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A Deep Learning Approach to Alzheimer's Disease Prediction Using VGG19 Algorithm

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ABSTRACT

Neurodegenerative diseases like Alzheimer's are disorders which, if left unchecked and undetected, can lead to severe dementia, and is the fifth leading cause of deaths among people over the age of 65. As the disease rapidly gets worse as time progresses, it is best to detect it as early as possible. By 2050, 11.44 million people in India are expected to be living with dementia, which is up from 3.84 million in 2019, according to the Global Burden of Disease study. The 197% jump in dementia will primarily be due to population growth, diabetes and population ageing. However, due to the lack of an adequate number of centers of neurological excellence in the country and a very limited number of radiologists, neurologists and other neuro specialists, this may result in grave consequences and a decrease in the quality of life for Alzheimer's patients and their families. Pathbreaking technology like Deep Learning (DL) models and Convolutional Neural Networks (CNNs) can accelerate the detection process by identifying the Alzheimer's stages so that the patient can seek further treatment at the earliest. Hence arises the need for using automated methods for Alzheimer's diagnosis. Also, as compared to manual methods, automated methods, like using DL for detecting and classifying Alzheimer's, require less effort, can be made available widely, are less prone to human errors and diagnose the problem efficiently. This method will expand the horizons of Alzheimer's detection and save time and energy by effective automated grading and screening techniques, cut down costs significantly, provide high performance and accuracy and make Alzheimer's diagnosis more convenient and attainable for low-income and economically weaker regions, or even in medical centers which do not have a neuro specialist.

Keywords: Convolutional Neural Network (CNN), Alzheimer Disease (AD), Deep Learning (DL), Machine Learning (ML), Biomedical Technology.

I. INTRODUCTION

Alzheimer's disease is a neurodegenerative disorder that leads to the progressive shrinkage of the brain, causing the cells to eventually die out. This results in dementia and is responsible for more deaths in older people than breast cancer and prostate cancer combined. Patients contract an impaired ability to think clearly, can't remember past actions and are unable to make decisions that play a major part in everyday activities. Diabetic

patients (who are suffering from type 2 diabetes) are also more susceptible to dementia and as India is unfortunately the diabetic capital of the world, this puts more than 70 million people in the country at a risk of Alzheimer's.

The symptoms and their severity worsen with time and there is no cure at the advanced stages for dementia. However, the symptoms can be kept in check by an early treatment, which can only be enabled through a timely detection of the disease.

One of the main objectives of the solution that this paper offers is to detect Alzheimer's in early stages and later stages. Deep learning models[3] can be used to detect this disorder in patients. These models use artificial neural networks (ANN) [1] to analyze the brain scan images to identify the signs of the disease. These brain scans are commonly MRI (magnetic resonance imaging) or CT scans which then need to be analyzed by experienced radiologists and neurologists who can identify the disorder. However, due to the dearth of neuro specialists in the country, this diagnosis is often delayed and prove deadly to the patient.

Convolution neural networks (CNNs) [1] can be used in order to analyze the various brain scan images and classify them into various categories by considering the severity that the brain scan image exhibits which turns out to be a better, quick and effective alternative. VGG-19 which is a deep convolutional neural network[1] architecture can be used in order to classify the images. This architecture can be trained on a large dataset of labeled images, which allows it to learn to recognize and categorize different objects and scenes.

The key strengths of VGG-19 is the ability to learn hierarchical representations of images[8], where each layer in the network represents a different level of abstraction. In this application of VGG-19 algorithm, the dataset consisting of brain scan images is analyzed and are grouped into classes which represents the stage that the Alzheimer's disease is at.

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II. LITERATURE SURVEY

The field of interest in the usage of Machine Learning and Deep Learning[8][6] for the detection of various diseases and in particular, neurodegenerative diseases like Alzheimer's disease has been on the rise in recent years, leading to significant research being conducted in this domain. Data analysis of the databases used for training have been done through the implementation of deep convolutional autoencoders. The degenerative procedure of these neurological disorders have been identified using the extraction of specific MRI features that have been obtained through the decomposition of the MRI[5] images provided in the datasets.

The extracted features were then put through classification and further analysis in several amalgamations and the accuracy was calculated. The algorithms used ranged from models like SVM, Decision Tree, NN, Naive Bayes[7], however, the prediction of cognitive functions was able to provide an accuracy of 75-80%. We have taken this study further by analyzing various ML algorithms and methods to arrive[6][8] on the VGG-19 algorithm, based on a 19 layered convolutional neural network, proving to be the most efficient, at an accuracy rate of more than 92%. This proposed approach makes the use of a pre trained deep neural network to arrive at a precise diagnosis of AD and the classification based on it's severity. The classification is clean, succinct and

has been found to be the most accurate for the determination and classification of a neurodegenerative disease like Alzheimer's. This can also be used to improve future techniques.

III. METHODOLOGY

The methodology is based on the VGG 19 architecture of the Convolutional Neural Networks [1], which consists of 19 layers and is effective in analysis and prediction of images. Through our interactive web application, the AD patient can upload their brain scans onto our model, which has already been pre trained through a practice dataset. Image processing techniques are then applied on the scan, and relevant features are extracted and used as inputs for the trained ML model. The model predicts the first stage of classification in ascertaining whether Alzheimer's is present in the brain scan. Once Alzheimer's is detected, the model goes to further classification in determining the exact level that the disease has progressed to. Accordingly, the report of the AD stage is generated, along with the provision of storing the report for future references for the patient. This can be implemented in programmable MRI machines in centers where there is a dearth of neurological or detection professionals and experts.

A. Objective

- The objective of the project is to predict the Alzheimer Disease (AD) stage in the patient by analyzing the brain scan image.
- It classifies the brain scan image based on the deep learning (DL) model[7] which is trained on the dataset.
- This project uses machine learning and deep learning[3] concepts which are implemented in python.

B. Machine learning and Deep learning concepts used

a). Feature extraction

Feature extraction is the process of transforming raw input data into a set of features that can be used to train a machine learning model. The goal is to capture the most relevant information in the data and represent it in a way that facilitates learning.

b). Convolutional neural networks (CNNs)

A deep learning system known as a convolutional neural network (CNN) [1][3] is used largely for processing images and videos. Convolutional layers are used to extract features from the input data, while pooling layers are used to shrink the feature maps' spatial dimensions. In applications like segmentation, object identification, and image classification, CNNs have attained cutting-edge performance.

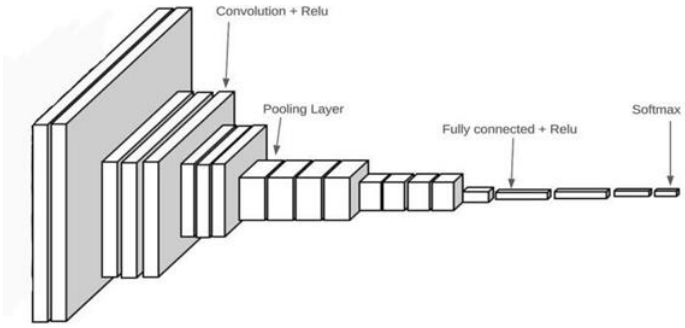


Fig. 1 CNN architecture

Fig. 1 depicts the various layers which are included. The layers include convolution with ReLU, pooling layers, fully connected with ReLU and softmax..

c). Transfer learning

A machine learning approach called transfer learning uses a model that has already been trained for one job as the basis for a new, related task. Transfer learning can enhance performance and shorten the amount of time needed to train for the target task by drawing on information from the source task.

d). Image augmentation

Image augmentation is a technique used to artificially expand the size of a dataset by adding modifications such as rotations, translations, and scaling to existing pictures. By enhancing the variety of the data and lowering overfitting, the objective is to improve the performance of machine learning models. In computer vision tasks like object detection and image classification, image augmentation is frequently used.

e). Supervised learning

Supervised learning is a machine learning approach in which a model is trained on a labeled dataset,[6] including input-output pairs. The model gains the ability to convert inputs into outputs and can then predict the outcomes of fresh, unlabeled data[9]. When performing tasks like classification, regression, and prediction, supervised learning is frequently used.

f). Deep learning optimizations

Deep learning optimization techniques are methods for improving the performance and efficiency of deep neural networks.

IV. IMPLEMENTATION

This project has a deep learning (DL) [8] based interface built with the principles of artificial neural network[1] which is capable of classifying the retinal scan into different classes.

A. Algorithm

1. The dataset consists of 6000 images [2]. These are the images that belong to various classes for Alzheimer Disease stages.
2. The data collected are preprocessed by removing any irrelevant or corrupt images, resizing the images to standard size, converting them to grayscale and splitting the dataset into training and testing sets.
   Extract the features from each image that will be used as inputs to the model. These features can be texture color, shape, and other relevant features.
3. After these steps the deep learning (DL) model [3] is trained on the training dataset using extracted features as inputs. Convolutional neural network (CNNs)[1] is implemented using visual geometry group (VGG-19) algorithm.
4. The performance of the model is evaluated on the testing dataset to determine the accuracy of the model. The model gave an accuracy of 93% on the test data.
5. The model is deployed as a web application and can work for any valid brain scan images that will be uploaded.

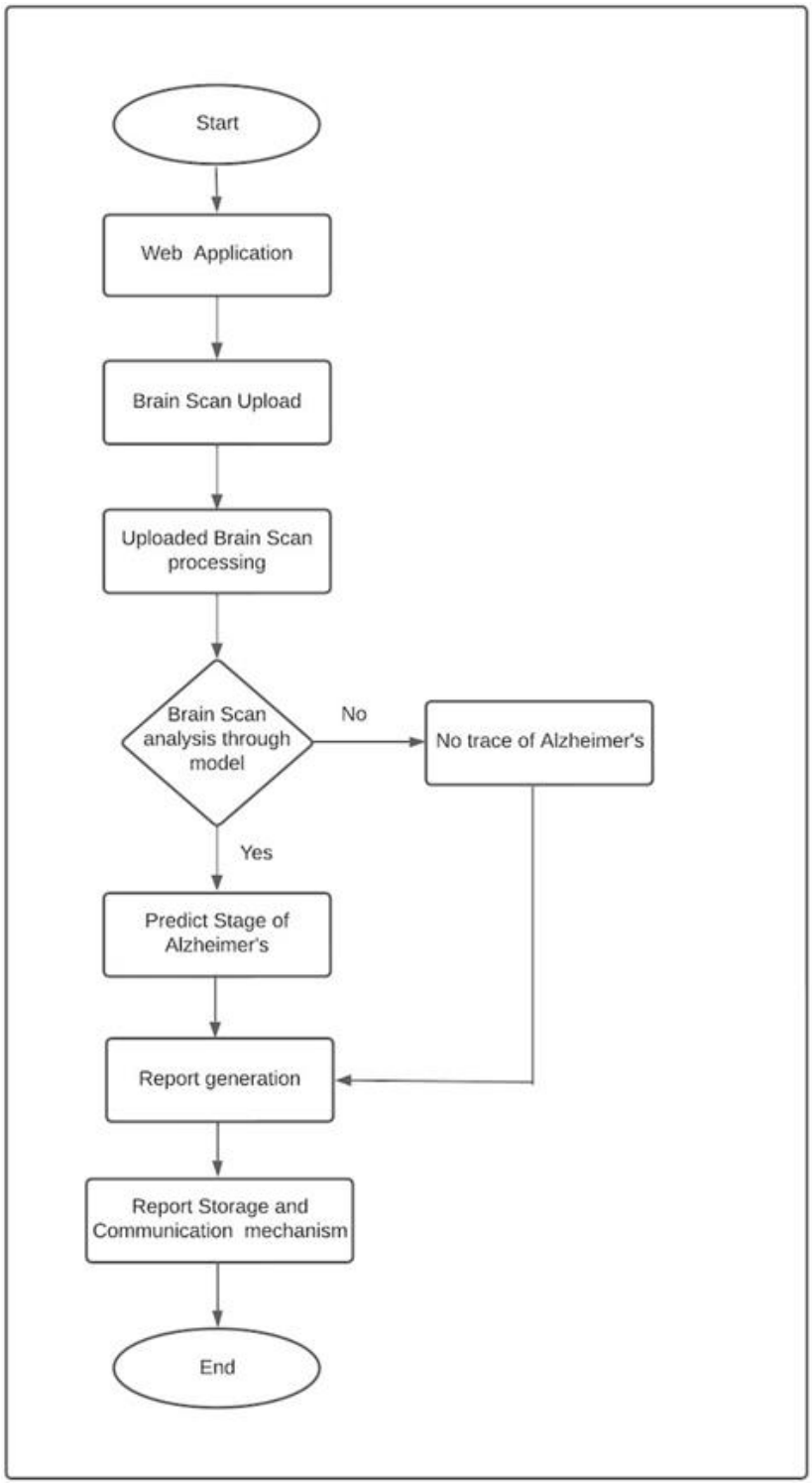


Fig. 2 Implementation setup flowchart

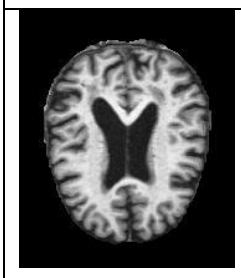
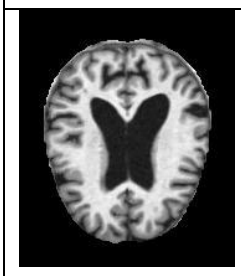
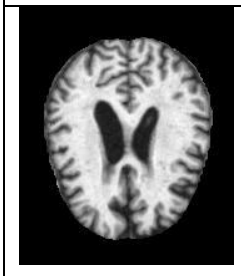
The Fig. 2 illustrates the flow of the implementation setup which is a web interface for users to upload their brain scans. The uploaded scans are then passed into the machine learning model that predicts the current stage of Alzheimer's disease.

B. Classifications and outputs.

The Table. 1 depicts the various cases of Alzheimer Disease which the model is capable of classifying and recognizing.

And generating a prediction output for these classifications are through the CNNs along with the deep learning (DL) [3] model which is implemented with the help of VGG-19 algorithm which consists of 19-layers of Convolutional neural networks (CNNs)[1]. It is a deep convolutional neural network algorithm used for image classification tasks. It consists of 19 layers, including 16 convolutional layers, 3 fully connected layers, and a final SoftMax classifier layer

Table. 1: Classification of Alzheimer Disease(AD)

Case Figure	AD Class	Details of ADClass
	Normal. Noapparent Alzheimer'sDisease.	No disease visible (Healthy Individual Prediction value = 0
	Very Mild Alzheimer's Cognitive Impairment Disease.	Earliest stage (preclinical stage). Patient might feel memory lapsesPrediction value = 1
	Mild Alzheimer'sCognitive Impairment Disease.	Early-stage memory and cognitive decline, depression, anxiety and agitation. Predictionvalue = 2
	Moderate Alzheimer's Cognitive Impairment Disease.	(mid-stage)Progressivedecline in cognitive function. Predictionvalue = 3

The output of this deep learning (DL)[7][8] model will be the stage of the Alzheimer Disease (AD) in the brain scan uploaded by the patient. The accuracy of the prediction is between the range of 90.20% to 93.00%.

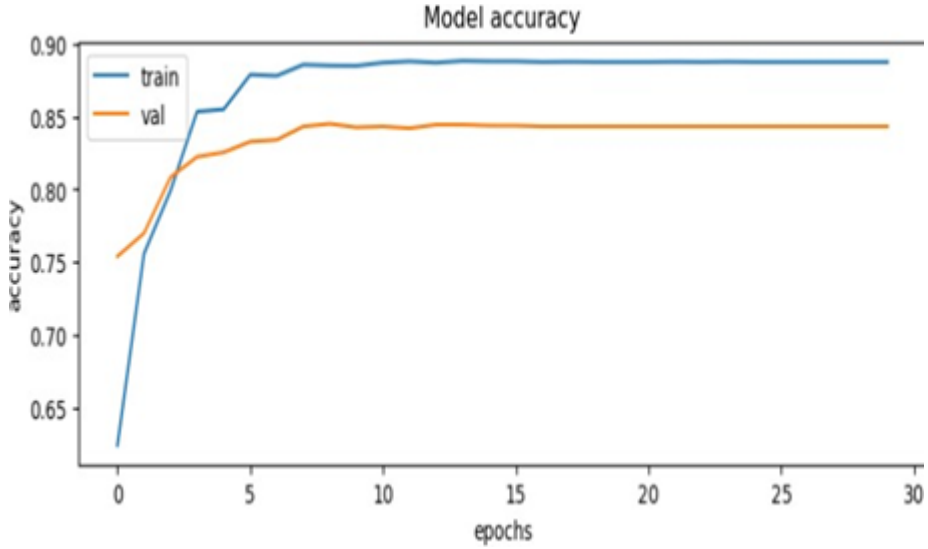


Fig. 3: Accuracy graph

The Fig. 3 depicts the training accuracies that were obtained from the model which is trained and has been revised [9] with the dataset in order to achieve highest accuracy of around 93.33%.
The generated reports of the prediction are stored into the Google Cloud Platform [10] for documentation purposes that can be retrieved in the future.

V. CONCLUSION

Alzheimer's disease, a neurodegenerative disorder that affects millions of people and results in severe dementia can be avoided by early detection of the same. Using the image processing scheme proposed in this research it is possible to classify the stages by use of Convolutional neural networks (CNNs). Automated screening of Alzheimer's significantly reduces the time required for determination of diagnosis. Automated systems for the detection of Alzheimer's disease plays an important role for detecting dementia in its early stages.
In future this research will lead to implementing an efficient and more accessible way of detecting Alzheimer's and dementia with the help of web applications or mobile applications.

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