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Early Detection of Alzheimer's Disease Using MRI Scans

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ABSTRACT—

Alzheimer's Disease (AD) is a neurological brain disorder marked by dementia and neurological dysfunction that affects memory, behavioral patterns, and reasoning. Alzheimer's disease is an incurable disease that primarily affects people over 40. Alzheimer's disease is diagnosed through a manual evaluation of a patient's MRI scan and neuro-psychological examinations. Deep Learning (DL), a type of Artificial Intelligence (AI), has pioneered new approaches to automate medical image diagnosis. This study aims to create a reliable and efficient system for classifying AD using MRI by applying the deep Convolutional Neural Network (CNN). In this paper, we propose a new CNN architecture for detecting AD with relatively few parameters, and the proposed solution is ideal for training a smaller dataset. This proposed model successfully distinguishes the early stages of Alzheimer's disease and shows class activation maps as a heat map on the brain. The proposed Alzheimer's Disease Detection Network model is built from scratch to precisely classify the stages of AD by decreasing parameters and calculation costs. The Kaggle MRI image dataset has a significant class imbalance problem, and we exploited a synthetic oversampling technique to evenly distribute the image among the classes to prevent the problem of class imbalance. The proposed model is extensively evaluated against DenseNet169, VGG19, and InceptionResNet V2 using precision, recall, F1-score, Area Under the Curve (AUC), and loss. The model achieved the following values for evaluation metrics: 98.63%, 99.76%, 98.61%, 98.63%, 98.58%, and 0.0549% accuracy, AUC, F1-score, precision, recall, and loss, respectively. The simulation results show that the proposed model outperforms other state-of-the-art models in all the evaluation metrics.

1. INTRODUCTION

Alzheimer's disease (AD) is a neurological disorder that mainly destroys the memory cells in the human brain. In AD, patients experience symptoms like memory loss, visual changes, confusions, etc. AD destroys the memory and thinking skills slowly and, in the end, it kills the capability to carry out even the simplest tasks. The effects of AD can be observed from the age of the early 60s. In 2019, ''National Institute on Aging, U.S.A'', has done a survey and found that around 6 million people from the U.S.A are affected by AD. In a similar kind of report, the ''Alzheimer's and Dementia Resources'' has concluded that in India, more than 4 million people are suffering from AD. Worldwide, the growth of AD patients is enormous and alarming.

MCI is a dementia stage, where a patient experiences more cognitive declination than a CN individual of the same ages. converting to AD from CN is 3 out of 10. Therefore, MCI is considered an early stage of AD. MCI is classified into two stages namely SMCI and PMCI. After following up the dementia stage for an MCI patient, over the years, if the dementia stage remains stable, or if it shows a very slow rate of progression to the AD, then the patients are said to be in SMCI dementia stage.

II. EXISTING SYSTEM

The study by Veeramuthu et al.[3] developed a CADtool for decision making about the presences of abnormalities in human brain. The author suggested pre- processing of PET dataset for instance, spatial normalization and intensity normalization. Fisher Discriminants ratio (FDR) was used for feature extractionto get ROIs. The instances were classified to normal if the extracted number of verified rules were above the final threshold otherwise image was classified as AD. It is observed that the authors did not mention the number of instances used in dataset. The methods adopted for dealing the missing data and class imbalance are also ignored. The dataset taken for the proposed study is not pathologically proven. Support and confidence, effective parameters of AR mining, are not discussed as well as no method for validation has been mentioned by the authors.

Table 1. Literature Summary

S. NO.	TITLE	METHODODLGY USED	LIMITATIONS
1.	A Survey on Classification Methods of Brain MRI for Alzheimer's Disease	Machine Learning Algorithms	It gives the less accuracy.
2.	A Survey on Classification Algorithms of Brain Images in Alzheimer's Techniques	wavelet transform- based feature extraction	It gives the less accuracy. It is not suitable to detect infection areas
3.	Alzheimer's Disease Detection Through Whole-Brain 3D-CNN MRI	CNN	It gives the less accuracy. It is not suitable to detect infection areas

Disadvantages of Existing System

- The existing system revealed noise.
- The existing system has small sample size which is very challenging to achieve good classification accuracy.
- Pathologically unproven data with no justification about missing values.
- The most common problems among them were the input size, attributes and validation.
- The data may contain Missing values which will cause uncertainty.

III. PROPOSED SYSTEM

The aim of this proposed system is to identify the stage of Alzheimer's Disease (AD) patients through the deep learning models. This process facilitates the monitoring of the disease and allows actions to be taken in order to provide the optimal treatment and the prevention of complications.

In the proposed system, it is classified into Mild Demented, Moderate Demented, Non-Demented, Very Mild Demented. Using Convolutional Neural Network architecture, the classification is done and results are predicted. The proposed system achieved training accuracy of 86.34% and validation accuracy of 86.45%.

The architecture of a system reflects how the system is used and how it interacts with other systems and the outside world. It describes the interconnection of all the system's components and the data link between them. The architecture of the system shown in Fig. 1 reflects the wayit is thought about in terms of its structure, functions, and relationships. The architecture of a system reflects the way it is used, and therefore changes as the system is used.

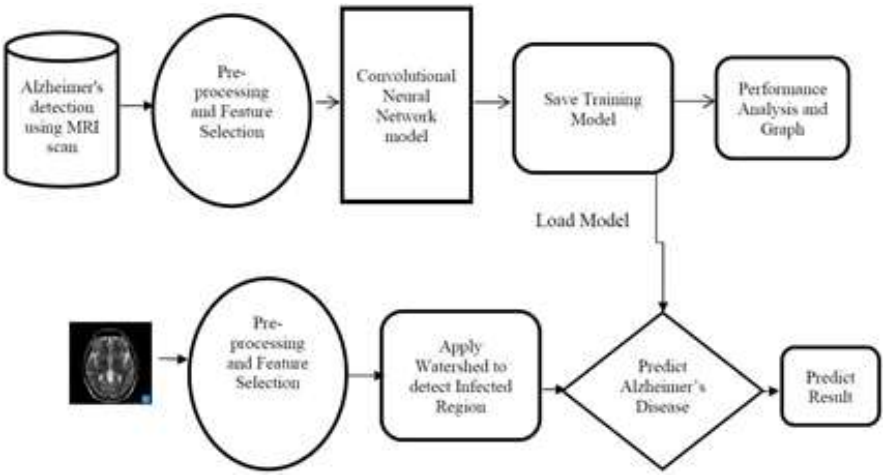

Fig 1: System Architecture

IV. METHODOLOGY

The project "Early Detection of Alzheimer's Disease using MRI scans" is developed on the following hardware specifications:16GB RAM,512 GB SSD, Windows 11 and is developed using python 3.11.0. The methodology involves several key steps. Firstly, a literature review is conducted to gather existing

knowledge and identify research gaps. Next, a suitable dataset of MRI scans is acquired and preprocessed to remove noise and normalize intensities. Relevant features associated with Alzheimer's disease are then extracted from the preprocessed scans, and dimensionality reduction techniques are applied to select the most informative features. A predictive model, such as a machine learning or deep learning algorithm, is developed and trained using the extracted features. The model's performance is evaluated using appropriate metrics and validated on independent datasets. The results are interpreted, visualized, and ethical considerations are considered throughout the project. The model consists of following modules: (i) Dataset: - This module deals with the importing of dataset and splitting for training and testing. (ii)Importing the necessary Libraries: -This modules takes care of importing all the necessary libraries like TensorFlow, Keras etc. (iii)Retrieving the images:-This module deals with preprocessing of the dataset. (iv)Splitting the dataset: -This module deals with splitting the dataset for training and testing data.(v)Building the model-This model deals with building and training the model. (vi)Apply the model and plot the graph for accuracy and loss:- This module applies the data for test data and plots graph for accuracy and loss. (vii)Saving the trained model:-This module saves the trained model for applying on incoming input. (viii)Detecting Infected region using Watershed Algorithm:- This module implements Watershed algorithm to detect the infected region.

Overall, this methodology provides a systematic approach to tackle the challenge of early Alzheimer's disease detection using MRI scans.

V. IMPLEMENATION

CNN Algorithm

//Input: Train and Test Data

//Output: Model and Performance Analysis Step 1: Load the dataset

Step 2: Preprocess the dataset

Step 3: Split the dataset into training and testing sets Step 4: Initialize the CNN model

Step 5: Train the model Step 6: Evaluate the model

Step 7: Save the trained model

WATERSHED ALGORITHM

// Input: Trained model and user values

// Output: Disease detection Begin

Step 1: Load the image

Step 2: Preprocess the image

Step 3: Apply watershed algorithm

Step 4: Postprocess the segmented image Step 5: Display or save the result

VI. RESULTS

Below Fig 2. shows the login page of web application.

Fig: 2 Login Page of Web Application

Below Fig.3. shows the grayscale image of uploaded MRI

This image depicts an MRI (Magnetic Resonance Imaging) scan converted to grayscale. The grayscale representation allows for a clearer visualization of the anatomical structures captured in the scan. It showcases different shades of gray to represent varying tissue densities or signal intensities within the scanned area.

Fig 3. Grayscale image

Below Fig.4 shows the enhanced grayscale image

This image presents a grayscale representation that has undergone enhancement techniques to improve the visibility of important details, such as edges, textures, or subtle features within the image.

Fig 4 Enhanced grayscale image

Below Fig.5 shows the blurred image for noise removal

This image showcases the application of a blurring filter to remove noise or unwanted artifacts from the original image. The blurring process smooths out the pixel intensities, effectively reducing high-frequency noise or minor irregularities.

Fig 5 Blur image

Below Fig. 6 shows the marking and flooding using watershed algorithm

This image demonstrates the application of the watershed algorithm for marking and flooding regions of interest within an image.

Fig 6 Marking and Flooding

Below Fig. 7 shows final output which depicts the stage of the disease.

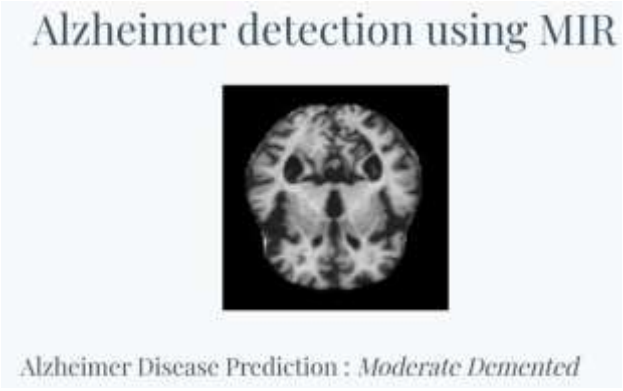

Fig 7 Final Output

Below Fig 8 shows comparative analysis with CNN model and InceptionV3 Model.

Fig 8 Comparative Analysis

In below Fig 9 Confusion matrix for the model is shown.

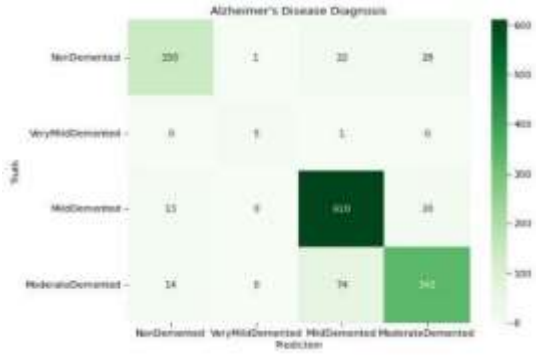

Fig:9 Confusion Matrix

Precision = True Positives / (True Positives + False Positives) Precision = 1107/1285 = 0.8614 or 86.14%.

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