ISSN: 1672 - 6553

JOURNAL OF DYNAMICS AND CONTROL

VOLUME 9 ISSUE 2: 34 - 43

A SURVEY ON AUTISM DETECTION USING MACHINE LEARNING

Shaba Irram[1], Dr. Mohammad Suaib[2]

Integral University Lucknow, Uttar Pradesh, India

DOI: https://doi.org/10.71058/jodac.v9i2004

A SURVEY ON AUTISM DETECTION USING MACHINE LEARNING

Shaba Irram[1], Dr. Mohammad Suaib[2]

[1,2]*Integral University Lucknow, Uttar Pradesh, India*
[1] *helloshabairram @gmail.com,* [2] *suaibcs09@iul.ac.in*

Abstract
Autism Spectrum Disorder (ASD) is a neurodevelopmental condition characterized by challenges in social interaction, communication, and repetitive behaviours. Early diagnosis and intervention significantly impact the long-term outcomes for individuals with ASD. However, the complexity and heterogeneity of ASD pose challenges to accurate and timely detection. The existing literature on autism detection through ML showcases promising developments. Various studies have explored the application of ML algorithms to diverse datasets, ranging from behavioural observations to neuro imaging data. These studies have demonstrated the potential of ML in providing objective and data-driven insights into the diagnostic process. However, there remains a need for further research to refine and expand these approaches. This research builds upon the foundation laid by previous studies, aiming to address gaps in the literature. By employing advanced ML techniques, we seek to enhance the accuracy of autism detection models in early stage and contribute to the ongoing efforts to develop efficient, scalable, and reliable diagnostic tools.

Keywords: *Autism Spectrum Disorder, ASD, machine learning (ML), brain development disorder, Behavioural Analytics*

Introduction

Autism Spectrum Disorder (ASD) is a complicated heterogeneous neurodevelopment impairment that can involve behavioural, social, or communication difficulties. The word "spectrum" denotes that the degree of symptoms varies between individuals, and symptoms differ due to the variety of the illnesses. Parents can recognize ASD in the early age itself. Since children undergo behavioural changes beginning in toddler age, that included linguistic and psychological interaction. Parents also notice behavioural changes in their children, such as turning items, making poor eye interaction, never reacting to their names, sleeping irregularly, and losing attention. Earlier parenting assessments are essential in recognising and diagnosing ASD in order to provide correct treatment or counselling to children at an early stage [1]. If we give early medical attention and treatment, their behaviour will undoubtedly improve, and they will be able to communicate with other kids and have a normal childhood like normal kids. The normal diagnoses of ASD are generally done by Neurologist and Psychiatric professionals. The diagnosis is done in a healthcare setting using diagnosing instruments to evaluate the child's Intelligence quotient, Behaviour Deficiency, and Sensory Issues. Diagnostic techniques that involve physical equipment to diagnose ASD take longer, and can extend up to five days. The diagnostic procedure is frequently carried out under the guidance of more than one specialist. Experts have already designed questionnaire based diagnosis tool for prediction of ASD. In order to predict the ASD, some tools are developed by the experts based on machine learning (ML) and Deep Learning (DL) methods.
Machine Learning is an inter-disciplinary discipline that combines analytics, datasets, and computer programming. Machine learning algorithms are used to retrieve secret knowledge or

DOI: https://doi.org/10.71058/jodac.v9i2004

expose essential data from big datasets. Three different forms of ML are Supervised, Semi-Supervised and unsupervised. Decision Trees, Random Forest, Support 2 Vector Machines, K-Nearest Neighbor, Nave bayes, Linear Regression, Logistic Regression are examples of supervised ML algorithms, while unsupervised ML methods include Clustering Approaches, Association Rule Mining, Hidden Markov Model, and others [2]. Nevertheless, diagnostic models produced with ML are not intended to replace physicians; rather, ML models provide recommendations to doctors in order to enhance their conclusions in ASD investigation. Machine Learning algorithms are more precise at recognizing ASD than other techniques. Deep learning (DL) is another technique for prediction and diagnosis of autism. It is a part of Artificial intelligence (AI) which is used for prediction and detection of diseases. Usually DL is used for un-structured dataset like image data, audio and video data. DL models have neural networks with input layer, hidden layers and output layer. The Neural Network algorithms have several models to deal with various kinds of information. For example, Recurrent Neural Networks (RNN) can operate on structured information while Convolutional Neural Networks (CNN) can work on unstructured information. DL models greatly enhance the ASD diagnostic process and ASD analysis from different viewpoints. DL models make it easier for Physicians, Specialists, Mental health professionals, and Surgeons to make precise diagnoses and decisions. DL approaches are also employed for classification issues with a wide range of data, however both ML and DL play an important part in classification. In this thesis, we used CNN model and ML algorithms for classification and prediction of ASD.
Recent advancements in machine learning (ML) present an opportunity to enhance the accuracy and efficiency of autism detection. ML algorithms, when trained on relevant datasets, can identify patterns and associations in data that may not be apparent through traditional diagnostic methods. This research aims to contribute to the growing body of literature on autism detection by leveraging machine learning techniques to improve the precision and timeliness of diagnoses. Numerous studies have explored the application of machine learning algorithms to various aspects of autism diagnosis.

Literature Review:

K. Radha et al. [3] focused on autism spectrum disorder (ASD), a neurodevelopmental condition that affects perception, communication, and behaviour throughout life. Due to a combination of immunological, environmental, and genetic factors, it typically first appears in early childhood and spans a wide range of symptoms and intensities. In this paper, a customised log spectrogram short-time Fourier transform (STFT) layered convolutional neural networks (CNN) model is used to introduce a new dataset for children ASD speech corpus (CASD-SC). Two models are evaluated in this investigation: the conventional feature-based CNN model and the raw waveform-based CNN model. After examining several CNN first layer configurations, including spectrogram and log spectrogram, it was discovered that the log spectrogram raw waveform-based CNN model was 86.6% accurate in identifying ASD.
S. Jain et al. [4] covered the use of artificial intelligence (AI) to speed up and improve the precision of ASD diagnosis. In contrast to a single, conclusive test, diagnosis entails a multidisciplinary approach that takes behaviour, social interaction skills, and developmental history into account. By examining a variety of data sources, including genetic and medical records, AI algorithms provide a promising remedy by finding patterns linked to ASD. The doctor can anticipate the diagnosis of ASD by combining the analysis of video data and questionnaire responses. The application encourages parents to seek additional evaluation from medical professionals by acting as a preliminary screening tool. This paper suggests an application that could improve the accuracy, efficiency, and accessibility of ASD diagnosis, thereby leading to better outcomes for children with ASD.

DOI: https://doi.org/10.71058/jodac.v9i2004

H. Raj et al. [5] created a technique that makes use of the Inception V3 algorithm to quickly ascertain whether the disease is present. A more accurate and efficient method of diagnosing autism spectrum disorder is through the use of video-based classification. A small percentage of infants appear to develop normally during the first year of life, but between the ages of 18 and 24 months, they experience a regression phase in which they display autism symptoms. Inception V3, a Deep Learning (DL) algorithm, is used in this study to identify disorders early on. Videos have been collected into datasets for the purpose of diagnosing autism spectrum disorder. The child videos are trained using a deep learning algorithm, which produces a model file. The model successfully detects the presence of the disorder when an input image is given for disease prediction. As a result, the suggested method offers a practical way to more accurately predict the existence of autism spectrum disorder. The results indicate that 93% accuracy was attained by the LSTM classification model. As a result, this research contributes to a more accurate and efficient diagnosis of autism spectrum disorder than current models.
M. Tuli et al. [6] proposed AI-based autism detection system that uses two different models. For kids ages 2 to 8, the XceptionNet model is used to evaluate facial dysmorphology in photos of autistic kids with an accuracy of 85%. For people ages 9 and up, the Light Gradient Boosting Machine Classifier is used to evaluate the images of autistic people with an accuracy of 99%. This classifier takes into account a variety of factors, including age, gender, ethnicity, and ASD score. Because the suggested models take into account the unique needs and traits of individuals with autism across all age groups, they improve the detection accuracy of ASD.
V. P et al. [7] used VGG19, Densenet121, and InceptionV3 Convolutional Neural Network (CNN) models to extract features. In order to correctly identify autism, a Deep Neural Network (DNN) model is also used as a binary classifier. In this study, facial images of children with autism diagnoses and control subjects who were categorised as neither autistic nor non-autistic are used in a publicly available dataset. Densenet121 performed better than the other models that were looked at, with 96.66% accuracy, 96.25% precision, 94.75% recall, and 95.50% F1 score.
R.S. Lalawat et al. [8] generated corresponding spectrograms, scalograms, and SPWVD-TFD by pre-processing, segmenting, and Time-frequency distribution (TFD) of multiple algorithms, including short time fourier transformation (STFT), continuous wavelet transformation (CWT), and smoothed pseudo-Wigner-Ville distribution (SPWVD). After being added to the pre-trained (ImageNet data-set) DenseNet-121 and ResNet-101 models, these TFD are fed into the suggested ASD-Net. With the help of these TFD photos, deep learning network (DLM) models were able to distinguish between subjects with ASD and those without. We used the SPWVD-based TFD and ASD-Net model to obtain a mean accuracy of 97.35%. The developed convolution neural network (CNN) model with five convolution layers is speedier and requires fewer learnable parameters than the benchmark DenseNet-121 and ResNet-101. It also has a lower computational overhead.
S. Fiza et al. [9] recommended an approach, called "Behavioural Biomarker Identification (BBI)," employs machine learning algorithms to identify behavioural patterns that might be indicative of autism spectrum disorder (ASD). These algorithms include logistic regression, random forests, and deep neural networks (DNNs). BBI is compared with six other widely used methods to see if it performs better. Studies have demonstrated that compared to other approaches, BBI is more efficient, accurate, and focused. To effectively detect cases of ASD, the BBI's high sensitivity (88%), which ensures a low level of false negatives, is crucial. Its 94% specificity is excellent for removing false positives by excluding circumstances unrelated to ASD. The suggested approach prioritises data privacy and ethical considerations and handles them transparently while enforcing stringent security measures. Because BBI prioritises data protection and ethical principles, it is more sensitive and accurate than traditional approaches,

DOI: https://doi.org/10.71058/jodac.v9i2004

which further ensures its responsible deployment in clinical settings. For these reasons, BBI is a useful tool for healthcare professionals.

M. Wang et al. [10] proposed a multimodal and cross-site WL-DeepGCN-based classification approach to diagnose autism spectrum disorder (ASD), builds a whole-brain functional connectivity network using functional MRI data, and augments the classification task for subject diagnosis with non-imaging data containing demographic information. This method addresses a current problem in deep learning ASD identification: its inability to utilise multimodal data effectively. The WL-DeepGCN represents the similarity of non-imaging data in the latent space by means of a weight-learning network, thereby introducing a novel approach to population graph edge weight creation. The WL-DeepGCN model achieves 77.27% accuracy and 0.83 AUC for ASD identification, significantly outperforming competing models built on the same subjects, as shown by nested 10-fold cross-validation.

H. Sharma et al. [11] used convolutional neural network (CNN) based learning techniques to analyse facial image data to identify children with autism. Three learning models are investigated in this research study. Xception, VGG16, and VGG19. The Xception model demonstrates its performance with an accuracy rate of 89% on a test dataset, following training and validation using the optimised configuration. Conversely, models such as VGG16 and VGG19 achieved accuracies of 76% and 80%, respectively. To evaluate how well they perform in terms of data-driven autism detection. Based on these models' accuracy, sensitivity, specificity, and computational efficiency, the study assesses their performance.

S. T. Tasmi et al. [12] proposed a machine learning-based method that uses various behavioural patterns and symptoms to diagnose ASD at different ages in children, ranging from one year old to twelve years old. Using machine learning algorithms that have been fine-tuned using Bayesian optimisation, including Random Forest, Decision Trees, Gradient Boosting, Support Vector Machine, Naive Bayes, K Nearest Neighbour, Light GBM, CatBoost, AdaBoost classifier, Ridge Classifier, Logistic Regression, and Artificial Neural Network, we have conducted a thorough analysis. Moreover, SHAP Analysis was carried out to verify the models' effectiveness using behavioural patterns. With SVM and ANN, we have achieved impressive prediction accuracy of 91% and 96%, respectively.

S. Mostafa et al. [13] presented a deep learning-based approach using Functional MRI and Structural MRI images. We used the ABIDE dataset for this research. After examining the MRI pictures, a method was developed to pick out particular layers from the MRI images. Our dataset was then constructed using images from ABIDE for our models to train and test without performing any pre-processing. Various cutting-edge deep learning architectures were chosen to train using our created dataset. Novel architectures were used to attain an accuracy of 80% to practically 84%. A custom block was used later in the research to expand the dataset and achieve more accuracy. Based on our findings, it is evident that the deep learning model with our modified block demonstrates superior performance when compared to alternative techniques. Consequently, it offers a feasible solution for the diagnosis of ASD using MRI images.

L. K et al. [14] investigated the link between particular ASD symptoms and EEG anomalies. To achieve their research goal, a systematic review of many academic publications was done. Result: the research from various articles involving our subjects produced a number of important findings about functional connectivity patterns, abnormalities in sensory processing, brain oscillations, event-related potentials (ERPs), neural responses to social stimuli, predictive modeling, and the potential for early detection. Discussion: The results of the EEG play a significant role in the ASD diagnosis. By describing the developments and challenges in this area, they highlighted the potential of EEG as a non-invasive tool to enhance the early detection and characterisation of ASD. The overall findings imply that EEG may enhance our understanding of the neurological underpinnings of ASD.

DOI: https://doi.org/10.71058/jodac.v9i2004

K. Patel et al. [15] proposed strategy shows potential in aiding physicians and researchers in early diagnosis by utilizing face clues and machine learning techniques. This study aims to investigate how well machine learning and feature extraction algorithms based on deep learning can identify ASD in young children. Deep convolutional neural networks known for their capacity to extract significant characteristics from images, VGG16 and VGG19, are used. Several machine learning algorithms, such as logistic regression, support vector machines (SVM), naive Bayes,, and artificial neural networks (ANN), are then applied with the retrieved characteristics as input.

R. Kumar et al. [16] integrated both “quantitative and qualitative methodologies” through an integrated approach and accessible study philosophy. Approaches for gathering data include compiling datasets, reviewing relevant research, and obtaining EEG, emotions, and eye motion data. In order to boost the accuracy of ASD screening, statistical models including “logistic regression, neural networks, and support vector machines have been created.” This quantitative analysis is enhanced by a thematic approach, which pinpoints recurrent themes and characteristics. Data protection and permission from subjects are given top priority in this study's ethical concerns. The theoretical and practical divide, the studies hope to improve effective ASD diagnosis and treatments.

A. Kusumaningsih et al. [17] suggested in their study A multi-kernel SVM technique to increase the accuracy of the model. The efficacy of the prediction model was assessed using the classification evaluation parameters, which include accuracy, precision, recall, and F1 score. The outcomes of their experiment show that the Multi-kernel SVM method performs well in autism prediction. Additionally, the performance of suggested method is excellent, with an accuracy of 0.976; the ASD class has an ideal precision of 1.00, while the normal class can be distinguished with high precision, recall, and f1-score.

A. Kusumaningsih, M. Risnasari et al. [18] used an alternative feature extraction method based on the Gray-Level Co-occurrence Matrix in order to reduce feature dimensionality. Lastly, in order to assess how well the system identified visual patterns suggestive of ASD, we tested several SVM kernels, including polynomial, radial basis function (RBF), and linear kernels. The system performance can be increased by 3.51% by using the green channel, and the RBF kernel yields the best performance of 0.73.

J. Mao et al [19] sought to conceptually validate whether, in different sensory stimuli conditions, head movements by participants could distinguish children with ASD from their typically developing peers. There were four types of sensory stimulation conditions: tactile, olfactory, auditory, and visual. A total of 160 head movement data entries were constructed from the data collected from 40 subjects who were exposed to four different sensory stimuli. For the purpose of classification, machine learning algorithms were used. The decision tree model used the rotation range in Z axis (ZRR) and the angular rotation per minute in Z axis (ZARPM) features to achieve the highest accuracy (90.0%) under olfactory stimulation conditions, according to the results. Both the neural network with three features and the decision tree with two features performed best under visual conditions (87.5%). Classifiers performed well overall across sensory conditions, suggesting the possibility of early ASD diagnosis

M. N. Mahamood et al. [20] proposed a global feature extractor and a sequencer-based patch-wise local feature extractor. The final feature for the classification of ASD is obtained by averaging the features from these modules. Tests conducted on an Autism Facial Image Dataset that is accessible to the public show that the suggested framework performs at the cutting edge. They received scores of 94.7%, 94.0%, 95.3%, and 94.6% for accuracy, precision, recall, and F1-score, in that order.

E. Arora et al. [21] Identified Autism Spectrum Disorder (ASD) through eye gaze that facilitated intervention earlier rather than waiting for additional symptoms like abnormal

DOI: https://doi.org/10.71058/jodac.v9i2004

behaviours, social disorientation, and non-standard speech to appear. In the long run, using the eye's scan path is a very beneficial preventive and economical measure. The goal of this study is to train a model using deep learning techniques so that it can be used to predict the presence of autism. Using ANN, we have achieved an accuracy of 74.57%, and with CNN, we have achieved 85.28%.

A. Zhang et al. [22] aimed to improve accessibility and accuracy for the early detection of autism spectrum disorders in children by presenting a novel method that combines hybrid eye tracking and speech data within a supervised learning framework. A dataset comprising both of these data modalities was gathered from 78 children without ASD and 30 children with ASD. On our gathered dataset, data processing techniques including Mel-frequency cepstral coefficients (MFCCs) extraction for speech data and scanpath visualisation for eye tracking data were used. Using this modified dataset, classifiers like XGBoost and neural networks were then used to create predictive models for the classification of ASD, yielding a classification accuracy of up to 82%.

A. Ashraf et al. [23] used a transfer learning algorithm to classify and represent learning tasks of the most powerful deep learning network, such as convolution neural network (CNN), on a combination of data from autism brain imaging data exchange (ABIDE I and ABIDE II). The four-dimensional (three spatial dimensions and one temporal dimension) nature of the resting state fMRI (rs-fMRI) data makes them potentially useful for the development of diagnostic biomarkers for brain dysfunction. A worldwide scientific collaboration is called ABIDE. For ABIDE-I and ABIDE-II, seventeen different sites provided eleven12 rs-fMRI datasets from 573 typical control (TC) and 539 autistic individuals and eleven14 rs-fMRI datasets from 521 autistic and 593 TC individuals, respectively. CNN's accuracy with our recommended optimisation was 81.56%. Compared to earlier conventional methods that were restricted to the ABIDE I datasets, this approach performs better.

Suman Raj et al. [24] Looked into the possible uses of Naïve Bayes, Support Vector Machine, KNN, Convolutional Neural Network, Logistic Regression, and Naïve Bayes for the analysis and prediction of ASD problems in kids, teens, and adults. We evaluate the proposed methodologies on three different publicly available non-clinically ASD datasets. The first dataset about ASD screening in children contains 21 attributes and 292 occurrences. The second dataset includes 704 instances total with 21 attributes associated with adult subjects undergoing ASD screening. In relation to ASD screening in adolescent subjects, the third dataset comprises 104 instances and 21 attributes. With higher accuracy of 99.53%, 98.30%, and 96.88% for Autistic Spectrum Disorder Screening in Data for Adult, Children, and Adolescents, respectively, after applying various machine learning techniques and handling missing values, the results strongly suggest that CNN-based prediction models perform better on all these datasets.

Rahman R et al. [25] used a general population sample to test whether machine learning (ML) models applied to electronic medical records (EMRs) could predict ASD early in life. The EMR information for parents of 1,397 ASD children (ICD-9/10) and 94,741 non-ASD children born between January 1st, 1997 and December 31st, 2008 was included in the data that they utilised from a single Israeli Health Maintenance Organisation. In order to create features for training different machine learning algorithms, such as multivariate logistic regression, random forest, and artificial neural networks, regularly available parental sociodemographic data, medical histories, and prescribed medication data were consulted. The performance of all tested ML models was comparable. For predicting ASD in this dataset, the average performance of all the models was C-statistic = 0.709, sensitivity = 29.93%, specificity = 98.18%, accuracy = 95.62%, false positive rate = 1.81%, and PPV = 43.35%.

Mujeeb Rahman et al. [26] examined whether static features taken from photos of autistic children's faces can be used as a biomarker to differentiate them from typically developing

DOI: https://doi.org/10.71058/jodac.v9i2004

kids. We employed a DNN model as a binary classifier to precisely identify autism in children, and five pre-trained CNN models as feature extractors: MobileNet, Xception, EfficientNetB0, EfficientNetB1, and EfficientNetB2. To train the proposed models, we used a publicly accessible dataset comprising facial images of children with autism diagnoses and controls divided into autistic and non-autistic categories. With an NPV of 88%, a sensitivity of 88.46%, and an AUC of 96.63%, the Xception model performed better than the others.

Wang M et al. [27] built a whole-brain functional connectivity network using functional MRI data, augments the classification task for subject diagnosis with non-imaging data containing demographic information, and suggests a multimodal and cross-site WL-DeepGCN-based classification approach to diagnose autism spectrum disorder (ASD). The inefficiency of deep learning ASD identification in using multimodal data is addressed by this method. By introducing residual units to prevent gradient disappearance and explosion, they proposed a graph convolutional neural network residual connectivity approach to mitigate the information loss caused by convolution operations. Their method achieves 77.27% accuracy and 0.83 AUC for ASD identification, bringing significant performance gains.

Ravindranath et al. [28] tested a binay firefly feature selection wrapper based on swarm intelligence on an ASD diagnosis dataset comprising 21 features sourced from the UCI machine learning repository. A machine learning model could be able to achieve a higher classification accuracy with fewer feature subsets, according to the experiment's alternative hypothesis. Ten features out of the 21 features in the ASD dataset are found to be sufficient to differentiate between patients with ASD and those without using a Swarm Intelligence-based single-objective binary firefly feature selection wrapper. By achieving an average accuracy with optimal feature subsets between 92.12% and 97.95%, which is roughly equivalent to the average accuracy produced by the entire ASD diagnosis dataset, the results obtained with our approach validate the hypothesis.

Thabtah F et al. [29] proposed a new machine learning method called Rules-Machine Learning that not only detects autistic traits of cases and controls but also offers users knowledge bases (rules) that can be utilized by domain experts in understanding the reasons behind the classification. Empirical results on three data sets related to children, adolescents, and adults show that Rules-Machine Learning offers classifiers with higher predictive accuracy, sensitivity, harmonic mean, and specificity than those of other machine learning approaches such as Boosting, Bagging, decision trees, and rule induction.

Vakadkar K et al. [30] used Q-Chat dataset to apply models like Support Vector Machines (SVM), Random Forest Classifier (RFC), Naïve Bayes (NB), Logistic Regression (LR), and KNN, and then built predictive models based on the results. Thus, the primary goal of this paper is to ascertain whether the child is at risk for ASD in its early stages, which would facilitate a quicker diagnosis. The findings show that, for the dataset chosen, Logistic Regression provides the best accuracy.

Table 1: comparison matrix among various methodologies

AUTHOR	DATA TYPE & DATASET	AGE GROUP	METHODOLOGIES USED	ACCURACY ACHIEVED	LIMITATION
K. Radha et al. [3]	Raw speech, ASD speech corpus (CASD-SC)	Early age	log spectrogram raw waveform-based CNN	86.6%	A low accuracy is achieved compared to other approaches
H. Raj et al. [5]	Videos	18-24 months	Inception V3, a Deep Learning (DL) algorithm, the LSTM classification model.	93%	Not worked for infants
M. Tuli et al. [6]	facial dysmorphology in photos	2-8 years 9 years & up	XceptionNet model, Light Gradient Boosting Machine Classifier	85% 99%	Accuracy is not upto mark for 2 to 8 years children

DOI: https://doi.org/10.71058/jodac.v9i2004

R.S. Lalawat et al. [8]	Time frequency distribution(TFD) images of EEG signals	Not early age	CNN	97.35%	No early age detection
H. Sharma et al. [11]	Facial images	Children	(CNN) Xception model	89%	A low accuracy is achieved compared to other approaches
S. T. Tasmi et al. [12]	Behavioural symptoms (text based)	Early age to 12 years	Bayesian optimisation & ANN	96%	It diagnosed ASD on text based dataset
A. Kusumaningsih et al. [17]	10 questions & 4 specific subject data features	Early	Multi-kernel SVM	97.6%	Text based dataset were used
J. Mao et al [19]	Head movement under 4 sensory stimulation conditions(visual, auditory, tactile, olfactory)	Children	Decision tree	90%	Data collected from 40 individuals only
M. N. Mahamood et al. [20]	Facial images	Early	Sequencer based patchwise local & global feature extractor	94.7%	Accuracy can be improved
E. Arora et al. [21]	Eye gaze	Early	CNN	85.28%	A low accuracy is achieved compared to other approaches
A. Zhang et al. [22]	Hybrid eye tracking & speech data (30 ASD & 78 NON ASD Children)	Early	XGBoost classifier and neural networks	82%	A low accuracy is achieved compared to other approaches
A. Ashraf et al. [23]	brain imaging data (eleven12 rs-fMRI datasets & eleven14 rs-fMRI datasets)	Children	CNN	81.56%	A low accuracy is achieved compared to other approaches

Identification of Research Gaps and the Need for Current Study:

There are still significant research gaps in autism identification despite the advancements in machine learning. Previous research frequently demonstrates differences in approach, which complicates direct comparisons. Furthermore, the influence of different features and data types on model performance has received less study, and when employing eye gazing, low accuracy is obtained in comparison to other methods. In order to facilitate future research in this area that takes into account a variety of datasets and assesses the efficacy of various machine learning algorithms, this study attempts to fill up these gaps.

Conclusion and Future Work:

Summary of Key Findings:

Finally, our work provides important new understandings into the use of machine learning for the early detection of autism spectrum disorder. The basis for improved intervention strategies is laid by this demonstration of the literature review of several methods for obtaining fast and accurate diagnoses.

Significance of the Study:

This study is important for reasons that go beyond academia. A more accurate and effective model for detecting autism has the potential to transform therapeutic settings and enhance the quality of life for people with ASD and their families. The beneficial effects on society highlight how important it is to continue conducting research in this area.

Recommendations for Practitioners and Policymakers:

In order to develop diagnostic procedures and intervention techniques, practitioners and policymakers should take our findings into account. It would be worthwhile to investigate how

DOI: https://doi.org/10.71058/jodac.v9i2004

machine learning techniques may be integrated into clinical settings, with a focus on joint efforts between researchers and medical professionals.

Future Work:
Potential biases in the dataset, variations in diagnostic criteria, and the dynamic nature of ASD pose challenges. Future research should focus on addressing these limitations, refining the model, and exploring additional factors that contribute to the heterogeneity of autism. Working together with healthcare organizations can help us apply our research in the real world and close the knowledge gap between clinical practice and research.

References:

[1] Faras H, Al Ateeqi N, Tidmarsh L. Autism spectrum disorders. Ann Saudi Med. 2010 Jul-Aug;30(4):295-300. doi: 10.4103/0256-4947.65261. PMID: 20622347; PMCID: PMC2931781.
[2] Naeem, Samreen & Ali, Aqib & Anam, Sania & Ahmed, Munawar. (2023). An Unsupervised Machine Learning Algorithms: Comprehensive Review. IJCDS Journal. 13. 911-921. 10.12785/ijcds/130172.

[3] K. Radha, D. V. Rao, K. V. K. Sai, R. T. Krishna and A. Muneera, "Detecting Autism Spectrum Disorder from Raw Speech in Children using STFT Layered CNN Model," *2024 International Conference on Green Energy, Computing and Sustainable Technology (GECOST)*, Miri Sarawak, Malaysia, 2024, pp. 437-441, doi: 10.1109/GECOST60902.2024.10474705.

[4] S. Jain, C. Jatoth, H. Palwe, N. Singh and S. Agrawal, "Design of a User Friendly IOT Based Interface for the Collection of Multimodal Data from Autistic Children," 2024 Third International Conference on Power, Control and Computing Technologies (ICPC2T), Raipur, India, 2024, pp. 834-839, doi: 10.1109/ICPC2T60072.2024.10474641.

[5] H. Raj, D. Kalangiyam and R. Vasanthi, "Classification of Autism Disorder using Deep Learning Techniques: A BlazePose-based Approach," 2024 2nd International Conference on Intelligent Data Communication Technologies and Internet of Things (IDCIoT), Bengaluru, India, 2024, pp. 692-698, doi: 10.1109/IDCIoT59759.2024.10467880.

[6] M. Tuli, A. Chandrasekhar, S. Tyagi and A. Singhal, "Development of AI Based Autism Detection System," 2024 14th International Conference on Cloud Computing, Data Science & Engineering (Confluence), Noida, India, 2024, pp. 41-46, doi: 10.1109/Confluence60223.2024.10463348.

[7] V. P and U. M. V, "Identification of Autism Spectrum Disorder in Children from Facial Features Using Deep Learning," 2024 Fourth International Conference on Advances in Electrical, Computing, Communication and Sustainable Technologies (ICAECT), Bhilai, India, 2024, pp. 1-6, doi:10.1109/ICAECT60202.2024.10469379.

[8] R. S. Lalawat and V. Bajaj, "An Automatic Framework For Detecting Autism Spectrum Disorder From EEG Signals Using TFD," in IEEE Sensors Journal, doi: 10.1109/JSEN.2024.3362341.

[9] S. Fiza, S. MP and G. Shukla, "Predictive Analytics and AI for Early Diagnosis and Intervention in Autism Spectrum Disorders," 2023 IEEE International Conference on ICT in Business Industry & Government (ICTBIG), Indore, India, 2023, pp. 1-8, doi: 10.1109/ICTBIG59752.2023.10456267.

[10] M. Wang, J. Guo, Y. Wang, M. Yu and J. Guo, "Multimodal Autism Spectrum Disorder Diagnosis Method Based on DeepGCN," in *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, vol. 31, pp. 3664-3674, 2023, doi: 10.1109/TNSRE.2023.3314516.

[11] H. Sharma and O. Sharma, "Performance Analysis of Transfer Learning Models for Detecting Autism Spectrum Disorder Using Facial Images," 2023 11th International Conference on Intelligent Systems and Embedded Design (ISED), Dehradun, India, 2023, pp. 1-5, doi:10.1109/ISED59382.2023.10444603.

[12] S. T. Tasmi, S. Ahmed and M. M. Sarker Raihan, "Performance Analysis of Machine Learning Algorithms for Autism Spectrum Disorder Level Detection using Behavioural Symptoms," 2023 26th International Conference on Computer and Information Technology (ICCIT), Cox's Bazar, Bangladesh, 2023, pp. 1-6, doi: 10.1109/ICCIT60459.2023.10441249.

[13] S. Mostafa, Z. Karim and M. I. Hossain, "Autism Detection Based on MRI Images Using Deep Learning," 2023 26th International Conference on Computer and Information Technology (ICCIT), Cox's Bazar, Bangladesh, 2023, pp. 1-6, doi: 10.1109/ICCIT60459.2023.10441006.

[14] L. K and S. M, "Identification of Biomarker for Autism Spectrum Disorder Using EEG: A Review," 2023 International Conference on Advanced Computing & Communication Technologies (ICACCTech), Banur, India, 2023, pp. 45-50, doi: 10.1109/ICACCTech61146.2023.00017.

[15] K. Patel, A. Ramanuj, S. Sakhiya, Y. Kumar and A. Rana, "Transfer Learning Approach for Detection of Autism Spectrum Disorder using Facial Images," 2023 10th IEEE Uttar Pradesh Section International Conference on Electrical, Electronics and Computer Engineering (UPCON), Gautam Buddha Nagar, India, 2023, pp. 247-253, doi: 10.1109/UPCON59197.2023.10434861.

[16]R. Kumar, D. Bordoloi, A. Shrivastava, C. P. Kumar, V. Kumari and A. Kumar, "Behavioral and Clinical Data Analysis for Autism Spectrum Disorder Screening with Machine Learning," 2023 10th IEEE Uttar Pradesh Section International Conference on Electrical, Electronics and Computer Engineering (UPCON), Gautam Buddha Nagar, India, 2023, pp. 1803-1810, doi: 10.1109/UPCON59197.2023.10434718.

[17] A. Kusumaningsih, C. V. Angkoso and A. K. Nugroho, "Autism Screening Prediction Based on Multi-kernel Support Vector Machine," 2023 IEEE 9th Information Technology International Seminar (ITIS), Batu Malang, Indonesia, 2023, pp. 1-5, doi: 10.1109/ITIS59651.2023.10420224.

[18] A. Kusumaningsih, M. Risnasari, K. Joni, K. E. Permana and C. Very Angkoso, "Enhancing Autism Detection Through Visual Pattern Analysis Based On Machine Learning," 2023 International Conference on Advanced Mechatronics, Intelligent Manufacture and Industrial Automation (ICAMIMIA), Surabaya, Indonesia, 2023, pp. 606-611, doi: 10.1109/ICAMIMIA60881.2023.10427704.

[19] J. Mao, C. Zhang, J. Feng and T. Han, "Head Movement Analysis in Differentiating Children with ASD from TD under Various Sensory Stimuli Conditions: A Machine Learning Approach," 2023 5th International Conference on Artificial Intelligence and Computer Applications (ICAICA), Dalian, China, 2023, pp. 322-327, doi: 10.1109/ICAICA58456.2023.10405618.

[20] M. N. Mahamood, M. Z. Uddin, M. A. Shahriar, F. Alnajjar and M. A. Rahman Ahad, "Autism Spectrum Disorder Classification via Local and Global Feature Representation of Facial Image," 2023 IEEE International Conference on Systems, Man, and Cybernetics (SMC), Honolulu, Oahu, HI, USA, 2023, pp. 1892-1897, doi: 10.1109/SMC53992.2023.10394092.

[21] E. Arora, H. S. Jolly and A. Rehalia, "Prediction of Autism Spectrum Disorder Using ANN and CNN," 2023 3rd International Conference on Technological Advancements in Computational Sciences (ICTACS), Tashkent, Uzbekistan, 2023, pp. 457-461, doi: 10.1109/ICTACS59847.2023.10390530.

[22] A. Zhang, "A Novel Eye-tracking and Audio Hybrid System for Autism Spectrum Disorder Early Detection," 2023 IEEE 3rd International Conference on Data Science and Computer Application (ICDSCA), Dalian, China, 2023, pp. 1495-1500, doi: 10.1109/ICDSCA59871.2023.10393215.

[23] A. Ashraf, Q. Zhao, W. H. Bangyal and M. Iqbal, "Analysis of Brain Imaging Data for the Detection of Early Age Autism Spectrum Disorder Using Transfer Learning Approaches for Internet of Things," in IEEE Transactions on Consumer Electronics, doi: 10.1109/TCE.2023.3328479.

[24] Suman Raj, Sarfaraz Masood, Analysis and Detection of Autism Spectrum Disorder Using Machine Learning Techniques,Procedia Computer Science, Volume 167, 2020, Pages 994-1004, ISSN 1877-0509, https://doi.org/10.1016/j.procs.2020.03.399.

[25] Rahman R, Kodesh A, Levine SZ, Sandin S, Reichenberg A, Schlessinger A. Identification of new borns at risk for autism using electronic medical records and machine learning. Eur Psychiatry. 2020 Feb 26;63(1):e22. doi: 10.1192/j.eurpsy.2020.17. PMID: 32100657; PMCID: PMC7315872.

[26] Mujeeb Rahman, K.K.; Subashini, M.M. Identification of Autism in Children Using Static Facial Features and Deep Neural Networks. *Brain Sci.* 2022, *12*, 94. https://doi.org/10.3390/brainsci12010094.

[27] Wang M, Guo J, Wang Y, Yu M, Guo J. Multimodal Autism Spectrum Disorder Diagnosis Method Based on DeepGCN. IEEE Trans Neural Syst Rehabil Eng. 2023;31:3664-3674. doi: 10.1109/TNSRE.2023.3314516. Epub 2023 Sep 20. PMID: 37698959.

[28] Ravindranath, Vaishali & Ra, Sasikala. (2018). A machine learning based approach to classify Autism with optimum behaviour sets. International Journal of Engineering and Technology. 7. 10.14419/ijet.v7i3.18.14907 Published.

[29] Thabtah F, Peebles D. A new machine learning model based on induction of rules for autism detection. Health Informatics J. 2020 Mar;26(1):264-286. doi: 10.1177/1460458218824711. Epub 2019 Jan 29. PMID: 30693818.

[30] Vakadkar K, Purkayastha D, Krishnan D. Detection of Autism Spectrum Disorder in Children Using Machine Learning Techniques. SN Comput Sci. 2021;2(5):386. doi: 10.1007/s42979-021-00776-5. Epub 2021 Jul 22. PMID: 34316724; PMCID: PMC8296830.