International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 11 Issue 04, April-2022

Autism Diagnosis Tool using Machine Learning

Maria Sofia S[1], Nithin Mohanan[2], Jomiya Joju C[3]
Department of Computer Science,
St. Thomas College (Autonomous), Thrissur

***Abstract* – Autism spectrum disorder is a neurological developmental disability that hampers normal brain development, affecting communication, social interaction, cognition, and behavior. Autism is a lifelong condition with no cure and there is no single medical test like a blood test for diagnosing autism but a set of specific evaluations and assessments to confirm the condition and hence can help the child learn the necessary skills to improve the quality of their life. But the cost of such assessments can be quite expensive. Families with autistic children often face a huge financial burden. This project makes an effort to design an automated system for autism diagnosis using machine learning techniques. It helps the doctor in complications, provides access for children and families to such practical assessments of diagnosis as financial help and also allowing it to be used in poor remote communities where there is a lack of specialists to diagnose autism in younger children, in which clinical symptoms are not evident. The system consists of three modules: (1) Detecting autism symptoms using Eye-tracking (2) Detection of Facial expressions (3) Prediction using Questionnaire.**

Keywords: Autism Spectrum Disorder (ASD), CARS, Computer Vision, OpenCV, Image Processing, Deep Learning, CNN, SVM, KNN, Haar Cascade Classifier

I. INTRODUCTION

Autism Spectrum Disorder is a neurodevelopmental disorder in which the patients find difficulties in social deficits of communication, interaction and imagination. ASD is a permanent problem which affects a large percentage of the population. But early diagnosis and intensive intervention can help to optimize the outcome of therapy especially in children. Yet diagnosis of ASD is a multifaceted problem. It requires specialist medical expertise with instruments that depends on interpretive enciphering of child observations, parent interviews and manual testing.

There is no specialized test like blood test, medical test that can be used to diagnose ASD. Therefore, diagnosis is quite a challenging task. Doctors explore the child's developmental history and behavioral patterns to make a diagnosis. A few of the assessment tools include physical and nervous system (neurological) test, Autism Diagnostic Interview – Revised (ADI – R), Autism Diagnostic Observation Schedule (ADOS), Childhood Autism Rating Scale (CARS) etc. ASD can sometimes be detected at an early age of 18 months or younger. By the age 2, the diagnosis carried out by an expert can be counted reliable. But most of the children do receive the final diagnosis until they are grown up. This delay will lead to loss of early help that is extremely important. Early signs of autism comprise eluding eye contact, having little interest in other people, limited language development capability or getting upset by minor changes in daily routine.

Normally autism diagnosis is a costly procedure which produces a financial burden on middle class families. Hence this project aims to put forward a cost-effective system that will help both parents and doctors. The system consists of 3 modules: detecting autism symptoms using eye tracking of the subject, analysing their facial expressions, and predicting autism through questionnaire system.

Now a days machine learning applications are gaining more and more importance in several sectors like medicine, engineering and science. Manual analysis and diagnosis system can be greatly improved by the use of these techniques. In eye tracking module, OpenCV library is used for tracking eye of the subject. In facial expression detection module, deep learning algorithm Convolutional Neural Networks is used for identifying facial expressions. In questionnaire system, Machine Learning algorithm KNN is used for prediction.

II. PROBLEM DEFINITION AND METHODOLOGY

A. Problem Definition

Autism Spectrum Disorder is characterized by challenges with social communication and interaction and by restricted, repetitive patterns of behavior, interests or activities. These symptoms become evident in early childhood. Though there is no treatment for autism, doctors use different assessment tools for diagnosis and provide behavioral therapies that helps in the step by step improvement of the child. But these assessments are quite expensive and may cause huge financial burden on the families of autistic children. Also, these expenses do not come under the coverage of any insurance companies. Furthermore, some individuals view autism as a shame and they are typically hesitant to seek medical help. Another issue is scarcity of specialized doctors in poor distant communities. Because standardized diagnosis is a time consuming and costly procedure, it is now time to devise a supportive system that aids doctors in dealing with complications and provide children and families access to practical diagnosis assessment as financial assistance and entry into intervention. So, this project designs a cost-effective automated system for autism diagnosis using machine learning techniques.

B. Objectives

The major objective is to create a cost-effective system that includes automatic and analytic tools for children's autism diagnosis. The system contains an ADI – R based questionnaire tools for parents or caregivers that focuses on child's developmental history and an ADOS based observatory system that focuses on the behaviors of autistic patients such as eye movements and facial expressions.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 11 Issue 04, April-2022

C. Motivation

One out of 160 children are estimated to have Autism Spectrum Disorder (ASD). ASD usually start in childhood and tend to persist into adolescence and adulthood. While some persons with ASD are able to live independently, others have significant disabilities that necessitate life long care and support.

Evidence-based psychosocial therapies, such as behavioral skills and parent training programmes, can help in reducing the challenges in communication and social behavior, with a positive impact on wellbeing and quality of life for persons with ASD and their caregivers. Interventions for people with ASD must be complemented by broader efforts to improve accessibility, inclusion and support in physical, social and mental environments. People with ASD are frequently subjected to stigma, discrimination and human rights violations. Globally, access to services and support for people with ASD is insufficient. Majority of the children were diagnosed at the age of four, despite the fact that autism can reliably be detected at an early age of two. Minority populations are diagnosed later and less often than others. Early intervention can provide help to support healthy development and deliver assistances for lifespan.

In a recent survey of pediatricians, it was discovered that many of them lacked sufficient information to appropriately diagnose children with ASD. ASD diagnosis can be obvious in some case and ambiguous in other cases. However, associated strengths and weaknesses need further investigation. Where there is intellectual disability, examining metabolic and genetic causes is important. A complete assessment may include physical tests, genetic and other blood tests, and brain scans and complete family and developmental history, assessment of parent-child relationships and family dynamics, similar assessment of child's school experience, psychometric, speech and language testing, structured testing such as ADOS, and hearing testing if needed. Following a thorough evaluation and correct diagnosis, most beneficial and cost-effective support for the child, parents and school can be provided. Such precision necessitates time and evaluation across a variety of contexts.

D. Methodology

The Childhood Autism Rating Scale (CARS) has been used for autism diagnosis. CARS differs from other behavioral rating assessments in that it can determine whether your child has autism or other developmental delay illnesses such as mental retardation.

The proposed project consists of three modules:

1) *Detection of Autism using eye tracking:* People with ASD don't know how to make eye contact. Based on this symptom of autism, this project implements an eye tracking system of subjects. Eye tracking is a process of identifying the point of gaze or motion of eye relative to their head. An eye tracker is a device for measuring the eye movements and eye positions. We use two benchmarks for tracking eyes
    a. Time of attentive looking
    b. Position of looking (Center, Left, Right)

To measure these, we setup a counter. The tracker displays the value of where the person is looking to the screen. If a person is not looking at the centre of the screen for a finite amount of time, then we can diagnose an autistic patient.

To identify location of eye in the tracker we take pixel locations from total pixel area. Using coordinates of pixel x and y, we identify whether the person looks to left, right or centre. When the eye blinks, tracker doesn't show these x and y values and it displays blinking.

For proper working of tracker, the Brightness should be adjusted in the room.

Tracking done purely on logical programming. OpenCV library in Computer vision technique is used for tracking. Spyder environment is used.

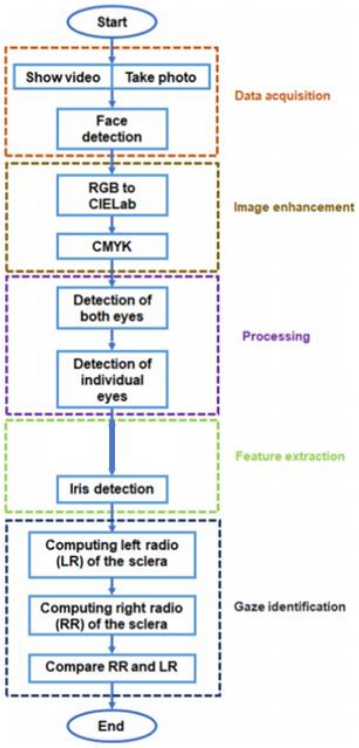

Fig 1: Workflow diagram of eye tracking system

2) *Detection of Facial Expression in Child:* Recent research has shed light on more subtle difference between children with ASD and others i.e, facial features. Scientists at the University of Missourie, discovered that children with autism shared certain common facial features. It employs emotional response module of CARS scale. The child exhibits a proper type and degree of emotional response as indicated by a change in facial expression, posture and manner.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 11 Issue 04, April-2022

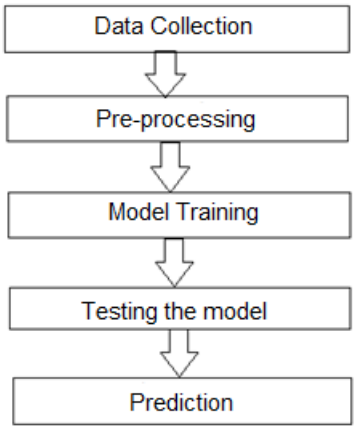

Fig 2: Workflow diagram of facial image classification

- **Data acquisition:** Dataset is taken from Kaggle. The Kaggle dataset version 5 contains 2940 photos that are evenly distributed into two categories namely: autistic and non-autistic. The photos are of different sizes but they are already cropped to reveal only the child's face. The age distribution of the dataset is around 2 to 14 years, but majority of the images are of children of age group 2 to 8 years. Gender ratios are similar to that of their respective population. Males are three times as likely, than girls to be diagnosed with autism. As a result, in the autistic class, the ratio of male to female photos is close to 3:1. The ratio in the non autistic group is substantially closer to 1:1. White children outnumber the children with colour. The ratio of white children to that with colour is 10:1. This approximates the real distribution in America which is 7:1.
- **Data pre-processing:** It is the first step for the initiation of the process. It cleans, formats and organises raw data, making it ready for the Machine Learning models to use. Certain pre-processing activities must be completed in order to prepare the image for subsequent segmentation and analysis. It includes image resizing to 256 X 256 pixels, grey-scale conversion, shuffling data, and labelling images as autistic and non-autistic with values 0 and 1 respectively. The output of pre-processing will be saved as two .npy files named data and target.
- **Model Training**
  - A. *Choose a model:* There are different algorithms for this. The deep learning algorithm CNN (Convolutional Neural Network)is used here for image classification and prediction.
  - B. *Train the model:* The purpose of training is to answer a question or make a prediction as frequently as possible. Each iteration of the process is a phase in training. First load the output files of the pre-processing step. Using Keras in Tensorflow, different layers of CNN trains the model. Following that the model is compiled and optimized using Adam optimizer. After that, in back propagation, 40 epochs were employed to get the correct training results.
  - C. *Evaluate the model:* Uses some metric or combination of metrics to "measure" the objective performance of the model. Test the model against previously unseen data.

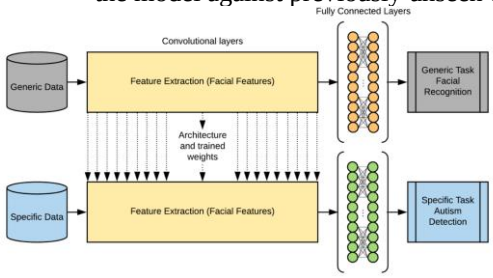

Fig 3: Algorithm model diagram

After model training got an accuracy of 72%.

- **Model Prediction:** Input data is given using live camera. When an image is given as input to the project OpenCV will do the image pre-processing. The image will be transformed into an array of integers and delivered as numpy arrays for pre-processing. The image is then converted to grayscale. HAAR feature extraction is carried out using HAAR Cacade from Cascade classifiers, and it produces a rectangular box around the human face as it detects it. The detected face is then cropped from the entire image to perform other operations. Output image will be labelled autistic or non-autistic after whole prediction process.

3) Prediction of Autism using Questionnaire

One of the most extensively used for identifying whether or not a kid has Autism Spectrum Disorder (ASD) is the Autistic Diagnostic Interview (ADIS). Along with ADOS (Autistic Diagnosis Observation Schedule), it is the diagnostic tool choice for many public school systems and psychological specialists when screening kids suspected of being in the spectrum. The Diagnostic and Statistical Manual of Mental Disorders, 5th Edition (DSM 5: American Psychiatric Association, 2013) serves as the diagnostic criteria. For diagnosing mental disorders, DSM includes symptoms, descriptions and other criteria. Among healthcare professionals DSM 5 is the standard reference for diagnosing mental and behavioral disorders including autism.

The questionnaire system obtains child's developmental history from parents or other caregivers manually. Scoring is done, based on the responses from assessment, on each of nine domains under 4 categories (communication and language, social interactions, and repetitive, restrictive behaviors). The questionnaire includes entire developmental history of the person who has been referred.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 11 Issue 04, April-2022

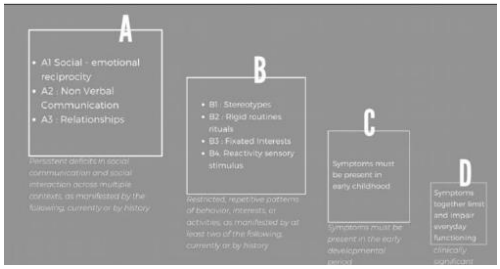

Fig 4: Categories of asssessment

- First section of the interview is used to assess the quality of social interaction and consists of questions, emotional sharing, offering and seeking comfort, social smiling and responding to other children.
- The communication and behavioral segment looks into stereotyped utterances, pronoun reversal, and social language usage. The few words or sounds the person uses most often are known as stereotyped utterances.
- Questions about unique preoccupations, hand and finger mannerisms, and odd sensory interests are included in restricted and repetitive behavior area.
- Finally, the questionnaire contains question on behaviors like self-injury, anger and over-activity, all of which might help in development of treatment plans.

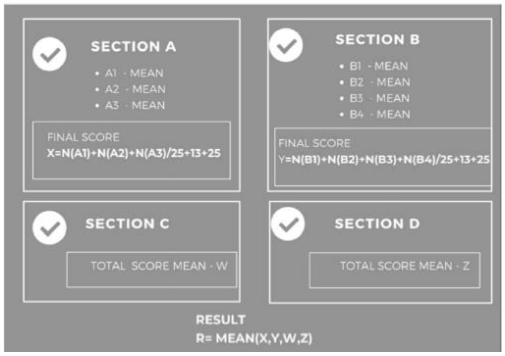

Fig 5: Score Report Model

Following the completion of the interview, system assigns a rating score to each question, based on their assessment of parent's or caregiver's response. For each of the interview's content sections, a total score is determined. The questions were more closely related to the criteria for diagnosis of Autism Spectrum Disorder (ASD) in DSM-V.

Rating Score:

- 0: "Never Seen"
- 1: "Used to be there, not any more"
- 2: "Often seen"
- 3: "Very often seen"

Dataset of toddler Autism screening test is taken from Kaggle. In this module SVM(Support Vector Machine) and KNN(K Nearest Neighbour) algorithms are used for prediction. KNN predicts autistic as 1 and non-autistic as 0. SVM predicts with 100.0 % and KNN with 99.32% accuracy.

III. LITERATURE REVIEW

Diagnosis of Autism in Children using Facial Analysis and Deep Learning by Madison Beary, Alex Hadsell, Ryan Messersmith, Mohammad-Parsa Hosseini, Department of Bioengineering, Santa Clara University—Santa Clara, CA, USA [1] proposes a deep learning model to determine whether a child is autistic or not

K. Prem Kumar, K. Murugapriya, M.R. Varsha, R. Asmitha, S. Sureka, International Journal of Innovative Technology and Exploring Engineering (IJITEE), May 2020[2] presents Emotion detection for Autism Spectrum Disorder children (ASD). It comes with python libraries Open CV, HAAR-cascade approach, and Age and gender prediction. Facial expression recognition (FER) predicts age, gender, and emotions by capturing a face in real time.

A Corpus of Text Data and Gaze Fixations from Autistic and Non-autistic Adults by Victoria Yaneva, Irina Temnikova, Ruslan Mitkov, Research Institute in Information and Language Processing, University of Wolverhampton[3] where data was elicited through reading comprehension testing combined with eye-tracking recording.

Diagnosis of autism using Eye tracking system by Natalia I. Vargas-Cuenta , Daniela Hidelgo, Avid Roman-Gonzalez ,Michel Power ,Robert H. Gilman , Mirko Zimie, Center of children with special needs – CCSN, Department of international health, school of public health, johns Hopkins university-JHU[4] proposes to detect autism in children at a first level(preclinical stage)using a tool "eye tracking" highly cost-effective and embedded in a tablet.

Machine Learning-Based Models for Early Stage Detection of Autism Spectrum Disorders,IEEE 2019 by Tania Akter, Shahriare Satu , Imran Khan, Mohammad Hanif Ali[5] which is used early-detected ASD datasets relating to toddlers, children, adolescents and adults, and applied several feature transformation methods, including log, Z-score and sine functions to these datasets. Various classification techniques were then implemented with these transformed ASD datasets and assessed for their performance. We found SVM showed the best performance for the toddler dataset, while ADABOOST gave the best results for the children dataset, GLMBOOST for the adolescent and ADABOOST for the adult datasets.

Detection of Autism Spectrum Disorder (ASD) using Machine Learning Techniques: A Review by Mamata V. Lohar1 and Suvarna S. Chorage2, International Journal of Future Generation Communication and Networking Vol. 13, No. 1, (2020)[6] presents the overview of recent studies in the semi-or fully-automatic computer-aided diagnosis of ASD and compares the parameters visualized as methods applied, classes considered, features used, criteria of assessment and results obtained. This paper also reveals the classification between ASD and TC subjects for sMRI and fMRI using the K-NN classifier for different feature sets. Using feature optimization and fusion of sMRI and fMRI images, classification efficiency can be enhanced.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 11 Issue 04, April-2022

IV. TOOLS

The project used the following tools:

- OpenCV – 3.2.0 library
- Anaconda environment
- Python programming language

V. CONCLUSION

ASD is a neurodevelopmental condition which adversely effects the lives of the people. The detection of Autism can be done at an early stage of two. But lack of cost-effective tools for diagnosis keep the families of austic children away from diagnosis and treatment. If diagnosed early their behavioral aspects can be improved to a great extent. The developed tool makes it easier and accessible to all. Using this tool, one can easily predict whether a child is autistic or not.

REFERENCES

[1] Madison Beary, Alex Hadsell, Ryan Messermith, Mohammed-Parsa Hosseini, Hamid Soltanian-Zadeh, "Diagnosis of Autism in Children using Facial Analysis and Deep Learning", Frontiers in Computational Neuroscience, January 2022.

[2] K. Premkumar, K. Murugapriya, M.R. Varsha, R.Asmitha, S. Surekha, "Facial Emotion Recognition for Autism Recognition", International Journal of Innovative Technology and Exploring Engineering, ISSN: 2278-3075 (Online), Volume-9 Issue-7, May 2020

[3] Victoria Yaneva, Irina Temnikova, Ruslan Mitkov, "A Corpus of Text Data and Gaze Fixations from Autistic and Non-autistic Adults", Proceedings of 10th International Conference on Language and Resource Evaluation, pp 480 – 487, May 2016

[4] Natalia I. Vargas-Cuentas, Daniela Hidalgo, Avid Roman-Gonzalez, Michael Power, Robert H. Gilman, Mirko Zimic, "Diagnosis of Autism using an Eye Tracking System", IEEE Global Humanitarian Technology Conference, pp. 13 – 16, October 2016.

[5] Tania Aktar, Md. Shahriare Satu, Md. Imran Khan, Md. Hanif Ali, Shahadut Uddin, Pietro Lio, Julian M.W. Quinn, Mohmmad Ali Moni, "Machine Learning-Based Models for Early Stage Detection of Autism Spectrum Disorders", IEEE Access (Volume 7), pp. 166509 – 166527, November 2019

[6] Mamata V Lohar, Suvarna S Chorage, "Detection of Autism Spectrum Disorder (ASD) using Machine Learning Techniques: A Review", International Journal of Future Generation Communication and Networking Vol. 13, pp. 426-438, 2020