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Autism Screening using Deep Learning

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Abstract: ***Autism spectrum disorder (ASD) is growing among childrens. Autism is normal chronic disorder which fails a person or a child to interact with others socially. Detecting of autism through screening test is very time consuming and cost effective till now there is no cure for autism. But if it is detected earlier we can motivate them to move socially and decrease the level of autism in them. So we detect autism using deep learning techniques so that we can detect it earlier stages.***

Keyword: Deep Learning, Chronic, Autism, Spectrum

I. INTRODUCTION

Leo kanner in 1943 identified for the first time autism who was an American psychologist. Leo observed characteristics that are common, distinctive in a group of children who were diagnosed with mental disorders in the beginning. Leo identified the inability of this group of people to relate in ordinary way with other common people and situations; hence he expressed it as "extreme autistic aloneness". Autism word was derived from the Greek meaning self. Autism is multiple combination of neurobehavioral disorder that is differentiated with marring in mutual social interaction, communications, recurring stereotypic interests, activities and behavioral presence. Puzzle is logo for autism, because puzzle show the ambiguity and difficulty of autism. All puzzle piece point out against the child with autism waiting to finish the picture and bring it significance. The term autism is used to depict a set of brain development disorders. Autism is permanent developmental disability which affects the way person communicates with and relates to other persons. People having autism might also experience high or low sensitivity towards touch, smells, color, and sound and as well tastes. Autism is known as spectrum condition that is where people having autism share common difficulties but their condition affects them in a different way. Few people diagnosed as autism patients are able to live independent lives, whereas some people has learning disability and requires a specialist support for a lifetime. Autism spectrum disorders (ASD) are a set of multifaceted neurodevelopment disorder which consists of shortfall in communication, interaction, with the presence of restricted and repetitive behaviors. The symptoms are normally present under the age of three years and could be accompanied with attention, learning, sensory process and cognitive function impairments.

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Persons diagnosed with autism pose a dramatically different social, emotional actions and as well reactions than that of non-autistic persons. As an example, most of the autistic children don't seem to care for the attention from their parents. Autistic spectrum disorders has effect on IQ also, where 30% of people having autism has an average IQ or they have gifted IQ the remaining 70% people are mentally retarded.

Autism spectrum disorder (ASD) a turmoil which shortcoming in communication with others socially, conversation, constant and deprived behaviors. This will be generally identified in child itself that is before the age of years. And may be lead by destruction in emotional functioning and erudition.

ASD throws a child into a failure of interacting to people socially, and maintain relationship with others and expand communication ability, lagging in dreaming.

Child with autism have different social and emotional actions we can easily differ the activities of a child having autism with a normal child.

ASD effects IQ level of child. only thirty percent of the children will get gifted IQ level while others will be treated as mentally disorder child.

II. LITERATURE SURVEY

DIAGADHD an artificial hybrid model of neural network was proposed by Arthi and Tamilarasi (2009) used in diagnosing Attention Deficit Hyperactive Disorder (ADHD) also a development disorder among children as autism. Hybrid consists of both Radial Basis Function and Self Organizing Feature Map (SOM) neural network. This new hybrid model produces results with improved accuracy over another back propagation algorithm when used same set of data. The data set collected has 165 instances [1].

The use of neural networks has been suggested as autonomous second judgment in the autism diagnosis by Florio et al., 2009. In a comparison study conducted among the Logistic Regression technique and Multi Layer Perceptron neural network, the output gave the best results for neural networks than Logistic regression for the diagnosis of the problem. The size of the sample was 638 and Developmental behaviour checklist (DBC) instrument was used in the assessment. While generalization test was carried out with 100 samples it predicts with accuracy rate of 80% [2]. Arthi et al 2011 projected application of FCM along with nonlinear Hebbian learning, in modelling to predict only an autistic disorder. This work overcomes few limitations of FCM while supervised training through improving its learning method. Training for FCM nonlinear Hebbian learning (NHL) was carried out using the dataset of 40 with modified checklist for autism in toddlers (MCHAT).

This approach proposed might serve as guide for planning and determining autistic children therapies. The tool for assessment is a questionnaire which has 23 questions from MCHAT. The model is trained using 40 datasets collected locally and it is able to give the performance of 79.9% accuracy average classification [3].

Guillen et al 2010 in a study of machine learning techniques such as clustering and classification of identification of subtypes in autism. This work majorly targeted the mining of patient's data with autism by use of cluster and classification method, with an idea to categorize Autism Spectrum Disorder. All models of machine learning are developed with data using from Autism Research Institute's E2 survey containing 150 questions. Clustering algorithms such as minimum message length algorithm and maximum algorithm have been used in data pre-processing. The resulted clusters were then subjected to analysis with JRip classification algorithm. The effectiveness in the use of this technique illustrate the use of such technique in identifying autism[4].

Veeraraghavan and Sirnivasan 2007, suggested the expert systems use for screening autism. The major intention for this work was identify autism in the early using technological aids in an individual. Therefore the work was planned using the internet as a tool to screen autistic children which provides final report. The developmental delays occurred in child were evaluated using the Delay Screener (DS). The neural net and reinforcement agents that are attached to intelligent gaming system are the framework for providing the training among children. The screener is helpful in detecting social developmental disorder and could be used for intervention in home [5].

Van den Bekerom, 2017 by using various machine learning techniques such as naive Bayes, random forest algorithm and SVM to predict autistic spectrum disorder qualities among children such as developmental delay, less physical activity and obesity and compare these outputs. Wall et al 2012 efforts on categorizing autism using short screening test and confirmation, he set up functional tree and autistic disorder tree has performed fine in terms of high sensitivity, accuracy and specificity [6].

Heinsfeld et al 2018 from Autism Imaging Data Exchange (ABIDE 1) used dataset of large brain imaging in identifying Autism spectrum Disorder patients by applying neural network and deep learning algorithm which achieved an mean classification accuracy of 70% and the accuracy range was between 66% to 71%. The accuracy achieved by SVM classifier and random forest classifier is 65% and 63% respectively [7].

This study using supervised machine learning algorithm predicts autism traits. To enhance the accuracy of prevailing classifiers, Random Forest Algorithm was included by researchers, with improvement in CART and ID3 algorithm to attain for better outcomes. Depending on these outcomes a mobile application has been developed for detecting autism in diverse age groups [8][21][22][23][24].

The method developed by researchers for prediction of ASD in toddlers is worked on ASD data of patient collected using Q-CHAT (Quantitative Checklist for Autism in Toddlers). The selected features are then passed to the Random Tree Classifier, in prediction of ASD [9] [25].

Depending on visual portrayal of eye tracking scan paths this method is useful in learning clusters. Compressed representations were used to train clustering model through a deep auto encoder. The experimental outcome reveals a promising trend of clustering structure. Moreover, clusters were investigated to deliver interesting understandings of gaze behaviour characteristics that are involved in autism [10].

Thabtah 2018 seriously analysed consequences related to experimental studies which implemented machine learning in classifying Autism Spectrum Disorder. The authors determined concerns associated with datasets and learning algorithm methodologies employed. These concerns consist of clarifying the classifiers subject obtained by the learning algorithm, autism datasets commotion, feature selection process, class imbalance and missing values, entrenching the classification algorithm within a present assessment method [11].

Clinical tools in routine use presently to determine Autism Spectrum Disorder symptoms have a propensity to consume extra time, and strongly swayed amid biased observations. In a few incidents, diagnosis is delayed, and involvement is delayed. Hence a gaze movement was devised by the scientists that are a biomarker to detect Autism Spectrum Disorder. Here in this paper, we intend to increase the speed in diagnosing autism through a combination of machine learning by means of gaze-based program as transformative process to find autism at the initial young ages. The crucial key feature of the gaze screening is collection of data using feature extraction, developing the prognostic model and eye tracking. It is imposed that support vector machine as a machine learning technique to find specificity, performance measures, area under curve and accuracy and sensitivity. The outcomes demonstrate support vector machine achieves high performance classification implemented on eye movement dataset [12].

Autism spectrum disorder is a debility among humans which separates those among normal humans in comparison with behavioural assessment and outgoing perplexity. Day to day number of autism cases are increasing around the world, therefore there is a need to expand numerous screening methods. The anticipated work compares machine learning algorithms through its performance which is consisted of various classifications such as random forest, IBK, naïve bayes, Radial basis function network. Measured performances are forced on 2017 UCI dataset. The outcomes are obtained via analysing the algorithms and noticed that random forest delivers consecutive determination among the others [13]. This recommended an innovative version of rationale and automated detection of autism conditions and routine subjects depending on society organization and deep learning, which can deliver better accuracy compared to conventional methods [14]. Heinsfeld researched on well-designed interaction patterns which separate ASD patients independently by functional brain imaging data and attempted to reveal the neural structures which are originated from classification.

Also, researchers identified the areas of brain which contributes more to separating ASD from normally developing controls corresponding to notion of deep learning [15]. Yan jin researched on well-designed interaction patterns which separate ASD patients independently from functional brain imaging data and tried to reveal the neural structures which are originated from classification. Also, researchers identified the areas of brain which contributes more to separating ASD from normally developing controls corresponding to notion of deep learning [16]. Duda in their study indicated six machine learning algorithms performance on data with the use of 65 objects in SRS as features and analysis of any ASD or ADHD being the forecast class. This kind of subsampling procedure was implemented to improve concern of substantially unequal classes, as well as to protect alongside gender biases or any age which might be intrinsic to data. Behavioural identification of these ASD and ADHD is a time taking process. In this evaluation of archival data, the major difficulty to be faced is limited content availability of data sets [17]. Omar by using amazon web services designed a mobile application and API was generated. To obtain the accurate results this application segregates the user into three separate age groups. Several machine learning techniques were tested and tried. The obtained outcomes revealed that Random Forest-CART has superior performance compared to Decision Tree-CART algorithm, although the grouping of Random Forest-CART and Random Forest-ID3 algorithm presented improved performance when associated with both the Random Forest-CART and Decision Tree-CART separately [18]. The involvement of technology in the early diagnosis of autism is more popular or in assisting the early intermediation applications. Random forest ID algorithm are being in use now days to research in autism diagnosis which help in speeding up the process [19]. Support Vector Machines the most prevalent of supervised machine learning techniques are routinely employed in detecting anatomical variations in brain of children with autism spectrum disorder [20].

III. DATASET

Dataset have been downloaded from UCI repository and the dataset is available publicly. It is published on UCI repository on 2017 December.

SNO	DATASET NAME	SOURCES	ATTRIBUTE TYPE	NUMBER OF ATTRIBUTES	NUMBER OF INSTANCES
1	ASD SCREENING DATA FOR CHILDREN	UCI repository	Categorical, Continuous and binary.	21	292

L IST OF ATTRIBUTES IN THE DATASET.

Attribute ID	Attributes Description
1-10	10 questions based on screening methods.
11	age of patient
12	gender
13	nationality
14	whether the patient have jaundice
15	any family member suffered before
16	country of patient
17	screening used app before or not?
18	score
19	age description
20	relation
21	Class/ASD

IV. PROPOSED METHODOLOGY

A. Deep Learning Techniques

Keras was among the most commanding and user friendly technique in deep learning. It encapsulates the mathematical computational libraries especially theono and tensor flow. In this project we mainly focus on tensorflow. The various phases of the proposed system are shown in Fig 1.

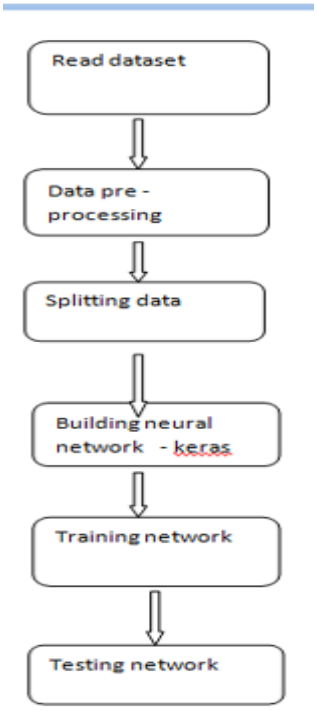

Fig. 1 Phases of the Proposed System

B. Data Preprocessing

Data which is collected will be many irrelevant features we have to remove unwanted data to develop prediction model. unwanted data such as age, age desc will be dropped to get accurate results of prediction. much of our data is reported using strings; as a result, we will convert our data to categorical labels. During our preprocessing, we will also split the dataset into X and Y datasets, where X has all of the attributes we want to use for prediction and Y has the class labels**.**

C. Splitting Data

Before we can begin training our neural network, we need to divide dataset as testing and training datasets. This will allow us to test our network after we are done training to determine how well it will generalize to new data. This step is incredibly easy when using the train test split () function provided by sklearn**.**

D. Training and Testing

The data which is collected will be splitted into two that is training and testing in 80:20 ratio these 80 percent data will be sent to training and twenty percent will be for testing and the eighty percent will be subdivided and splitted into two in same ration for training and testing.

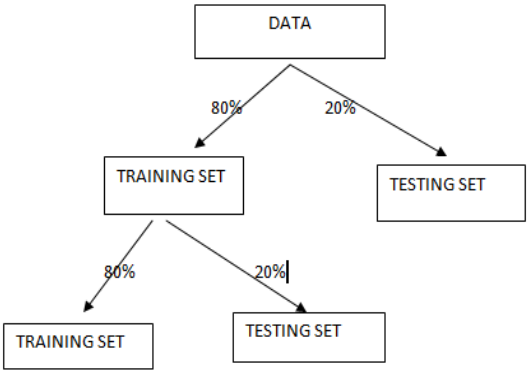

Fig. 2. Training and Testing

E. Convolutional Neural Network (CNN)

One of the deep learning techniques which is used popularly to develop models for different problems. This neural network is motivated by the human brain. It has many layers but it has only one input and one output layer and the other layers are max pooling, convolution layer, fully cconnected layer, normalization layer.

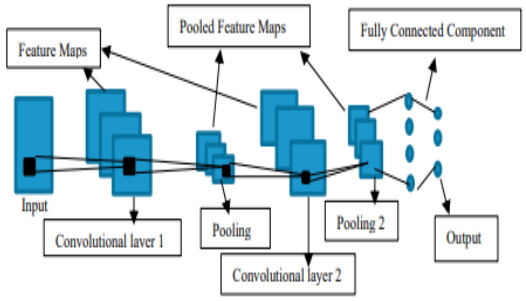

Fig. 3. Convolutional Neural Network

F. Artificial Neural Network

A network which has multiple connections with multiple neurons is ANN. Each cell has its input values and weights associated with it. The forward neural network is 0 which feed forward neural network in this the information is moved only in forward direction. This ANN has only 3 layers input,hidden and output layer.

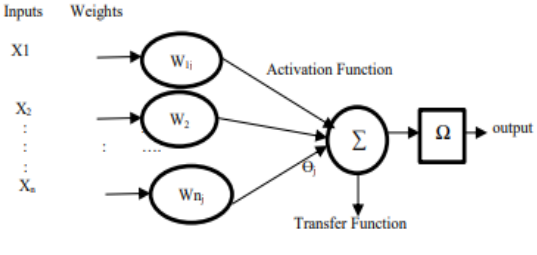

Fig. 4. Artificial Neural Network

G. Building Network

We are going to use Keras to build and train our network. This model will be relatively simple and will only use dense (also known as fully connected) layers. This is the most common neural network layer. The network will have one hidden layer, use an Adam optimizer, and a categorical crossentropy loss. We won't worry about optimizing parameters such as learning rate, number of neurons in each layer, or activation functions in this project; however, if you have the time, manually adjusting these parameters and observing the results is a great way to learn about their function.

H. Results

The results are calculated in terms of precision, F1 score, Recall.

H.1 preformance Evaluation Metrics

Performance measurements is the key to evaluate the performance to achieve the target. And it is used to identify how well the performance of the classification model.

	Predictive ASD values	
Actual ASD values	True positive (TP)	False Positive (FP)
	False Negative (FN)	True Negative (TN)

$$\text{Precision} = \frac{True\ Positive}{True\ Positive + False\ Positive}$$

$$\text{Recall} = \frac{True\ Positive}{True\ Positive + False\ Negative}$$

F-measure=(2*Precision*Recall)/(Precision+Recall)

$$\text{Accuracy} = \frac{(TP + TN)}{(TP + FP + TN + FN)}$$

The results of machine learning and deep learning algorithms are used to check the accuracy with all features have been showed for the ASD screening.

Classifier	precision	recall	accuracy
Random forest			89%
CNN	0.96	0.90	0.93
Weighted avg	0.93	0.93	0.93

We should import some important libraries for the project to classify and analyse the data. Some important libraries are sys, pandas, sklearn, keras. System specific parameters and function sys package is imported to provide access to the interpreter to use some variables and to maintain by the interpreter to function strongly with it.

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Pandas is an open source library of data analysis libraries it is simple to use and to utilize investigate apparatuses for python language and the information structures. It is used for the control of the data and to investigate.

Models in keras is series of layers, in this we generate a chronological model and then we can include any number of layers you wanted to add until your output is satisfied for you. Keras gives you to connect layers fully which is distinguished with Dense class were we could denote number of neurons and nodes within layer and indicate commencement function using the argument activation.

RELU (rectified linear unit activation function) has been used in first layer and second layer which was followed with using sigmoid function for the outer layer.

Sklearn which in the past is known as scikits and lateron it is modified as sklearn . It is a free AI programming library for the python programming language. With the help of sklearn we prepare and test our information.

```
import sys
import pandas as pd
import sklearn
import keras
```

Fig. 5 Importing Libraries

Next step we need to import our data

```
file = "C:\\Users\\91829\\Downloads\\Telegram Desktop\\Autism-Child-Data.csv"
data = pd.read_table(file, sep = ',', index_col = None)
```

Fig. 6 Importing our Data

This will provide an output of our first column in dataset

```
A1_Score                1
A2_Score                1
A3_Score                0
A4_Score                0
A5_Score                1
A6_Score                1
A7_Score                0
A8_Score                1
A9_Score                0
A10_Score               0
age                     6
gender                  m
ethnicity          Others
jundice                no
austim                 no
contry_of_res      Jordan
used_app_before        no
result                  5
age_desc      '4-11 years'
relation            Parent
Class/ASD               NO
Name: 0, dtype: object
```

Fig. 7 Output of the Data Set

To know what type of data is used in our dataset we project first 10 columns using data.loc[:10] command in python and output is as shown as below

	A1_Score	A2_Score	A3_Score	A4_Score	A5_Score	A6_Score	A7_Score	A8_Score	A9_Score	A10_Score	...	gender	ethnicity	jundice	austim
0	1	1	0	0	1	1	0	1	0	0	...	m	Others	no	no
1	1	1	0	0	1	1	0	1	0	0	...	m	'Middle Eastern'	no	no
2	1	1	0	0	0	1	1	1	0	0	...	m	?	no	no
3	0	1	0	0	1	1	0	0	0	1	...	f	?	yes	no
4	1	1	1	1	1	1	1	1	1	1	...	m	Others	yes	no
5	0	0	1	0	1	1	0	1	0	1	...	m	?	no	yes
6	1	0	1	1	1	1	0	1	0	1	...	m	White-European	no	no
7	1	1	1	1	1	1	1	1	0	0	...	f	'Middle Eastern'	no	no

Fig. 8 Sample Data in Our Dataset

Next we are visualizing our whole data in an histogram format for that the following code will be

```
data.hist(figsize=(10,13));
```

Fig size represents the size of an output picture we can minimise or maximise to our need

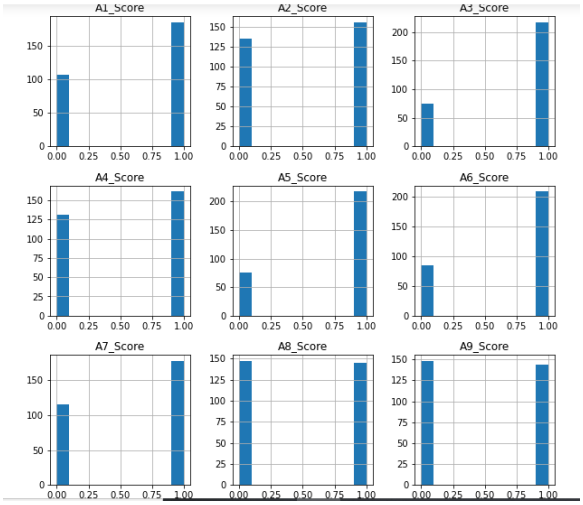

Fig. 9 Output of Histogram 1

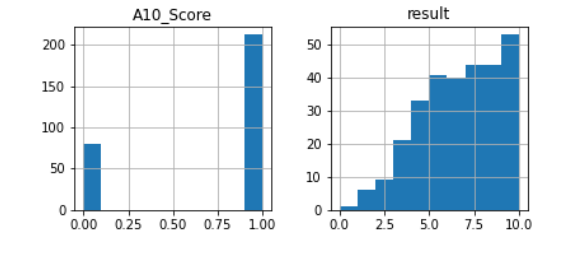

Fig. 10 Output of Histogram 1 Contiuation

Below we drop the unnecessary columns in the dataset and then we project the scores after dropping of the table using graph representation. using the command as follows

```
positive=graph[['A1_Score','A2_Score','A3_Score','A4_Score','A5_Score','A6_Score','A7_Score','A8_Score','A9_Score','A10_Score']]
```

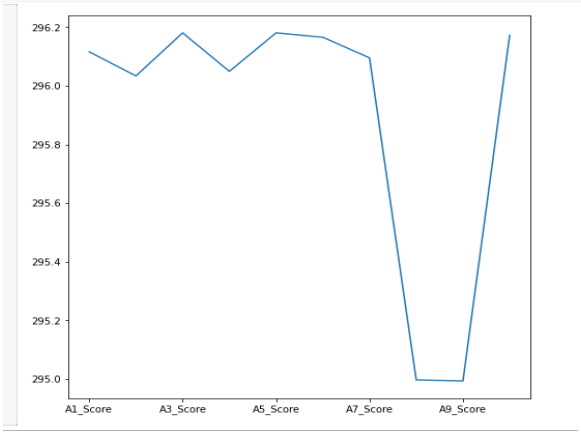

Fig. 11 Output of Graph

```
x = data.drop(['Class/ASD'], 1)
y = data['Class/ASD']
x.loc[:10]
```

Fig. 12 Code for Dropping Class/Asd

After dropping of class/asd it is easy to predict the autism because we drop unwanted data.

A4_Score	A5_Score	A6_Score	A7_Score	A8_Score	A9_Score	A10_Score	age	gender	ethnicity	jundice	austim	contry_of_res	used_app_before	relation
0	1	1	0	1	0	0	6	m	Others	no	no	Jordan	no	Parent
0	1	1	0	1	0	0	6	m	'Middle Eastern '	no	no	Jordan	no	Parent
0	0	1	1	1	0	0	6	m	?	no	no	Jordan	yes	?
0	1	1	0	0	0	1	5	f	?	yes	no	Jordan	no	?
1	1	1	1	1	1	1	5	m	Others	yes	no	'United States'	no	Parent
0	1	1	0	1	0	1	4	m	?	no	yes	Egypt	no	?
1	1	1	0	1	0	1	5	m	White-European	no	no	'United Kingdom'	no	Parent
1	1	1	1	1	0	0	5	f	'Middle Eastern '	no	no	Bahrain	no	Parent
1	1	1	1	0	0	0	11	f	'Middle Eastern '	no	no	Bahrain	no	Parent
1	1	0	1	1	0	0	11	f	?	no	yes	Austria	no	?
0	1	1	1	1	1	1	10	m	White-European	yes	no	'United Kingdom'	no	Self

Fig. 13 Output After Dropping

When we get dummy values to eliminate unwanted or repeated data.

```
X = pd.get_dummies(x)
X.columns.values
X.loc[1]
```

Fig. 14 Code for Getting Dummy Values

After the code is run we get following output.

```
A1_Score              1
A2_Score              1
A3_Score              0
A4_Score              0
A5_Score              1
                     ..
relation_?            0
relation_Parent       1
relation_Relative     0
relation_Self         0
relation_self         0
Name: 1, Length: 96, dtype: int64
```

Fig. 15 Output of Getting Dummy Values

We divide the data into testing and training of the data. Thirty percent data is splitted to testing and whereas the remaining is for training the data after that the triaing data is again splitted into training and testing the data in same manner as above mentioned. The code for splitting the data is as follows.

```
from sklearn import model_selection
# split the X and Y data into training and testing datasets
X_train, X_test, Y_train, Y_test = model_selection.train_test_split(X, Y, test_size = 0.2)


# In[33]:

print (X_train.shape)
print (X_test.shape)
print (Y_train.shape)
print (Y_test.shape)
```

Fig. 16 Code for Splitting the Data for Trianing and Testing

After the above output we comes to the building of keras model here we import keras and we use dense, sequential and adam classes to build our network .
The code for importing and building is as shown below

```
from keras.models import Sequential
from keras.layers import Dense
from keras.optimizers import Adam
```

Fig. 17 Importing Keras Model

After importing the keras we build our keras model using sigmoid and relu activation function .the code for the same is given below.

```
def create_model():
    # create model
    model = Sequential()
    model.add(Dense(8, input_dim=96, kernel_initializer='normal', activation='relu'))
    model.add(Dense(4, kernel_initializer='normal', activation='relu'))
    model.add(Dense(2, activation='sigmoid'))
     # compile model
    adam = Adam(lr=0.001)
    model.compile(loss='categorical_crossentropy', optimizer=adam, metrics=['accuracy'])
    return model

model = create_model()

print(model.summary())
```

Fig. 18 Code for Creating Model

The output will be

```
Model: "sequential_1"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense_1 (Dense)              (None, 8)                 776
_________________________________________________________________
dense_2 (Dense)              (None, 4)                 36
_________________________________________________________________
dense_3 (Dense)              (None, 2)                 10
=================================================================
Total params: 822
Trainable params: 822
Non-trainable params: 0
_________________________________________________________________
None
```

Fig. 19 Output of Model Creation

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Fitting the model to the training data we use function model.fit() to fit into it the code for same as shown below.

```
model.fit(X_train, Y_train, epochs=50, batch_size=10, verbose = 1)
```

Fig. 20 Code for Fitting Model into Training Data

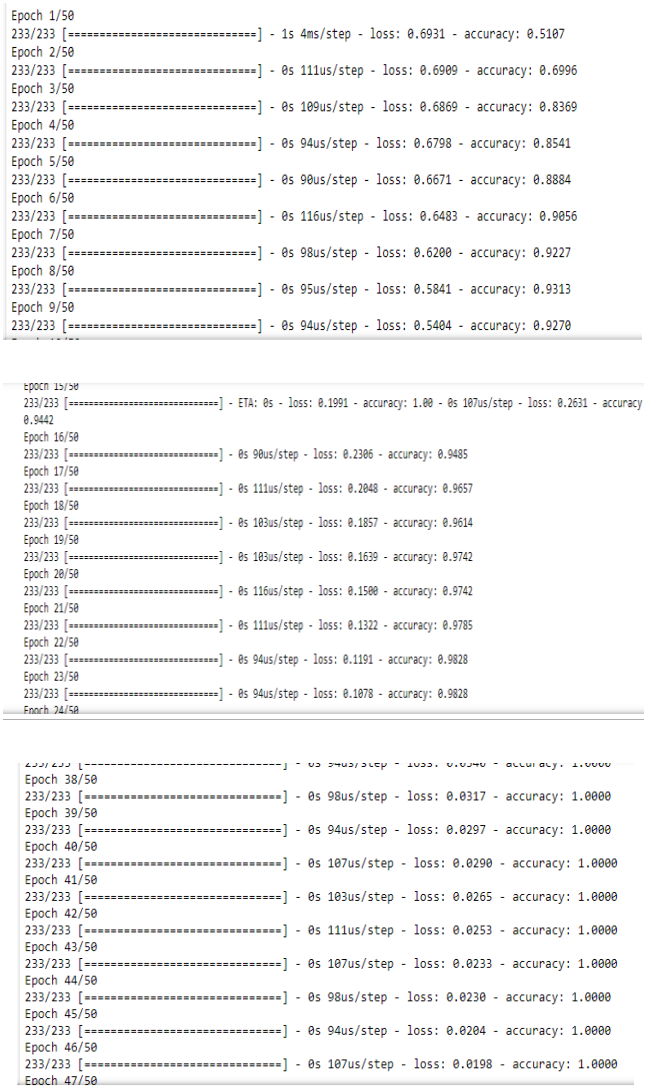

Fig. 21 Output of Modelfit

Generate classification report using prediction for categorical using sklearn.

```
from sklearn.metrics import classification_report, accuracy_score

predictions = model.predict_classes(X_test)
predictions
```

Fig. 22 Code to Generate Classification Report

Output will be shown in array datatype as shown below and it shows its datatype.

```
array([1, 0, 1, 0, 0, 0, 1, 0, 0, 0, 1, 0, 1, 1, 1, 1, 1, 0, 0, 0, 1, 0,
       0, 1, 1, 0, 1, 1, 0, 0, 1, 1, 1, 0, 0, 0, 1, 1, 1, 0, 1, 1, 1, 0,
       0, 0, 0, 0, 1, 1, 1, 1, 0, 1, 0, 1, 0, 1, 1], dtype=int64)
```

Fig 23 Output to Generate Classification Report

We generate results for categorical model and provide accuracy score and classification report. Code is as shown as below.

```
print('Results for Categorical Model')
print(accuracy_score(Y_test[['YES']], predictions))
print(classification_report(Y_test[['YES']], predictions))
```

Fig. 24 Code for Accuracy Score

The output is as follows.

```
Results for Categorical Model
0.864406779661017
              precision    recall  f1-score   support

           0       0.93      0.81      0.87        32
           1       0.81      0.93      0.86        27

    accuracy                           0.86        59
   macro avg       0.87      0.87      0.86        59
weighted avg       0.87      0.86      0.86        59
```

Fig. 25 Output of Accuracy, and Classification Report

V. CONCLUSION

Using machine learning and deep learning techniques we have attempted to detect the autism in child data. The performance evaluation which is mentioned above is used to evaluate the autism detection on non-clinical data for the childrens. In this we have used both machine learning and deep learning techniques in which machine learning technique we have used random forest algorithm which given the accuracy of 89% whereas in deep learning we have used CNN and it gives the accuracy of 93%. From the above obtained results the CNN model gives the best accuracy for detecting autism when compared to random forest algorithm. From the results we strongly suggest that the CNN model can be used to detect the autism spectrum disorder instead of using other machine learning techniques in order to get better accuracy.

Model	Accuracy
Random Forest	89%
Convolutional Neural Network	93%

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Ethical Approval and Consent to Participate	No, the article does not require ethical approval and consent to participate with evidence.
Availability of Data and Material	In this research work authors used publicly available data across Ecommerce websites.
Authors Contributions	I am only the sole author of the article

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