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Classification and Predication of Alzheimer's Disease using Deep Learning

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Abstract

Alzheimer's disease is an incurable, progressive neurological brain disorder. Alzheimer's disease causes the brain to shrink and brain cells to die. Early detection of Alzheimer's disease can help patient with proper treatment and prevent severe brain damage. In this paper a deep convolutional neural network model by analysing MRI scans for diagnosis of Alzheimer disease at early stage. performed morphological operations on MRI images to achieve better training set. Segmentation is done on training set that extracts features and gives significant information about Alzheimer's Disease (AD) and Mild Cognitive Impairment (MCI). This will eventually help doctors to predict the stage of disease and patient will get proper treatment accordingly .Our method uses machine learning algorithms to predict the Alzheimer disease.

Keywords: *-Alzheimer Disease, Deep Learning, Convolution Neural Network, MRI, Mild Cognitive Impairment (MCI)*

I. INTRODUCTION

Alzheimer's disease is a progressive neurodegenerative disease, where dementia symptoms gradually worsen over a number of years. It is the cause of 60-70% of the cases of Dementia. The greatest known risk factor is increasing age, the majority of people with Alzheimer's being 65 and older. But Alzheimer's is not just a disease of old age .To extract patterns from neuroimaging data, various techniques, including statistical methods and machine learning algorithms, have been explored to ultimately aid in Alzheimer's disease diagnosis of older adults in both clinical and research applications. However, identifying the distinctions between Alzheimer's brain data and healthy brain data in older adults is challenging due to highly similar brain patterns and image intensities. Recently, cutting-edge deep learning technologies have been rapidly expanding into numerous fields, including medical image analysis. The best way to fight this disease is early detection. This can help target the disease before irreversible brain damage or mental decline has occurred. Although current Alzheimer's treatments cannot stop Alzheimer's from progressing, they can temporarily slow the worsening of dementia symptoms and improve quality of life for those with Alzheimer's and their caregivers. The goal of this project was to create a basic neural network that can differentiate between normal patients and those affected by Alzheimer based on their MRI brain scan. The main objective of this project is to overcome the problem of pre-detecting Alzheimer's disease.

II. RELATED WORK

A. Naikodi , N. Fatima first used the SVM based criteria to select the most discriminative features, and then applied the SVM-based classifier to diagnose healthy controls and AD patients using MRI brain images. In general, SVM has a lower generalization error than the other classifiers hence SVM has been commonly used to solve pattern classification problems [1].

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E. Nigri, N. Ziviani, F.Capabianco worked on diagnosis of the disease different methods, such as lumbar puncture , blood tests , structural Magnetic Resonance Imaging (MRI) , functional MRI , and Positron Emission Tomography . While each type of exam has its advantages, structural MRI is desirable for its low sensibility to early changes in the affected region [2].

N. Dhanchandra, K. Manglem , Y. Jina Chan used ANNs to solve a wide variety of tasks that are hard to solve using ordinary rule-based programming. Deng showed that a higher sensitivity and a higher accuracy can be derived using ANN than the traditional discriminant function analysis used in dementia classification using MRI [3].

C. Ge , Q. Qu, Irene Y. H. Gu , A. Jakola proposed AD detection method to incorporate multi-scale feature learning into a deep convolutional network architecture for the characterization of Alzheimer's disease from MRIs. In the proposed method, 3D MRI scans first pre-processed, followed by 3D multi-scale convolutional network (3D MSCNN) to extract features in different scales [4].

K.R. Kruthika,, H.D. Maheshappa proposed a method called multistage classifier by using machine learning algorithms like Support Vector Machine, Naive Bayes and K-nearest neighbor PSO (particle swarm optimization) which is a technique that best selects the features to obtain best features. In the initial stage GNB classifier was used to classify the objects between AD, MCI and NC [5].

IM Farooq , S.M.Anwar , M. Awais, S. Rehman In this paper author has presented a convolutional neural network based framework for classifying MRI images to diagnose Alzheimer's disease ,MCI, LMCI and normal controls[6].

K. A. N. N. P Gunawardena, R. N Rajapakse , N. D Kodikara , I. U. K. Mudalig. Support Vector Machines (SVM) technique is used for initial tests, where author attempted to train and test a SVM with linear kernels which was implemented using MATLAB's svm train and svm classify functions [7].

P. Lodha,A. Talele K. Degaonkar tested 5 models namely support vector machine, gradient boosting, neural network., k-nearest neighbor, random forest and concluded the best model depending on their respective accuracies[8].

III. SYSTEM METHODOLOGY

The basic block diagram of Alzheimer's detection and classification is given in Fig.1

Fig.1 System block diagram

Magnetic Resonance images (MRI) are given as an input to the system. This is widely used technique for brain tumor detection through imaging. MRI is used to create detailed image of the human body organ. In this Phase the MRI is processed by using necessary image processing techniques. This technique is used to improve the feature of the image at lowest level. This need not add some extra feature but remove undesirable feature from image. Image resizing are done. After preprocessing Morphological Operations are applied on image. A set of image processing operations that process digital images based on their shapes is morphology. Classification of disease is done in classes that is healthy brain, mild demented, moderate demented, very mild demented, non-demented. The results are predicted by displaying the probability of chances of having Alzheimer disease .The output also displays which type of Alzheimer is present.

Network Architecture - CNN architecture of the system is composed of DenseNet169, batch normalization, activation and dense layers. CNN has the best results when compared to any other image classification method. Therefore, a CNN was implemented to classify brain images.

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DenseNet169 – The DenseNet169 model is one of the DenseNet group of models designed to perform image classification.

It is used as a base model for this system. Basically feature extraction is done by this network. Traditional architectures such as LeNet5, VGG16 suffer from vanishing gradient as the depth increases .Fig. 2 shows the layout of the DenseNet. Last layer x_n receives the feature-maps of all preceding layers, x0, ... x−1. Input x = H([x0, x1, . . . , x−1]), where [x0, x1, . . . , x−1] refers to the concatenation of the feature-maps produced in layers 0, . . . ,x−1 because of its dense connectivity.

Pooling layers: The concatenation operation used is not feasible when the size of feature-maps changes. An important part of convolutional networks is down-sampling layers that change the size of feature-maps. To perform down-sampling in this architecture the network is divided into multiple densely connected dense blocks. Layers between dense blocks are referred as transition layers, which do convolution and pooling. The transition layers used in this experiment consist of a batch normalization layer and convolutional layer.

Flatten Layer: Flattening is basically converting the data into 1 dimensional array .Once the pooled feature map is obtained, the next step is to flatten it. Flattening is done to create single long feature vector and this is connected to final classification model, which is called as fully connected layer.

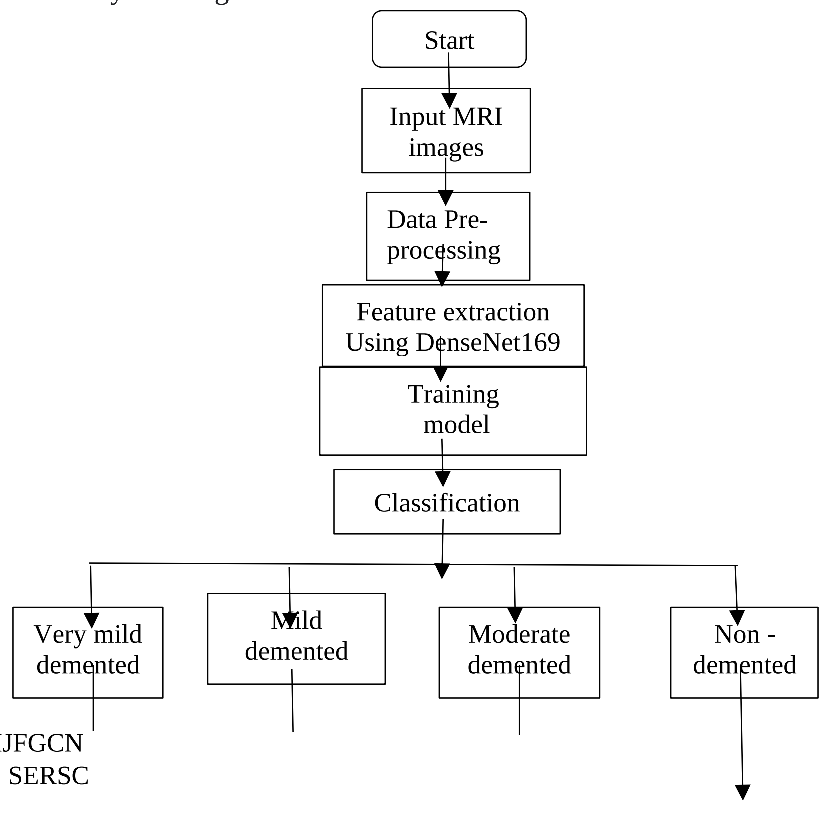
Dense Layer: After the flatten layer, we have used two dense layers. The dense layers are also known as fully connected layers.

Activation Layer : The rectified linear unit (Relu) activation function overcomes the vanishing gradient problem ,allowing models to learn faster and perform better. This step is usually followed by convolution and pooling layer. Mathematically it is defined as Relu: y=max (0,x)→∂f∂x=1 if x>=0 else 0. This activation function will output the input directly if it is positive. Otherwise it will output zero. This brings non linearity and avoids overfitting problem.

IV. EXPERIMENTATION

For implementation of this system we are using Python language and libraries such as numpy, pandas, matplotlib etc. Keras library is also used with tensorflow at backend. Dataset is divided into 4 classes namely non demented, very mild demented, mild demented, moderately demented. Training images are 4098, validation images are 1023 and test images are 1280.

The flow diagram of this system is given below.



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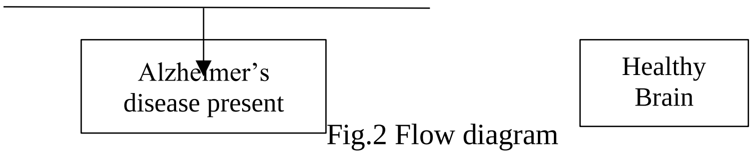

Fig.2 Flow diagram

For this system implementation MRI images are used as a input. Data pre-processing is primary and important step while giving input to CNN mode. Here image rescaling, zooming, image rotation is done. Next part is feature extraction. In machine learning and image processing, feature are created from the initial dataset. Which is used for the training process. The selected features include information about the input data. Feature extraction layer of DenseNet uses multiple layers of convolution activation, max pooling and normalization. After feature extraction, the images are classified in the fully connected layers of classification stage. activation function ReLu is used to avoid overfitting as this is non-linear function and at the output layer activation function softmax is used as this is multiclass classification.

V. RESULTS AND DISCUSSION

Model accuracy and model loss graphs are plotted. These figures shows that this model is neither underfit nor overfit. As shown in the graph 1(FIG.3) as no. epochs increases model accuracy increases and in FIG.4 as number of epochs increases, model loss decreases.

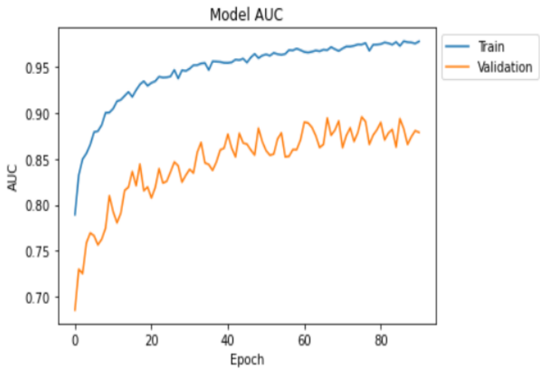

FIG.3

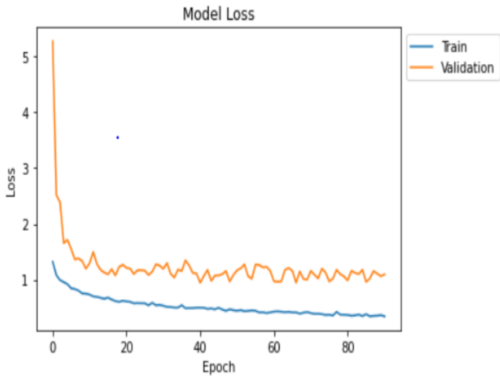

FIG.4

87.17% model accuracy has achieved and image is correctly classified by the model.

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VI. CONCLUSIONS

The purpose of early detection of Alzheimer’s disease is achieved. Image preprocessing techniques and transfer learning techniques are being used. Machine learning approach to predict the Alzheimer’s disease using machine learning algorithms is successfully implemented and gives greater prediction accuracy results. The model has got 87.17% accuracy. The amount of enlargement will classify the patient as Healthy patient , Mild demented, Non demented. The majority of the existing research works focuses on binary classification, this model provides significant improvement for multi-class classification. This network can be very beneficial for early-stage AD diagnosis.

VII. FUTURE SCOPE

Though the model has been tested only on AD dataset, it can be used successfully for other classification problems of medical domain. There is always room for improvement, innovation or change of existing techniques in any research field. So, despite availability of so much quality research work in this field, yet there is a lot of work to be done in making those automatic monitoring systems more accurate and reliable.

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