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Early detection of autism spectrum disorder based on parental input

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Abstract

Nowadays, the Autism Spectrum Disorder (ASD) movement is moving at a breakneck pace. Screening for autism characteristics is a laborious and costly process. It is now possible to detect autism in its early stages thanks to developments in AI and ML. Although several research have been conducted using various methods, no conclusive results have been drawn regarding the prediction of autism features by age group.

Consequently, the purpose of this paper is to establish a mobile app that may predict ASD in individuals of any age using a model that is based on ML techniques. The study's results include a mobile app built on top of a prediction model for autism that was created by combining Random Forest- and Adaboost. The AQ-10 dataset and 250 real datasets, gathered from both autistic and non-autistic individuals, were used to assess the suggested model. In terms of accuracy, specificity, sensitivity, precision, and false positive rate (FPR), the evaluation findings demonstrated that the suggested prediction model produced superior outcomes for both types of datasets.

Keywords: Autism Spectrum; Adaboost; Random Forest; Classification

1. Introduction

Autism spectrum disorder is a neurological disorder that has a negative effect on a person's social interaction, communication, and learning abilities. People who are diagnosed with autism often have a multitude of challenges, including difficulties with cognition, emotional disorders (such as sorrow or anxiety), motor skills, and sensory processing. Although they may have exceptional abilities in areas like art, music, mathematics, or memory, some people may struggle with communicating. This might lead to outstanding results on tests that test critical thinking and problem-solving skills. Autism is characterized by a lack of eye contact, a restricted interest range, and hyper concentration on a small number of subjects. Displaying a lack of social awareness and engaging in repetitive activities like oscillating back and forth, vocalizing the same words or phrases, or repeatedly manipulating a lever are all symptoms of hyperacusis, hyperesthesia, hyperosmia, or hypersensitivity to stimuli that may appear ordinary to those without this trait.

Costs associated with autism management tend to rise as the disorder progresses. Early diagnosis of autism in youngsters opens the door to more cost- and time-effective treatment options. Symptoms of autism can be identified at any age; however, they often manifest during infancy and early childhood and progress at a gentle pace. The complicated condition known as autism is driven by a combination of genetic and environmental factors. Individuals on the autism spectrum display a wide range of skills and limitations.

Individuals on the autism spectrum can exhibit a wide range of cognitive abilities, from obvious strengths to clear weaknesses, in the areas of learning, reasoning, and problem-solving. Some individuals with Autism Spectrum Disorder (ASD) may require more assistance with daily activities than others. Different people have different levels of support needs; some may be completely dependent on others, while others may only require basic care and even be able to live

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on their own. In most cases, the first symptoms of autism manifest themselves between the ages of two and three. As early as 18 months of age is often the first sign of some developmental delays that are associated with one another. According to the research, early intervention is linked to better long-term outcomes for individuals with autism. Using Machine Learning approaches, we initially identified Autism. In addition, it distinguishes between three levels of Autism severity: moderate, mild, and severe.

The Exisitng endeavor seeks to build a very effective prediction model using machine learning techniques. Making a mobile app that can reliably foretell when Autism Spectrum Disorder (ASD) may manifest in individuals of any age is the ultimate objective. A model for autism prediction was developed by combining Iterative Dichotomiser 3 with Random Forest-CART (Classification and Regression Trees). The areas that were the main focus of the AQ-10 dataset were social interaction, creativity, communication, attention switching, and detail orientation. The question scoring criterion states that each of the ten questions can only be given a maximum score of one point.

In order to build our model, we will utilize a dataset that includes children aged 12–36 months. In order to prepare the data for early detection, two stages are to remove missing values and to numerically represent textual values. We used the AdaBooster and Random Forest (RF) algorithms to make our model better and faster. The goal of the Adaboost algorithm, which aims to improve a weak collection of classifiers into a strong one, is to address classification challenges. By factoring in their weights, it accurately depicts the computed sum of M weak classifiers. The user can aid the trained model in determining if the child has autism by answering the questions.

Early diagnosis of autism can have a significant impact by ensuring patients receive the appropriate medicine at the appropriate time. For this reason, there is an immediate need for a screening test that is simple, fast, and accurate. In order to ascertain whether a comprehensive autism evaluation is required, this test can foretell the onset of autistic symptoms.

2. Literature review

We will employ machine learning methods such as Naïve Bayes, Support Vector Machine Logistic Regression, KNN Neural Network Convolutional Neural Network, and others to forecast and examine Autism Spectrum Disorder (ASD) in children, adolescents, and adults globally in the study [1]. The results showed that Convolutional Neural Network (CNN) based models worked better in all three scenarios: adults (99.53%), children (98.30%), and teenagers (96.88%). However, the study's conclusions can't be applied to all people with ASD because the datasets were different in terms of sample size, input data quality, and overall characteristics. Additionally, the long-term efficacy of these machine learning methods has not been quantified.

According to research [2] on using machine learning to diagnose autism spectrum disorder, the MLP classifier can get 100% accuracy across all datasets. Reportedly, the'relief F' characteristic range operations give very accurate evaluations of the important aspects. While heredity and sensory preferences play a significant role in ASD, early diagnosis and treatment can alleviate symptoms to a large extent. Machine learning can automate the diagnosis process, leading to improved results. Some potential limitations of the study include an exaggeration or underestimation of the following: biases; generalizability; power; socioeconomic status; data ethics (including issues of confidentiality and permission); and real-world applications.

Studies in individuals with Autism Spectrum Disorder (ASD) have identified brain regions related to sensory processing, movement planning and deployment, and attentional signals. In a comparison study [3] that evaluated performance of ML and DL techniques, Support Vector Machines (SVM) AND eXtreme Gradient Boosting (XGBoost) outperformed TabNet and Multi Layer Perceptron when analyzing functional connectivity measures from the ABIDE dataset for ASD, with an Area Under the Curve (AUC) of 75%. The study's findings may not generalize to other ASD populations, though, since they may have been influenced by the dataset utilized.

Analyses of the ABIDE II dataset show that people with ASD [4] have an abundance of connections between subcortical and unimodal brain regions, but an inadequate number of connections between supramodal and subcortical regions. It implies that higher-level cognitive processes should have fewer connections and sensory processing should have more. Subcortical region connection to a single sensory modality was positively correlated with ASD phenotype, according to this study. This research article found that the connection of the subcortical area towards many sensory modalities was inversely connected with the ASD phenotype. However, there are a number of potential limitations to the study that could make it inapplicable outside of the general population. These include the use of a cross-sectional design, an exclusive focus on functional connectivity, and the absence of consideration of other potential confounders or intervening variables. Results may be skewed in certain cases due to publication bias and other methodological limitations.

Among the machine learning algorithms tested in a study [5] that studied autism diagnoses in children, the KNN-based model achieved the highest accuracy rate of 87.14%. The sensitivity and accuracy levels were lower in other models, such SVM and Naïve Bayes. As impressive were the results from the Decision Tree and Random Forest models. Because this research only used one dataset, its results may not be generalizable to all ASD cases. This study's autism prediction did not account for demographic or environmental factors. It is essential to use many separate and real-world datasets to confirm the results' practicality.

The current state of the art in early autism spectrum disorder (ASD) prediction employs machine learning and artificial intelligence techniques such as XGBClassifier, Random Forest, and Artificial Neural Networks. Creating accurate diagnostic tools for ASD is the primary objective [6]. Model selection must prioritize accuracy, efficiency, and interpretability. The promise of AI and ML in ASD identification suggests that treatments can be accurate, efficient, and fast. However, the screening process could be affected by issues such as inaccessible datasets, difficulties with interpretation, and an excessive dependence on AI. Data privacy, ethical considerations, and the function of technology must all be considered in healthcare decision-making. It is critical to update and evaluate algorithms on a regular basis to make sure these screening models are accurate and relevant.

The study delves into the application of machine learning techniques, such as support vector machines (SVMs), to the diagnosis of autism spectrum disorder (ASD) [7]. Research using 16 articles culled from digital libraries revealed that Support Vector Machines (SVM) were able to attain a 65.75 percent accuracy rate. The results do, however, provide cause for optimism regarding the possibility of enhancing diagnostic accuracy. Nevertheless, due to its reliance on a small sample size, the study may lack the necessary rigor. There is also the possibility that the study will ignore practical and ethical concerns, and that the quantity and quality of data will impact the findings. Furthermore, the results may not be accurate because of the publications' intrinsic biases.

The increasing incidence of Autism Spectrum Disorder (ASD) is examined in this article [8], which highlights the importance of early diagnosis in nursing care. A wide number of classifiers were analyzed in the study, and the best results were obtained by the Gaussian Radial Kernel. It attained a 95% accuracy rate on typical ASD datasets. Due to its reliance on publicly available standard ASD statistics, the study may have overlooked some aspects of the range of ASD presentations. Little research has focused on the factors that influence ASD diagnosis and treatment. The study also doesn't consider any of the possible problems or outcomes of using the suggested classifier in actual clinical situations.

A recent study [9] built a predictive model for Autism Spectrum Disorder (ASD) using machine learning techniques and a mobile app. The AQ-10 dataset, along with real-world data from autistic and non-autistic individuals, as well as ASD patients, was used to evaluate the model. Random Forest-CART and Random Forest-Id3 are both used in the model. All four metrics—sensitivity, accuracy, precision, and false positive rate—were enhanced by the model. Factors that limit the study include ethical considerations and potential biases. Additionally, the researchers are investigating the model's performance in various contexts and with various demographics. Validation and upgrades are required on a regular basis to maintain it operational.

Early diagnosis of Autism Spectrum Disorder (ASD) using structural MRI, magnetic resonance imaging (MRI), and hybrid imaging techniques has demonstrated promise using machine learning (ML) [10]. When children are identified promptly, they can receive tailored educational support and intervention to help them overcome obstacles. To improve the accuracy and dependability of machine learning algorithms, however, large-scale, in-depth investigations are necessary. Both patients and healthcare practitioners may reap the benefits of machine learning's prospective impact on the precision and timeliness of ASD diagnoses in the future. The ethical considerations and potential biases, as well as the appropriateness of machine learning algorithms for various demographics and populations, require further investigation and validation.

One study indicated that a machine learning algorithm could enhance the diagnosis of Autism Spectrum Disorder (ASD) in high-functioning adults and adolescents [11]. Focusing on a subset of the behavioral features found in ADOS Module 4 allowed us to do this. The purpose of the study was to find five distinct sets of behaviors that reliably indicated the presence of Autism Spectrum Disorder (ASD). The findings have the potential to influence the development of new diagnostic methods for the detection of Autism Spectrum Disorder (ASD) and aid medical professionals in differentiating between different conditions. Having said that, there are a couple things to keep in mind. To begin, just a subset of the clinical population was included in the study. The second concern is that there may be limits to how well the machine learning technology captures behaviors associated with ASD. Furthermore, people exhibiting more severe symptoms of Autism Spectrum Disorder (ASD) may not be able to use the results. Additional research is necessary to validate the effectiveness of the discovered behavioral traits.

Autism Spectrum Disorder (ASD) affects around 1% of the world's population and has a negative effect on language development, communication, cognition, and social aptitude [12]. It can be costly and time-consuming to do clinical testing in order to get a diagnosis. Machine learning methods, such as Logistic Regression, are being considered by scientists as potential solutions to the accuracy problem. Nevertheless, data analysis still faces unanswered questions. Ethical concerns, inadequate sample sizes, complex symptom accounting, and the requirement for precise input data are all examples of such problems.

Further information on the use of Federated Learning (FL) for the accurate diagnosis of ASD in both children and adults may be found in the article [13]. This model employs a meta-classifier constructed from two machine learning classifiers—logistic regression and support vector machines—that were trained locally and then transmitted to a central server. The study reached an accuracy rate of 81% in adults and 98% in children through the examination of four datasets that included information about persons diagnosed with Autism Spectrum Disorder (ASD). Potential obstacles to the model's real-time implementation and verification inside clinical settings, issues with data privacy, and poor information quality are all considerations that might restrict its practical deployment.

Research [14] using machine learning approaches to detect characteristics associated with Autism Spectrum Disorder (ASD), with the goal of expediting the diagnostic process. While the Logistic Regression (LR) and Support Vector Machine (SVM) models achieve a flawless score of 100% when it comes to children, the Artificial Neural Network (ANN) model only manages 94.24%. In situations when actual labels cannot be found, spectral clustering is employed. However, the study has a few flaws, such as an inadequately sized sample, an undiversified dataset, an inadequate focus on the explainability and interpretability of the algorithms employed, and an absence of consideration for potential performance compromises in the model. Additional validation and external testing is necessary to guarantee the robustness and dependability of these methods.

The Autism Spectrum Quotient and the Modified Checklist for Autism in Toddlers are two expensive and time-consuming diagnostic tools for ASD [15]. Screening for autism spectrum disorder could be made more accurate and efficient with the help of machine learning. By identifying characteristics associated with autism, the suggested Rules-Machine Learning method seeks to compile data useful for professionals in the area. More details regarding the data sets utilized, comparisons to alternative methods, exploration of potential privacy, bias, ethical, and limiting concerns, and discussion of the method's applicability in clinical settings would enhance the article.

3. Proposed methodology

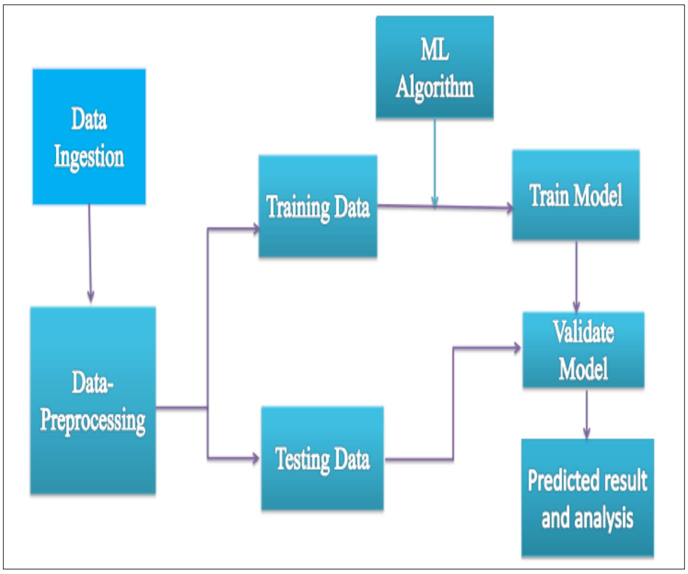


Figure 1 System Architecture

Figure 1 depicts the suggested model and shows that the data utilized for this research is sourced from the Kaggle website. There are ten questions that make up the screening survey. In each question, you can only choose between two possible values: 1 or 0. Additionally, it includes information such as the baby's gender, age, the presence or absence of jaundice at birth, and the place of birth. Pretreatment of raw data, which include cleaning and arranging it before mining, is one approach to data mining. In order to train the model, the ingested data must first be cleaned up. We eliminate any observations that have blank columns. Integers are generated from textual values. Data used for training the model accounts for 80% of total consumption. The model is trained using two Machine Learning techniques: Random Forest and Adaboost. Twenty percent of the data is utilized for testing the trained model. Following the training and testing phases, we assess the model's efficiency. The model generates a prediction when it receives the data.

The modules splitted from the architecture as shown below:

- Gathering data

Here data from kaggle is used. It is based on 10 screening questions focus on different domains such as-attention to detail, attention switching, communication, imagination and social interaction. For each question, it is either 1 or 0. It also contains certain features such as Age, Gender, jf born with Jaundice or not.

- Preparing the data

The collected data is synthesized to remove irrelevant features. Observations with null columns are removed. And string values are converted to integer values.

- Choosing a model

A machine learning classifier is trained using 80% of the training data. The classifier is based on Random Forest and Adaboost.

- .Evaluation

Then the model is evaluated using the test data which comprises of 20% of the original data.

- Prediction

We will use a new record to predict whether the child has autism or not.

4. Machine Learning Algorithms

Machine learning allows computers to learn new skills and information automatically by analyzing past data and examples; this process does away with the need for explicit programming. Multiple discrete Machine Learning techniques strengthen our programs by enabling them to autonomously acquire knowledge from the input data we supply. As the software is subjected to larger quantities of training data, its performance enhances. Our concept primarily employs two algorithms: 1) Adaboost algorithm. 2) Random Forest.

4.1. Adaboost

The fundamental concept as given in figure 2 underlying boosting approaches is to train predictors in a sequential manner, with each predictor attempting to rectify the errors made by its predecessor. AdaBoost is the most often employed boosting algorithm.

- Input: Training Data, Answers, Number of Trees
- Output: The output is the class prediction generated by the algorithm.
- Step 1: Set the initial values for the weights of the sample
- Step 2: Construct a decision tree using each characteristic, categorize the data, and assess the outcome.
- Step 3: Determine the statistical relevance of the tree in the ultimate categorization. The significance of an event can be find using the following formula:

significance = 1/2 * log((1 - total error) / total error).

Step 4: Adjust the sample weights to incorporate the errors made by the previous decision tree into consideration for the next decision tree. To calculate the significance of the improperly categorized sample, multiply the standard deviation of the sample by the exponential of the significance level. The formula for calculating the significance of correctly classified samples is:

n.s.w = s.w * e^-significance.

Step 5: Create a fresh dataset

Step 6: Continue repeating steps 2–5 until the total number of iterations equals the tree count (i.e., no. from trees).

Step 7: To make predictions using data that isn't in the training set, use the decision trees collection.

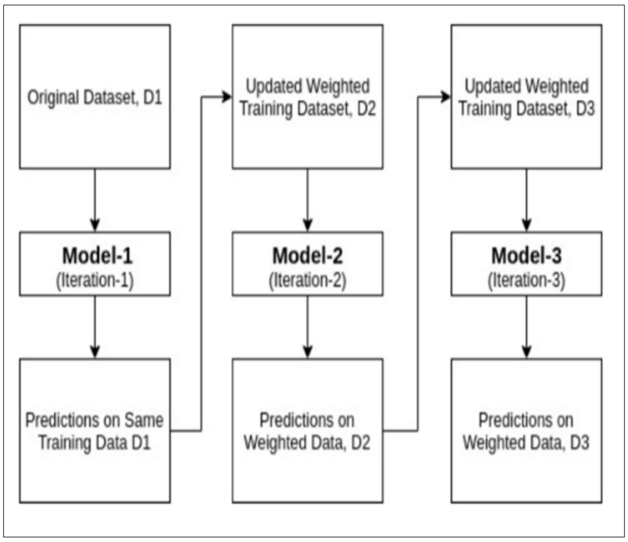


Figure 2 Steps to Adaboost Algorithm

4.2. Random forest

Ensemble learning is a technique used for a variety of tasks, including classification and regression as shown in figure 3. It involves training several decision trees. During the training phase, each tree within a random forest gains information from a randomly chosen portion of the data points. In the case of classification, the highest recorded forecast is considered.

Input: Training Data, Answer, Number of Trees

Output: Level prediction

- Step 1: An algorithm is employed to sequentially traverse a predetermined number of trees, commencing at 1 and concluding at the total count of trees.
- Step 2: Data used for training is selected at random. In order to construct a decision tree, a specific set of sample data is used.
- Step 3: All of the given information is taken into account as answers. From this, we may deduce that all decision trees will ultimately lead to the same projected outcome. The number of trees that have predicted the resultant class determines the level prediction.

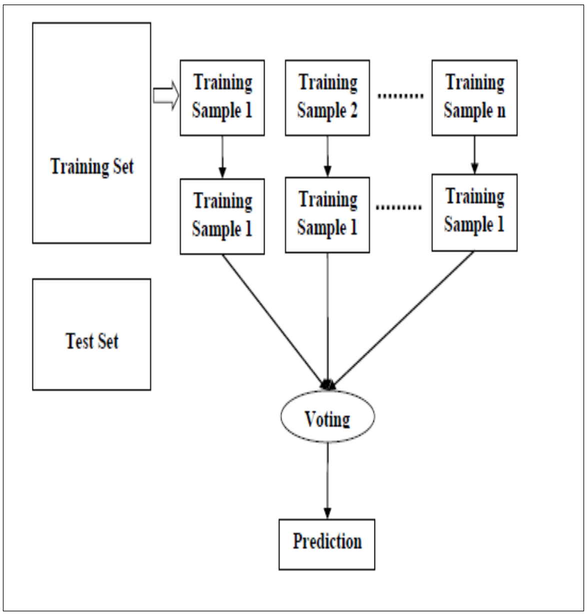


Figure 3 Working of Random Forest

5. Results

The figure 4 mentioned below about the dataset which are preprocessed, The collected data is synthesized to remove irrelevant features. Observations with null columns are removed. String values are converted to integer values.

Case_No	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	Age_Mons	Sex	Jaundice	_mem_wit	mpleted_	Class
1	0	0	0	0	0	0	1	1	0	1	28	1	1	0	0	0
2	1	1	0	0	0	1	1	0	0	0	36	0	1	0	0	1
3	1	0	0	0	0	0	1	1	0	1	36	0	1	0	0	1
4	1	1	1	1	1	1	1	1	1	1	24	0	0	0	0	1
5	1	1	0	1	1	1	1	1	1	1	20	1	0	1	0	1
6	1	1	0	0	1	1	1	1	1	1	21	0	0	0	0	1
7	1	0	0	1	1	1	0	0	1	0	33	0	1	0	0	1
8	0	1	0	0	1	0	1	1	1	1	33	0	1	0	0	1
9	0	0	0	0	0	0	1	0	0	1	36	0	0	0	0	0
10	1	1	1	0	1	1	0	1	1	1	22	0	0	0	1	1
11	1	0	0	1	0	1	1	0	1	1	36	0	1	1	0	1
12	1	1	1	1	0	1	1	1	0	1	17	0	1	0	0	1
13	0	0	0	0	0	0	0	0	0	0	25	1	1	0	0	0

Figure 4 Dataset After Preprocessing

The figure 5 explains about the count of data who has autism or not in the given dataset for analysis purpose. It Uses the PyPlot to count the number of people having autism with following.

count-plot(x='Family_mem_with_ASD',hue='Class',data=asd_data, palette='Set1')

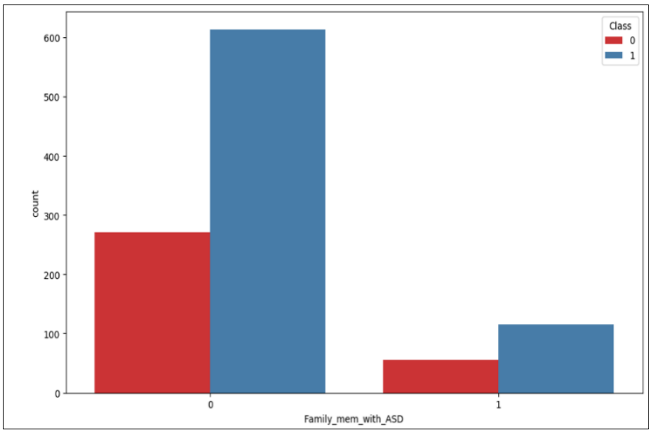


Figure 5 Graphical Display of Analysis of Dataset

Following figure 6, detailed about user interface who can give input for the queries to check the disorder whether autism or not. Figure 7 tells the result screen for the user inputs, which tells prediction result of autism or not.

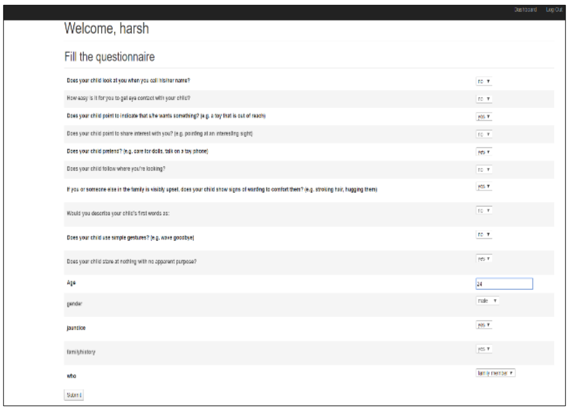


Figure 6 Screen of User Interface to enter the inputs

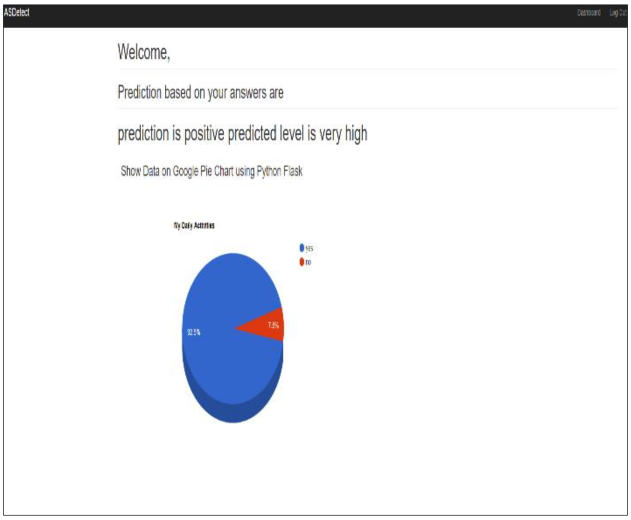
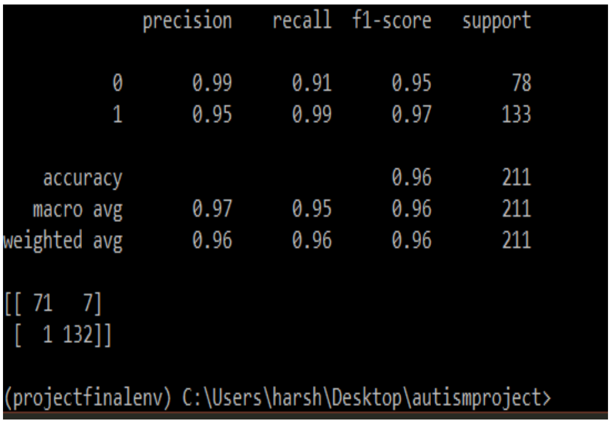


Figure 7 Result Screen to show the Prediction

Below figure 8 and table 1 describes about the performance of the algorithm random forest given.



```
              precision    recall  f1-score   support

           0       0.99      0.91      0.95        78
           1       0.95      0.99      0.97       133

    accuracy                           0.96       211
   macro avg       0.97      0.95      0.96       211
weighted avg       0.96      0.96      0.96       211

[[ 71   7]
 [  1 132]]

(projectfinalenv) C:\Users\harsh\Desktop\autismproject>
```

Figure 8 Performance Score

Table 1 Performance Table

	Precision	**Recall**	**Accuracy**
Adaboost	0.95	0.92	0.93
Random Forest	0.97	0.95	0.96

6. Conclusion

A predictive model was created to forecast characteristics associated with autism. The suggested model, utilizing the AQ-10 data set, can accurately predict autism in children with a precision of 92.26%. This finding demonstrated superior efficacy in comparison to the alternative method of screening for autism.

Using the proposed prediction model, an accessible web application has been developed for end users. Users may easily anticipate the onset of autistic symptoms with this software. Since most earlier studies just dabbled with developing and evaluating prediction models or techniques, this finding represents a significant expansion of such efforts into the realm of end-user mobile application creation.

Ultimately, the results of this study provide a practical and efficient way to detect autistic traits in toddlers and preschoolers. Recognizing autism in children and teenagers can be challenging, leading to delays in the procedure because of the high expense and time-consuming nature of diagnosing autistic traits. The use of an autism screening app allows for early intervention, which in turn reduces the costs associated with a delayed diagnosis and keeps the condition from getting worse.

A limitation of our study is its exclusive focus on a single age group, specifically newborns. Therefore, it has the potential to be expanded in future to encompass additional age demographics. The enhancement of User Experience is possible. Additional inquiries can be considered. In addition to the questionnaire, child behavior patterns might be examined and considered. Furthermore, it is possible to conduct concurrent screening for several illnesses, including ADHD, language difficulties, intellectual disabilities, and others, in addition to autism.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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