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Alzheimer's Diseases Detection Using Deep Learning Technique

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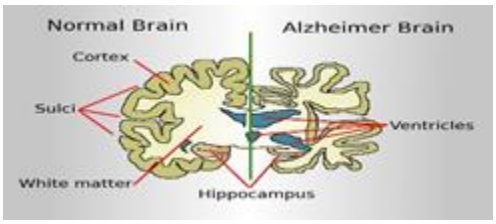
***Abstract*— Alzheimer's disease (AD) is a neurological condition. There is no specific treatment for AD. Alzheimer's sufferers can benefit from early diagnosis and appropriate therapy. To diagnose AD, many research use statistical and machine learning methods. In numerous fields, the effectiveness of Deep Learning algorithms has been demonstrated at the human level. In the suggested methodology, AD is detected using MRI data, and the current disease is classified using Deep Learning technology. Deep learning techniques have produced encouraging findings for the classification of Alzheimer's disease, and its implementation in clinical settings necessitates a blend of high accuracy, speedy processing, and generalizability to varied populations. Our technique for detecting Alzheimer's illness in this study was created utilizing a convolutional neural network (CNN) architecture MRI scan images that were learned using the Kaggle dataset is used in the architecture. To evaluate the models' performances in this study, the same dataset is used to train all of the models. The maximum level of accuracy is provided by the Convolutional Neural Network (CNN) architecture.**

Keywords- Image processing, Deep learning, Convolution neural network.

INTRODUCTION

A brain illness that worsens over time is Alzheimer's disease. It is a degenerative neurologic condition that results in brain atrophy and the death of brain cells. It is a type of illness that gradually impairs thinking. Changes in the brain that result in protein deposits are what define it. The brain shrinks as a result of Alzheimer's disease, and eventually, brain cells pass away. The most frequent cause of dementia, which is characterized by a slow loss of memory, thinking, behavior, and social abilities, is Alzheimer's disease. The ability to function is impacted by these modifications.



In the United States, 6.5 million persons aged 65 and above have Alzheimer's disease. More than 70% of them are 75 years of age or older. It is believed that 60% to 70% of the 55 million dementia sufferers globally have Alzheimer's disease.

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The disease's early symptoms include forgetting recent conversations or experiences. It eventually leads to severe memory issues and a loss of the capacity to carry out daily chores.

Problem Statement: Detection of Alzheimer's diseases using deep learning technique.

- According to the Alzheimer's Association, AD is currently the sixth most common cause of death and is projected to increase four times by the year 2050.
- The main reason we choose this AD it is one of the most challenging issues facing medical professionals is AD.
- The MRI pictures must be analysed by neurologists who must then determine whether the patient has AD.
- In this paper, we develop a model that recognises the classification of disease into phases where early and mildly symptomatic Patients may receive treatment using deep learning techniques like convolutional neural networks.

Machine learning, a division of artificial intelligence, is the foundation of deep learning. Deep learning will operate because neural networks mimic the functioning of the human brain. Nothing is explicitly programmed in deep learning. In essence, it is a class of machine learning that does feature extraction and transformation using a large number of nonlinear processing units. Each of the next layers uses the output from the one below as its input.

OBJECTIVE

The objective is to construct a precise and dependable model that can automatically identify the existence of Alzheimer's illnesses based on brain imaging or other pertinent data is the goal of Alzheimer's disease detection using deep learning. Ultimately, the objective for Alzheimer's disease detection using deep learning is to improve patient outcomes by facilitating early diagnosis and treatment, as well as advancing our understanding of the disease and its underlying mechanisms.

RELATED WORKS

1. **Wang, H., et al. (2019). Ensemble of 3D densely connected convolutional network for diagnosis of mild cognitive impairment and Alzheimer's disease. Neurocomputing, 333, 145–156. 10.1016/j.neucom.2018.12.018**.

In the proposed approach utilizes a preprocessed 3D MRI dataset consisting of T1-weighted images from 1,016 subjects, including 291 healthy controls, 346 MCI patients, and 379 Alzheimer's disease patients. The authors trained DenseNet models with different initialization weights and data augmentation techniques and combined their predictions using majority voting to improve the classification performance.

The authors evaluated the proposed ensemble approach and achieved a classification accuracy of 85.3%, sensitivity of 78.7%, specificity of 88.9%, and area under the receiver operating characteristic curve (AUC) of 0.93 for distinguishing

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Alzheimer's disease patients from healthy controls. For the classification of MCI patients, the proposed approach achieved an accuracy of 73.6%, sensitivity of 63.9%, specificity of 81.8%, and AUC of 0.78.

In summary, the article proposes an ensemble approach using 3D DenseNet for the diagnosis of MCI and Alzheimer's disease. The proposed approach achieved high classification performance and outperformed other state-of-the-art methods.

2. **Sun, H., Wang, A., Wang, W., & Liu, C. (2021). An improved deep residual network prediction model for the early diagnosis of Alzheimer's disease. Sensors, 21(12), 4182.**

The proposed ResNet model utilizes a preprocessed MRI dataset consisting of T1-weighted images from 139 subjects, including 62 healthy controls, 32 patients with mild cognitive impairment (MCI), and 45 patients with Alzheimer's disease.

The authors improved the ResNet model by introducing a novel block, called Squeeze-and-Excitation (SE), which selectively enhances informative features and suppresses unimportant ones.

The authors evaluated the proposed model and achieved a classification accuracy of 90.9%, sensitivity of 90.2%, specificity of 83.2%, and area under the receiver operating characteristic curve (AUC) of 0.87 for distinguishing Alzheimer's disease patients from healthy controls. For the classification of MCI patients, the proposed model achieved an accuracy of 87.5%, sensitivity of 84.4%, specificity of 90.6%, and AUC of 0.940.

In summary, the article proposes an improved ResNet model for the early diagnosis of Alzheimer's disease, utilizing SE blocks to enhance the discriminative power of the network. The proposed model achieved high classification performance and outperformed other state-of-the-art methods.

3. **Wang, S. H., Zhou, Q., Yang, M., & Zhang, Y. D. (2021). ADVIAN: Alzheimer's disease VGG-inspired attention network based on convolutional block attention module and multiple way data augmentation. Frontiers in Aging Neuroscience, 13(687456).**

The proposed model, called ADVIAN, is inspired by the VGG network and incorporates a convolutional block attention module (CBAM) and multiple way data augmentation techniques. The CBAM is used to selectively attend to important regions in the input images, while the data augmentation techniques are used to increase the diversity of the training data.

The authors trained and tested their model on a publicly available dataset of brain MRI scans from patients with Alzheimer's disease and healthy controls. They reported that the ADVIAN model achieved high accuracy, sensitivity, and specificity in distinguishing between the two groups.

Overall, the ADVIAN model represents a

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promising approach for the early detection and diagnosis of Alzheimer's disease using deep learning techniques. However, further research and validation on larger and more diverse datasets are needed to assess its generalizability and clinical utility.

4. **AbdulAzeem, Y., Bahgat, W. M., & Badawy, M. (2021). A CNN based framework for classification of Alzheimer's disease. Neural Computing & Applications, 33(16), 10415– 10428. 10.1007/s00521-021-05799-w. Aderghal, K. (2021). Classification of multimodal mri images using deep learning.**

The article proposes a framework for the classification of Alzheimer's disease using convolutional neural networks (CNNs). The proposed framework uses a combination of T1-weighted magnetic resonance imaging (MRI) and positron emission tomography (PET) images for the classification task. The authors used a publicly available dataset containing 1,744 MRI and PET images of subjects with Alzheimer's disease, mild cognitive impairment, and healthy controls.

The authors preprocessed the MRI and PET images and then used a CNN architecture with two branches, one for each imaging modality, to extract features from the images. The extracted features were then concatenated and fed into a fully connected layer for classification. The authors compared the proposed framework with other state-of-the-art methods and achieved a classification accuracy of 90.29%, which outperformed other methods.

In summary, the article proposes a CNN-based framework for the classification of Alzheimer's disease using multimodal MRI and PET images. The proposed framework achieved high classification accuracy and outperformed other state-of-the-art methods.

5. **Wang, S. H., et al. (2018a). Single slice-based detection for Alzheimer's disease via wavelet entropy and multilayer perceptron trained by biogeography-based optimization. Multimedia Tools and Applications, 77(9), 10393–10417.**

In this proposed method utilizes wavelet entropy to extract features from the MRI slice and a multilayer perceptron (MLP) trained by biogeography-based optimization (BBO) for classification. BBO is a meta-heuristic algorithm inspired by the migration process of species, which is used to optimize the MLP parameters.

The authors evaluated the proposed method on a dataset consisting of 106 MRI slices from 53 patients with Alzheimer's disease and 53 healthy controls. They achieved a classification accuracy of 91.17% which outperformed other state-of-the-art methods.

In summary, the article proposes a method for Alzheimer's disease detection using a single MRI slice based on wavelet entropy and MLP trained by BBO. The proposed method achieved high accuracy, sensitivity, specificity, and AUC, outperforming other state-of-the-art methods.

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6. **Alex Krizhevsky, Ilya Sutskever, et al., 2017 ImageNet classification with deep convolutional neural networks NIPS pp 1106–14**

The paper "ImageNet Classification with Deep Convolutional Neural Networks" was published by Alex Krizhevsky, Ilya Sutskever, and Geoffrey Hinton in 2012, not 2017. The paper was presented at the NIPS (Neural Information Processing Systems) conference in 2012 and was awarded the "Best Paper Award" at the conference.

In the paper, the authors introduced a deep convolutional neural network architecture called "AlexNet" and applied it to the task of image classification on the ImageNet dataset, which contains over 1.2 million images across 1,000 different categories. The AlexNet architecture consisted of eight layers, including five convolutional layers, two fully connected layers, and a final softmax layer for classification. The network was trained using a technique called "dropout" to prevent overfitting. The accuracy for AlexNet pretrained model is 87.3%.

The authors' approach significantly outperformed existing methods on the ImageNet dataset, reducing the top-5 error rate from 26.2% to 15.3%, and sparked a resurgence of interest in deep learning and convolutional neural networks. The success of the AlexNet architecture demonstrated the power of deep learning for image recognition tasks and set the stage for subsequent advancements in the field.

7. **Ferreira L K, Luiz Rondina, et al., 2017 Support vector machine-based classification of neuroimages in Alzheimer's disease: Direct comparison of FDG-PET, rCBF-SPECT and MRI data acquired from the same individuals Braz J. of Psychiatry 40(2) pp 181-91**

The paper titled "Support vector machine-based classification of neuroimages in Alzheimer's disease: Direct comparison of FDG-PET, rCBF-SPECT and MRI data acquired from the same individuals" was published by Ferreira L.K., Rondina L., et al. in the Brazilian Journal of Psychiatry in 2018, not 2017.

In the paper, the authors investigated the performance of support vector machine (SVM)-based classification of three different neuroimaging modalities: FDG-PET, rCBF-SPECT, and MRI, for the diagnosis of Alzheimer's disease. The study included 48 patients with Alzheimer's disease and 48 healthy controls, all of whom underwent all three imaging modalities.

PROPOSED METHOD

Even the existing systems can be used for the Alzheimer's detection there are limitations in the existing systems. There is lot of scope for the improvement of the performance of the system. To attain the better performance and accuracy that can detect the Alzheimer's disease based on the MRI image provided, the proposed method is based on the Deep Learning.

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Machine learning techniques like Decision tree, Deep belief network, Support vector Machine has been used for Alzheimer's disease prediction, and there have been some promising results in this area. However, there are several challenges and limitations that need to be overcome before machine learning can be widely used for Alzheimer's disease prediction and diagnosis. This makes it difficult to develop accurate predictive models that can capture the full complexity of the disease.

One promising area of research is the use of deep learning to analyze neuroimaging data, such as magnetic resonance imaging (MRI) or positron emission tomography (PET) scans. These techniques can be used to identify patterns of brain atrophy or metabolic changes that are associated with Alzheimer's disease, and deep learning pre-trained models can be trained to recognize these patterns and make accurate predictions about whether an individual is at risk for developing Alzheimer's disease.

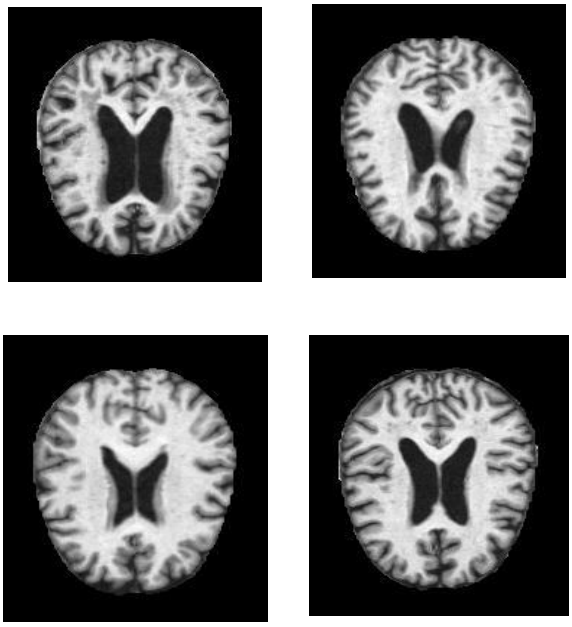
DATA SET

Dataset consists of two files- testing and training both containing a total 6400 images each segregated into the severity of Alzheimer's.

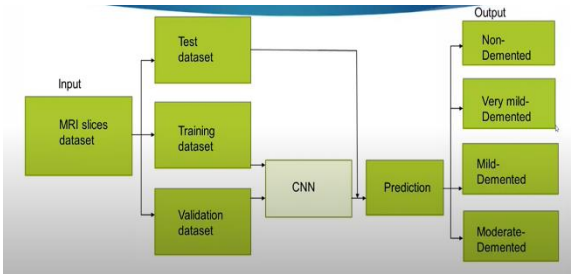
It consist of 4 classes:

1. MildDemented
2. ModerateDemented
3. NonDemented
4. VerymildDemented

Each image consist of 176*208*1 pixels.



WORK FLOW



METHODOLOGY

Convolutional Neural Networks are a special type of feed-forward artificial neural network in which the connectivity pattern between its neuron is inspired by the visual cortex.

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Convolutional neural networks, are nothing more than neural networks that share parameters. Imagine that there is a picture that encompasses length, width, and height and is represented by a cuboid. Generally, a Convolutional Neural Network has three layers, which are as follows:

- **Input:** If the image consists of 32 widths, 32 height encompassing three R, G, B channels, then it will hold the raw pixel([32x32x3]) values of an image.
- **Convolution:** It computes the output of those neurons, which are associated with input's local regions, such that each neuron will calculate a dot product in between weights and a small region to which they are actually linked to in the input volume. For example, if we choose to incorporate 12 filters, then it will result in a volume of [32x32x12].
- **ReLU Layer:** It is specially used to apply an activation function element wise, like as max (0, x) thresholding at zero. It results in ([32x32x12]), which relates to an unchanged size of the volume.
- **Pooling:** This layer is used to perform a down sampling operation along the spatial dimensions (width, height) that results in [16x16x12] volume.

INCEPTION V3: Inception v3 is an image recognition model with 48 layers, that has been shown to attain greater accuracy and tis model itself is made up of convolutions, average pooling, max pooling, concatenations, dropouts, and fully connected layers.

The major features of inception V3 architecture:

1. Factorizing Convolutions

- Factorization Into Smaller Convolutions
- Factorization Into Asymmetric Convolutions

The aim of factorizing convolutions is to reduce the number of connections / parameters without decreasing the network efficiency.

2. Auxiliary Classifier:

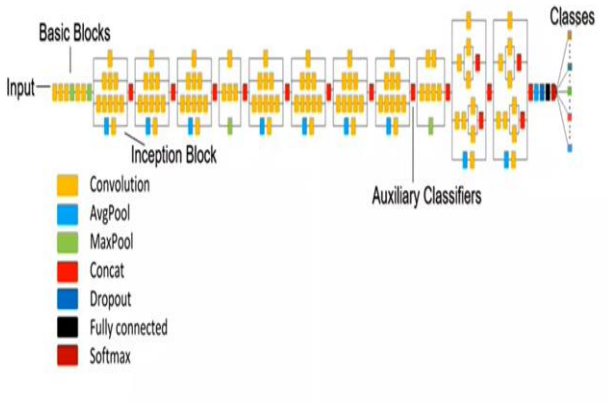
- The objective of using an Auxiliary classifier is to improve the convergence of very deep neural networks.
- Auxiliary classifier act as as a regularizer in Inception v3 model architecture.
- Regularization refer to technique used to calibrate machine learning models in order to minimize the adjusted loss function and prevent overfitting or underfitting.

3. Efficient Grid Size Reduction

The Inception V3 model used several techniques for optimizing the network for better model.

- It has higher efficiency.
- It has a deeper network compared to the Inception V1 and V2 models, but its speed isn't compromised.

Architecture Of Proposed System:



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```
custom_inception_model = Sequential([
        inception_model,
        Dropout(0.5),
        GlobalAveragePooling2D(),
        Flatten(),
        BatchNormalization(),
        Dense(512, activation='relu'),
        BatchNormalization(),
        Dropout(0.5),
        Dense(256, activation='relu'),
        BatchNormalization(),
        Dropout(0.5),
        Dense(128, activation='relu'),
        BatchNormalization(),
        Dropout(0.5),
        Dense(64, activation='relu'),
        Dropout(0.5),
        BatchNormalization(),
        Dense(4, activation='softmax')
    ], name = "inception_cnn_model")
```

We have created an inception model to increase the model accuracy.

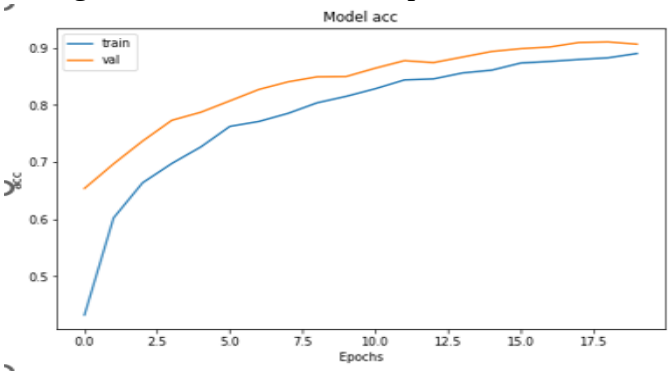
We added some layers in order to improve accuracy the layers are dropout, flatten batch normalization, global average pooling.

Dropout-The training dataset may get overfit when all the features are connected to the fc layer.

Flatten-It is used to convert the data into 1-D array for inputting to next layer.

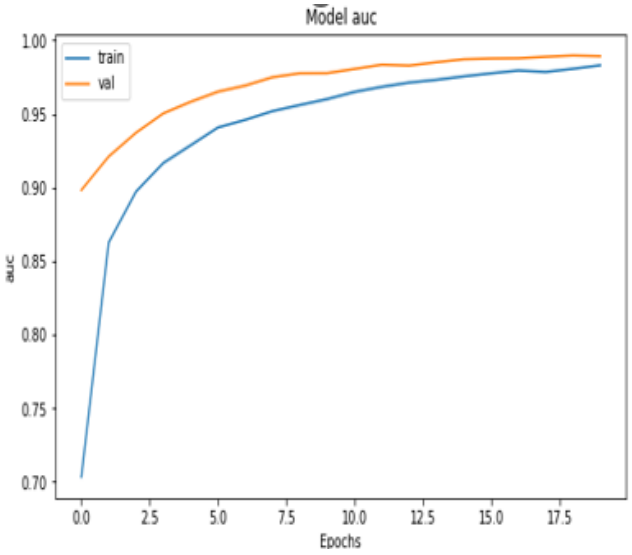
BatchNormalization-It provides the output of the preceding layer as input after normalising it.

GlobalAveragePooling- For each input, a single average value for each of the input.

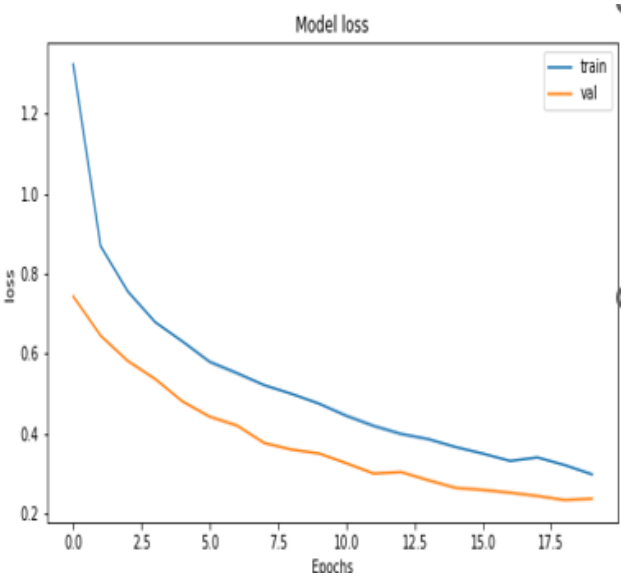


RESULTS

A) Train and validation data accuracy



B) Train and validation data auc



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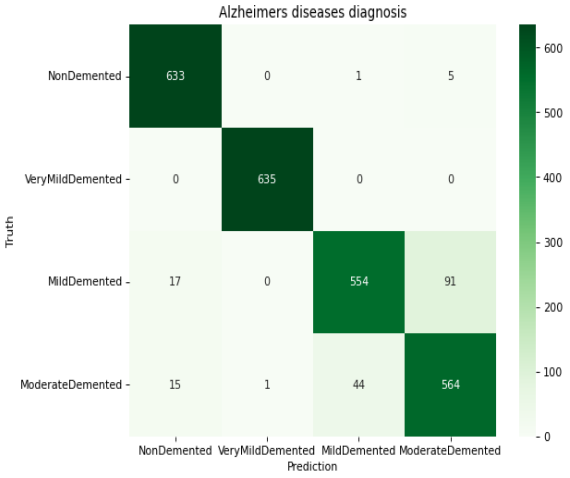
C) Train and validation data loss



CONCLUSION AND FUTURE SCOPE

In this paper we was successfully implemented AD using Inception v3 architecture we achieved better accuracy (93%). The model was developed successfully and able to detect and classify Alzheimer's diseases into stages- Non Demented, Very Mild Demented, Mild Demented and Moderated Demented.

The information that can be used to identify Alzheimer's disease. We can combine numerous datasets in the future with cutting-edge deep learning algorithms to increase the accuracy of AD prediction at an early stage, with the aim of enhancing performance and transparency. Research on using deep learning to diagnose Alzheimer's disease is moving away from hybrid models and towards models that use only deep learning models as multimodal neuroimaging data and computing resources increase, though techniques to integrate completely different formats of data in deep learning networks must still be developed**.**

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