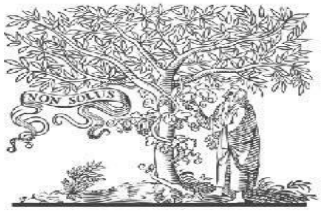
International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org

COPY RIGHT



ELSEVIER SSRN

IJIEMR Transactions, online available on 05th Apr 2023. Link :http://www.ijiemr.org/downloads.php?vol=Volume-12&issue=Issue 04

10.48047/IJIEMR/V12/ISSUE 04/48

Title **A NOVEL ENSEMBLE APPROACH FOR DETECTION AUTISM IN CHILDREN**

Volume 12, ISSUE 04, Pages: 396-409

Paper Authors

Kommu Bhushanm, Prasad Rao Medida, K.Suneel Kumar, K.Srinivasa Reddy

USE THIS BARCODE TO ACCESS YOUR ONLINE PAPER

To Secure Your Paper As Per UGC Guidelines We Are Providing A Electronic Bar Code

International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org

A Novel Ensemble Approach for Detection autism in Children.

Kommu Bhushanm[1], Assistant Professor, Department of IT,
Kallam Haranadha Reddy Institute of Technology, Chowdavaram, Guntur Dt., Andhra Pradesh

Prasad Rao Medida[2], **K.Suneel Kumar[3]**, **K.Srinivasa Reddy[4]**.
[2,3,4] Assistant Professors, Department of CSE,
Kallam Haranadha Reddy Institute of Technology, Chowdavaram, Guntur Dt., Andhra Pradesh
[1] **bhushanamkommu@gmail.com**, [2] **prasads1240@gmail.com**,
[3]**sunielkumar1219@gmail.com**, [4] **reddysrinu32@gmail.com.**

Abstract

ASD is a common condition that affects 1 in 44 people, according to the Centres for Disease Control and Prevention (CDC). A lot of suffering occurs during this illness for both the children's parents. So early detection of disease is an immediate requirement. Many papers have been published with approaches involving image, video, emotions, face to face interaction, web browsing, social interaction and gaze and demographic studies. The use of eye-tracking technology, machine learning, and other diagnostic methods is currently used to assess early-onset ASD. Now, subjective criteria rather than objective ones are used to assess ASDs. There is evidence to support the idea that combining eye-tracking and machine learning could be a helpful tool in the early and accurate diagnosis of autism. This review paper intends to focus on all such research contributions and bring out a new methodology for early detection of ASD in children. The study reveals that video-based study has been effective with 92% accuracy.

Keywords: Machine Learning, ASD, Autism, Assessment, Classification, Eye Tracking, Types of Study, Eye Movement Metrics.

I. Introduction

Autism Spectrum Disorder being one of the notable neuro developmental disorders those results in cognitive impairments in children is to be concentrated. Over the past few decades, the presence of autism and its related spectrum of disorders did not take a major concern comparatively to the present. This is due to the fact that individuals in rural regions are less familiar with the causes, contributing factors, and communicational and behavioral changes seen in children with ASD.ASD is Independent on any racial, ethnicity, socio-economic categories, etc., that can occur in anyone. This is purely due to the developmental delay experienced by the children as part of their altered neurodevelopmental

functioning. Along the autism spectrum, there are three main groups of illnesses. There are three of them: Asperger's Syndrome (AS), Autism Spectrum Disorder (ASD), and Pervasive Developmental Disorder (PDD) as discussed by Bone et al. [21]. Though the disorders are varied over names, the disabilities on the spectrum are classified based on the levels of autism functioning. The most similar disabilities of the system include sensory, communicational, social, behavioral activities and motor activities and skills. The features of the basic sort of the disorders are as follows:

Asperger's syndrome (AS): The children having great difficulty in creating interests and relatedness with narrow scope of interest fall under the category of autism spectrum. They possess minimized non-verbal problems but will be good in verbal and communication abilities.

Autistic Disorder (AD): The children having severe verbal and nonverbal communication difficulty along with the unusual behaviour in their daily routine will fall under the (CNS) category of AD. these nonverbal and unusual behaviour stands as a key point in screening kids with autism.

PDD-NOS or Pervasive Developmental Disorder-Not Otherwise Specified: The children having delayed development in social and communication skills will be categorised as PDD. The children with PDD characteristic and who do not fall under any other category of the disability spectrum are PDD-NOS.Other conditions connected to the autism spectrum include hyperlexia, semantic pragmatic communication disorder (SPCD), nonverbal learning disabilities, and attention deficit hyperactivity disorder (ADHD).

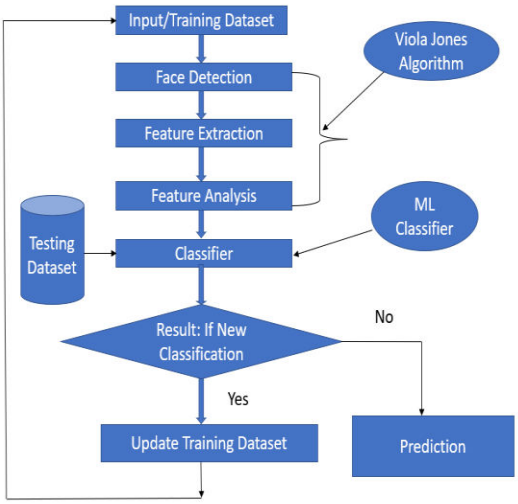


Fig.1: Model of Autism Spectrum Disorder

II. Characteristics and features

Numerous challenges, including low vision clarity, communication difficulties, repetitive behaviour, insecure emotions, sensory issues, uninterested behaviour, etc. are linked to ASD as discussed by Constantino & Marrus [22]. The common characteristics and features of the disability spectrum analyzed by various researchers are discussed as follows:

Impaired Social Communication

Autism is characterized by impaired social communication and relationship that make them fail to engage themselves with the society. This results in abnormal comfort seeking towards their parents and completely become dependent on the sameness of person and even objects.

Non-Responsive Nature

As a cause of sensory development disability, the autistic child neglects the surrounding and does not consider any object they face. This avoidance makes them non responsive in nature even to their names and remains detached from the environment. This in turn will make them expression free by continuously exploring themselves neutral was analyzed by Stagg et al.[23].

Anxiety and Fear

The youngster expresses and engages in behaviors that are clearly reflective of the neurodevelopmental abnormalities. Analyzing these expressions, the response component, and their disengagement behavior might help us understand how a child's brain is developing. This analysis would contribute towards the early identification of autism. Owing to the disengagement behavior, the autistic child possesses anxiety and fear in facing new objects, persons and finds them difficult in making a positive bonding circumstance.

Inappropriate Response and Repetitive Actions

The fundamental cause of autism spectrum disease is damage done to the five sensory organs, which causes the youngsters to either underreact or overreact. It has been determined that specific instances of these abnormalities result in neutral and repetitive behaviors, respectively, which are only neurodevelopmental disorders.

Language and Communication Deficit

Owing to the sensory behavior and impairment caused in children with ASD, the child cannot respond to the fullest. The linguistic ability of the child is decreased along with pragmatic language impairments resulting in non- verbal communication and expressions as responses. The children with language deficit are found to have missing of repeated actions and repetitive behavior but a higher sign of self-exclusion and self-preventing. Including to the language deficit, the acoustic analysis of research proves varied vibration and pitch during cry, breath and moan by the children.

Eye gaze

Prospective study claims that the children with high functioning autism have decreased visual sensitivity. This visual sensitivity results in poor interpretation of social visual screen processing and responding. Many experimental researches suggest that the visual instability is owing to their altered neurodevelopmental disorder when compared to the typically developing toddlers. The eye gaze was found to have a varied pattern in their visual sight under dynamic social screen and multi-dimensional scaling screens says Schurgin et al. [24].

International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org

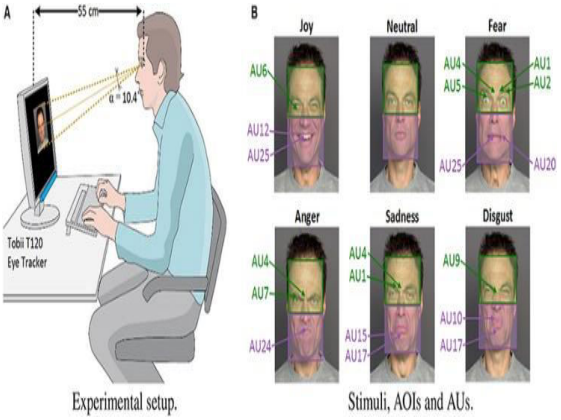


Fig. 2: Eye Tracking Setup and Examples of Stimuli Images

III. Indian Autism

According to the Autism Society of India, the prevalence of autism in India has increased over time. Numerous researchers in India are focusing on detection, along with basic biomarkers and appropriate counselling, even if it appears that the causes of this autism are still being investigated [25]. Additionally, there are no specific social, community, or population research in India that could reveal the precise predominance of the autism spectrum. According to numerous studies and polls, it took parents a long time to match their child's characteristics at an earlier developmental stage with the autistic character.

Insufficient understanding of autism and its different observational traits, as well as a lack of granular examination of their children's characteristics, are to blame for this. Most of the individual in our country with ASD are still not diagnosed properly and majority live a life of ignorance, deprivation and non-acceptance nature of the disability says Juneja et al. [25]. The social acceptance of the disability, poor infrastructure for screening and diagnosis, minimal power of handling and training such students are destitute as a result of late diagnosis of autism in India. Owing to these barriers, the Indian government and many researches strive hard to repair the gap of such a late realization of autistic feature through improvised techniques that supports the parental and clinical experts' community.

It is analyzed and observed in the autism research, that the exploring neurodevelopmental disorder could be identified in children at an early stage. The early stage corresponds to the identification and realization of the mother, family members and sensing their regular living environment. This could also be identified with the steadiness maintained in their head at an age of 3 months. Owing to these reasons, there has always been a thrust in finding of such neurodevelopmental disorder at its very initial stage says Somogyi et al. [26]. The current diagnosis of autism is made through explicit dyads over a series of iterations. Such early identification through improved assessments and diagnosis prodigy could support the parents and clinicians to make micro analysis in the children. The major driving force for the early identification of autism is that the mother could identify the abnormal behaviour in the child during breast feeding through the contact with eyes and the expression possessed by the child was initiated by Young et al. [27]. This scenario indicates that the symptoms

International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org

are shown by the age of 3 to 6 months on an average. The research focuses on supporting such early intervention through the expression and movement of the children during their developmental stage.

The greatest challenges in the health care domain is the huge population it has to cater to, which is further compounded by the problem of lack of sufficiently trained doctors. Because of this, researchers are struggling to improve the overall efficiency of healthcare system such as reducing healthcare cost, quality of healthcare etc. The majority of today's techniques employ machine learning (ML) in healthcare domain to provide assistance to the physicians in various ways. ML reduces healthcare cost and improves services and treatment quality. ML techniques are used to solve prognostic problems, various human behavioural problems and mental health problems. ML tools are used in medicine to improve the children care.

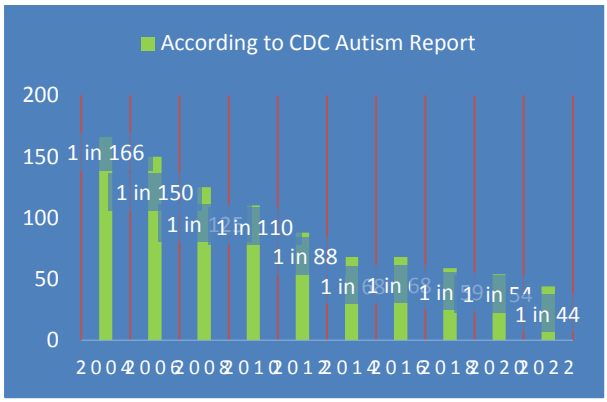


Fig. 3: According to Centre for Disease Control in ASD Statistics

IV. Literature Survey

[1] Fadhel, Zainab M et al:(2022) suggested concentrating on utilizing a classification model in machine learning with specialized implementations of the Support Vector Machine Approach to detect autism spectrum disorder in children. Two of the techniques utilized in this article for diagnosis are the DhiQar Autism Center of the Iraqi Ministry of Health and a typical data set for children from the Kaggle website. There are also classifiers and predictions. With the aid of vector machines and the computer vision technique, an accuracy of 89% has been reached. The limitations or research gaps in the research manuscript is focusing on the single data set from one medical Centre. It can be elevated to multiple data sets from multiple locations or regions.

[2] A. Kaliukhovich, Dzmitry A et al:(2021have suggested a technique for identifying children and people with autism spectrum condition who exhibit a visual preference for biological motion. It was found that there are several features of biological motion and ocular motions that differ between those with TD and those who have ASD. computed the subsequent eye movement metrics. As these percentage of total valid time, percentage of preferred biological motion, The percentage of time where biological motion was the initial fixation Average fixation time for biological (nonbiological) motion is measured in milliseconds (msec) (across all videos) time. The limitations or research gaps in the research manuscript

is the limited number of TD participants with multiple number of ASD participants. Particularly, the TD group lacked IQ tests, which restricts conclusions about how IQ affects performance. Since there was no intervention in this study, it was unable to gauge how receptive the characteristics that distinguish between the ASD and TD groups are to change. Future research is necessary to ascertain whether intervention can raise attention to biological motion.

[3] Vabalas, Andrius et al:(2020) An investigation into the use of machine learning to forecast the diagnosis of autism looked at the physical and ocular movement parameters of such a moving imitating task. Using motion and eye tracking data from a movement imitation task in conjunction with supervised machine learning approaches, 22 autistic and 22 non-autistic people were identified in this study. They created models that could predict a diagnosis with a 73 percent accuracy based on kinetic data, a 70 percent accuracy based on eye movement features, and a 78 percent accuracy based on combined features. The study used three feature selection methods: ensemble, t-test with bagging, and wrapped t-test.However, the study only made use of a small amount of data. When copying unusual movement kinematics, autistic persons typically fail while non-autistic people frequently succeed.

[4] Yaneva, Victoria et al:(2020) have a study using eye tracking to examine the visual processing disparities between high-functioning autistic individuals and non-autistic individuals. The data were collected from 71 distinct people in total (31 with ASD and 40 controls), and they were preserved for 68 different participants (28 ASD and 32 Control). Browse and search activities were included in Study 1, while Study 2 also included browsing and synthesis activities. The study uses both a generic technique and a page-specific approach to define the AOIs. Both strategies are organized and replicable with other web sites. Logistic Regression algorithm used for classification. The limitations or research gaps in the research manuscript is Tasks are often unsuitable for children and relatively small number of participants. Despite being more sophisticated, the Synthesis job did not produce a classification accuracy that was higher than the Search task.

[5] Kanhirakadavath, Mujeeb Rahman et al:(2022) have proposed on Autism prediction using classification models in Machine learning and Conventional Neural Networks. In place of the 1-dimensional gaze time series information utilized in previous studies, the two-dimensional gaze scan path (ETSP) images employed in this study are used instead. Deep neural networks (DNN), decision trees (BDT), decision jungles (DJ), and deep support vector machines (DSVM) are the main classifiers in this

work. Area under the ROC curve (AUC), specificity, sensitivity, positive predictive value (PPV), and negative predictive value are used to assess the model's performance (NPV). Only a few open-access ET datasets are available, which represents one of the manuscript's weaknesses or research needs. Instead of using a single test from a broad sample, they mix several ETSP images from a small group of subjects, rendering them inappropriate for accurate ASD screening. The accuracy of the suggested ASD screening method depends on the caliber and reliability of the training data.

[6] Goodwin, Sarah, et al:(2022) have suggested an approach to explore gaze patterns and behaviors using visual eye-tracking analytics. The current system could make it possible to analyze eye-tracking data more effectively through interactive exploration, allowing comparisons between various individuals or situations and improving the way complex data analysis is presented to non-experts. The research contributes three things: (1) a study of a use case for inspiration that highlights the requirement for sophisticated visual analytics workflow tools for eye-tracking data; (2) a very dynamic method to visually explore and present intricate eye-tracking data; and (3) Findings from our user interviews and applied use case evaluation that highlight the system's and visual analytics' potential for the greater eye-tracking community. The limitations or research gaps in the research manuscript is users who wear contact lenses or have long eyelashes are ineligible. Before it produces findings that are good, it needs some calibration time.

[7] Rafee, Sameer et al:(2022) have a study on Kalman Filter and Deep Learning Techniques to analyze and predict eye movements. In this study, a technique for forecasting and analyzing eye movements was proposed. a real-time eye- movement analysis system that uses deep learning methods like CNN and the Kalman filter to reliably estimate eye motions. According to the results, the proposed method did a decent job of classifying and predicting eye movements. The study publication has several restrictions or research gaps because it only tests and evaluates a small number of deep learning approaches. Eye movement prediction can be done using a variety of simple techniques.

[8] The study of Amrita Budarapu, Nara Kalyani et al:(2021) on using the ensemble classification method to screen for autism in children. The study suggests a strategy that enhances the accuracy of identifying autistic characteristics in kids utilizing face photographs recognizing the children's expressions based on a live video screening of viewers' emotional responses and eye contact. To assess the effectiveness of the created model, machine learning measures like AUC-ROC curves, sensitivity, and specificity are employed. The algorithm is around 84 percentage points more accurate in classifying the positive emotions, such as

surprise and happiness, than the negative ones, such as contempt and fear. Simultaneously, The child's eye gaze is observed to determine their level of concentration, which is expected to be approximately 65%. The limitations or research gaps in the manuscript is authors only test the dataset from Kaggle.

[9] Kathan Vyas, Rui Ma et al:(2019) have put out a technique for diagnosing autism from videos that uses pose estimation over time to identify usual behavior. The study introduced a novel method for categorizing behaviors that makes use of latent low-level data, such as changes in body position across time. They did begin by retraining a cutting-edge given our manually annotated children's pose dataset, a human pose estimator to predict in every video frame, youngsters are posed. Finally, to distinguish between typical and atypical behaviors, on the representations of posture and motion, a binary classification network is trained. Obtain a classification accuracy of 72.4 percentage on the test dataset in this study (precision=0.72 and recall=0.92). The PoTion Representation, which only works with 2D trajectories, is one of the manuscript's limitations.

[10] Abigail Bangerter1, Meenakshi Chatterjee et al:(2020) have examined how people with ASD react to hilarious movies to a TD group in an effort to discover a useful clinical response variable for diagnosis. As expected, the ASD group displayed a generally decreased positive facial expression when watching humorous movies. The authors looked for differences between the ASD and TD groups as well as within the ASD group in terms of evidence of facial action unit (AU) activation connected to the display of a grin or other positive facial emotion. Limited TD dataset compared to ASD dataset are the research manuscript's shortcomings or research gaps. Positive feelings can still be expressed through positive facial expressions, even in those with ASD.

[11] Natalia I Vargas-Cuentas ,Avid Roman-Gonzalezet al:(2017) studied on the creation of a method for eye tracking has been examined as a prospective method for diagnosing ASD in children early. As a foundation for the prospective validation of a low-cost ASD potential screening tool, the authors created a straightforward eye-tracking algorithm that doesn't require head holding or calibration. Eight children with a clinical diagnosis of ASD and 23 children without a history of the disorder underwent examination. The child's eye movement in the recorded video was analyzed manually and automatically by an observer and an algorithm, respectively. The weaknesses or research gaps in the research paper prevent comparison of the importance of the location of social and abstract contexts. Another problem with this inquiry is that there can be differences between the algorithm results and the manual results.

[12] Le An Ha, Victoria Yaneva, and others: (2018) have shown a series of

studies in which classifiers were trained to identify between individuals with and without autism using info from two websites related to activities. As a result of the bigger between-group differences that the Search task produced, the classifier trained on this data attained an accuracy of 0.75 as opposed to 0.71 for the Browse task, according to the results by gathering data from generic AOIs (2 2 grid) and page-specific AOIs, two different situations. The study additionally investigated effects of various methods for designating the interest areas. Visual activities that would produce significant between-group differences in the data collected are the study manuscript's limitations or research gaps. The inability of web search activities to be used by infants and toddlers, for whom Early autism diagnosis would be most effective beneficial, is another drawback of study.

[13] Liaqat et al. (2021) examined using the STAR-FC synthetic saccade methodology. The data was fed into a deep learning classifier, which then fed either an RNN or CNN utilizing a series of fixation patterns and an image-based method. Regarding precision and AUC, image-based methods performed marginally better than synthetic saccade methods. Both the test dataset (62 percentage) and the validation dataset (67 percentage) had a comparatively high prediction accuracy. The small amount of data in this study is one of its weaknesses.

[14]Zhong Zhao et al[2021] during a face-to-face dialogue, a strategy was put forth regarding the oculomotor performance in kids with autism spectrum disorder (ASD). The eye movements of 23 children with typical development and 20 children with ASD were captured by a face imaging system. On the amount and randomness of eye movement, group comparisons were made. The study manuscript's restrictions or research gaps are there was no difference in the interviewer's quantity of movement between groups, according to statistical analysis. Uncontrolled variables included background distractions and the interviewer's interactive style.

[15]Shuntaro Fukushima et al [2021] examined the viability of utilizing Gazunder on infants between the ages of 4 and 11 months. In measurements made with this equipment, with pre-recorded eye movements of infants under a year old, the author focuses on confirming the equivalence. All sequences' average fixation length percentage 81, did not significantly differ between the four age groups. At all age categories, the requirement of "50 percentage or more" was satisfied. Finally, it was established that joint attention abilities improved in line with their developmental process. The study's weaknesses include its restricted geographic scope. As a result, the study's statistics were incorrectly represented children having TD.

[16] Kirana, Kartika Candra, Slamet Wibawanto et al [2018] have contrasted the performance of the Fisher Face-based

Haar cascade classifier and the original Haar cascade classifier for the identification of facial emotions. The findings reveal that the suggested technique achieves 0.82, 0.78, 0.84, and 1 fps while the traditional Haar cascade classifier only manages accuracy, precision, recall, and time up to 0.78, 0.77, 0.80, and 15 fps, respectively. The algorithm is 15 times slower than the original Haar cascade classifier which is the study's shortcoming. Windows are still moved in the traditional manner from left to right.

[17] Dhanyatha Sriram, Greeshma A et al[2021] have evaluated prediction of ASD based on Random Forest, Naive Bayes (NB), Decision Tree, K-Nearest-Neighbor (KNN), Logistic Regression (LR) and Support Vector Machine (SVM) tested on dataset consists of 22 attributes and 1100 instances. The output of the dataset consists of two values i.e., value 1 is YES, “person has ASD” (393 instances), value 2 is NO, “Not having ASD” (707 instances). The limitations in the research manuscript is the limited dataset.

[18] Erina S, Elly M et al [2020] The ASD was categorized using ML and Deep Learning. There are 292 participants in the Children ASD dataset, 49 of them have ASD and 243 do not. dataset on adolescents with ASD includes 104 participants 63 with ASD and 41 without it. The effectiveness of the various classification algorithms was evaluated. The Random Forest algorithm with full features, when compared to other algorithms, is the best algorithm for identifying ASD in children and adolescents based on its specificity and sensitivity values. The algorithms with the highest precision, recall rate, specificity, and sensitivity were used in this investigation. Compared to the other algorithms, the Random Forest algorithm has the best performance. The small dataset is one of this study's drawbacks.

[19] Tania Akter, Md. Shaihaire Satu et al [2019] have created machine learning-based models for detecting autism spectrum diseases in their early stages. They used a variety of feature transformation techniques, such as log, Z-score, and sine functions, on ASD datasets pertaining to toddlers, kids, teens, and adults. In this article SVM fared best on the dataset for toddlers, followed by Adaboost on the dataset for kids, Glmboost on the dataset for teenagers, and Adaboost on the dataset for adults. Accuracy, kappa statistics, sensitivity, specificity, and log loss are some of the measures that were analyzed. The study's shortcomings are that some of the classifiers, despite having high accuracy, provided biased findings for these datasets, which prevented them from producing consistently favourable results.

[20] A study by Suman raj, Sarfa raj et al [2019] There is information available on the analysis and detection of ASD using techniques such as Naive Bayes, Support vector machines, Logistic Regression, neural networks, and convolutional

neural networks. The UCI Repository, which is open to the public, is where the data were gathered. The results strongly imply that Convolution neural simulations perform better than all test classifiers, with great precision for autism spectrum screening of 99%, 98.6%, and 96% for information for adults, toddlers, and adults, respectively. The dataset is non-clinical and small, which is a shortcoming of this research publication. Limited dataset is drawback of study.

V. Discussion

Autism Spectrum Disorder (ASD) is a social communicational and behavioural disorder. ASD depends on different factors like genetics, environmental, and various biological factors. Diagnosis of ASD is difficult, since some ASD symptoms are reliant on how a child responds to cognitive functioning, and sometimes it is difficult to tell the difference between very little non-autistic children and autistic children. Meanwhile, the quality of life has been improved by the use of wearable sensing technology for the patients with chronic disease. Mobile computing helps the patients by communicating their details of laboratories reports. The continuous monitoring of the patients during any therapies is very important for further decision making. This technology also helps in observing the impact of stress in the mental condition due to their daily activities [8].

Embedded smartphone with the sensing device helps easy monitoring of different physical and mental behaviours of the children. The social interactions are also measured through it for testing human behaviour and their mental status in autistic children. Currently, Machine Learning techniques are mostly used in the healthcare industry to help physicians in a variety of ways. The traditional papers analyzing Autism from the collected datasets are having missing data. In some cases, the authors are managing missing data and sometime deleting the datasets which are having the missing data. It is also observed that some of the authors (Thabtah, Fadi, et al[28]) have achieved good accuracy in the detection of ASD, where the datasets are fully organized (labelled datasets) and carefully collected from the parents who were aware of the Autism.

However, these types of models are not suitable for the rural areas because parents of autistic children in rural locations are not fully informed about the behaviors and activities associated with autism. The parents often hesitate and hide the symptoms of their child due to privacy. It makes them unable to express all the symptoms of their child to the doctor, which leads to improper diagnosis. Diagnosis with insufficient number of symptoms may lead to improper treatment of the children. Finding the particular type of Autism from only one or two symptoms is very difficult. Autism research is important for both those who have ASD and those in whom the symptoms may be prevented.

However, research on ASD is essential to comprehending the broader class of neurodevelopmental disorders. As children disabilities shift from the category of physical to the category of behavioral and neurological, there are undoubtedly some similarities in the aetiologias and treatments of the disorders.

VI. Conclusion

We have thoroughly reviewed all such research contributions that detects ASD in children. A comparison is made among all such research contributions for better understanding. The review reveals that video-based ASD detection has been moreeffective with 92% accuracy. We will propose a new methodology for early detection of ASD in children in near future. This study includes 20 publications from 2015 that discuss algorithms and gaze autism investigations. Due to the fact that each of the aforementioned research used different tasks, datasets, algorithms, eye-tracking technology, and had different goals, it is challenging to compare the results of all of them.

REFERENCES

[1] Fadhel, Zainab M., and Qasim M. Hussein. "Detecting autism spectrum disorder in children using eye tracking and machine learning." 2022 International Congress on Human-Computer Interaction, Optimization and Robotic Applications (HORA). IEEE, 2022.

[2] A.Kaliukhovich, Dzmitry A., et al. "Visual preference for biological motion in children and adults with autism spectrum disorder: an eye-tracking study." Journal of Autism and Developmental Disorders 51.7 (2021): 2369-2380.

[3] Vabalas, Andrius, et al. "Applying machine learning to kinematic and eye movement features of a movement imitation task to predict autism diagnosis." Scientific reports 10.1 (2020): 1-13.

[4] Yaneva, Victoria, et al. "Detecting high-functioning autism in adults using eye tracking and machine learning." IEEE Transactions on Neural Systems and Rehabilitation Engineering 28.6 (2020): 1254-1261.Goodwin, Sarah, et al. "VETA: Visual eye-tracking analytics for the exploration of gaze patterns and behaviors." Visual Informatics 6.2 (2022): 1-13.

[5] Kanhirakadavath, Mujeeb Rahman, and Monica Subashini Mohan Chandran. "Investigation of Eye-Tracking Scan Path as a Biomarker for Autism Screening Using Machine Learning Algorithms." Diagnostics 12.2 (2022): 518.

[6] Goodwin, Sarah, et al. "VETA: Visual eye-tracking analytics for the exploration of gaze patterns and behaviors." Visual Informatics 6.2 (2022): 1-13.

[7] Rafee, Sameer, et al. "Eye-movement Analysis and Prediction using Deep Learning Techniques and Kalman Filter." International Journal of Advanced

Computer Science and Applications 13.4 (2022).

[8] A. Budarapu, N. Kalyani and S. Maddala, "Early Screening of Autism among Children Using Ensemble Classification Method," *2021 3rd International Conference on Advances in Computing, Communication Control and Networking (ICAC3N),* 2021, pp. 162-169, doi:10.1109/ICAC3N53548.2021.9725586.

[9] Kathan Vyas, Rui Ma Recognition of Atypical Behavior in Autism Diagnosis from Video Using Pose Estimation Over Time. October 2019 DOI:10.1109/MLSP.2019.8918863.

[10] Abigail Bangerter1, Meenakshi Chatterjee on Automated recognition of spontaneous facial expression in individuals with autism spectrum disorder: parsing response variability. Bangerter et al. Molecular Autism (2020) 11:31 https://doi.org/10.1186/s13229-020-00327.

[11] Natalia I Vargas-Cuentas ,Avid Roman-Gonzalez on Developing an eye-tracking algorithm as a potential tool for early diagnosis of autism spectrum disorder in children. 2017 Nov 30;12(11): e0188826. Doi:10.1371/journal.pone.018826.

[12] Victoria Yaneva, Le An Ha (2018) detecting autism based on eye tracking data from web searching tasks. DOI: 10.1145/3192714.3192819.

[13] Liaqat, Gregory Young Predicting ASD diagnosis in children with synthetic and image-based eye gaze data. (2021).

[14] Zhao Z, Xing J, Zhang X Random and Short-Term Excessive Eye Movement in Children with Autism During Face-to-Face Conversation.Journal of Autism and Developmental Disorders (2022) 52:3699–3710 https://doi.org/10.1007/s10803-021-05255-7.

[15] Shuntaro Fukushima, Tomo Takahashi The feasibility of Gaze finder under 12 months of age infants. Scientific Reports(2021)11:10009,https://doi.org/10.1038/s41598-021-89585-7.

[16] Kirana, Kartika Candra, Slamet Wibawanto, and Heru Wahyu Herwanto. "Emotion recognition using fisher face-based viola-jones algorithm." 2018 5th International Conference on Electrical Engineering, Computer Science and Informatics (EECSI). IEEE, 2018.

[17] Dhanyatha Sriram1, Greeshma A2 Prediction of Autism Spectrum Disorder based on Machine Learning Approach. Volume: 08 Issue: 07 | July 2021e-ISSN: 2395-0056 .

[18] Comparison of Machine Learning Algorithms for Autism Spectrum Disorder Classification Erina S. Dewi1, Elly M.

[19] Tania Akter, Md. Shaihaire Satu Machine learning based models for early-stage detection of autism spectrum disorders. Digital Object Identifier

10.1109/ACCESS.2019.2952609 IEEE Access.

[20] Suman raj,Sarfa raj on Analysis and detection of Autism spectrum disorders using Machine learning Techniques. Procedia Computer Science 167 (2020) 994–1004.

[21] Bone, D, Lee, C-C, Black, MP, Williams, ME, Lee, S, Levitt, P & Narayanan, S 2014, 'The psychologist as an interlocutor in autism spectrum disorder assessment: Insights from a study of spontaneous prosody', Journal of Speech, Language, and Hearing Research, vol. 57, no. 4, pp. 1162-1177.

[22] Constantino, JN &Marrus, N 2017, 'The early origins of autism', Child and Adolescent Psychiatric Clinics, vol. 26, no. 3, pp. 555-570.

[23] Stagg, SD, Slavny, R, Hand, C, Cardoso, A & Smith, P 2014, 'Does facial expressivity count? How typically developing children respond initially to children with autism', Autism, vol. 18, no. 6, pp. 704-711.

[24] Schurgin, M, Nelson, J, Iida, S, Ohira, H, Chiao, J &Franconeri, S 2014, 'Eye movements during emotion recognition in faces', Journal of vision, vol. 14, no. 13, pp. 14-14.

[25]Juneja, M, Sharma, S & Mukherjee, SB 2010, 'Sensitivity of the autism behavior checklist in Indian autistic children', Journal of Developmental & Behavioral Pediatrics, vol. 31, no. 1, pp. 48-49.

[26] Somogyi, E, Kapitány, E, Kenyeres, K, Donauer, N, Fagard, J &Kónya, A 2016, 'Visual feedback increases postural stability in children with autism spectrum disorder', Research in Autism Spectrum Disorders, vol. 29, pp. 48-56.

[27] Young, RL, Brewer, N & Pattison, C 2003, 'Parental identification of early behavioural abnormalities in children with autistic disorder', Autism, vol. 7, no. 2, pp. 125-143.

[28] Thabtah F, Peebles D. A new machine learning model based on induction of rules for autism detection. Health Informatics Journal. 2020;26(1):264-286. doi:10.1177/1460458218824711.