Detection and Classification of Alzheimer's Disease using Deep Learning Techniques

Nagarathna C R, Kusuma M

DDSATM, Bangalore, India

Corresponding author: Nagarathna C R, Email: nagarathna.binu@gmail.com

From the previous decade, the specialist utilized machine learning procedures for their examination. The goal of different applications is accomplished utilizing these methods. Alzheimer's is a physical brain disease, as of late much exploration is proceeding to foster a proficient model to analyze the beginning phases of Alzheimer's. Early detection of Alzheimer's has been considered an interesting research as it helpful to the individual and their family to think about their future. In this paper, we tested the deep learning model for identifying and classifying the various phases of Alzheimer's. We analyzed the model for the Magnetic resonance imaging dataset received from Kaggle and achieved an accuracy of 94.74%.

Keywords: Alzheimer's, Data preprocessing, CNN, Deep-learning.

2021. In Rahul Srivastava & Aditya Kumar Singh Pundir (eds.), *New Frontiers in Communication and Intelligent Systems*, 301–307. Computing & Intelligent Systems, SCRS, India. https://doi.org/10.52458/978-81-95502-00-4-31

1 Introduction

Alzheimer's Disease (AD) is a steady neurodegenerative ailment that for the most part starts at a more seasoned age and starts falling apart after some time. Promotion begins from the hippocampus (cerebrum region where the memory is framed) and advances in a central fugal way towards various locales of the mind [1] [2].

The AD progression happens in 3 phases. In the primary phase of AD brain nerve cells begin to harm, this stage is extremely challenging to separate from ordinary on the grounds that an individual doesn't encounter any recognizable indication. The following stage is Mild cognitive impairment (MCI), in this stage individual encounters an issue identified with thinking ability. During this stage, people are not completely reliant upon othersfor their daily activities. The last level is Alzheimer's. At this level, people have more intellectual and conduct changes and influence their day by day exercises [3].

No medication will stop AD except for can dial back the movement of AD. As of late a group of Bengaluru researchers found the little particle TGR63 that can keep away from the instrument that outcome in neurons useless in Alzheimer's illness [4]. In Alzheimer's patients, the tissues and cerebral cortex psychologist, and cerebrum chambers comprise of cerebrospinal liquid development. These impacts are utilized to track down the progression of AD [5].

2 Proposed Method

Numerous researchers have put forth earnest attempts to find an assortment of strategies to recognize Alzheimer's utilizing MRI information. Those strategies incorporate the extraction of discriminative elements from anenormous arrangement of highlights, and choosing proficient characterization models from machine methods. In the current framework, we saw that the characterization of AD is binary, where they decide whether it is Alzheimer's sickness or not. In our proposed framework, we intend to accomplish a four-way classification of AD from Magnetic resonance imaging (MRI) utilizing deep neural network.

The deep neural network is made up of convolution layers, ReLU layers, and pooling layers. The convolution layer extracts the features of input by striding filter or kernel through the input. The filter/kernel is in a small size like 3x3 or 5x5. The convolution is followed by RELU is an activation function it going to replace negative values with null values. After ReLU performs pooling, that reduces the size of an image to half of its original value. The working architecture of the proposed system is depicted in fig 1.

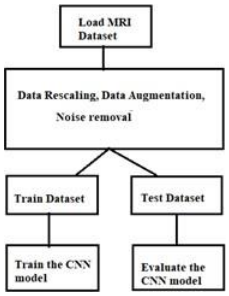

Fig. 1. System architecture

The working flow of proposed system is given in following algorithm:

Step 1: Load the dataset

Step 2: To increase the performance of the system input dataset is preprocessed by doing rescaling, augmentation,and remove noise.

Step 3: Divide dataset into train and test dataset

Step 4: Train CNN model using train dataset. Step 5: Evaluate the model by using test dataset.

A. Dataset

Consider the Kaggle dataset [24] consists of 4 classes of images are shown in fig 1 where 0 indicates Non- Dementia (ND), 1 indicates Very Mild dementia, 2 denotes Mild Dementia, and 3 indicates moderate dementia.

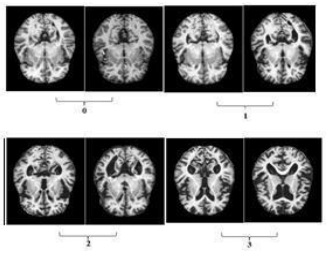

Fig. 2. Kaggle dataset samples 0: ND, 1: VMID, 2:MID, 3:MOD

Data count of each class is given in table 1.

Table 1. Dataset Count

Classes/Count	Kaggle_Dataset_Count
ND	3200
VMD	2240
MID	896
MOD	64
ND	3200

B. Data preprocessing

The data preprocessing starts with data rescaling, it is performed to represent the pixels of the dataset between 0 and 1 by dividing the pixels by 255.0. After data rescaling resize all images into 50x50 fallowed by data Augmentation to increase the dataset count, perform data augmentation by rotating images in the angle of 45 degree and 75 degree separately. The data Augmentation is followed by the noise removal method, in this method removes pepper and salt noise using a median filter. After data preprocessing, the dataset is divided into train and test datasets. Train dataset is used to make the model learn and test dataset is used to evaluate the model.

C. Deep learning Model

Used Convolutional deep neural network for extracting features and classifying the stages of Alzheimer's. To extract features from preprocessed image used 4 convolutional layer. Each

convolutional layer uses a filter of size 3x3 , activation function RELU and padding is 'same' to keep original image size, followed by maxpooling layer to reduce the image size. The extracted features are classified using classification model, it is constructed by adding the layers like flatten , to convert 2 dimensional array input into single dimensional array, hidden layer with 1024 neurons with RELU activation function finally classification layer with 4 neurons for 4 classifications with softmax function.

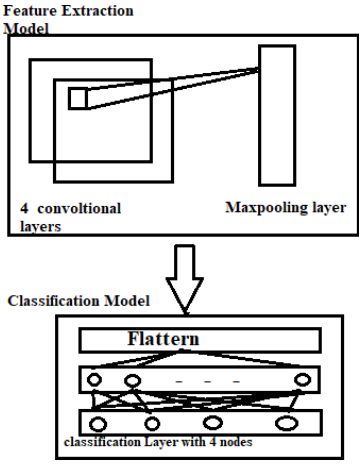

Fig. 3. Deep learning model

3 Results

This section discusses the results of CNN models. Make the model run for 100 epochs and achieve an accuracy of94.74%. More epochs might improve the accuracy of the system. Figure 4 shows the accuracy history and figure 5shows the loss history of the model. Training accuracy was 29%% at the 1st epoch and increased to 98% at the 30thepoch. With respect to validation, data accuracy was 30%% at the 1st epoch than it varies between 50% to76.78%.Finally for test data obtained 83.57% of accuracy.

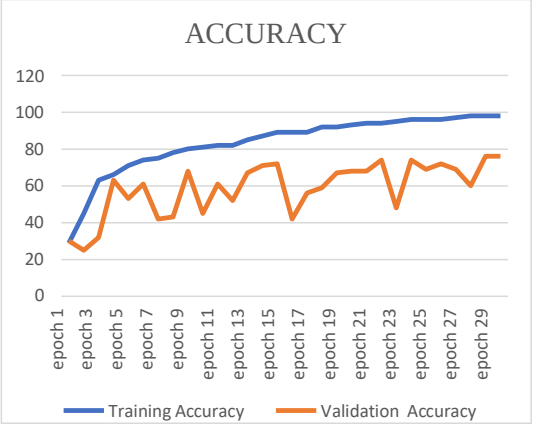

Fig. 4. Accuracy history of Deep learning model

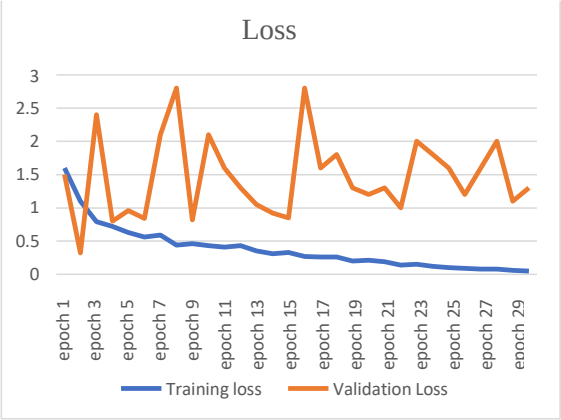

Fig. 5. Loss History of Deep learning Model

The loss history of CNN is shown in figure 5. At 1st epoch the training loss it is 1.15 and it reduces to 0.06 at30th epoch. With respect to validation loss is 1.6 at 1st iteration and it going to fluctuate between 2.6 to 0.5The confusion matrix of deep learning model is given in table 1.

Classes	ND	VMD	MID	MOD
ND	496	28	98	0
VMD	0	592	0	30
MID	4	0	561	60
MOD	25	0	67	530

From confusion matrix measure the performance metric values such as accuracy, precision, sensitivity,Specificity, and f1 score, and they are depicted in equations 1, 2, 3, 4 respectively.

$$\text{Accuracy} = \frac{T_P+T_N}{T_P+T_N+F_P+F_N} \times 100 \quad (1)$$

$$\text{Precision} = \frac{T_P}{T_P+F_P} \times 100 \quad (2)$$

$$\text{Sensitivity (Recall)} = \frac{T_P}{T_P+F_N} \times 100 \quad (3)$$

$$f1 - Score = 2 * (Recall * Precission)/(Recall + Precission) \quad (4)$$

Accuracy will predict how efficiently the model will predict the output. The precision will indicate how manypositive inputs are correctly classified.

Classes	Precission	Recall	F1-Score
ND	97%	95%	96%
VMD	92%	96%	94%
MID	95%	93%	94%
MOD	100%	95%	97%
Average	96%	94.75%	95.25%

Few sample of the output is given in figure 6

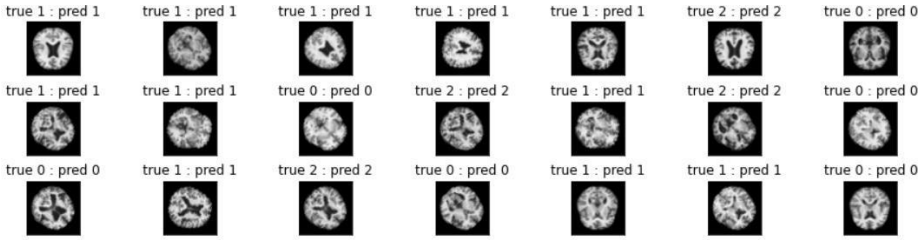

Fig. 6. Sample Output

4 Conclusion

Alzheimer's is a neurodegenerative brain disease, no medicine can cure this disease but early detection can help patients to do plan for their future. In this paper, we have experimented with deep learning models for detecting and characterizing stages of disease in that the Hybrid model shows the best performance compared to CNN. In the future let experiment with another dataset from different organizations and also plan to use differentmodality datasets for the experiment.

References

[1] Suk, H. I. and Shen, D. (2013). Deep learning-based feature representation for AD/MCI classification International conference on medical image computing and computer-assisted intervention. Springer, Berlin, Heidelberg.

[2] Abadi M. et al. Tensor Flow: large-scale machine learning on heterogeneous dis-tributed systems. Unpublished paper.

[3] Alberdi, A., Aztiria, A. and Basarab, A. (2016). On the early diagnosis of Alzheimer's disease from multimodal signals: a survey. *Artificial Intelligence in Medicine*, 71: 1–29.

[4] Richhariya, B. et al. (2020). Diagnosis of Alzheimer's disease using universum support vector machine based recursive feature elimination (USVM-RFE). *Biomedical Signal Processing and Control*, 59, 101903.

[5] vgg19 Customized VGG19 Architecture for Pneumonia Detection in Chest X-Rays.

[6] Solano-Rojas, B. and Villalón-Fonseca, R. (2021). A Low-Cost Three- Dimensional DenseNet Neural Network for Alzheimer 's disease Early Discovery. *Sensors*, 21(4): 1302.

[7] Pan, D. et al. (2020). Early Detection of Alzheimer's Disease Using Magnetic Resonance Imaging: A Novel Approach Combining Convolutional Neural Networks and Ensemble Learning. *Frontiers in Neuroscience*, *14*.

[8] Feng, W. et al. (2020). Automated MRI-Based Deep Learning Model for Detection of Alzheimer's Disease Process. *International Journal of Neural Systems*, 30(06): 2050032.

[9] Liu, S. et al. (2020). On the design of convolutional neural networks for automatic detection of Alzheimer's disease. In *Machine Learning for Health Workshop*, 184-201.

[10] Yildirim, M. and Cinar, A. (2020). Classification of Alzheimer's Disease MRI Images with CNN Based Hybrid Method. *International Information and Engineering Technology Association*, 25(4): 413-418.

[11] Acharya, U. R. et al. (2019). Automated detectionof Alzheimer's disease using brain MRI images–a study with various feature extraction techniques. *Journal of Medical Systems*, 43(9): 1-14.

[12] Thavavel, V. and Karthiyayini, M. (2018). Hybrid feature selection framework for identification of alzheimers biomarkers. *Indian J. Sci. Technol*, 11(22): 1-10.

[13] Yan, Y., Somer, E. and Grau, V. (2019). Classification of amyloid PET images using novel features for early diagnosis of Alzheimer's disease and mild cognitive impairment conversion. *Nuclear medicine communications*, *40*(3): 242-248.

[14] Islam, J. and Zhang, Y. (2018). Brain MRI analysis for Alzheimer'ss disease diagnosis using an ensemble system of deep convolutional neural networks. *Brain informatics*, 5(2): 1-14.

[15] Feng, X. et al. Alzheimer's disease diagnosis based on anatomically stratified textureanalysis of the hippocampus in structural MRI. In *IEEE 15th International Symposium on Biomedical Imaging,* 1546-1549.

[16] Liu, M. et al. (2018). Multi-modality cascaded convolutional neural networks for Alzheimer's disease diagnosis. *Neuro Informatics*, *16*(3-4): 295-308.

[17] Armañanzas, R. et al. (2016). Voxel-based diagnosis of Alzheimer's disease using classifier ensembles. *IEEE journal of biomedical and health informatics*, *21*(3): 778-784.

[18] Nanni, L. et al. (2016). Combining multiple approaches for the early diagnosis of Alzheimer's Disease. *Pattern Recognition Letters*, *84*: 259-266.

[19] Moradi, E. et al. (2015). Machine learning frameworkfor early MRI-based Alzheimer's conversion prediction in MCI subjects. *Neuro Image*, *104*: 398-412.