Schizophrenia Prediction from rsFMRI Images using RESNET-50 based Classifier

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***Abstract*-- Schizophrenia (SZ) is a mental disorder that affects many young people. Early detection and treatment can release the stress of family members and save societal costs. Deep learning in neuro imaging creates new insights in modification of brain structures during various brain disorders. Therefore, resting state functional Magnetic Resonance Image (rsFMRI) data for schizophrenia is used in this paper. At first, the images in the dataset are preprocessed. After that, data augmentation is done and data is divided into training and testing images. Then, the model based on the deep learning framework RESNET 50 is constructed to extract features and the test images are given to the pre trained model to predict schizophrenia and Healthy Controls (HC). The classification accuracy of95.53% is achieved according to the experimental results. Based on the comparative analysis, we conclude that our model outperforms some recent methods and also increases the schizophrenia prediction accuracy.**

***Index Terms*-- Convolutional Neural Network, Deep learning, Neuro Imaging, Residual Network, Schizophrenia**

I. INTRODUCTION

Schizophrenia is a serious and deactivating mental disorder that often occurs in adults. It is characterized by major changes in perception, thoughts and behavior [1]. Symptoms include false belief, lack of motivation, unclear thinking, less social involvement and emotional expression. It gives countless agony to the patients and heavy burden to their families and their neighbours. Mostly people with age between 15 to 34 are affected by this disease. So, it is necessary to retain the disease from progressing too far [2]. Early intervention and cognitive behavioral therapy may reduce the risk of disease progression. However, early diagnosis of SZ remains a challenging task due to the complexity of the disease. Currently, SZ diagnosis is primarily relies on the activities of SZ patients [3]. The medical diagnosis of patients is primarily depends on the experience of doctors and interrelated level of assessments. But, there is lack of diagnosis criterion.

To solve this, various techniques of Artificial Intelligence (AI) and Machine Learning (ML) have been employed with advanced neuro imaging to precisely detect SZ. In [13], the researchers have reviewed various artificial intelligent techniques used for diagnosing SZ. Deep Learning (DL) is sub field of ML which is used to construct models to learn high dimensional feature from the data. DL is widely used in neuro imaging for the automated diagnosis of various mental disorders such as bipolar disorder, Alzheimer's disease and SZ. Functional Magnetic resonance imaging (FMRI) is the popular neuro imaging technique used to explore structural or functional abnormalities of brain regions to detect SZ disorder. Resting state is a kind of fMRI that measures the changes in blood oxygen level, volume and flow in brain regions. It can also improve early diagnosis of SZ by solving classification problems of small and high dimensional dataset by using deep learning models.

II. RELATED WORK

Now days, many researchers have used rsFMRI data to classify SZ [9]. Presently, some researchers have examined and summarized the deep learning techniques in medical imaging field [4]- [8]and [10], [13]. In [11], the authors have used VGG16 net and transfer learning to predict schizophrenia and healthy controls. In [14], the researchers classified SZ patients from health controls from various sites with an accuracy of 85.8% using a Graph Convolutional

model. The authors constructed Brain Net-GACNN and produced an accuracy of 83.13% in [15].

The researchers have used revised gcForest to classify SZ patients from Health controls [16]. The authors have developed a Multi Kernel Capsule Network based on the brain anatomical structure to diagnose SZ [17]. B. Yang etal., [18] have used am multiple feature image capsule networks ensemble method and produces classification accuracy of 82.83%.

In order to improve accuracy, this work aim at the outlook of deep learning and implement RESNET 50 architecture to extract features from rsFMRI data to predict SZ patients.

III.PROPOSED WORK

In this work, the input rsFMRI images are processed and augmented and the RESNET 50 is constructed to extract features and the test images are given to the pre trained model to predict schizophrenia and Healthy Controls (HC). The architecture of our model is depicted in fig.1

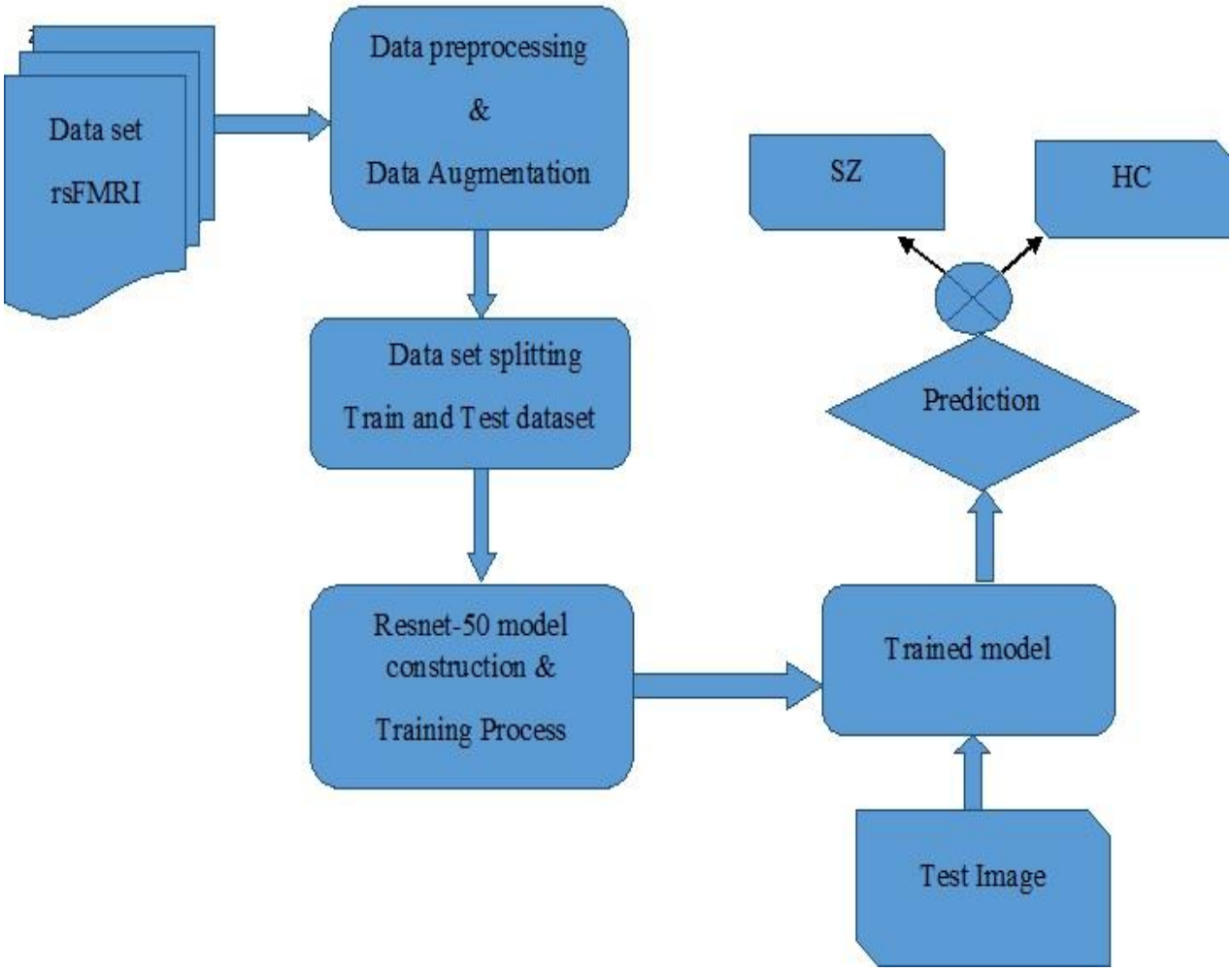

Fig.1 Architecture of our proposed Model

A. Data set:

From the Center for Biomedical Research Excellence (COBRE) dataset, we have collected rsFMRI images for schizophrenia and it is downloaded from the following link (http://fcon_1000.Projects.nitrc.org/indi/retro/cobre.html). The COBRE dataset is more efficient and popular than other datasets for the studies on automatic detection of SZ [11]. We have collected 253 rsFMRI images between the age of 18 and 65.

B. Preprocessing

The rsFMRI data are preprocessed using SPM12 software tool accessible from (http://www.fil.ion.ucl.ac.uk/spm/).The preprocessing steps namely binarization, standardization and smoothing is performed in each data. Binarization is used to transform data features of any entity into binary numbers. In standardization, the attributes are rescaled. Smoothing is used to reduce noise within an image consequently produces a less pixelated image.

C. Data augmentation

The augmented data is derived from the original images by adding geometric transformations such as flipping, translation, rotation to increase the diversity of training set.

D.Data splitting

Data splitting is done to separate training data and testing data. From the dataset, 50 % samples are taken for training the model and remaining 50%samples are used for testing the model.

E. Construction of model

In this work, we have implemented Resnet-50 architecture for predicting SZ. Residual Network (RESNET) was first introduced by Karming et al., in [7]. Resnet has several alternates. They work with same idea but different layers are used.Resnet-50 architecture consists of 50 neural network layers. It uses a stack of 3 layers. Resnet 50 produces higher accuracy than Resnet 34. It achieves a performance

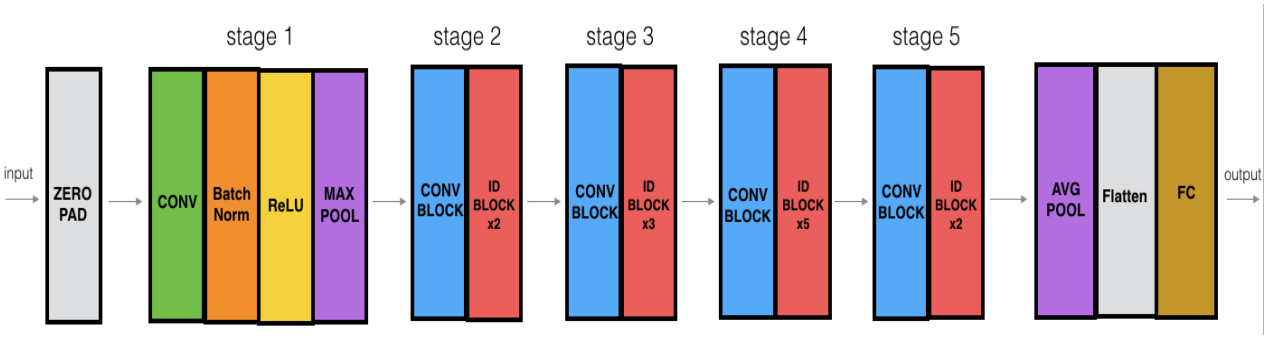

Fig.2 Resnet-50 Architectural diagram

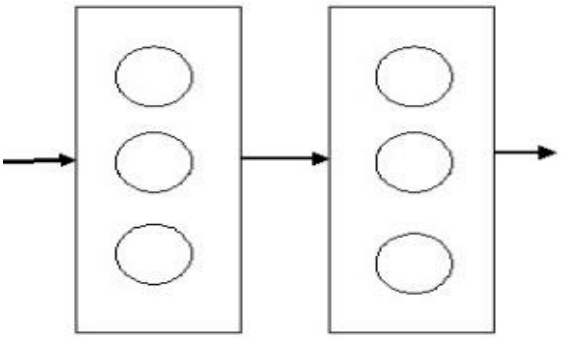

Fig.3.a) Without Skip Connection

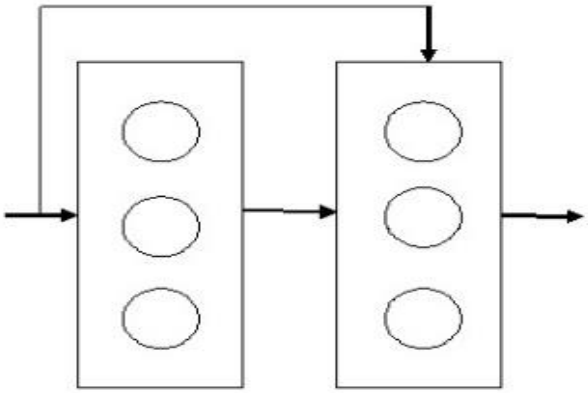

Fig. 3.b) With skip connection

of 3.8 bn FLOP. Resnet 50 architectural diagram is shown in fig.1.Resnet 50 contains 5 stages. At each stage, there is a convolution block and identity block. Every identity block has 3 convolutional layers. Resnet make use of skip connections to add output from one layer to another layer and it is illustrated in the fig.2a and fig.2b given above. The Layers in Resnet 50 are described below.

i) Convolution layer

Extraction of features from the input images is done using this layer. It maintains the relation among the pixels. This process takes image matrix and a filter as input as shown in fig.4.

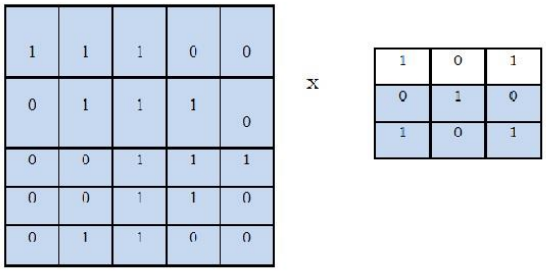

Fig.4 Convolution layer

ii) RELU layer

Rectified Linear Unit (RELU)layer is used to increase the nonlinearity in the given input.it will output zero if it is negative otherwise it will output the same input value directly and it is illustrated in fig.5.

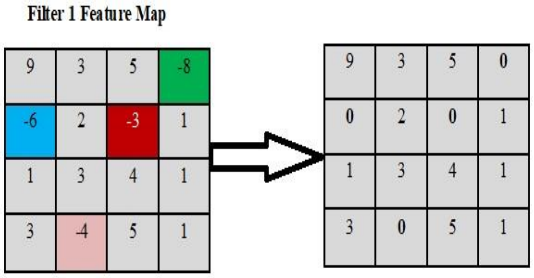

Fig.5 RELU layer

iii) Pooling Layer

It pools each group of outputs of the preceding layer into a single neuron. Here, we have used max pooling which selects the max of 2*2 feature map element with a stride of 2 in each dimension.fig.6 depicts max pooling.

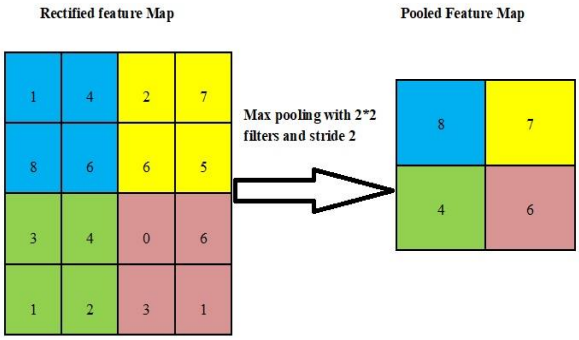

Fig.6 Pooling layer

iv) Flatten layer

As shown in fig.7, flatten layer converts all 2D arrays of data received from pooling layer into 1D continuous linear vector. This Flattened data is given as an input to the next layer for classification.

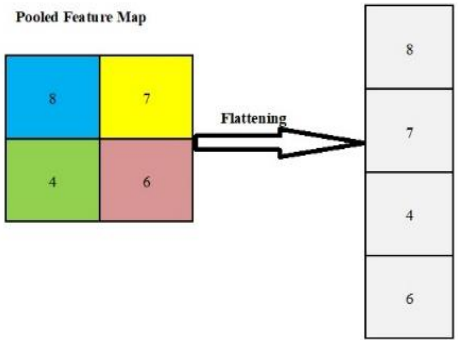

Fig.7 Flatten layer

v) Fully connected layer

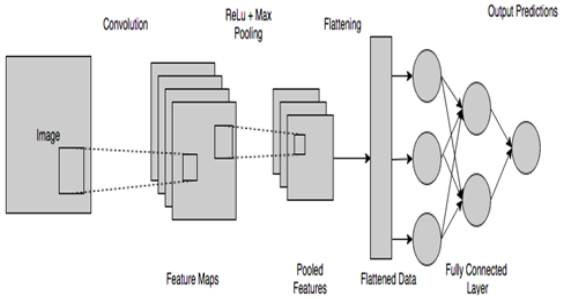

Fig.8 Fully connected layer

The output of convolution layer denotes high level data features. So, the output may perhaps be flattened and forwarded to the output layer. Learning nonlinear combination of these features is done by fully connected layer. It is represented in fig.8.

vi) Softmax function

Softmax function is an activation function that predicts a multinomial problem distribution. It is used for multiclass classification problems where class membership is needed on more than two class labels.

F. Classification

Then input images are given to the trained model to predict SZ patients and HC.

IV.RESULTS AND DISCUSSION

The proposed model is programmed in python language and is implemented on the framework Tensor Flow and Pycharm. After that, it is evaluated on the schizophrenia rsFMRI dataset from COBRE. The user interface of the proposed model is shown in fig.9.a and fig.9.b

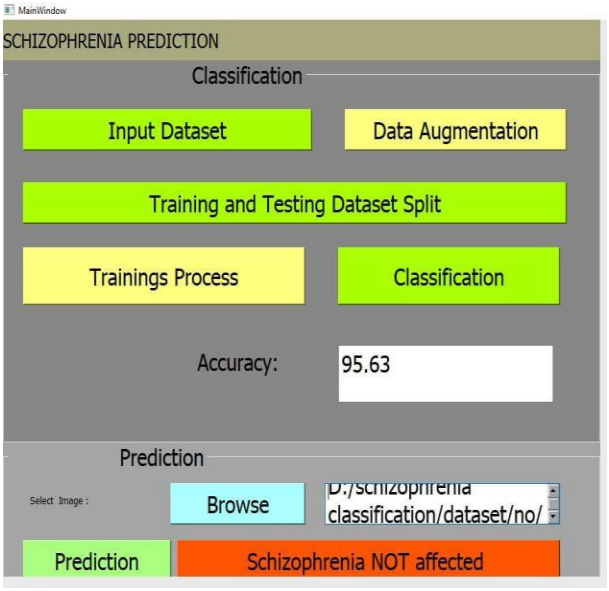

Fig.9a Prediction of Health Control

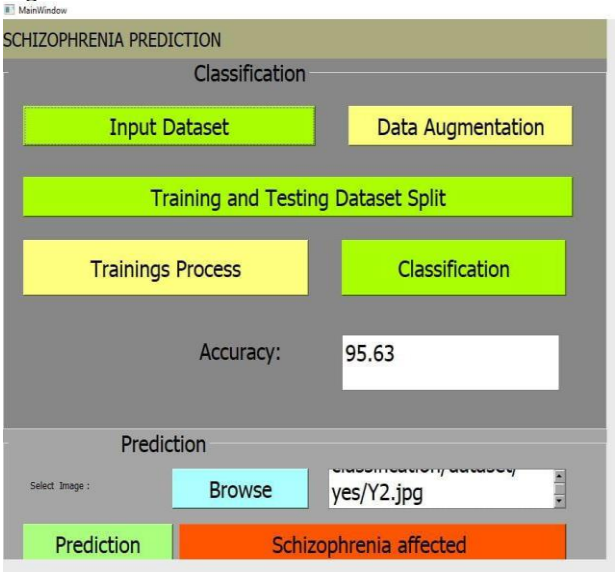

Fig.9 b Prediction of Schizophrenia (SZ)

For evaluating the performance of schizophrenia prediction, the following evaluation metrics are examined namely accuracy rate, precision rate, recall rate and AUC (Area under the Curve). The proposed work is evaluated in the data set taken from COBRE. In order to find the effectiveness of the proposed model, the evaluation metrics values are compared with three existing methods. Table .1 gives the Performance analysis of different deep learning models.

Table.1 Performance analysis of different deep learning models

Models	Accuracy	Precision	Recall
Alex Net	78.36%	81.29%	75.66%
VGG16	85.27%	86.33%	87.48%
ResNet34	83.09%	86.59%	79.98%
Our Model	95.53%	96.64%	95.89%

Fig.10 depicts the Comparative analysis of various models with our model. We realized that our model produces high classification accuracy of 95.53% compared with other methods given above. It also shows that this model has high precision and recall values other comparison models and can classify SZ patients effectively.

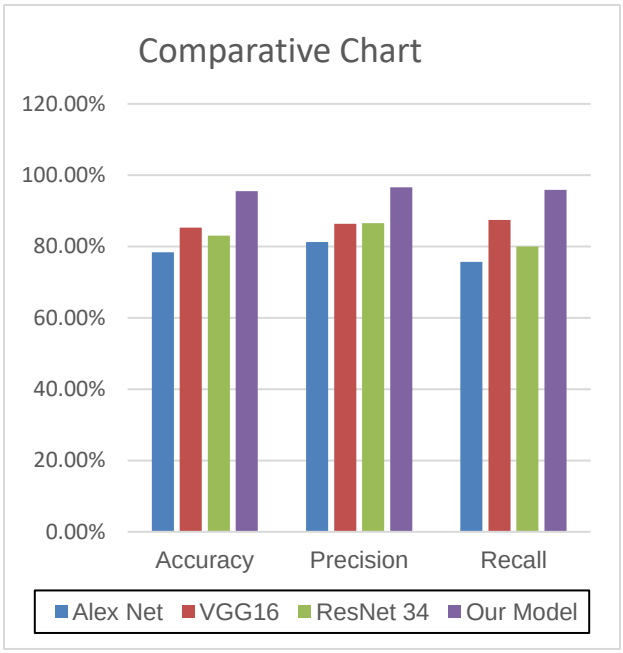

Fig.10 Comparative analysis of models

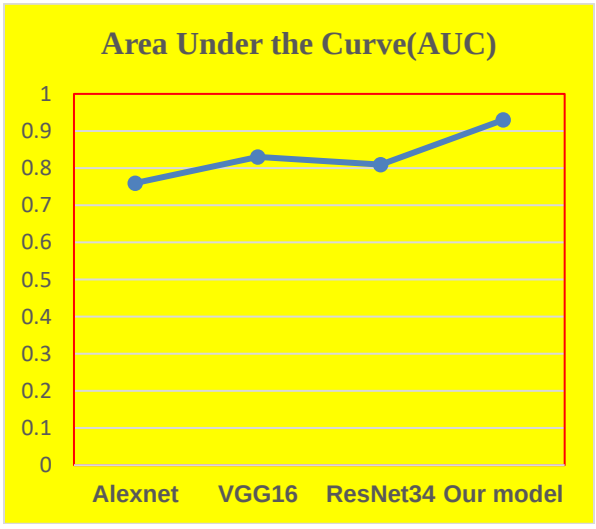

Fig.11 Area under ROC Curve

The area under Receiver Operating Curve (ROC) is denoted as AUC. It summarizes the overall performance of the classifier. The ROC curve of four models are drawn in fig.11.It shows that our proposed model has highest AUC index value than that of other models.

V.CONCLUSION

In this work, the diagnosis model is constructed to predict schizophrenia patients and health control based on deep learning framework in rsFMRI dataset. It can offer an allusion for doctors to diagnose the disease in time and offer well-timed treatment for schizophrenia. To overcome the difficulties of low accuracy in prediction, a schizophrenia diagnosis model was developed using Resnet50.The network starts with Data Augmentation and then the model based on RESNET 50 was designed. Here, the convolution structure of the neural network used to extract the features of rsFMRI and for training and optimization, the fully connected layer is used to get the best weight values. Lastly, the diagnosis of schizophrenia was established. It has a good capability to predict SZ and HC in COBRE dataset. Using this model, the classification accuracy of 95.53% is achieved. However, it needs further improvements to meet real application requirements.

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