuring that the system could be used in real time. [32] identified the most crucial traits and automated them with the help of current classification techniques; the study aims to streamline the diagnostic process. The author examined datasets containing information on adults, teens, and toddlers with autism spectrum disorder and then compared state-of-the-art feature selection and categorization techniques for these four ASD datasets to determine the best-performing feature set and classification. Research shows that the multilayer perceptron (MLP) classifier utilizes the fewest

features possible to achieve 100% accuracy across datasets of toddlers, kids, teens, and adults. It also concluded that, in all four ASD datasets, the most significant characteristics are ranked highest by the suggested feature selection method

Table: Results of the DL methods used for the detection and prediction of ASD

Ref No.	Dataset	Methodology	Results
[25]	Website data of adult Patients suffering from ASD	Machine learning, eye-tracking technology, the Internet of Things (IoT)	Successfully predicted the Disease in early stages in adult patients
[26]	Clinical dataset	XAI with SHAP 7-layer model	Accuracy:79% F1score:0.98 Recallmatrix:0.97
[27]	Kaggle and UCI image library	Multi-interesting-state fMRI deep learning	Accuracy88% F1-score87% Sensitivity90%
[28]	Facial images of ASD patients from Kaggle	NASNET Mobile, Xception VGG19deep learning model	Accuracy (91%).
[29]	Web page publicized by A Professor of Data Analytics.	DNN10-fold cross-validation Model	F1 score 91 % Sensitivity87% Accuracy89%
[30]	UCI Machine learning repository.	The Deep Neural Network (DNN)	Accuracy99.4%
[31]	Data from mental health websites	Google Net ResNet-18 (ResNet-18+SVM)	accuracy95.5% (GoogleNet+SVM)94.5% (ResNet-18 + SVM)
[32]	ASD patient's Facial Images Dataset from Kaggle	VGG 16 transfers a learning-based model	F1-scoreof0.95 accuracyof95%.
[33]	UCI image repository	CNNRNN	ASD patients successfully Identified
[34]	ASD patients from the Blood bank	LSTMCNN	sensitivityof97.1%and specificityof94.3%.
[35]	Patients suffering from genetic diseases in the Genetic Disease Center	Deep ASD Producing CNN and LSTM	Deep ASD Pred performed the best and validated its effective performance in identifying the ASD risk gene.
[36]	Kaggle	Rasnet-50 InceptionV3 InceptionV3+2layerLSTM	Accuracy91%
[37]	Data and videos from websites	Deep learning RCNNs	Accuracy of approximately 92%
[38]	ABIDEII	Multi-layer perceptron (MLP)	Achieve 100% accuracy across Datasets of toddlers, kids, teens, and adults.

2.3 Using Hybrid Models

[39] Predicted that early screening and diagnosis of ASD would benefit the child's timely provision of sufficient medical care, initial educational planning and treatment, and family support. The author predicted the forecasting models for childhood ASD diagnosis using facial image analysis and a variety of ML and DL techniques, the author used the dataset of autistic children that included 2936 facial photos of both typical and autistic kids. Using techniques like SVM and om forest. Apart from the DL techniques, automated machine learning (AutoML), was employed which is a cutting-edge approach. They performed at the highest level, achieving about 96% accuracy. Additionally, quick prediction of the ideal feature engineering parameter settings using Auto ML techniques saves the use of human labor. Studied both ML and DL algorithms and concluded that there are certain disruptive behaviors in children with ASDs. They often struggle with speaking clearly. Instead, they establish relationships through pointing words and gestures. Thus, one of the hardest things for

caregivers to do is to understand their needs; however, this task can be significantly simplified by an early diagnosis. The (IoT) and assistive technologies have the potential to eradicate both verbal and nonverbal communication deficits. (DL) and (ML) algorithms are employed by Internet of Things (IoT)-based systems to improve and diagnose patient outcomes. A thorough review of ASD methodologies is conducted in about IoT devices. This review's primary objective is to identify important research themes in the Internet of Things-based medical care. Moreover, the author provided a technical taxonomy to classify the current research on ASD methods and algorithms. Functional and statistical analysis of the reviewed ASD approaches based on assessment metrics such as sensitivity and accuracy. The study by [41] introduced an EEG signal's T-F spectrogram picture to aid in differentiating between kids with ASD and typical kids. Shorter signals are created from the EEG signal. Images from Fourier transform spectrograms are classified using both (ML) and (DL) techniques. Six separate classifiers are used in the machine learning-based classification. The spectrogram images are processed using three distinct CNN models in the DL-based method. The findings demonstrated that it provides the highest classification accuracy in ML-based classification, with an accuracy value of 95.25%, while the suggested CNN model achieved an accuracy of 99.15% in DL-based classification. The results demonstrated that, with this outcome, the suggested method exceeds most methods in the literature currently in inclusion and can serve as the foundation for CAD systems intended to identify additional neurological disorders for which EEG recordings are utilized in the diagnostic process. According to the study, ASD is a disorder of development that affects behavior and speech. However, because the ASD screening data is heterogeneous a n d comes from multiple sources, the screening methods currently in use are costly, time-consuming, and lack predictive accuracy. For ASD screening, use a deep learning classifier in conjunction with innovative techniques for feature encoding and feature engineering. To diagnose ASD based on behavioral traits and individual characteristics, algorithms were developed using a robust DL Deep embedding representation and classifier about categorical variables along with machine learning algorithms like random forests and decision trees. The suggested algorithm achieves 99% sensitivity and 99% specificity, which is effective when compared to baselines.

Table: Results of hybrid models used for prediction and detection of ASD

Ref No.	Dataset	Methodology	Results
[39]	2936 facial photos of both typical and autistic kids	Automated machine learning (AutoML)+ LSTM	96%Accuracy.
[40]	Publicly available datasets from websites	(DL)and (ML) algorithms in IoT-based systems	Proved as a baseline for future models in IoT-based Systems
[41]	ABIDE I dataset	T-F spectrogram images With CNN model +SVM	Accuracy95.25%,
[42]	ASD center	Deep learning classifier Feature engineering feature encoding + DT and RF	99% specificity 99% sensitivity

2.4 Future Work and Discussion

One kind of developmental disorder that can significantly impact a person's cognitive capacities, language abilities, object recognition skills, social interactions, and communication abilities is ASD. This disease is primarily genetically based, and early identification and treatment can reduce the likelihood that the affected person will have to pay astronomical medical costs and endure drawn-out diagnostic tests. An ML and DL architecture that can precisely classify and identify ASD traits by analyzing datasets of toddlers with autism. This study looks at the various ways that ML and DL techniques can be used to diagnose and categorize ASD. It has highlighted the benefits and drawbacks of these approaches. To achieve this, a careful evaluation and examination of ongoing research projects is conducted. To identify ASD in publicly available nonclinical ASD screening datasets, the current study used a variety of ML techniques, like SVM, KNN algorithm, DT, and DL models like LSTM. The effectiveness of the models rated for the identification of ASD was assessed using a variety of performance assessment criteria.

3. Conclusion

This work comprised a systematic review of the methods for predicting and detecting ASD, particularly in adults, using computer vision techniques. Blood tests, RNA-based analysis, eye gaze, facial expressions, and other approaches are used together with a range of DL and ML technology-based techniques to predict the disorder in patients. It has been noted that deep learning models yield the highest accuracy and perform the best. Furthermore, hybrid models combine various modalities to achieve better performance. The practical method that employs handwritten tasks to identify ASD is very driven. Its primary benefit is that it is easy to use and does not require specialized knowledge from a professional. So, in the future, there is a need to improve the handwritten approach with better datasets to collect more data for the deep learning method testing and training by handwriting data from patients with and without ASD. The best task data are those that are handwritten, and

these will be crucial for the disorder's diagnosis. The basic idea behind more data collection and experimentation is that deep learning networks learn better the more data they must work with.

References

[1]. Autism spectrum disorder (ASD)," Online Available, 07 June (2024).
[2]. U.S. Department of Health and Human Services. (n.d.). Autism spectrum disorder. National Institute of Mental Health. https://www.medicalnewstoday.com/articles/326841#signs-and-symptoms
[3]. Zauderer, S. September 20). Do autistic people get married? Autism & relationships. Life-Changing ABA Therapy - Cross River Therapy, (2023).
[4]. https://www.crossrivertherapy.com/autism/do-autistic-people-get-married
[5]. T. K. R. &. G. D. Soni, "Performance Analysis of Autism Spectrum Disorder using various Machine Learning Techniques., "4th International Conference for Emerging Technology (INCET) IEEE, pp. 1-4, (2023).
[6]. D. D. &. K. S. D. (Khudhur, "The classification of autism spectrum disorder by machine learning methods on multiple datasets for four age groups," Measurement: Sensors, 27, (2023).
[7]. I. F. O. Y. A. A. F. R. E. &. G. D. Voinsky, "Machine learning-based blood RNA signature for diagnosis of autism spectrum disorder, "International Journal of Molecular Sciences, (2023).
[8]. Machine learning-based blood RNA signature for diagnosis of autism spectrum disorder.
[9]. S. J. S. &. V. J. P. Pandya, "AI-based Classification for Autism Spectrum Disorder Detection using Video Analysis., IEEE" pp. (pp. 1-6), (2022).
[10]. K. F. S.-D. C. K. S. P. &. F. G. F. Kollias, " Autism detection in High-Functioning Adults with the application of Eye-Tracking technology and Machine Learning," In 2022 11th International Conference on Modern, pp. 1-4, (2022).
[11]. C. R. D. G. A. L. M. I. S. S. A. &. D. Magnusson, "Migration and autism spectrum disorder: a population-based study. The British Journal of Psychiatry, 201, 2, pp. 109-115, (2019).
[12]. K. &. K. R. Khan, "Machine Learning Techniques for Autism Spectrum Disorder: current trends and future directions." IEEE, pp. pp. 1-7, (2023).
[13]. K. D. N. N. &. A. G. Garg, " A Review On: Autism Spectrum Disorder Detection by Machine Learning Using Small Video," pp. 1-8, (2023).
[14]. W. C. K. M. M. S. A. C. J. L. M. C. &. S. D. J. o. A. a. D. Mandy, " Assessing autism in adults: An evaluation of the developmental, dimensional and diagnostic interview-Adult version (3Di-adult)," Journal of Autism and Developmental Disorders, pp. 549-560, (2018).
[15]. A. O. U. &. E. K. M. Hendr, "Diagnosis of Autism Spectrum Disorder Using Convolutional Neural Networks," Networks. Electronics, pp. 12(3), 612, (2023).
[16]. S. &. A.-H. R. K. S. &. A.-H. R. N. P. T. f. K. S. &. A.-H. R. Kamel, "Newly Proposed Technique for Autism Spectrum Disorder Based Machine Learning. .," AIRCC's International Journal of Computer Science and Information Technology, pp. 1-15, (2021).
[17]. D. B. S. L. B. M. P. G. M. S. L. C. &. N. S. S. Bone, " Use of machine learning to improve autism screening and diagnostic instruments: effectiveness, efficiency, and multi-instrument fusion," Journal of Child Psychology and Psychiatry, pp. 927-937, (2016).
[18]. M. H. G. T. T. K. A. K. M. S. &. M. M. Al Banna, "A monitoring system for patients of autism spectrum disorder using artificial intelligence," pp. 251-262, (2020).
[19]. C. R. D. G. A. L. M. I. S. S. A. &. D. C. Magnusson, "Magnusson, C., Rai, D., Goodman, A.,

Lundberg, M., Idring, S. Svensson, A., & Dalman, C. (2012). Migration and autism spectrum disorder: population-based study," The British Journal of Psychiatry, pp. 109-115, (2019).

[20]. Y. P. P. R. S. &. R. S. Justindhas, "Early Onset Autism Detection Using Deep Learning Techniques," B, Padmavathi and Justindhas, Y and Preetha, P and Rithanya, S and Renooh, S, Early Onset Autism Detection Using Deep Learning Techniques (March 8, 2023). Proceedings of the International Conference on Innovative Computing & Communication (ICICC) 2022, Av, (2023).

[21]. D. D. &. K. S. D. Khudhur, "The classification of autism spectrum disorder by machine learning methods on multiple datasets for four age groups," Measurement: Sensors, 27, (2023).

[22]. M. S. Q. M. B. A. J. A. F. &. A. A. Qureshi, "Prediction and analysis of autism spectrum disorder using machine learning techniques," Journal of Healthcare Engineering, (2023).

[23]. K. L. G. N. H. J. H. H. W. E. M. F. S. &. M. D. G. (Ashwood, "Predicting the diagnosis of autism in adults using the Autism-Spectrum Quotient (AQ) questionnaire," Psychological medicine, pp. 2595-2604, (2016).

[24]. K. F. S.-D. C. K. S. P. &. F. G. F. Kollias, "Autism detection in High-Functioning Adults with the application of Eye-Tracking technology and Machine learning," 11th International Conference on Modern, (2022).

[25]. Classification and Detection of Autism Spectrum Disorder Based on Deep Learning Algorithms," Intelligence and Neuroscience, C, (2023).

[26]. A. S. P. P. &. P. K. C. Mohanty, "Mohanty, A. S., P Identification of autism spectrum disorder using deep neural network.," Journal of Physics: Vols. Conference Series, 1921, No. 1, p. 012006, IOP Publishing, (2021).

[27]. M. F. S. A. A. E. F. A. M. H. A. S. Z. A. H. H. &. H. M. F. Misman, "Classification of adults with autism spectrum disorder using deep neural network," 1st International Conference on Artificial Intel IEEE, pp. 29-34, (2019).

[28]. I. A. S. E. M. R. T. H. A. M. A. S. H. S. A. A. S. M. &. A. M. Ahmed, "Eye tracking-based diagnosis and early detection of autism spectrum disorder using machine learning and deep learning technique," Electronics, 11(4), 530, (2022).

[29]. A. &. P. M. Lu, "). Deep learning approach for screening autism spectrum disorder in children with facial images and analysis of ethno racial factors in model development and application". Brain Sciences, 11(11), 1446, (2021).

[30]. F. C. S. K. Y. H. C. K. A. &. L. S. W. Ke, "Exploring the structural and strategic bases of autism spectrum disorders with deep learning," IEEE Access, 8, 153341-153352, (2020).

[31]. Y. X. H. &. S. G. Fan, "Deep ASD Pred: a CNN-LSTM-based deep learning method for autism spectrum disorders risk RNA identification," BMC bioinformatics, pp. 24(1), 1-14., (2023).

[32]. J. W. Y. N. R. J. S. M. L. G. Y. &. K. B. N. Song, “Neuroimaging-based deep learning in autism spectrum disorder and attention-deficit/hyperactivity disorder." Journal of the Korean Academy of Child and Adolescent Psychiatry, 31(3), 97. (2023).

[33]. L. S. Z. X. J. Y. J. L. J. &. W. J. Xu, “Identification of autism spectrum disorder based on short-term spontaneous hemodynamic fluctuations using deep learning in a multi-layer neural network.," Clinical Neurophysiology, pp. 132(2), 457-468, (2021).

[34]. Y. X. H. &. S. G. Fan, " Deep ASD Pred: a CNN-LSTM-based deep learning method for autism spectrum disorders risk RNA identification," BMC bioinformatics, pp. 24(1), 1-14., (2023).

[35]. S. J. S. &. V. J. P. (Pandya, "AI-based Classification for Autism Spectrum Disorder Detection

using Video Analysis, "IEEE., vol. Bombay Section Signature Conference (IBSSC), pp. (pp. 1-6), (2022).

[36]. V. S. P. G. F. T. G. K. &. V. A. Patnam,. Deep learning-based recognition of meltdown in autistic kids," IEEE, pp. pp. 391-396, (2017).

[37]. M. K. J. B. A. O. R. F. A. S. A. M. A . . . &. B. M. Hosseinzadeh, "A review on diagnostic autism spectrum disorder approaches based on the Internet of Things and Machine Learning.," The Journal of Supercomputing, 77, pp. 2590-2608., (2021).

[38]. B. R. G. Y. E. M. A. A. A. &. I. O. A. S. Elshoky, "Comparing automated and non-automated machine learning for autism spectrum disorders classification using facial images." "ETRI Journal, 44(4), pp. 613-623, (2022).

[39]. K. F. S.-D. C. K. S. P. &. F. Kollias, ", "Autism detection in High-Functioning Adults with the application of Eye-Tracking technology and Machine Learning,", "IEEE, pp. 1-4, (2022).

[40]. A. P. D. B. S. J. D. S. M. M. M. A. A Garg, "Autism spectrum disorder prediction by an explainable deep learning approach," Computers, Materials & Continua, (2022).

[41]. Z. S. J. X. J. Y. J. L. J. W. -. C. N. 2. -. E. L Xu, "Identification of autism spectrum disorder based on short-term spontaneous hemodynamic fluctuations using deep learning in a multi-layer neural network," Clinical Neurophysiology, 2021 - Elsevier, (2021).

[42]. R. K. D. G. T Soni, "Performance Analysis of Autism Spectrum Disorder using various Machine Learning Techniques," IEEE, (2023).

[43]. K. F. S.-D. C. K. S. P. &. F. Kollias, "Autism detection in High-Functioning Adults with the application of Eye-Tracking technology and Machine Learning.," IEEE, pp. pp. 1-4, (2022).

[44]. L. S. Z. X. J. Y. J. L. J. &. W. J. I. o. a. s. d. b. o. s.-t. s. h. f. u. d. l. i. a. m.-l. n. n. C. N. Xu, Clinical Neurophysiology, pp. 132(2), 457-468.

[45]. https://www.who.int/news-room/fact-sheets/detail/autism-spectrum-disorder

[46]. https://fcon_1000.projects.nitrc.org/indi/abide

[47]. M. N. A. S. S. W. H. W. F. W. K. &. Z. Y. Tawhid, "A spectrogram image-based intelligent technique for automatic detection of autism spectrum disorder from EEG," Plos one, pp. 16(6), e0253094, (2021).

[48]. H. L. L. C. L. &. Z. Z. Wang, "Autism screening using deep embedding representation," Springer International, pp. Part II 19, pp. 160-173, June 12–14, (2019).

[49]. A. S. P. P. &. P. K. C. Mohanty, " Identification of autism spectrum disorder using deep neural network.," In Journal of Physics: Conference Series, Vols. Conference Series, 1921, No. 1, p. 012006, IOP Publishing, (2021).

[50]. P. P. K. P. AS Mohanty, "Identification of autism spectrum disorder using deep neural network," Journal of Physics: Conference Series, (2021).

[51]. Z. S. J. X. J. Y. J. L. J. W. -. C. N. 2. -. E. L Xu, "Dentification of autism spectrum disorder based on short-term spontaneous hemodynamic fluctuations using deep learning in a multi-layer neural network," Clinical Neurophysiology, Elsevier, (2021).

[52]. R. K. D. G. T. Soni, "Performance Analysis of Autism Spectrum Disorder using various Machine Learning Techniques," IEEE, (2023).