# Child autism diagnosis using deep learning-based facial expression analysis

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***Abstract*- Autism Spectrum Disorder (ASD) is a group of neurodevelopmental diseases associated with behavior, social interaction, and communication. Within the first two years of life, or during developmental phases, the disease's symptoms typically manifest. There are two approaches to ASD diagnosis and rehabilitation. The first is the manual method, based on observation or interviews that primarily entails the analysis of behavioral symptoms. The other approach makes use of EEG readings, brain MRIs, and conventional machine learning (ML) for automatic diagnosis. ASD cannot currently be diagnosed using a diagnostic test, which makes the diagnosis difficult. This paper has explored the early detection of Autism Spectrum Disorder (ASD) by identifying autistic children by face feature recognition using a Convolutional Neural Network. The accuracy of the suggested method is 99%, which is higher than the results of existing systems like SVM and mobileNet algorithms, which only provide 70% accuracy. With the use of a Deep Learning-based strategy that incorporates face analysis, our findings should greatly help researchers, therapists, psychologists, and other pertinent stakeholders in the advancement of ASD screening, monitoring, and diagnosis.**

***Index Terms*- Machine Learning models, Deep Learning models, Autism Spectrum Disorder, Facial features extraction.**

## I. INTRODUCTION

A neurodevelopmental illness known as autism spectrum disorder impacts a person's ability to interact, communicate, and learn. Autism can be diagnosed at any age, although symptoms usually start to show in the first two years of life and get worse over time. Patients with autism spectrum disorders deal with a variety of issues, including difficulties focusing, learning disabilities, mental health issues including anxiety and depression, as well as issues with motor skills, sensory processing, and many more [1]. Autism is currently spreading rapidly over the world and is affecting a large number of people. The WHO estimates that one child out of every 160 has ASD. While some persons with this illness are able to live independently, others need care and support for the rest of their lives. Autism diagnosis demands a large financial and time investment. While medical practitioners frequently diagnose patients with ASD using neurophysiological signs, there is yet no conclusive biosignature or pathological approach for accurately diagnosing autism [2]. Early identification of autism can greatly benefit patients by enabling early prescription of appropriate medication. It can stop the patient's illness from getting worse and assist cut down on the long-term expenses related to a delayed diagnosis. Therefore, there is a great need for a quick, accurate, and simple screening test that can anticipate an individual's qualities related to autism and determine whether or not they need a full autism examination. Numerous research has looked at the key traits of autism from a number of angles, including face recognition [3], biomedical image analysis [4], application development, facial feature extractions utilizing eye-tracking techniques [5], and speech recognition [6]. Face recognition is one of these techniques that is very helpful in assessing an individual's emotional state and may be able to correctly diagnose autism. It is a well-liked technique for examining human faces, extracting traits that set normal and abnormal faces apart, and mining important data to identify patterns in behavior.

Figure 1: The first row shows children with autism while the second row shows children without autism with different facial traits...

AI and machine learning have many practical uses that aim to address societal issues. AI is being applied in every aspect of healthcare to assist medical professionals in managing conditions like autism. In particular, artificial neural networks have drawn attention as a means of identifying characteristics in ASD patients that can be utilized to distinguish between individuals with and without ASD. CNNs and recurrent neural networks (RNNs) [7, 8] are two examples of deep learning techniques that have been utilized or suggested to diagnose autism in children.

Our project's primary goal is to accurately forecast or categorize autism as normal or abnormal.

- To put the deep learning algorithm into practice.
- To improve the classification algorithms' overall performance.

The main contributions of our research are as follows:

- The image is scaled down and turned to grayscale during the image pre-processing stage.
- Using LBP, we may extract features from a pre-processed image.
- 70% of the data are utilized for training and 30% are used for testing when training and testing a model with images.
- CNN An algorithm that classifies images and predicts autism which has a 99% accuracy rate compared to existing models.

## II. LITERATURE REVIEW

Autism Spectrum Disorder (ASD) is becoming more and more popular in the modern era. Using screening tests to identify autism symptoms is highly costly and time-consuming. The development of machine learning (ML) and artificial intelligence (AI) has made it possible to anticipate autism symptoms early on. Despite the fact that numerous research have been conducted using various methodologies, these studies have not produced a conclusive result regarding the prediction of autism features in terms of various age groups. In [9] Kazi Shahrukh Omar el al., developed a mobile application to predict ASD in individuals of any age and suggested an efficient prediction model based on ML method. As a result of this study, Random Forest-CART (Classification and Regression Trees) and Random Forest-ID3 (Iterative Dichotomiser 3) were combined to create a prediction model for autism. A mobile application was also created based on the suggested prediction model. The AQ10 dataset and 250 real datasets, which were gathered from individuals with and without autism symptoms, were used to assess the suggested model. The evaluation's findings demonstrated that, for both types of datasets, the suggested prediction model produced superior outcomes in terms of accuracy, specificity, sensitivity, precision, and false positive rate (FPR).

In [10] A. S. Heinsfeld et al., used deep learning algorithms to identify patients with autism spectrum disorder (ASD) based only on their brain activation patterns from a large brain imaging dataset. We looked into brain imaging data from ASD patients from the global multi-site database called ABIDE (Autism Brain Imaging Data Exchange). ASD is a brain-based condition marked by repetitive behaviours and social difficulties. Recent data from the Centers for Disease Control indicate that one in 68 American youngsters suffers from ASD. From functional brain imaging data, we looked at functional connectivity patterns that can be used to objectively identify individuals with ASD. We also tried to determine the neural patterns that arose from this classification. The findings raised the bar to a state-of-the-art level by identifying ASD patients in the dataset with 70% more accuracy than control patients.

In [11] Sara Karim1 et al., used Machine learning techniques such as Support Vector Machines, Random Forests, Naive Bayes, K-nearest Neighbours, and many more are used in several investigations to predict autism meltdowns. This study provides an extensive overview of research using machine learning to predict ASD in addition to data analysis and classification algorithms. The materials are compiled from the internet and comprise over eighty research publications. In the end, 41 research publications satisfied the study's requirements. This review's primary objective is

to identify and highlight the machine learning trends in the literature on ASD and to point out important research directions for academics who are interested in deepening their understanding of the fundamentals of ASD data prediction. Future scholars who wish to work in the subject of ASD meltdown prediction can use this paper as a guide.

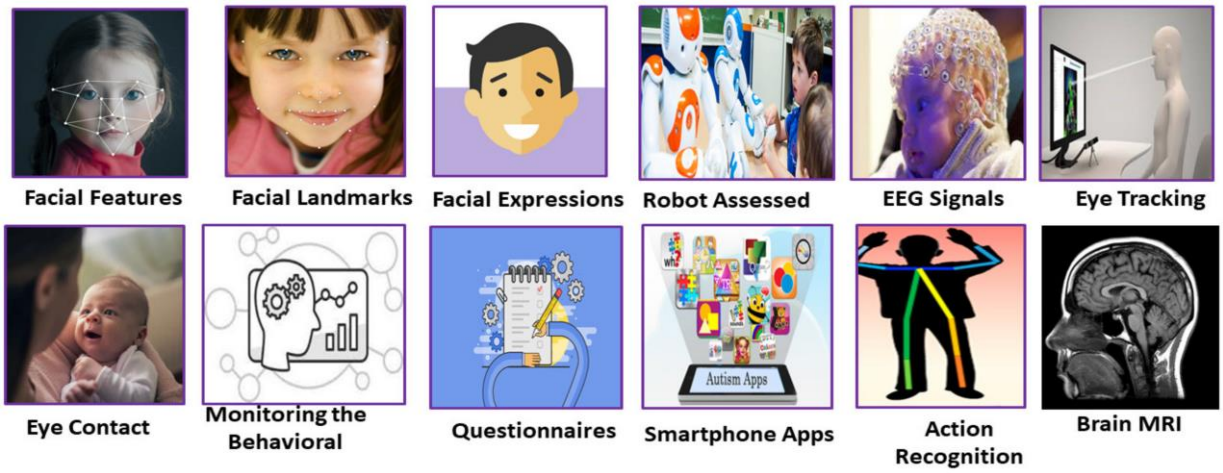


Figure 2: Different types of technology to detect autism

## III. PROPOSED SYSTEM

In this paper, we have shown that there are many ways to interpret the type of look that mentally unstable children communicate. However, the final outcome depends on how accurate the calculation is, and there is another scenario that should have been considered: if the calculation predicts the probabilities of different articulations in a similar way, it can be challenging to select the appropriate expression. To precisely arrange the statement, the accuracy needs to be improved. By using Convolutional Neural Organization (CNN), this ought to be achievable.

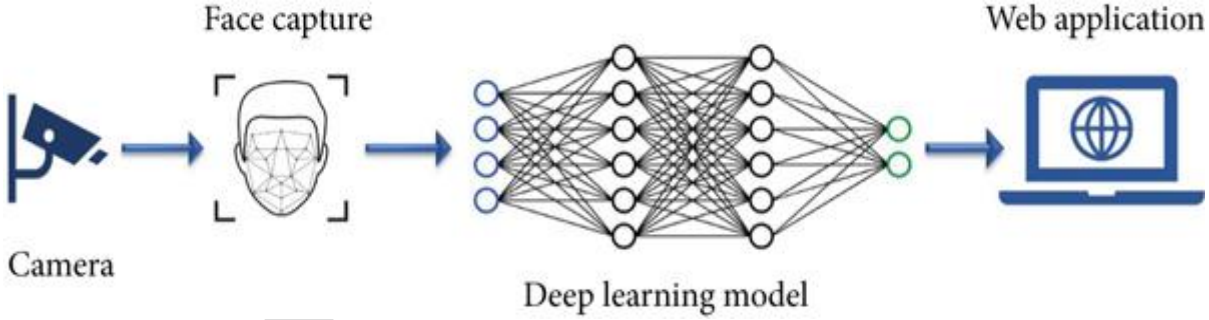


Figure 3: Architecture of the proposed system to identify autism

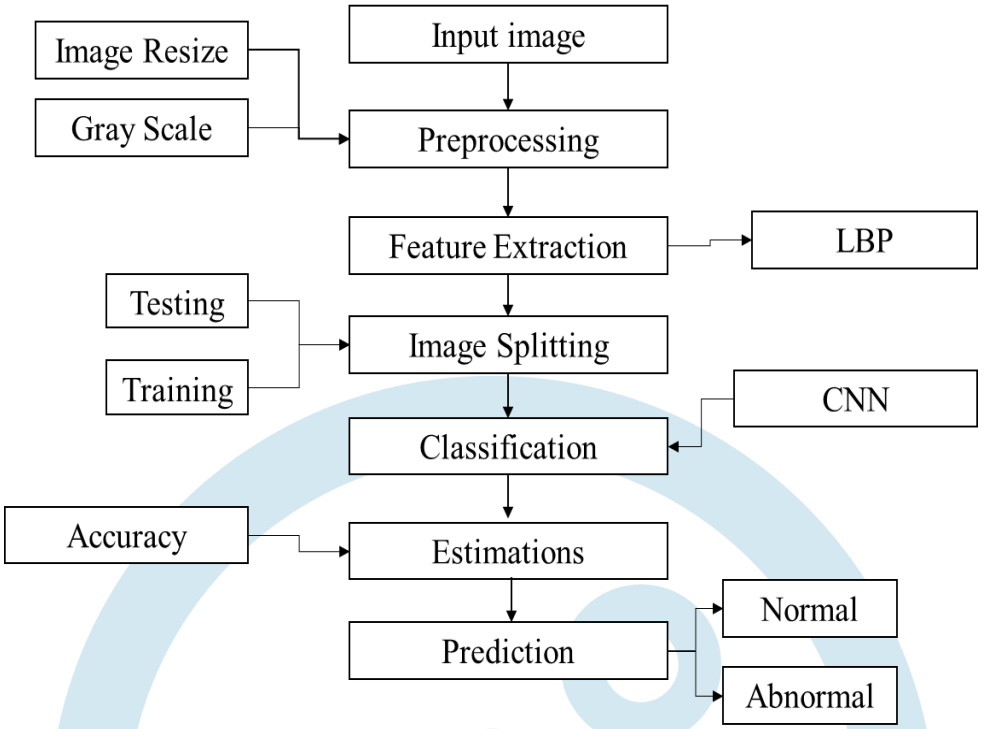


Figure 4: Flow diagram of proposed system to identify autism

***Data set***

This study examined facial images of children with autism and typical kids that were taken from the publicly available online Kaggle platform [11]. 100 face images made up the dataset; half of the images showed children without autism, and the other half showed children with autism. This dataset was gathered from online resources, including autism-related Facebook pages and webpages.

***Pre-Processing***

The photos were cleaned and cropped as part of the data preprocessing. The data had to be pre-processed before they could be used to train the deep learning model because Piosenka [11] gathered them from online sites. Image is converted int grayscale image. When used in a monochrome display or printout, grayscale refers to a range of gray tones from white to black. Because smaller data sets allow developers to perform more complicated operations faster, grayscale images are most frequently utilized in image processing. An RGB image can be converted to a grayscale image using a variety of frequently used techniques, including the weighted and averaged methods. The luminosity approach, also known as the weighted method, assigns wavelengths to red, green, and blue. The improved formula is as follows

imgGray = 0.2989 * R + 0.5870 * G + 0.1140 * B. (1)

***Feature Extraction***

The Local Binary Pattern (LBP) texture operator is a straightforward yet highly effective technique that assigns a binary number to each pixel in an image by thresholding its surrounding pixels. Owing to its capacity for discrimination and ease of computation, the LBP texture operator has gained popularity across a range of applications. It can be viewed as a unifying method for texture analysis's historically disparate statistical and structural models. The robustness of the LBP operator to monotonic gray-scale changes, such as those brought on by variations in illumination, may be its most crucial feature in practical applications. Its computational simplicity, which enables image analysis in difficult real-time environments, is another significant feature. The basic methodology for LBP based face description proposed by Ahonen et al. (2006) is as follows: The facial image is divided into local regions and LBP texture descriptors are extracted from each region independently. The descriptors are then concatenated to form a global description of the face, as shown in figure 5

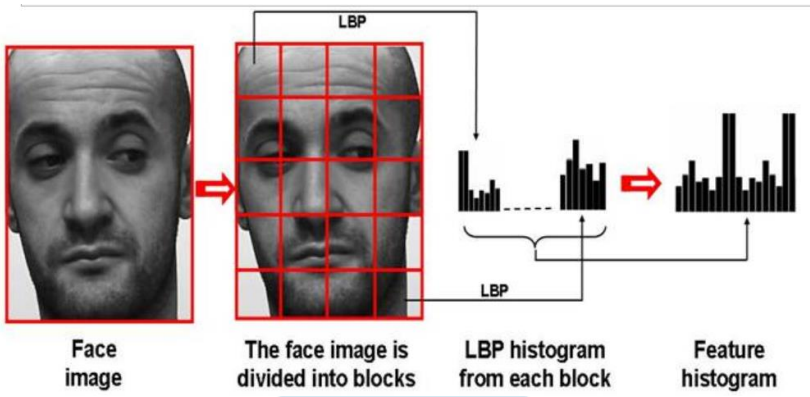


Figure 5: Face descriptions with LBP

***Image Splitting***

Data are required for machine learning in order for learning to occur. Test data are necessary in addition to training data to assess the algorithm's performance and determine its effectiveness. We classified 70% of the input dataset as training data and the remaining 30% as testing data during our process. The process of dividing available data into two parts, commonly for cross-validator reasons, is known as data splitting. One Portion of the data is used to construct a prediction model and the other to evaluate the model's performance. Separating data into training and testing sets is a key aspect of analysing data mining algorithms.

***Classification***

The CNN algorithm has aided in behavioural and psychological research as well as disease identification. Three components make up a CNN: convolution, pooling, and a fully connected layer. Local picture properties are gathered via convolution, dimensionality is decreased through pooling, and the required output is produced by the fully connected layer. Brighter pixels are used in this mode to highlight local image details and show the borders of the image. Additionally, it enables improved processing [12,13]. The basic components of the CNN model are the input layer, convolutional layer, activating function, pooling layer, fully connected layer, and output prediction [14].

***Convolutional Layer with a Pooling Layer***

An image in the form of a matrix of pixel values serves as the convolutional layer's input. The convolutional layer's goal is to simplify the images so they may be processed more quickly without sacrificing any of the crucial characteristics that will aid in the identification of autism. Low-level features like edges and color are extracted by the CNN model's first layer. The CNN model have additional layers added to it in order to extract higher-level information that will aid in its understanding of images.

One of the two methods max pooling or average pooling was used to limit the number of weights because the convolution layer outputs a high number of parameters that could greatly elongate the arithmetic operations of the matrices. The mean value of each window in the stride is the basis for average pooling, whereas the maximum values in each window in the stride are the basis for max pooling. The model used in this investigation was based on maximum pooling. The convolutional layer, average pooling, and max pooling procedures are displayed in Figure 6. After extracting the features from the input image and converting it into a matrix, the kernel's sliding window uses max pooling and average pooling to mathematically limit the number of parameters.

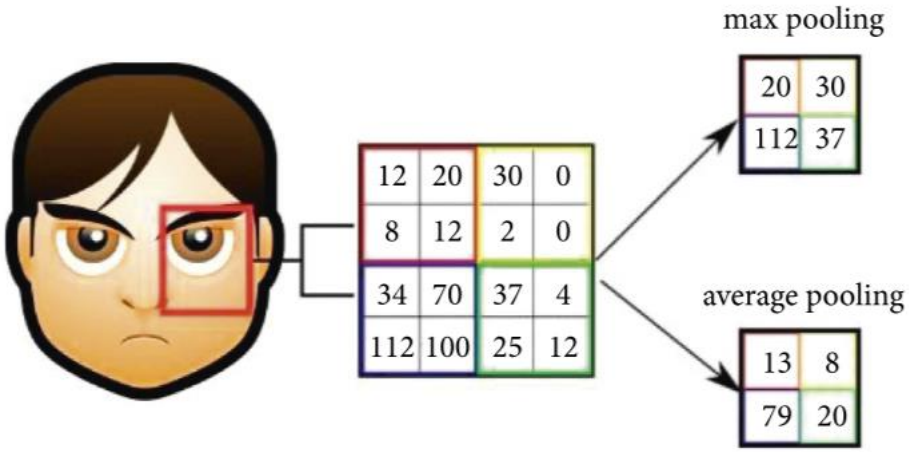


Figure 6: The convolution layer and max pooling and average pooling.

***Fully Connected Layer and Activation Function***

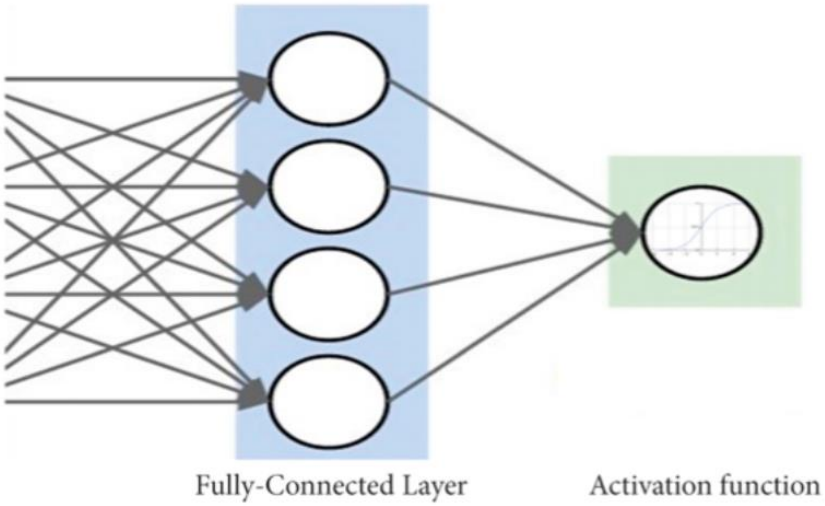


Figure 7**:** The fully connected layer and the activation function.

High-level information that were input by the hidden layers and represented as outputs are combined nonlinearly to form the fully connected (FC) layer. The input image is represented as a column vector in the FC layer. There are two methods for training the model: backpropagation and forward neural networks. The output layer is flattened by the forward neural network feeds. By increasing the number of training iterations, the neural network reduces loss mistakes and gains additional feature knowledge during backpropagation. The majority of deep learning models exhibit strong performance as the number of hidden layers and training iterations is increased, enabling the neural network to thoroughly extract low-level data. As seen in Figure 7, the softmax classifier computes the attributes to predict the output after receiving the parameters from the FC layer. An picture is considered to be in class 0 if the Softmax output is 0, and class 1 if it is a Softmax output of 1. Class 0 represents the autism class in this study, while class 1 represents the typical class.

***Activation Function***

The output is classified by the activation function. When there are two or more classes, the output is categorized using the SoftMax activation function. There are two classifications in this study: TD and ASD. Binary classification issues can be addressed with the sigmoid activation function. The formula Eq. 2 is used to calculate the activation function. The slope and intercept of a line is the name given to this formula Eq. 2 An activation function diagram is displayed in Figure 8.

$$y=x1*w1 + x2* w2+b \quad (2)$$

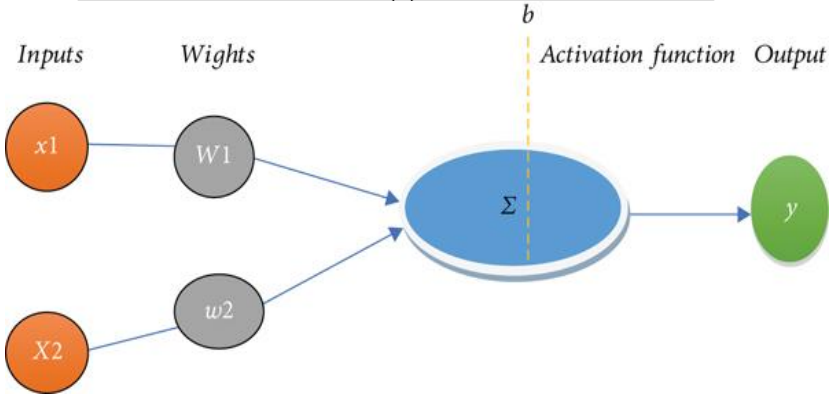


Figure 8 Node with Activation Function

## IV. RESULTS

For the models in this work, various performance evaluation criteria are used, including a confusion matrix, accuracy, sensitivity, and specificity. One kind of classification performance metric that shows a table of the true and false values of the test results is called a confusion matrix.

The equations for these metrics are as follows:

$$\text{Accuracy} = \frac{\text{TP} + \text{TN}}{\text{FP} + \text{FN} + \text{TP} + \text{TN}} \times 100\%. \quad (3)$$

where TP is the True Positive, FP is the False Positive, TN is the True Negative, and FN is the False Negative. Specificity is the capacity of the model to correctly identify the normal children, and sensitivity is the capacity of the model to correctly identify autistic children.

```
------------------------------------------------------------
Performance Analysis
------------------------------------------------------------


1.Accuracy    =  99.30671375989914 %

2.Error Rate =  0.6932862401008606
```

***Sample screen shorts***

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-----------------------------------------------------------
Convolutional Neural Network
-----------------------------------------------------------


Model: "sequential_3"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d_2 (Conv2D)           (None, 50, 50, 16)        208

 max_pooling2d (MaxPooling2D  (None, 25, 25, 16)       0
 )

 conv2d_3 (Conv2D)           (None, 25, 25, 32)        2080

 max_pooling2d_1 (MaxPooling  (None, 12, 12, 32)       0
 2D)

 conv2d_4 (Conv2D)           (None, 12, 12, 64)        8256

 max_pooling2d_2 (MaxPooling  (None, 6, 6, 64)         0
 2D)
```

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       PREDICTION
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 IDENTIFIED = AUTISIUM
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## V. CONCLUSION

It has been demonstrated that a child's long-term health results are significantly improved by an early diagnosis of ASD. Currently, every detection method is dependent on the expertise of specialists, which is both expensive and subjective. In this study, we suggested identifying children with ASD by utilizing a deep learning system that incorporates multiple facial landmark traits. By using this technology, expenses might be decreased and the detecting process' efficacy raised. The main advancement in this area is the creation of an expert system that uses facial landmarks to identify autism spectrum disorder in youngsters. We shall offer advanced AI algorithms in our future research because the performance accuracy of the given system has to be improved.

## REFERENCES:


1. Lord, C.; Elsabbagh, M.; Baird, G.; Veenstra-Vanderweele, J. Autism Spectrum Disorder. Lancet **2018**, 392, 508–520.
2. Kojovic, N.; Natraj, S.; Mohanty, S.P.; Maillart, T.; Schaer, M. Using 2D Video-Based Pose Estimation for Automated Prediction of Autism Spectrum Disorders in Young Children. Sci. Rep. **2021**, 11, 1–10.
3. [Guillon, Q.; Hadjikhani, N.; Baduel, S.; Rogé, B. Visual Social Attention in Autism Spectrum Disorder: Insights from Eye Tracking Studies. Neurosci. Biobehav. Rev. **2014**, 42, 279–297. [
4. Kanhirakadavath, M.R.; Chandran, M.S.M. Investigation of Eye-Tracking Scan Path as a Biomarker for Autism Screening Using Machine Learning Algorithms. Diagnostics **2022**, 12, 518.
5. [Aldhyani, T.H.H.; Nair, R.; Alzain, E.; Alkahtani, H.; Koundal, D. Deep Learning Model for the Detection of Real Time Breast Cancer Images Using Improved Dilation-Based Method. Diagnostics **2022**, 12, 2505.
6. Jiang, X.; Chen, Y.F. Facial Image Processing. In Applied Pattern Recognition; Bunke, H., Kandel, A., Last, M., Eds.; Studies in Computational Intelligence; Springer: Berlin/Heidelberg, Germany, 2008; pp. 29–48.
7. [M. Li, D. Tang, J. Zeng et al., "An automated assessment framework for atypical prosody and stereotyped idiosyncratic phrases related to autism spectrum disorder," *Computer Speech & Language*, vol. 56, pp. 80–94, 2019.
8. F. B. Pokorny, B. W. Schuller, P. B. Marschik et al., "Earlier identification of children with autism spectrum disorder: an automatic vocalisation-based approach," in *Proceedings of the Annual Conference of the International Sp*, August 2017
9. Kazi Shahrukh el al.," A Machine Learning Approach to Predict Autism Spectrum Disorder" in International Conference on Electrical, Computer and Communication Engineering (ECCE), 7-9 February, 2019

10. A. S. Heinsfeld, A. R. Franco, R. C. Craddock, A. Buchweitz, and F. Meneguzzi, "Identification of autism spectrum disorder using deep learning and the abide dataset," NeuroImage: Clinical, vol. 17, 2018.
11. G. Piosenka, "Detect autism from a facial image," 10 December 2021, https://www.kaggle.com/cihan063/autism-image-data accessed on.
12. Khosla, Y.; Ramachandra, P.; Chaitra, N. Detection of autistic individuals using facial images and deep learning. In Proceedings of the 2021 IEEE International Conference on Computation System and Information Technology for Sustainable Solutions (CSITSS), Bangalore, India, 16–18 December 2021; pp. 1–5.
13. Krithika, L.B.; Priya, G.G.L. MAFONN-EP: A Minimal Angular Feature Oriented Neural Network based Emotion Prediction system in image processing. J. King Saud Univ. Comput. Inf. Sci. **2022**, 34, 1320–1329.
14. Fawaz Waselallah Alsaade and Mohammed Saeed "Classification and Detection of Autism Spectrum Disorder Based on Deep Learning Algorithms" Hindawi Computational Intelligence and Neuroscience Volume 2023, Article ID 9893015