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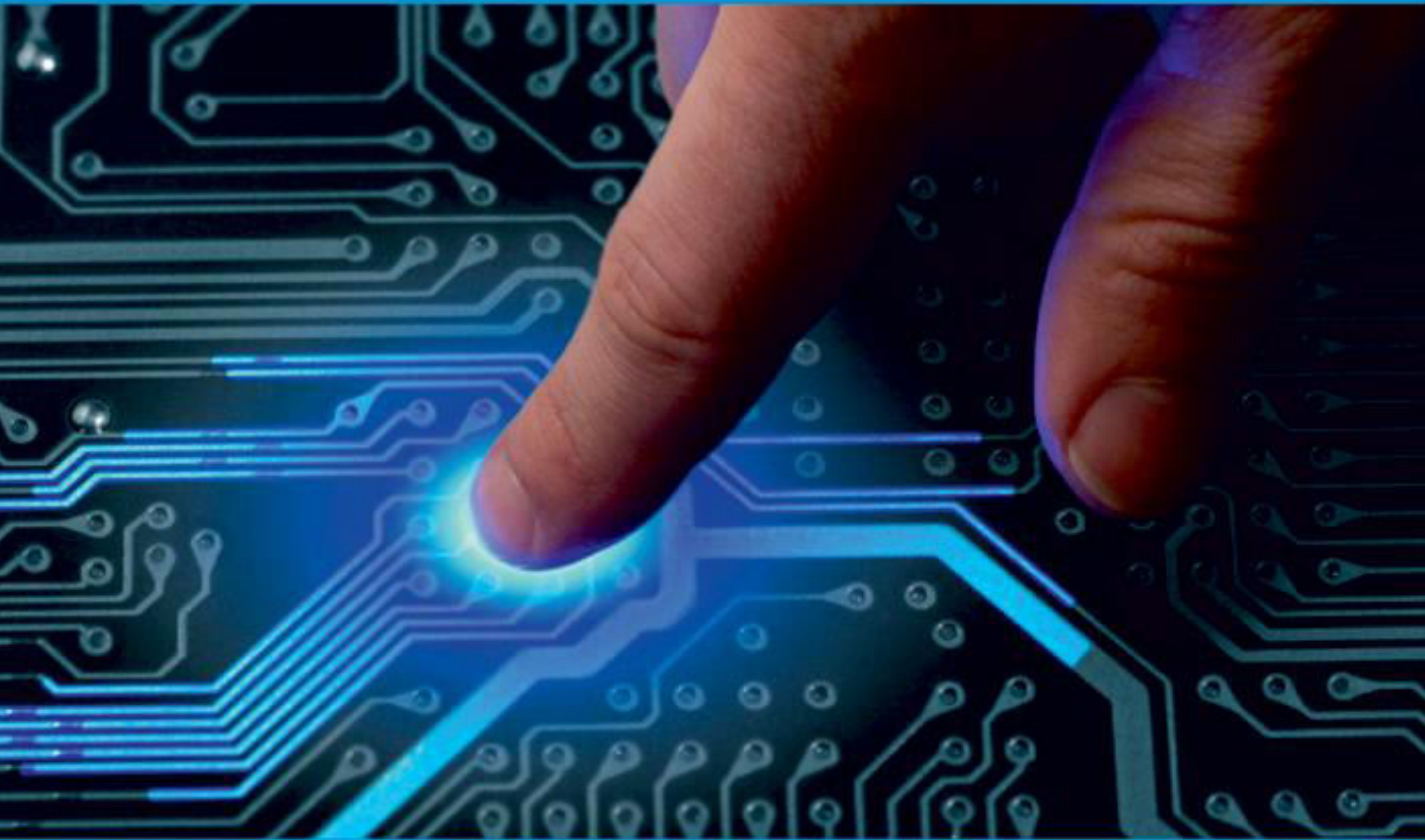

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Detection of Alzheimer's Disease using Neural Networks

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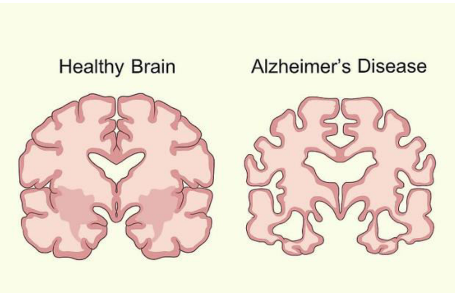
ABSTRACT: Alzheimer's disease (AD) is the primary cause of amnesia in older adults and is a progressive neurodegenerative disorder associated with cognitive decline and memory loss. Other conditions that can lead to amnesia include Traumatic Brain Injury, Stroke, Encephalitis, and Transient Global Amnesia. Early and accurate diagnosis of AD plays a crucial role. Machine learning techniques have shown great potential in aiding the diagnosis of AD by analyzing large-scale datasets and extracting meaningful patterns and features from the MRI images of brain. The classification of MRI images from the open accessible datasets. Classification of the AD using deep learning and Convolutional Neural Networks (CNN) along with VGG16 algorithm. The system follows various activities like dataset acquisition, image segmentation, feature extraction and classification. The projected arrangement accomplishes noteworthy performance with the finest accuracy. As, the accuracy increases classification will be accurate without any prior errors.

KEYWORDS: Energy efficient algorithm; Manets; total transmission energy; maximum number of hops; network lifetime

I. INTRODUCTION

Alzheimer's disease (AD) represents a profound challenge to global healthcare systems, affecting millions of individuals and their families worldwide. This progressive neurodegenerative disorder is characterized by a relentless decline in cognitive function, memory loss, and a host of associated symptoms that profoundly impact the affected individual's quality of life. As the population ages, the prevalence of AD is projected to rise dramatically, posing significant social, economic, and healthcare burdens in the coming decades. Early detection of AD is paramount for several reasons.



Comparision of Healthy and Demented Brain

Firstly, it enables individuals to access appropriate medical care and support services promptly, thereby enhancing their quality of life and delaying the progression of the disease. Secondly, early intervention may allow for the implementation of lifestyle modifications and pharmacological treatments that can help manage symptoms and potentially slow disease progression. Furthermore, early diagnosis facilitates participation in clinical trials aimed at developing novel therapies and interventions, thus advancing our understanding and treatment of AD. Magnetic Resonance Imaging (MRI) has emerged as a cornerstone in the diagnosis and management of AD. MRI offers exquisite anatomical detail, allowing clinicians to visualize structural changes within the brain associated with AD, such as

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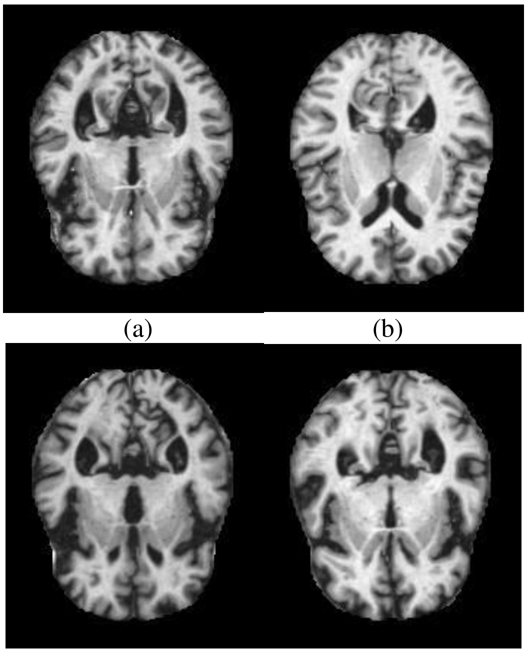
hippocampal atrophy, cortical thinning, and ventricular enlargement. However, the manual interpretation of MRI scans for AD diagnosis is labor-intensive, time-consuming, and subject to inter-observer variability. Consequently, there is a pressing need for automated and objective methods to assist in the diagnosis of AD from MRI images. In recent years, advancements in machine learning, particularly deep learning techniques, have revolutionized medical image analysis. Convolutional Neural Networks (CNNs) have demonstrated remarkable capabilities in extracting complex patterns and features from large-scale datasets, making them well-suited for tasks such as medical image classification and segmentation. The VGG16 architecture, a deep CNN model pretrained on ImageNet, has garnered significant attention for its performance in various image recognition tasks.
Our research paper explores the application of machine learning, particularly deep learning techniques, in the classification of Alzheimer's disease using MRI images.



(a) (b)

(c) (d)

Example of different brain MRI images presenting different AD stage. (a) very mild demented; (b) non demented ; (c) moderate demented; (d) mild demented.

Leveraging the VGG16 algorithm, a widely recognized CNN architecture, this study aims to develop a robust classification model capable of accurately distinguishing between different stages of AD and non-AD conditions. The proposed methodology encompasses various stages, including dataset acquisition, image segmentation, feature extraction, and ultimately, classification. Through meticulous model training and evaluation, the study endeavors to achieve significant advancements in AD diagnosis, thereby facilitating early interventions and enhancing patient care. In this paper, we present a comprehensive overview of the methodology employed, detailing each step involved in the development and evaluation of the VGG16-based classification model. Furthermore, we discuss the significance of accurate AD diagnosis, the potential impact of machine learning approaches in healthcare, and the implications of our findings in advancing the field of neuroimaging and dementia research.

II. RELATED WORK

In their paper titled "A Novel Deep Learning based Multi-Class Classification Method for Alzheimer's Disease Detection using Brain MRI Data" by Jyoti Islam and Yanqing Zhang presents a significant contribution to the field of Alzheimer's disease (AD) detection and classification. The authors highlight the limited exploration of deep learning techniques for AD detection using brain MRI data, despite the success of such methods in other medical image analysis tasks. They propose a novel deep learning model designed specifically for multi-class classification of AD stages using brain MRI data, leveraging the Open Access Series of Imaging Studies (OASIS) database for evaluation. Experimental results on the OASIS dataset demonstrate the efficacy of the proposed model, achieving an accuracy of 73.75% in detecting and classifying AD stages. The performance surpasses traditional methods and showcases the potential of deep learning in improving the speed and accuracy of AD diagnosis. Importantly, the authors emphasize the

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significance of their approach in eliminating the need for manual feature extraction, which is labor-intensive and time-consuming in traditional methods. By directly learning features from the MRI images, the proposed model offers a more streamlined and efficient process for AD detection and classification.[1]

In their paper titled "Deep Learning-based Pipeline to Recognize Alzheimer's Disease using fMRI Data," presented at the Future Technologies Conference 2016, Sarraf and Tofighi introduced a novel approach utilizing convolutional neural networks (CNNs) for the classification of Alzheimer's disease (AD) from functional magnetic resonance imaging (fMRI) data. The authors highlighted the importance of machine learning techniques, particularly deep learning, in biomedical research, emphasizing their role in assisting researchers in understanding complex medical issues comprehensively. The study employed a CNN architecture, specifically LeNet-5, to classify fMRI data of AD subjects from normal controls. The preprocessing steps involved the extraction of functional brain activity from fMRI scans and the removal of non-brain tissue, motion correction, skull stripping, and spatial smoothing. The CNN architecture comprised convolutional layers for feature extraction, pooling layers for downsampling, and fully connected layers for classification. This high accuracy suggests the effectiveness of CNNs in extracting shift and scale invariant features from fMRI data, enabling robust classification between AD and normal brain activity. The study's results hold promise for developing predictive models or systems to recognize Alzheimer's disease symptoms and estimate disease stages accurately. Moreover, the proposed deep learning-based approach opens avenues for further research in medical image analysis and provides insights into potential applications for predicting different disease stages and generalizing the methodology to address more complex problems in neuroimaging.[2]

In their paper titled "Detection of Alzheimer's Disease and Dementia States Based on Deep Learning from MRI Images: A Comprehensive Review," Emre Altinkaya, Kemal Polat, and Burhan Barakli provided an extensive examination of the use of deep learning techniques for the detection of Alzheimer's disease and dementia states using MRI images. The study, published in the Journal of the Institute of Electronics and Computer, delves into the importance of early diagnosis and treatment of these neurological disorders and highlights the role of computer-aided systems in improving diagnostic accuracy. The authors underscored the significance of quality MRI images in detecting Alzheimer's and dementia, noting that while high-quality images are essential, they often come with challenges such as reduced spatial coverage and longer scanning times. This has led to significant advancements in biomedical image processing, with computer-aided systems playing a crucial role in the diagnosis process. One of the key technologies highlighted in the paper is super-resolution (SR), which has gained prominence in image processing applications. SR enables the generation of high-resolution images from low-resolution inputs, thereby reducing processing time and improving image quality. This is particularly beneficial in MRI imaging, where quick and accurate diagnosis is essential. The authors presented insights into the success and efficacy of deep learning techniques in detecting Alzheimer's and dementia. They cited examples of high accuracy rates achieved by these models, demonstrating their potential in improving diagnostic outcomes.[3]

In their paper titled "Detection of early stages of Alzheimer's disease based on MEG activity with a randomized convolutional neural network," Manuel Lopez-Martin, Angel Nevado, and Belen Carro explore the use of magnetoencephalography (MEG) activity combined with a randomized convolutional neural network (CNN) for the early detection of Alzheimer's disease. The study investigates novel approaches to diagnosing Alzheimer's disease in its early stages, leveraging advanced computational techniques. The authors begin by addressing the critical need for early detection methods in Alzheimer's disease, highlighting the significant challenges posed by late-stage diagnosis and the potential benefits of early intervention. They emphasize the importance of utilizing non-invasive imaging modalities, such as MEG, to capture subtle changes in brain activity associated with the onset of Alzheimer's disease. The study introduces a randomized CNN framework designed to analyze MEG data and identify patterns indicative of early-stage Alzheimer's disease. CNNs are a type of deep learning algorithm known for their effectiveness in processing spatial data, making them well-suited for analyzing brain imaging data. Through their research, Lopez-Martin et al. demonstrate the feasibility and efficacy of their proposed approach in accurately detecting early-stage Alzheimer's disease. They present results indicating high accuracy rates in distinguishing between healthy individuals and those with early signs of the disease, highlighting the potential clinical utility of their method.[4]

III. PROPOSED ALGORITHM

The proposed system is a web-based platform that leverages advanced machine learning techniques to predict Alzheimer's disease stages from MRI images. Users can upload MRI scans of the brain through a user-friendly interface, and the system employs a deep learning model to analyze the images and predict the stage of Alzheimer's

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disease. Upon prediction, the system provides personalized recommendations and precautions based on the predicted stage, aiding caregivers and individuals in understanding and managing the disease effectively.

A. Workflow of System

The proposed system used the following workflow:

1.Data Acquisition and Preprocessing: The study utilized a dataset comprising MRI images obtained from individuals diagnosed with Alzheimer's Disease (AD) at different stages of severity. The dataset included images categorized into four classes: MildDemented, ModerateDemented, NonDemented, and VeryMildDemented. Prior to model development, the dataset underwent preprocessing steps, including image resizing and normalization, to ensure uniformity and facilitate efficient model training.

2.Model Architecture: Implemented VGG16 architecture, a widely adopted CNN model pre-trained on the ImageNet dataset. While retaining the convolutional base of VGG16, we introduced modifications to adapt it to our Alzheimer's disease classification task. These modifications included the addition of Dropout layers to mitigate overfitting, Batch Normalization layers for stabilizing and accelerating the training process, and Dense layers for final classification. By fine-tuning the pre-trained VGG16 model, we aimed to capture meaningful features from MRI images relevant to Alzheimer's disease diagnosis.

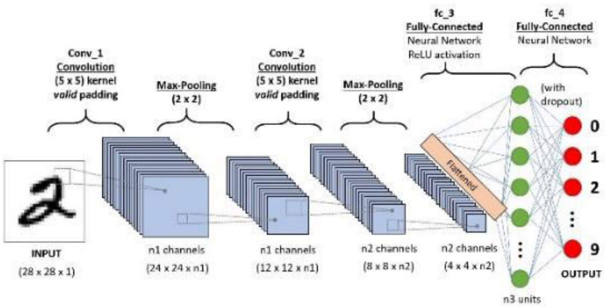
3.Model Training and Optimization: Iteratively update the parameters of our modified VGG16 architecture using the training dataset. We employed the Adam optimizer with a learning rate of 0.001 to optimize the model's weights, aiming to minimize the categorical cross-entropy loss function. Throughout training, the model's performance was continuously monitored using the area under the ROC curve (AUC) metric, which is particularly effective for binary classification tasks like Alzheimer's disease diagnosis. Early stopping and model checkpoint callbacks were incorporated to prevent overfitting and save the best performing model weights.

4.Model Evaluation and Testing: After training, the performance of our Alzheimer's disease classification model was rigorously evaluated using the validation dataset. This evaluation phase aimed to assess the model's ability to generalize to unseen data and accurately classify brain MRI images into the four predefined categories: Mild Demented, Moderate Demented, Non-Demented, and Very Mild Demented. We computed key performance metrics such as loss and AUC (area under the ROC curve) across epochs to analyze the convergence and discriminative ability of the model. Additionally, visualizations such as ROC curves and confusion matrices were generated to provide insights into the model's behavior and performance across different disease stages.

B. Convolutional Neural Networks(ConvNets):

Convolutional Neural Networks (CNNs) have emerged as powerful tools in the field of medical image analysis, including the detection and classification of Alzheimer's disease (AD) from MRI scans. CNNs are a type of deep neural network specifically designed for processing structured grid-like data, such as images. They are composed of multiple layers, including convolutional layers, pooling layers, and fully connected layers, each responsible for extracting and learning increasingly abstract features from the input data. Overall, CNNs represent a powerful framework for Alzheimer's disease detection through deep learning in MRI scans, offering robustness, scalability, and automated feature extraction capabilities essential for developing accurate and clinically relevant diagnostic tools. As research in this field Progresses, further advancements in CNN architectures and interpretability techniques are expected to contribute to improved AD detection and patient care.

Convolutional Neural Network (CNN) Architecture



1-INPUT, 2-CONVOLUTION, 3-POOLING, 4-FULLY CONNECTED, 5-OUTPUT, 6- FEATURE EXTRACTION, 7- CLASSIFICATION

C. VGG16 Model:

VGG16 is a widely used convolutional neural network (CNN) architecture for image classification tasks, originally developed for the ImageNet Large Scale Visual Recognition Challenge. It consists of 16 layers, including 13

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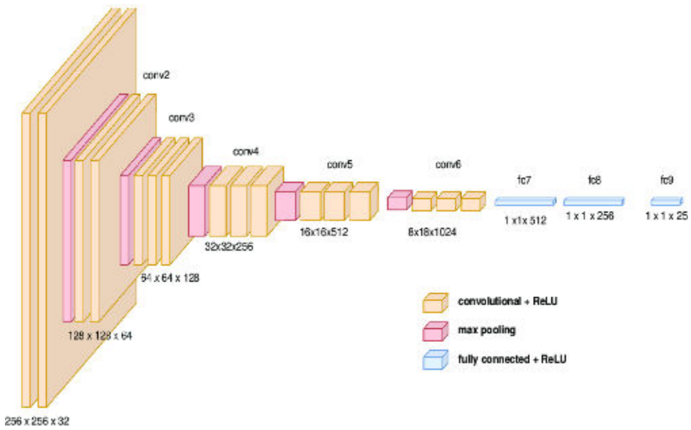
convolutional layers and 3 fully connected layers. VGG16's deep architecture allows it to learn hierarchical representations of features from input images, capturing intricate patterns and structures. One of the key advantages of VGG16 is its simplicity and uniformity in architecture, with small 3x3 convolutional filters and maxpooling layers. Transfer learning with VGG16 involves initializing the model with pre-trained weights and then fine-tuning it on the MRI dataset. By leveraging knowledge learned from diverse image domains, VGG16 can expedite model training and potentially improve detection performance. Its effectiveness in feature extraction and classification makes VGG16 a valuable asset in developing accurate and robust diagnostic tools for Alzheimer's disease.



VGG16 Architecture

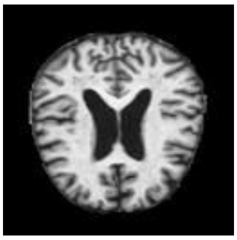
IV. PREREQUISITES

The following will be necessary for the reader to follow along:

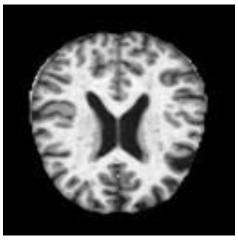
1. Verify that Python is installed on your computer. The official Python website offers downloads and installation instructions for Python.
2. Verify that the necessary libraries(keras, tensarflow, matplotlib, numpy, sklearn, seaborn) are imported and installed.
3. Verify that an image-based dataset is accessible in the local storage.

V. RESULTS

The results of our study demonstrate the effectiveness of the proposed Alzheimer's disease classification model based on the VGG16 architecture. Through rigorous training and evaluation, the model achieved high accuracy and AUC scores in classifying brain MRI images into four distinct categories representing different stages of the disease. These values demonstrate the model's robustness and ability to generalize well to unseen data. Our model's ability to accurately differentiate between Mild Demented, Moderate Demented, Non-Demented, and Very Mild Demented cases highlights its potential as a valuable tool for early diagnosis and intervention. The model can assist healthcare professionals in early diagnosis and intervention, potentially leading to improved patient outcomes and quality of life.



VeryMildDemented



NonDemented

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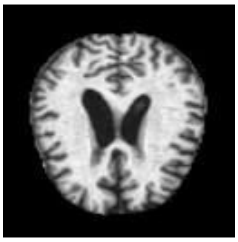
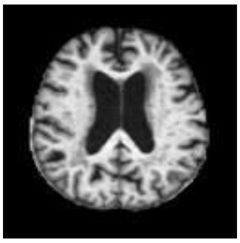
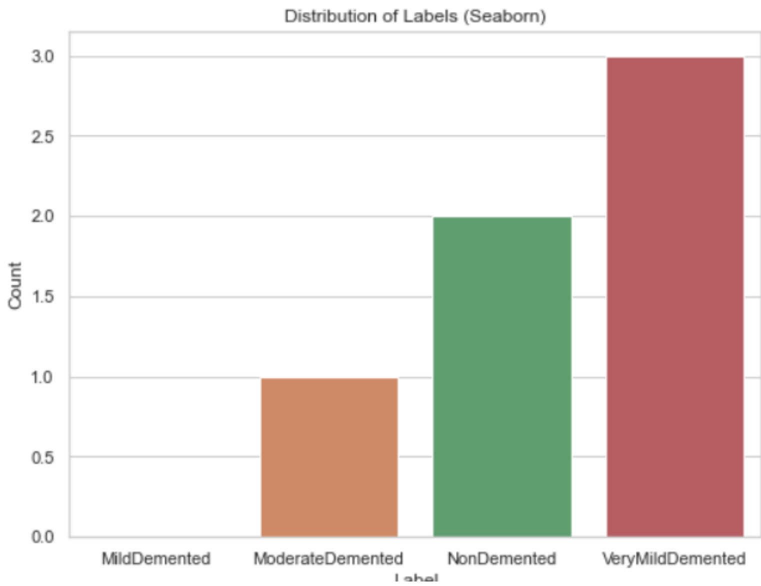


ModerateDemented

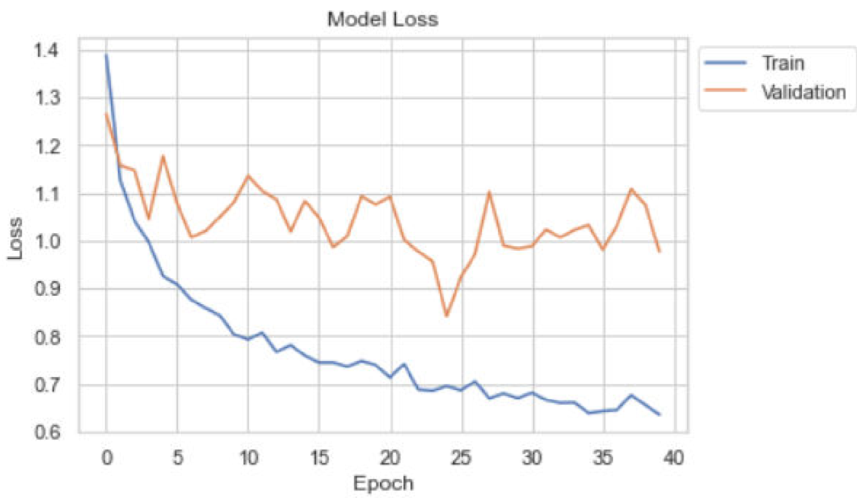


MildDemented

Classified Output of the Alzheimer's disease dataset



Labeling of data



After training,model loss

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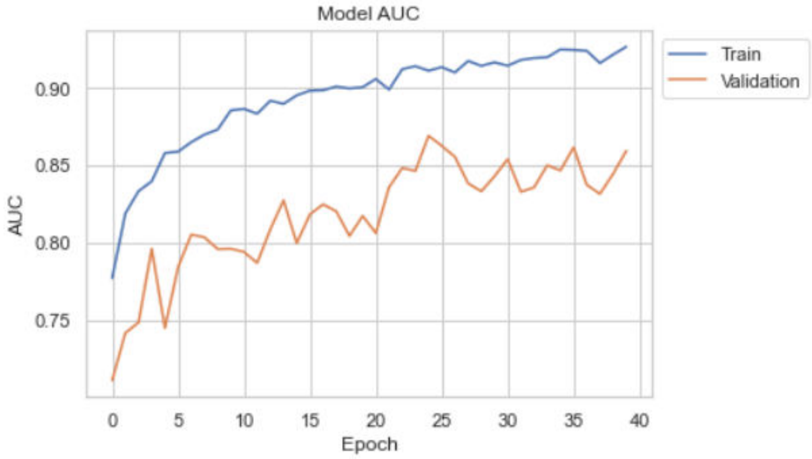

After training, model Accuracy

No of Epoches	Loss Value	Accuracy
2	1.1261	0.8188
5	0.9255	0.8580
30	0.6697	0.9166
35	0.6388	0.9250
40	0.6356	0.9268

Loss and Accuracy values for Various number of epochs

VI. CONCLUSION AND FUTURE WORK

Our research presents a significant advancement in the field of Alzheimer's disease diagnosis through the development of a robust classification model based on deep learning and convolutional neural networks. By leveraging the VGG16 architecture, we have demonstrated the model's capability to accurately classify brain MRI images into distinct stages of the disease as either Mild Demented or Moderate Demented or Non-Demented or Very Mild Demented with high accuracy and reliability. The promising results obtained through rigorous training, validation, and testing underscore the potential of our model as a valuable tool for early detection and intervention in Alzheimer's disease. Future work include expanding the dataset to encompass a more diverse range of cases and demographics, thereby enhancing the model's generalization ability. Additionally, exploring advanced deep learning architectures and techniques, such as attention mechanisms and transfer learning, could further improve the model's performance and robustness. Furthermore, integrating multimodal data sources, such as genetic markers and clinical variables, may provide additional insights and improve diagnostic accuracy.

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