Automated diagnosis of Alzheimer's disease using CNN

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Abstract- Alzheimer's disease damages brain cells over time, especially in the hippocampus area. This illness is the foremost cause of dementia in people aged above 65. It is a neurological condition that is both progressive and irreversible. An early sighting of Alzheimer's disease is pivotal because it could help prevent catastrophic brain damage to the brain. An accurate and rapid treatment of the disease is crucial to prevent the irreversible illness from progressing. The goal of this research is to develop a machine learning algorithm for identifying Alzheimer's disease using Magnetic resonance Imaging (MRI) data. The recommended strategy focuses on the brain's hippocampus area. The dataset has been acquired from Kaggle. The study uses an effective method of using a Convolutional Neural Network (CNN) which predicts whether a patient is impacted by the condition or not. The proposed technique results in prediction accuracy of 81.15%.

Keywords: Convolutional Neural Network (CNN), Alzheimer's disease, Hippocampus region, Machine Learning Algorithm, Magnetic resonance imaging (MRI)

I. INTRODUCTION

Alzheimer's disease is a degenerative neurological disease which often manifests in middle age and worsens over time. One of the most common causes of dementia in the elderly people is this disease [1]. This is a long-term degenerative condition that gradually weakens and eventually kills one's thinking capacities, resulting in a significant loss of analytical and mental strength, as well as behavioral and language challenges. Heredity and lifestyle are the common factors affecting AD.

AD begins in the hippocampus (brain area where memories are created) and proceeds in a central-fugal pattern to various parts of the brain [2]. Plaques and tangles are two of the disease's most prominent symptoms. The healthy neurons begin to work less effectively as tangles and plaques rises, and they gradually lose their ability to function.

Many people worked hard to come up with a range of strategies for detecting Alzheimer's disease with the help of MRI data [3]. Two of these tactics are the extraction of preferential features from a massive number of features and the selection of efficient classification methods utilizing machine learning approaches [4]. An MRI scan is used to give a high-contrast image of the brain. The protein analysis of AD can detect the biomarkers and helps in target drug designing [5].

Due of its numerous layers and possibly ordered structure network, Machine learning let the machine to learn how to categorize data from scratch [6]. CNN, is a form of neural network for extracting high-level characteristics from image classification and prediction [7][8]. Due to its strong performance in picture classification and analysis, it is also the most often used deep learning approach.

The foregoing is the order of the paper: Section 2 reviews usage of various techniques employed in Alzheimer's Detection. Section 3 gives the CNN Architecture used for Alzheimer's prediction. Section 4 presents a comparative analysis of the work carried out. At the last, the conclusion of obtained work is presented in Section 5.

II.LITERATURE SURVEY

Due to its great many layers along with an ordered network, deep learning being a subdivision of machine learning that helps machine to gain an understanding of categorization from primary data [9]. This section shows a brief about various techniques used by researchers and authors in diagnosing AD using MRI data.

Basher et al., [10] In their proposed work, the detection of AD is with the usage of MRI. Features such as the texture, area, and shape are drawn out using the Gray-Level Co-Occurrence Matrix (GLCM) and Moment Invariants from the hippocampus. GLCM collects the second-order statistical texture, features, and Moment Invariants to define the group of attributes used for the identification of shape. The disease is later classified into different categories based on the features obtained from the hippocampus, using Artificial Neural Network (ANN) which is trained using Error Back Propagation (EBP) algorithm.

The detection of Alzheimer's Subjects and to analyze images of Alzheimer's Disease-related regions of the brain, Lodha in [11] have used MRI scans to get numeric data which in turn is processed using algorithms like gradient boosting, K-Nearest neighbor, Random forest. Nagarathna [12] has used a hybrid method. For detection and classification, the authors used a hybrid model, which is a combination of two models, which is of VGG19 and additional layers, as well as a CNN deep learning model. The comparison and classification of the various phases of Alzheimer's disease, their performance demonstrates that the hybrid model, is effective in recognizing and categorizing the various stages of Alzheimer's. The dataset for magnetic resonance imaging was examined.

The research by Sayed Us Sadat is [13] aimed at classifying Alzheimer's disease into three stages namely, very mild (early stage), mild (middle-stage), and moderate stage (late-stage). The authors here applied five prevailing efficient and promising CNN models using transfer learning, including VGG19, ResNetv2, ResNet152v2, EfficientNetB5, and Inception-ResNetv2, they have also implemented a custom model of their own, and they ensembled three times with a variety of model combinations to improve their final results. As a result, they were able to attain the proposed model, a weighted average ensemble of six parameters with desired results.

Chima S Eke [14] developed a system to recognize probable blood-based non-amyloid biomarkers with the help of SVM for initial AD detection. Convolutional Neural Network has greater affinity while choosing various prediction techniques that involve images as input data. It is an efficient and go-to technique in classification prediction problems.

III.METHODOLOGY

In this segment, we discuss the dataset, proposed methodology and the CNN model generated for the proposed work.

A. Dataset Collection

Our trials were carried out using the Kaggle dataset, link for the dataset- https://www.kaggle.com/datasets/tourist55/alzheimers-dataset-4-class-of-images. This dataset makes it simple to explore and analyze MRI scans. The dataset comprises of MRI pictures that have been processed. For the training stage of our work, we use 5121 pictures (classified into 4 different stages namely Mild Demented, Moderate Demented, Non

Demented, Very Mild Demented). A total of 1279 images were used in the test phase. Table 1 shows the number of images for each phase of the training dataset.

Table 1. Number of images for each phase of the training dataset.

Stages	Number of images
Mild Demented	716
Moderate Demented	51
Non Demented	2559
Very Mild Demented	1791

B. Proposed System

Two steps involved in our method are : extraction of region of interest being the first step and classification of images being the second. Flowchart representing the identification of AD by the method proposed is shown in Fig1.

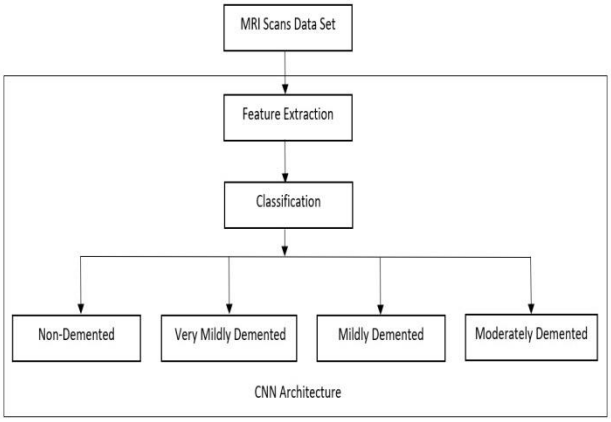

Fig.1 Flowchart representing the identification of Alzheimer's Disease by the method proposed.

Region of interest extraction: In image processing, you need to extract the area of interest. There have been several strategies identified, some of which are more proficient than others. Our work uses block splitting. The idea behind this technique is to split the image in 32 * 32 pixel square fragments. Next, we only need to extract the blocks that contain the hippocampus area in the brain. The remaining portion of the block will then be discarded.

Classification: A classifier divides different objects into different classes based on some classification criteria. There are four classes in our situation, those are, Mild Demented,

Moderate Demented, Non-Demented, Very Mild Demented. As a result, when the blocks have been eliminated, the CNN method will be used to carry out the classification step.

C. CNN Architecture

CNN is a layered network structure that evolved from the classical neural network approach, layered perceptrons.

The first part is the convolution, which acts as an image feature extractor. Convolution maps are created when a picture is run through a series of filters. Next, assemble the convolution map to create the feature vector. This vector is combined with the input in the next half of the classification section, which consists of fully connected layers. and allows images to be classified into four categories. Our networks have three convolution layers with 3*3 filter sizes and 32 filters with ReLU activation function, and the output is provided by a completely connected layer. The structure of this network is depicted in Fig.2.

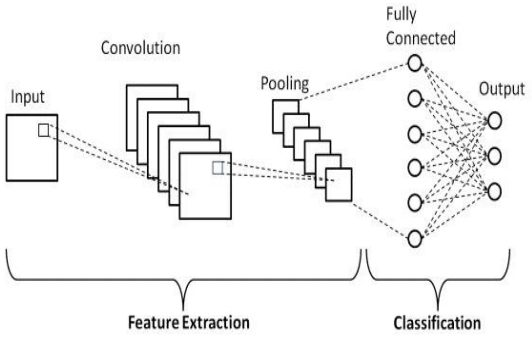

Fig 2. CNN Architecture

The convolution layer: Drag the filter over the entire image to convolve it with the underlying image [15]. The filter starts at the apex left of the image and shifts a few squares to the right as the convolution progresses. Moves downward one step until the filter traverses the complete image until it reaches the end of the image. The intend of this technique is to highlight key features of the images.

The pooling layer: This layer allows us to reduce the dimension of an image while keeping its necessary properties. 'Max Pooling' is the most commonly utilized method. It involves shrinking the image while retaining the pixels' highest values [15][16].

The fully connected layer: The classification rationale is done via these layers subsequent to numerous convolution and pooling layers have been applied. The neurons in this layer are connected to all the neurons from the previous layer[17]. The Softmax function is used to extract the probability distribution vectors from the outputs of this layer. The size of the vector returned by this function is N, where N stands for the amount of classes in our picture categorization task. The likelihood that the input image belongs to a class is indicated by each element of the vector.

IV. EXPERIMENTAL RESULTS

Python is used as software development language for the training and testing the model. For the implementation of the model, the machine with Intel i3, 12GB RAM, and Windows 10 operating system is used. Tensor Flow is being utilized for both training and testing of the model on the backdrop of keras.

Data aggregation was performed during the experiments and the image dataset was integrated. We used methods concerning to photo flipping, image rotation and zoom range. The standardized classifiers like svm, decision tree and LDA are found to be inaccurate due to the feature dimensionality of the dataset, and all these methods do not provide accurate results for image classification as compared to cnn algorithm which work well for image classification. Therefore we have employed CNN model to detect and forecast Alzheimer's disease using MRI scans. The model obtained 81.15% test accuracy rate. The precision and loss of the model's training and testing are represented as graphs.

In Fig 3, the training set is utilized to train the model and the validation to evaluate the performance of the model. The loss of model training and validation is shown in Fig 4. Losses are calculated for both training and validation, the interpretation of which depends on how good the suggested system works in the two sets, and the loss value is how fit the model is after every optimization iteration, which is used to indicates whether it works poorly or well.

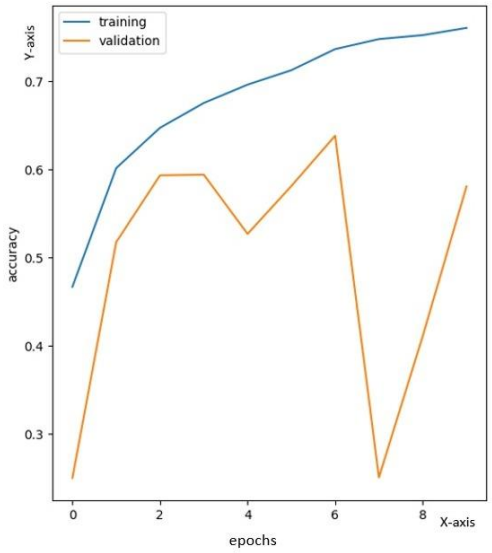

Fig 3. Accuracy indication of training and validation of the model

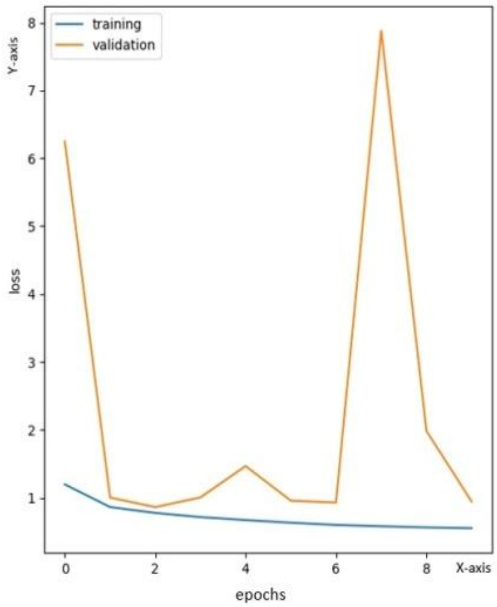

Fig 4. Indication of training and validation loss of the model

V.CONCLUSION AND FUTURE WORK

Alzheimer's disease progresses slowly over time. When it reaches the severe stage, the person is completely dependent on others for care. In this paper, a CNN algorithm-based technique for early Alzheimer's disease detection was applied on Kaggle dataset. The texture, area, and shape features of hippocampus regions are extracted from MRI scans. After extracting all the features, the percentage of the Alzheimer's in an MRI scan will be displayed on the web page. The accuracy attained after training and testing the model was 81.15 percent. The advantage of the proposed method is, it is used to detect Alzheimer's disease at a faster rate as compared to other traditional methods such as blood test.

As a future work, the outcome might be enhanced further by using a deep convolutional neural network, with potentiality in neuroimaging research. Furthermore, precisely adjusting the CNN model can improve the performance further. The hippocampus region of an MRI was the focus of this study. Other two perspectives (Axial view and Sagittal view) can be employed in the future to identify the disease's markers. In the future, the experiment might be repeated with a new dataset from a different organization, and it could potentially include alternative modality datasets.

REFERENCES

[1] Arafa, D.A., Moustafa, H.ED., Ali-Eldin, A.M.T. et al. Early detection of Alzheimer's disease based on the state-of-the-art deep learning approach: a comprehensive survey. Multimed Tools Appl (2022).

[2] G. Gupta, A. Gupta, P. Barura, V. Jaiswal, C. S. Engineering, and N. Delhi, “Mobile Health Applications and Android Toolkit for Alzheimer Patients, Caregivers and Doctors,” vol. 11, no. 1, pp. 199–205, 2019.

[3] T. E. and K. Saruladha, "Design of FCSE-GAN for Dissection of Brain Tumour in MRI," 2020 International Conference on Smart Technologies in Computing, Electrical and Electronics (ICSTCEE), 2020, pp. 1-6 .

[4] Y. Zhu and X. Zhu, “MRI-driven PET image optimization for neurological applications,” Front. Genet., vol. 10, no. JUL, pp. 1–15, 2019, doi: 10.3389/fnins.2019.00782.

[5] A. Ali, R. Viswanath, S. S. Patil and K. R. Venugopal, "A review of aligners for protein protein interaction networks," 2017 2nd IEEE International Conference on Recent Trends in Electronics, Information & Communication Technology (RTEICT), 2017, pp. 1651-1655.

[6] W. Lin et al., “Convolutional neural networks-based MRI image analysis for the Alzheimer’s disease prediction from mild cognitive impairment,” Front. Neurosci., vol. 12, no. NOV, 2018, doi: 10.3389/fnins.2018.00777.

[7] Manoharan, Samuel. "Image detection classification and recognition for leak detection in automobiles." Journal of Innovative Image Processing (JIIP) 1.02 (2019): 61-70.

[8] A. W. Salehi, P. Baglat, and G. Gupta, “Alzheimer’s Disease Diagnosis using Deep Learning Techniques,” Int. J. Eng. Adv. Technol., vol. 9, no. 3, pp. 874–880, 2020, doi: 10.35940/ijeat.c5345.029320

[9]A. Farooq, S. Anwar, M. Awais, and S. Rehman, “A deep CNN based multi-class classification of Alzheimer’s disease using MRI,” IST 2017 - IEEE Int. Conf. Imaging Syst. Tech. Proc., vol. 2018-Janua, pp. 1–6, 2017, doi: 10.1109/IST.2017.8261460.

[10] A. Basher, B. C. Kim, K. H. Lee and H. Y. Jung, "Volumetric Feature-Based Alzheimer’s Disease Diagnosis From sMRI Data Using a Convolutional Neural Network and a Deep Neural Network," *IEEE Access*, vol. 9, pp. 29870-29882, 2021.

[11] P. Lodha, A. Talele and K. Degaonkar, "Diagnosis of Alzheimer's Disease Using Machine Learning," 2018 Fourth International Conference on Computing Communication Control and Automation (ICCUBEA), 2018, pp. 1-4, doi: 10.1109/ICCUBEA.2018.8697386.

[12] N. C. R and K. M, "Comparative study of detection and classification of Alzheimer's disease using Hybrid model and CNN," 2021 International Conference on Disruptive Technologies for Multi-Disciplinary Research and Applications (CENTCON), 2021, pp. 43-46.

[13] Sayed Us Sadat, “Alzheimer’s Disease Detection and Classification using Transfer Learning Technique and Ensemble on Convolutional Neural Networks”, 2021 IEEE International Conference on Systems, Man, and Cybernetics (SMC)

[14] Sathiyamoorthi, V., Ilavarasi, A. K., Murugeswari, K., Ahmed, S. T., Devi, B. A., & Kalipindi, M. (2021). A deep convolutional neural network based computer aided

diagnosis system for the prediction of Alzheimer's disease in MRI images. *Measurement, 171*, 108838.

[15] Y. Zhang, C. Pan, J. Sun and C.Tang, ”Multiple sclerosis identification by convolutional neural network with dropout and parametric ReLU”, Journal of Computational Science, vol. 28, pp. 1-10, September 2018.

[16] W. Shen and W. Wang,” Node Identification in Wireless Network Based on Convolutional Neural Network”, IEEE 14th International Conference on Computational Intelligence and Security (CIS), vol. 31, pp. 238-241, 2018.

[17] S. H. Wang, P. Phillips, Y. Sui, B. Liu, M. Yang, and H. Cheng, “Classification of Alzheimer’s Disease Based on Eight-Layer Convolutional Neural Network with Leaky Rectified Linear Unit and Max Pooling,” J. Med. Syst., vol. 42, no. 5, p. 85, 2018, doi: 10.1007/s10916-018-0932-7.