2023 4th International Conference for Emerging Technology (INCET)
Belgaum, India. May 26-28, 2023

Automated Identification and Classification of Autism Spectrum Disorder using Behavioural and Visual Patterns in Children

Bhavana Yadav K
Computer Science & Engineering
PES University
Bengaluru, India
bhavanayadav7090@gmail.com

Shreya Vishwas
Computer Science & Engineering
PES University
Bengaluru, India
shreya250101@gmail.com

Nikitha Anand
Computer Science & Engineering
PES University
Bengaluru, India
nikithaanand44@gmail.com

Rishab Kashyap B S
Computer Science & Engineering
PES University
Bengaluru, India
rishab182001@gmail.com

Raghu Bangalore
Computer Science & Engineering
PES University
Bengaluru, India
raghubarao@pes.edu

2023 4th International Conference for Emerging Technology (INCET) | 979-8-3503-3575-0/23/$31.00 ©2023 IEEE | DOI: 10.1109/INCET57972.2023.10170707

***Abstract*—Autism Spectrum Disorder is a challenging developmental disorder that can lead to serious social, communication, and behavioral difficulties. The primary goal is to resolve the problems these kids are having and to help them realize that this illness does not define or restrict who you can be or place you in a superior or inferior position to others. We propose a system to detect ASD in children using two approaches viz., behavioral traits and facial images.In the behavioral trait approach, eight individual traits that have been found to be useful in diagnosing ASD patients based on controls in behavioral science are added to the ten behavioral features (AQ-10-Child) that have been approved by the National Institute of Health Research (NHS) in the behavioral trait approach. In the facial recognition approach, the images of the children are used and pass them into the pre-trained CNN EfficientNet model which detects the presence of autism. Finally, we integrate these machine learning models into a fully functional website which will act as a link between the users and the admin team.**

***Index Terms*—EfficientNet, Vision Transformer, Keypoint detection, Facial recognition, (ASD-Autism Spectrum Disorder, ML-Machine Learning, CNN-Convolutional Neural Network , SVM-Support Vector Machine, KNN-K Nearest Neighbour, WHO-World Health Organization)**

I. INTRODUCTION

Autism Spectrum Disorder is a complicated developmental disorder which is caused by differences in the brain that can cause significant social, communication and behavioral challenges. It might be difficult to diagnose ASD because there is no specific medical test, like a blood test, for the condition. Physicians use textual and digital data through a variety of interviews and questionnaires that are lengthy and expensive and not affordable by all. Treatments for the disorder aim to reduce symptoms that interfere with daily functioning and quality of life. To combat these problems, we have decided to build a prediction model using facial images or behavioral patterns.

A. Background

In 2021, the CDC reported that about 1 in 44 children in the United States is diagnosed with ASD, according to 2018 data,

- 1 out of every 27 boys was diagnosed with autism.
- 1 out of every 116 girls was diagnosed with autism.

Boys are four times as likely to receive a diagnosis of autism as girls. Most children were still diagnosed after the age of four, although autism can be reliably diagnosed from the age of two. The WHO estimates that approximately one in every 100 children worldwide suffers from autism spectrum disorder.

B. Relevance

Autism is a spectrum, and can be characterized by severe challenges on behavioral, emotional, mental and cognitive fronts, or be characterized by simply being different from their neurotypical peers by communicating, interacting, behaving, and learning in distinctive ways. We want to address this issue so that we can help solve the issues faced by the children and make them understand that this is not a disease, which defines or limits who you can be or which makes you superior or inferior to others

II. RELATED WORKS

The work done on paper by Md.Fazle Rabbi et.al (2021)[1] for detecting ASD using an image dataset of 2,940 photos of autistic images of children sourced from Kaggle. The paper mentioned use of different machine learning algorithms providing comparative proof among the considered models. Out of all the ML algorithms used, it was observed that CNN

based prediction model outperformed the other ML algorithms used. but the models require a huge amount of data to train the model. They could have obtained even better accuracy if they handled the overfitting and underfitting problems in a better way. Five different algorithms have been used to categorize children with ASD: Multilayer Perceptron (MLP), Random Forest (RF), Gradient Boosting Machine (GBM), AdaBoost (AB), Convolutional Neural Network (CNN). "Out of all the ML models mentioned above the highest accuracy was observed in CNN with an accuracy of 92.31%. Hence, a prediction model based on CNN was proposed to be used for detecting ASD in children. Similarly, in paper F. Catherine Tamilarasi et al.(2020) used thermal

images". The activation layer for ResNet50, which comprises of multiple convolutional layers dubbed the max-pooling layers and was used in the methodology, achieved 89.2% accuracy. Although the model may avoid fading gradients with the additional insertion of connections that skip multiple weighted layers, the restricted memory proved a challenge when putting the concept into practise with a huge data set. The number of training errors increased with the increase in depth of convolutional layers as the accuracy got saturated and then started degrading and required huge amounts of computing power for a larger dataset. A paper written by Madison Beary (2020) used Facial analysis and deep learning. This research focuses on performing feature extraction and image classification using a deep learning model called MobileNet and two dense layers. When compared to regular convolutions in nets with identical depth, MobileNet uses depth-wise separable convolutions, which consume fewer parameters. Making use of MobileNet results in much faster output as it can decrease the model and computation size. A high accuracy of 94.6% with 15 epochs was observed. Making use of validation versus consolidated components along with test and training sets. The success of this algorithm would help diagnose other diseases such as Down syndrome. This study employs the CNN model with an image as its input and prioritizes various things in the image, comparing the image's objects to one another. The first of the two dense layers, which is responsible for the distribution, provides weight modification as an input to the second layer, which is responsible for classification. The study compares Mobilenet with other models such as GoogleNet, VGG 16, Squeezenet, and AlexNet. According to Mobilenet, making their models bigger and thinner produced identical accuracy while drastically lowering the number of multi-adds and parameters necessary for analysis. F W Alsaade and M S Alzahrani (2022)[6] use children's photographs which are cropped and cleaned using a convolution layer with a pooling layer to turn them into a kind that can be processed without losing crucial facial traits that aid in autism identification . The image is converted into a matrix. The Xception model was trained for the recognition of images and classification of tasks based on the ImageNet dataset with two concepts - feature extraction and fine-tuning.

Coming to the behavioral dataset Astha Baranwal et al. (2020) used the UCI repository and a paper by Aishwarya J et al. (2020) used a dataset containing 15 attributes including numerical and categorical data such as age, gender, if born with Jaundice, any family member having ASD which consist of categorical and binary values used different models like Decision Tree, Random Forest, Logistic Regression, Support Vector Classifier and Artificial Neural Network and the paper compared these models. The report claims that after testing each model, Decision Tree produced an over-fitted model for each applicable dataset and according to the adult autism dataset, ANN fared the best. The further optimum outcome for the adolescent autism dataset was found using logistic regression.

III. Proposed Methodology

To detect the presence of ASD, we have arrived at two methods, one using behavioral analysis and the other being facial recognition.

A. Behavioural Analysis

For behavioral analysis, we used two datasets, one for the 0-3 year age group and the other for the 4-11 year age group. For 0-3 years we have a dataset that has 1054 instances and 18 attributes, in which the first 10 attributes were (AQ-10) questionnaires which are given by the NHS and the remaining were a few personal information that is required to make the prediction. For 4-11 years we have a dataset that has 292 instances and 21 attributes, in which the first 10 attributes were (AQ-10) questionnaires which are given by the NHS and the remaining were a few pieces of personal information that are required to make the prediction. The responses to these questionnaires should be sent to a machine learning model as input which will process it and then provide the result.

B. Facial Recognition

For facial recognition, we have a dataset that consists of 2940 images of which 1470 are autistic images and 1470 are non-autistic images of children of age group 4-11 years. Here we have trained and tested the model using these images from the dataset with the help of the model, such that when a new image from the user is received from the website it serves as input to the model which then provides us with the output which is a result stating whether the child is autistic or non-autistic. After the completion of all the above 3 models, these models are going to be integrated into a single website that can be accessed by the users to take the test.

IV. IMPLEMENTATION AND PSEUDO CODE

A. Behavioral Analysis

0-3 years: All the columns are converted to binary form, ethnicity column has 9 options which is split into 9 columns and if the particular ethnicity is found then 1 is added to the row else 0 is appended to the row because all linear models need data in binary form. In order to achieve better understanding and more insights into our data we used a few visualization techniques:

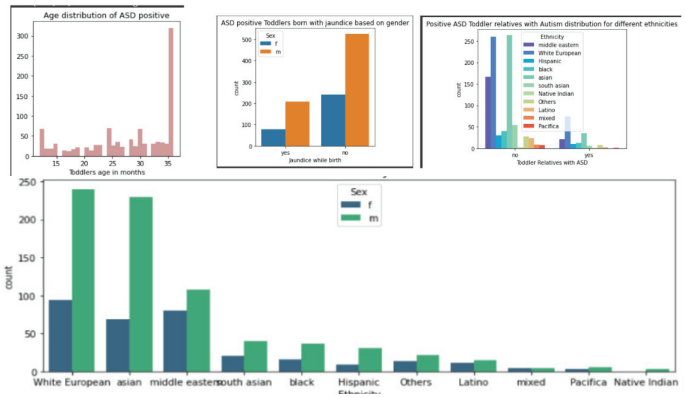

Fig. 1. Visualization on 0-3 years

We implemented machine learning models in order to make the prediction. Our model is first trained and tested using the dataset which contains 1024 instances and then the user questionnaire is sent as input to the model which provides the prediction as a result. We implemented four different machine learning models and obtained the below result: Logistic regression outperformed all the other models by getting an accuracy of 100%. Logistic regression is essentially a controlled classification algorithm. In a classification problem, the target variable (or output), y, can only take discrete values for a given set of characteristics (or inputs),X. So we used this model in the integration of the website for 0-3 years of prediction using behavioral analysis.

4-11 years: All the columns are converted to binary form, ethnicity column has 9 options which are split into 9 columns and if the particular ethnicity is found then 1 is added to the row else 0 is appended to the row because all linear models need data in binary form. In order to achieve a better understanding and more insights into our data we used a few visualization techniques:

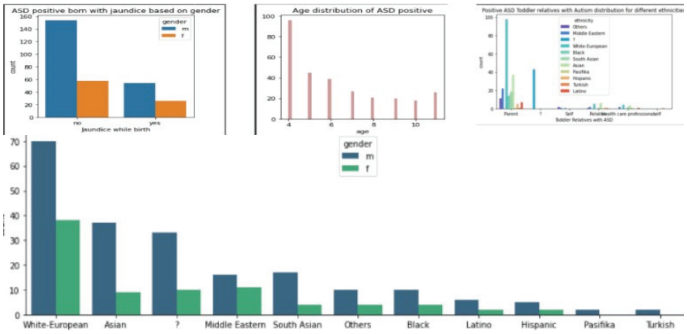

Fig. 2. Visualization on 4-11 years

Our paper proposes implementation of machine learning models in order to make the prediction. Our model is first trained and tested using the dataset which contains 292 instances and then the user questionnaire is sent as input to the model which provides the prediction as a result. The implemented four different machine learning models and obtained the below result: Logistic regres- sion outperformed all the other models by bringing the highest accuracy again. Logistic regression is essentially a controlled classification algorithm. In a classification problem, the target variable (or output), y, can only take discrete values for a given set of characteristics (or inputs), X. So this model is used in the integration of the website for 4-11 years prediction using behavioral analysis.

B. Facial Recognition

Our paper focuses on experimenting with different approaches to get better accuracy and approach. Our paper considered the Kaggle dataset that consists of 2940 images of children between 4-11 years of which 1470 are autistic and 1470 are non-autistic. Firstly, approach was to mimic how doctors analyze children and come to conclusion about whether the child is autistic or non-autistic. To do so Facial Keypoint detection method was carried out. In order to obtain the key points of an image MediaPipe Face Mesh was used. MediaPipe Face Mesh is a solution that evaluates 3D facial markers in real-time. It uses machine learning to infer the surface of the 3D face, requiring just one camera input without needing a dedicated depth sensor. The distance between the obtained key points was calculated and sent as input into linear machine-learning models and deep-learning neural network model which we built using python in Keras. This model used the distances of all the key points as input and provides us with the prediction as 0,1 that is autistic or non-autistic. This model provided an accuracy of 73.3%. Even though this model provided us with better accuracy compared to the above machine learning models, it was still not efficient.

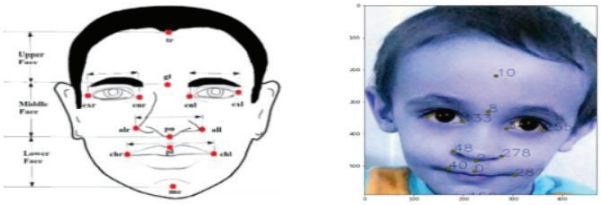

Fig. 3. Keypoints considered

Model	Accuracy
Logistic Regression	60.8
Support Vector Machines	59.18
Decision Tree	55.78
Random Forest	60.77
Naive Bayes	52.4
KNN	56.3

Fig. 4. Model Accuracy for image dataset

So implementing the CNN model which is considered to be one of the best models for image classification. Firstly paper implemented a CNN model with mobilenet. Depth-wise separable convolutions are used by MobileNet. When compared to a network with conventional convolutions of the same depth in the nets, it dramatically reduces the number of parameters. Lightweight deep neural networks are the outcome of this. Using this model we obtained an accuracy of 94.53 Then implementing the same CNN model but with a different architecture which is EfficientNet architecture. Real-time pixel-wise semantic segmentation is possible because of Efficient Neural Network. EfficientNet is up to 18 times faster than earlier models, uses 75 times fewer FLOPs,

and has 79 times less parameters while still providing accuracy that is equal to or better than earlier models. In terms of semantic segmentation, EfficentNet is the fastest model. Using this model we obtained an accuracy of 95.3% at 37 epochs, which is the highest we have obtained compared to the other models we tested. Paper used a logistic regression model for the behavioral analysis of both 0-3 years and 4-11 years age groups and a CNN EffcientNet model for facial recognition on the website. The trained models are saved in .sav format and are used to integrate with frontend flask, a web framework that provides libraries to build lightweight web applications in python, and the frontend form information is rendered to the back end and is passed into the model for prediction

The image classification models are saved in the .tflite format, while the behavioural models are saved in the .sav format. It's an approach that can be quickly and readily included into workplaces. The model is also very easy to use, as we just pass an image to the model's predict function it predicts whether the person in the image is autistic or non-autistic.

V. RESULT AND DISCUSSION

For this study, Python-3 as the programming lan- guage and Google Colab as the environment was used. After preprocessing the data, all three datasets are divided into a 70:30 ratio where 70% is utilized as the training set and 30% is utilized as the testing set. For facial recognition, we implemented a total of nine models of which 6 models were machine learning models and the remaining 3 were deep learning models. We have found that Logistic Regression, SVM, Decision tree, random first, naive Bayes, KNN, deep neural network(key point detection), CNN MobileNet, and CNN EfficentNet provide accuracy of 60.8, 59.18, 55.78, 60.77, 52.4,56.3, 73.3,94.53, 95.3 respectively. CNN EfficientNet model provided the maximum accuracy of 95.3% compared to all the other models.

For behavioral analysis, the paper implemented four different machine learning models for both data sets which are 0-3 years and 4-11 years.

We have found that for 0-3 years logistic regression, random forest, KNN, and SVM provide accuracy of 100, 97, 94, and 97.16 respectively. And for 4-11 years logistic regression, random forest, KNN, and SVM provide accuracy of 98, 97,88, and 96.61 respectively. Logistic Regression provided the maximum accuracy in detecting the presence of autism in the case of both datasets.

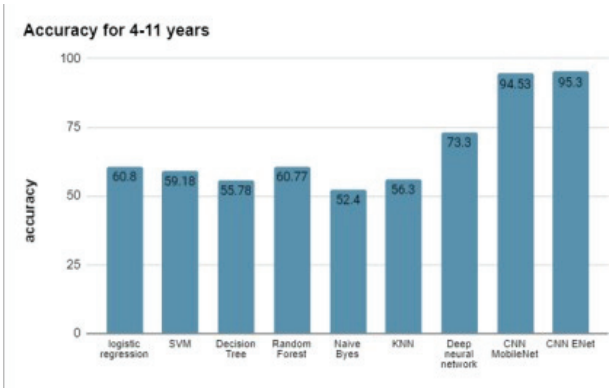

Fig. 5. Model Accuracy for image dataset

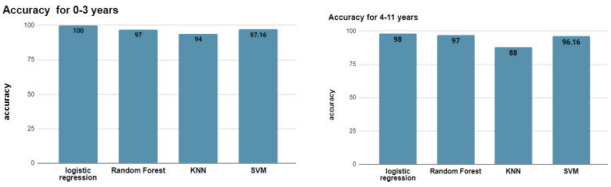

Fig. 6. Accuracy for Behavioral data

Model	Result			
	Accuracy	Precision	Recall	F1 score
Logistic Regression for 0-3 years	1.00	1.00	1.00	1.00
Logistic Regression for 4-11 years	0.98	0.98	0.98	0.98

Fig. 7. Metrics Table for logistic regression on 0-3 years and 4-11 years dataset

VI. CONCLUSION AND FUTURE WORK

Making the diagnosis of ASD may be difficult because there is no specific medical test, such as a blood test, for the condition. In order to determine a diagnosis, doctors consider the child's behavior and developmental history which is a very lengthy and costly process that cannot be afforded by everyone. So the paper has developed machine learning models that help in the prediction of ASD in children using facial recognition or behavioral analysis. The paper used Logistic Regression to determine the prediction using behavioral analysis by following the AQ-10 questionnaire. The paper uses CNN EfficientNet for ASD using facial images. Finally, developed a fully functional website integrated with the ML model that can be used to detect ASD and act as a link between the users and our team. We are planning on deploying our fully functional websites to schools and also conducting campaigns to raise awareness about Autism.Improving the key point detection approach by using a state of art model for key point detection and further optimising the deep neural network. Improvising accuracy of CNN EfficientNet model by tuning

hyper parameters. We want to remove the barrier faced by autistic kids, to pave a way for a better world with a feeling of inclusion. With our project on the map, we will be able to quicken the treatment of the process, where time is of the essence.

ACKNOWLEDGMENT

We would like to express our gratitude to Prof. Raghu B A, Associate Professor, Department of Computer Science and Engineering, PES University, for his continuous guidance, assistance, and encouragement throughout the development of the Capstone Project. We are grateful to the project coordinator, Prof. Mahesh H.B., for organizing, managing, and helping with the entire process. We take this opportunity to thank Dr. Shylaja S S, Chairperson, Department of Computer Science and Engineering, PES University, for all the knowledge and support we have received from the department. We would like to thank Dr. B.K. Keshavan, Dean of Faculty, PES University for his help. We are deeply grateful to Dr. M. R. Doreswamy, Chancellor, PES University, Prof. Jawahar Doreswamy, Pro-Chancellor – PES University, Dr. Suryaprasad J, Vice-Chancellor, PES University for providing us with various opportunities and enlightenment every step of the way. Finally, this project could not have been completed without the continual support and encouragement we have received from our family members, friends, and the technical/office staff of the CSE department

REFERENCES

[1] M. F. Rabbi, S. M. Hasan, A. I. Champa, and M. A. Zaman, "A convolutional neural network model for early-stage detection of autism spectrum disorder," 2021 International Conference on Information and Communication Technology for Sustainable Development (ICICT4SD), 2021

[2] A. Baranwal and M. Vanitha, "Autistic spectrum disorder screening: Prediction with machine learning models," 2020 International Conference on Emerging Trends in Information Technology and Engineering (ic-ETITE), 2020.

[3] F. C. Tamilarasi and J. Shanmugam, "Convolutional neural network based Autism Classification," 2020 5th International Conference on Communication and Electronics Systems (ICCES), 2020.

[4] M.-P. Hosseini, M. Beary, A. Hadsell, R. Messersmith, and H. Soltanian-Zadeh, "Deep learning for autism diagnosis and facial analysis in children," Frontiers in Computational Neuroscience, vol. 15, 2022. 55 Detection Of Autism Spectrum Disorder

[5] A. J, A. N, A. H, S. J, and D. Mahadev, " Engagement Detection with Autism Spectrum Disorder using Machine Learning," International Research Journal of Engineering and Technology (IRJET), vol. 07, no. 07, 2020.

[6] Fawaz Waselallah Alsaade, Mohammed Saeed Alzahrani, "Classification and Detection of Autism Spectrum Disorder Based on Deep Learning Algorithms", Computational Intelligence and Neuroscience, vol. 2022, 2022.

[7] "What is autism spectrum disorder?," Centers for Disease Control and Prevention, 31-Mar-2022. [Online]. Available: https://www.cdc.gov/ncbddd/autism/facts.html. [Accessed: 27-Nov-2022].

[8] M. Tripathi, "Image processing using CNN: Beginner's Guide to Image Processing," Analytics Vidhya, 30-Jun-2021. [Online]. Available: https://www.analyticsvidhya.com/blog/2021/06/image-processing-using-cnn-a-beginners-gu ide/. [Accessed: 05-Dec-2022].

[9] K. Vakadkar, D. Purkayastha, and D. Krishnan, "Detection of autism spectrum disorder in children using machine learning techniques," SN computer science, 2021. [Online]. Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8296830/. [Accessed: 05-Dec-2022].

[10] K. Vakadkar, D. Purkayastha, and D. Krishnan, "Detection of autism spectrum disorder in children using machine learning techniques," SN computer science, 2021. [Online]. Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8296830/. [Accessed: 05-Dec-2022]. 56 Detection Of Autism Spectrum Disorder