

A Project Report
On

Detection of Alzheimer's Disease using Deep Learning

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Declaration

We declare that this written submission for B.E. Declaration entitled "**Detection of Alzheimer's Disease using Deep Learning**" represent our ideas in our own words and where others' ideas or words have been included. We have adequately cited and referenced the original sources. We also declared that we have adhere to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any ideas / data / fact / source in our submission. We understand that any violation of the above will cause for disciplinary action by institute and also evoke penal action from the sources which have thus not been properly cited or from whom paper permission have not been taken when needed.

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Abstract

Alzheimer's disease is a neurological disorder in which the death of brain cells causes memory loss and cognitive decline. It is a type of dementia that gradually destroys brain cells, affecting a person's memory. It is an irreversible, progressive brain disorder that slowly destroys memory, thinking skills and the ability to carry out the simplest tasks. Alzheimer's disease is the most common cause of dementia among older adults. Pre-detection is crucial for such a disease as drugs will be most effective if administered early in the course of the disease. If not done on time, it can lead to irreversible brain damage. Therefore, it is very important to utilize automated techniques for pre-detection of Alzheimer's symptoms from such data. The system uses an experimental approach to evaluate the best pre-detection method of Alzheimer's disease. The study consists of two parts. First is obtaining the Alzheimer's disease Neuroimaging Initiative (ADNI) dataset and performing Image Processing on it which will be used to train the system. Next is using a Deep Learning algorithm to detect the disease from this neuroimaging data.

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Chapter 1

Introduction

1.1 Background

Alzheimer's disease is a "progressive" disease. It is a neurological disorder that causes memory loss and dementia. It is mainly observed in elderly individuals over the age of 60. The disease is generally caused due to the death of brain cells but can also be due to concussions or traumatic brain injuries. It causes brain cells to die and spread the damage across the brain. Its symptoms usually start slowly and are mild. In the later stages, a person who has Alzheimer's is no longer able to communicate and depends entirely on his/her family or friends. There are many ways to diagnose and detect it. MRI scans, MMSE (mini-mental state exams) expressed in terms of CDR (Clinical Dementia Rating) standards are a few. Though the above methods help in predicting the disease accurately, identifying distinctions between Alzheimer's brain and normal brain in elderly individuals (over the age of 75) is difficult. This is because they share similar brain patterns and image intensities. The main disadvantages of the MMSE are difficulty in identifying mild cognitive impairment and difficulty in recording changes in cases of severe dementia.

1.2 Motivation

Alzheimer's is on the rise throughout the world. Worldwide, at least 50 million people are believed to be living with Alzheimer's disease or other dementia. According to the United Nations, that is more than the population of Columbia. If breakthroughs are not discovered, rates could exceed 152 million by 2050. In India, more than 4 million people are estimated to be suffering from Alzheimer's and other forms of dementia, giving the country the third highest caseload in the world, after China and the US. India's dementia and Alzheimer's burden is forecast to reach almost 7.5 million by the end of 2030. Statistics show how crucial the issue is and that there is a need to focus on the same so as to help people physically and financially. Though there isn't any cure for the disease, an early detection with effective medication can help keep the brain cells active, thus making a person's life a little better. Other reason behind selecting the topic is the desire to learn how Deep Learning algorithms can be applied for detection and classification purposes. This desire in turn motivates us to develop models which can be made applicable in the medical field.

1.3 Aim and Objective

Aim: Alzheimer's disease is known to have a profound effect on an individual's brain as it progresses. Nerve cell damage and death can lead to brain's inability to transmit and store information. This irreversible progressive brain disorder can destroy a person's ability to carry out the simplest tasks. Its early diagnosis makes individuals eligible for a wider variety of clinical trials.

Objective: The objective of this project is to develop a system for detecting Alzheimer's Disease (AD) using the methodology of Deep Learning. This is to accomplish the aim of reducing human (Doctor) efforts for detecting the disease by developing a reliable system.data set

1.4 Report Outline

The aim of our project is to develop a system for detecting Alzheimer's disease from MRI scans. The system provides an MMSE test in the beginning followed by an MRI tester that takes in the input and gives an output indicating percentage of Alzheimer's Disease a person is suffering from. The implementation includes image processing in the beginning followed by using the pre-processed images to train a deep learning model. This Deep Learning model classifies the data into two categories, namely CN (Cognitively Normal) and second AD (Alzheimer's Disease). Related research papers were read to understand more about this project. A comparison was made to understand the advantages and disadvantages of using different deep learning algorithms. We concluded that Convolutional Neural Network is the best algorithm as it gives a really good accuracy. Different designs were made to understand the flow of our project. Data set was obtained from ADNI (Alzheimer's Disease Neuroimaging Initiative). The website provides a large data set of MRI scans of brains of people suffering from Alzheimer's disease and many more types of dementia. The initial problem we faced from was the quality of data set on ADNI. The images contained a lot of noise and hence needed to be pre-processed. Also, Alzheimer's disease mainly affects the grey matter in brain. This grey matter needed to be extracted. The images were segmented using MATLAB and then trained with the help of a CNN (Convolutional Neural Network) model for classification purpose.

Chapter 2

Study Of the System

About Alzheimer's Disease

Alzheimer's disease is an incurable, progressive neurological brain disorder. It is a type of dementia that gradually destroys brain cells, affecting a person's memory and their ability to learn, make judgments, communicate and carry out basic daily activities. Alzheimer's disease is characterized by a gradual decline that generally progresses through three stages: early, middle and late stage disease. These three stages are distinguished by their general features, which tend to progress gradually throughout the course of the disease. The exact causes of Alzheimer's disease aren't fully understood, but at its core are problems with brain proteins that fail to function normally, disrupt the work of brain cells (neurons) and unleash a series of toxic events. Neurons are damaged, lose connections to each other and eventually die.

The stages of Alzheimer's disease don't always fall into neat boxes, and the symptoms might vary, but these stages can be a guide and help an individual with a proper medical treatment, hence controlling the deterioration process. There are seven stages in all. They are as follows:

1. **Stage One: No Impairment** In the first stage, a person with Alzheimer's disease has no memory impairment with any evident symptoms of dementia. At this stage, Alzheimer's disease is undetectable. The stage is also sometimes called No Cognitive Decline.
2. **Stage Two: Very Mild Cognitive Decline** In this stage, a person with Alzheimer's disease begins to experience the typical forgetfulness associated with aging e.g. They may forget where they left their car keys or their purse. These symptoms are typically not noticed by the individual's family members or physician.
3. **Stage Three: Mild Cognitive Decline** Individuals in this stage experience increased forgetfulness as well as slight difficulty with focus or concentration. These symptoms may result in decreased work performance for those in the workforce, or for those who do not hold outside employment, they may experience decreased performance in ordinary household tasks such as cleaning or paying bills. The average duration of stage three is approximately seven years prior to the onset of dementia.
4. **Early-Stage Dementia** In the first three stages, an individual is not considered to have dementia. At stage four, however, that changes,

and a person is considered to have early-stage dementia. Note that early-stage dementia differs from early-onset dementia or early-onset Alzheimer's disease, which refers to the onset of clinical symptoms prior to age 65.

5. **Stage Four: Moderate Cognitive Decline** Stage four comprises what is clinically described as early-stage dementia. A person with early-stage dementia (in stage four of the seven-stage model) will experience increased forgetfulness, often forgetting recent events, as well as difficulty concentrating, difficulty with problem-solving, and difficulty managing finances. They may have challenges when traveling to unfamiliar areas alone, and they may have difficulty performing complex tasks or organizing and expressing thoughts.
6. **Stage Five: Moderately Severe Cognitive Decline** Major memory deficiencies are present beginning in stage five, and people in this stage of the disease may require assistance with activities of daily living, such as bathing, dressing, and preparing meals. Memory deficits in this stage are severe, with individuals often forgetting prominent bits of information that affect their daily lives – such as their home address or phone number. They may not be able to identify where they are (orientation to place) or what time of day it is (orientation to time). Stage five lasts, on average, one and a half years.
7. **Stage Six: Severe Cognitive Decline** Also known as Middle Dementia, stage six marks a period in which a person requires substantial assistance to carry out day-to-day activities. They may have little memory of recent events and forget the names of close friends or family members. Many people in stage six have limited memory of their earlier lives and will also have difficulty completing tasks or successfully exhibiting cognitive skills such as counting backwards from 10. Significant personality changes may also be noticeable at this stage, as individuals may suffer from delusions, anxiety, or agitation. This stage lasts an average of about two and a half years.
8. **Stage Seven: Very Severe Cognitive Decline** Also known as Late Dementia, stage seven is the final stage in the progression of Alzheimer's disease. At this stage, most people will have lost their ability to speak or communicate. They often require assistance with most of their activities, including toileting, eating, dressing, bathing, and other daily activities. This stage lasts an average of two and a half years

Diagnosis

Diagnosis of Alzheimer's starts with the doctor taking a mini mental state exam of the patient. The doctor finds out a CDR (Clinical Dementia Rating) from this test. The CDR is measured on a scale of 0-3.

1. No memory loss or slight inconsistent forgetfulness (0)
2. Mild consistent forgetfulness; partial recollection of events; "benign" forgetfulness (0.5)
3. Moderate memory loss; more marked for recent events; interferes with everyday activities (1)
4. Severe memory loss; only highly learned material retained; new material rapidly lost (2)
5. Severe memory loss; only fragments remain (3)

In case CDR rating comes out to be 2-3, the doctor intends to perform an MRI scan. No single test can determine whether a person has Alzheimer's disease. A diagnosis is made by determining the presence of certain symptoms and ruling out other causes of dementia. This involves a careful medical evaluation, including a thorough medical history, mental status testing, a physical and neurological exam, blood tests and brain imaging exams, including:

- CT imaging of the head: Computed tomography (CT) scanning combines special x-ray equipment with sophisticated computers to produce multiple images or pictures of the inside of the body. Physicians use a CT of the brain to look for and rule out other causes of dementia, such as a brain tumor, subdural hematoma or stroke.
- MRI of the head: Magnetic resonance imaging (MRI) uses a powerful magnetic field, radio frequency pulses and a computer to produce detailed pictures of organs, soft tissues, bone and virtually all other internal body structures. MRI can detect brain abnormalities associated with mild cognitive impairment (MCI) and can be used to predict which patients with MCI may eventually develop Alzheimer's disease. In the early stages of Alzheimer's disease, an MRI scan of the brain may be normal. In later stages, an MRI may show a decrease in the size of different areas of the brain (mainly affecting the temporal and parietal lobes).

- PET and PET/CT of the head: A positron emission tomography (PET) scan is a diagnostic examination that uses small amounts of radioactive material (called a radiotracer) to diagnose and determine the severity of a variety of diseases. A combined PET/CT exam fuses images from a PET and CT scan together to provide detail on both the anatomy (from the CT scan) and function (from the PET scan) of organs and tissues. A PET/CT scan can help differentiate Alzheimer's disease from other types of dementia. Another nuclear medicine test called a single-photon emission computed tomography (SPECT) scan is also used for this purpose. Using PET scanning and a new radiotracer called C-11 PIB, scientists have recently imaged the build-up of beta-amyloid plaques in the living brain. Radiotracers similar to C-11 PIB are currently being developed for use in the clinical setting.

2.1 Traditional Methods of Detection

What is an MRI scan?

Magnetic resonance imaging (MRI) is a type of scan that uses strong magnetic fields and radio waves to produce detailed images of the organs and tissues within the body. An MRI scan uses a large magnet, radio waves, and a computer to create a detailed, cross-sectional image of internal organs and structures. The scanner itself typically resembles a large tube with a table in the middle, allowing the patient to slide in.

Why is it used?

An MRI scan is used to examine almost any part of the body, including the:

- brain and spinal cord
- bones and joints
- breasts
- heart and blood vessels
- internal organs, such as the liver, womb or prostate gland

The results of an MRI scan can be used to help diagnose conditions, plan treatments and assess how effective previous treatment has been.

How is it done?

The MRI scan contains two powerful magnets. These are the most important parts of the equipment. The human body is largely made up of water molecules which are comprised of hydrogen and oxygen atoms. At the center of each hydrogen atom there is an even smaller particle called a proton, which serves as a magnet and is very sensitive to magnetic fields. The water molecules are randomly arranged, but on entering the MRI scanner, the first magnet causes the water molecules to align in one direction either north or south.



Figure 2.1: MRI scans work by rearranging water molecules in the body with magnets

The second magnetic field is then turned on and it is used to send short quick pulses of radio waves to a certain area of the body, causing each proton in the hydrogen molecule to change its alignment. And then the radio waves are quickly shut down so that the protons realign it. This sends out radio signals which are picked by the receivers. These signals provide information about the exact location of protons in the body.

This can also help to distinguish between the various types of tissue in the body, because the protons in different types of tissue realign at different speeds and produce distinct signals. Although the patient cannot feel these changes, the scanner can detect millions of pixels in conjunction with a computer screen and can create complex pictures, the signals from the millions of protons in the body are combined to create a detailed cross-sectional image of the inside of the body for the radiologist.

More about MRI

MRI provides clear images of parts of the brain that can't be seen as well with an X-ray, CAT scan, or ultrasound, making it particularly valuable for diagnosing problems with the pituitary gland and brain stem.

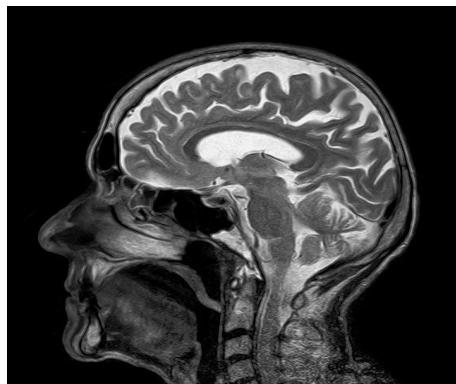


Figure 2.2: Example of MRI Scan

An MRI of the brain usually takes 30-45 minutes to perform. A special plastic device called a coil is placed around the patient's head. A table slides into the tunnel and the technician takes images of the head. Each scan takes a few minutes contrast solution is sometimes used to highlight certain areas of the brain, such as blood vessels, so doctors can see more detail in specific areas.

Getting the Results

The MRI images are viewed by a radiologist who's specially trained in interpreting the scans. The radiologist sends a report to your doctor, who discusses the results with the patient or patient's family. In most cases, results can't be given directly to the patient or family at the time of the test. If the MRI is done on an emergency basis, the results can be made available quickly.

Views of an MRI

Unlike x-ray and computed tomography (CT) exams, MRI does not use radiation. Instead, radio waves re-align hydrogen atoms that naturally exist within the body. This does not cause any chemical changes in the tissues. As the hydrogen atoms return to their usual alignment, they emit different amounts of energy depending on the type of body tissue they are in. The scanner captures this energy and creates a picture using this information.

In most MRI units, the magnetic field is produced by passing an electric current through wire coils. Other coils are located in the machine and, in some cases, are placed around the part of the body being imaged. These coils send and receive radio waves, producing signals that are detected by

the machine. The electric current does not come in contact with the patient. A computer processes the signals and creates a series of images, each of which shows a thin slice of the body. These images can be studied from different angles by the radiologist.

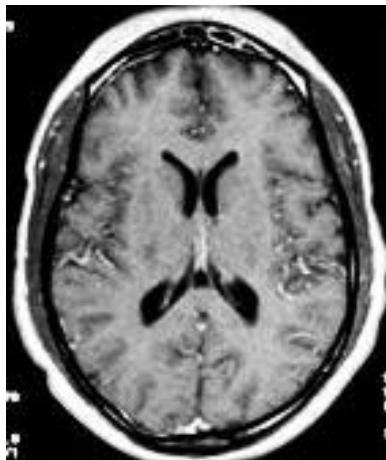


Figure 2.3: Axial view



Figure 2.4: Sagittal View

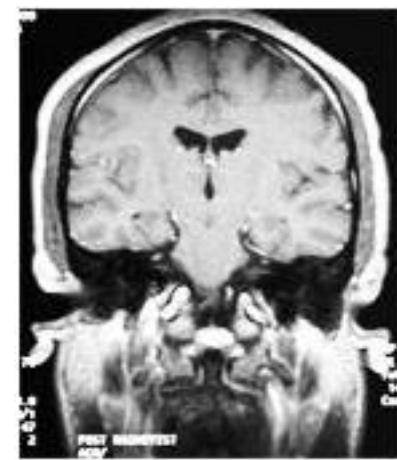


Figure 2.5: Coronal View

2.2 Algorithms used for Classifications

1. Watershed Algorithm

Watershed is a transformation on gray scale images. The aim of this technique is to segment the image, typically when two regions-of-interest are close to each other — i.e., their edges touch. This technique of transformation treats the image as a topographic map, with the intensity of each pixel representing the height. For instance, dark areas can be intuitively considered to be ‘lower’ in height, and can represent troughs. On the other hand, bright areas can be considered to be ‘higher’, acting as hills or as a mountain ridge [1].

Various algorithms can be used to compute watersheds. One of the most popular algorithms is Watershed-by-flooding, which was later improved as the Priority-Flood algorithm.

2. Sparse Filtering And Softmax

In contrast to most other feature learning methods, sparse filtering does not explicitly attempt to construct a model of the data distribution. Instead, it optimizes a simple cost function. Sparse filtering scales gracefully to handle high-dimensional inputs, and can

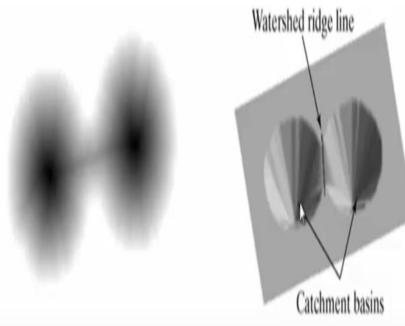


Figure 2.6: **Visualizing the watershed; the image on the left can be topographically represented as the image on the right**

also be used to learn meaningful features in additional layers with greedy layer-wise stacking. We can evaluate sparse filtering on natural images, object classification (STL-10), and phone classification (TIMIT). This method works well on a range of different modalities[2].

Sparse filtering works by optimizing exclusively for sparsity in the feature distribution[?].

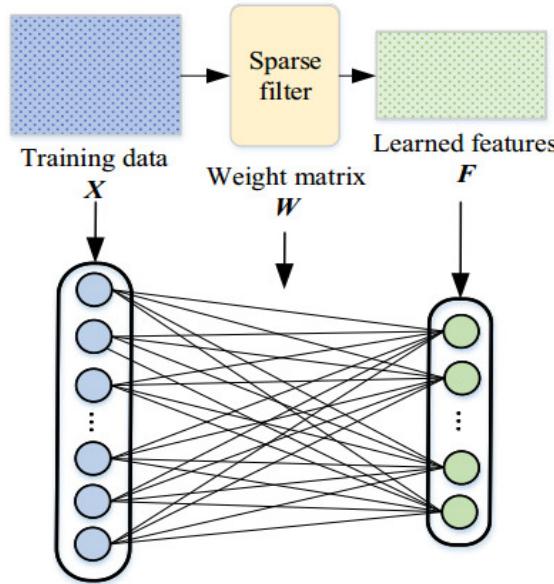


Figure 2.7: **Structure of Sparse Filtering**

Softmax:

The Softmax regression is a form of logistic regression that normalizes an input value into a vector of values that follows a probability distribution whose total sums up to 1. The output values are between the range [0, 1] which is nice because we are able to avoid binary

classification and accommodate as many classes or dimensions in our neural network model. This is why softmax is sometimes referred to as a multinomial logistic regression[?]. The function is usually used to compute losses that can be expected when training a data set.

3. Convolutional Neural Network

A Convolutional Neural Network, also known as CNN or ConvNet, is a class of neural networks that specializes in processing data that has a grid-like topology, such as an image. A digital image is a binary representation of visual data. It contains a series of pixels arranged in a grid-like fashion that contains pixel values to denote how bright and what color each pixel should be. A CNN typically has three layers: a convolutional layer, pooling layer, and fully connected layer[3].

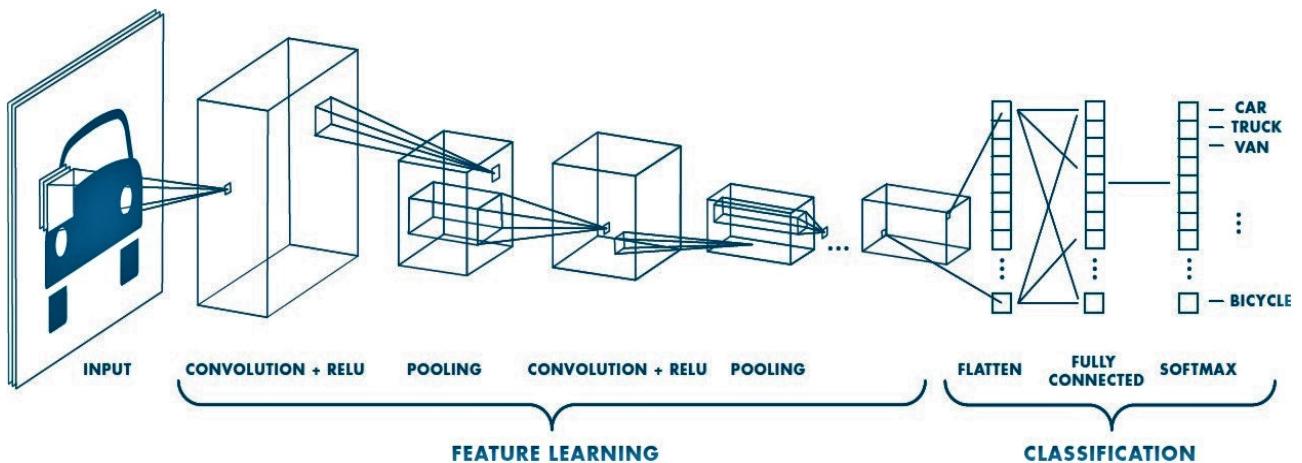


Figure 2.8: Convolutional Neural Network

Convolution Layer:

This layer performs a dot product between two matrices, where one matrix is the set of learnable parameters otherwise known as a kernel, and the other matrix is the restricted portion of the receptive field. The kernel is spatially smaller than an image, but is more in-depth. This means that, if the image is composed of three (RGB) channels, the kernel height and width will be spatially small, but the depth extends up to all three channels. During the forward pass, the kernel slides across the height and width of the image producing the image representation of that receptive region. This produces a two-dimensional representation of the image known as an activation map that gives the response of the kernel at each spatial position of the

image. The sliding size of the kernel is called a stride. Fig 2.9 shows the convolution of 5×5 image matrix with 3×3 filter matrix. The resultant matrix obtained is called the feature map which is depicted in Fig. 2.10 .

1	1	1	0	0
0	1	1	1	0
0	0	1	1	1
0	0	1	1	0
0	1	1	0	0

*

1	0	1
0	1	0
1	0	1

5 x 5 Image Matrix **3 x 3 Filter Matrix**

Figure 2.9: Image matrix multiplication of kernel and filter matrix

1	1	1	0	0
0	1	1	1	0
0	0	1 _{x1}	1 _{x0}	1 _{x1}
0	0	1 _{x0}	1 _{x1}	0 _{x0}
0	1	1 _{x1}	0 _{x0}	0 _{x1}

4	3	4
2	4	3
2	3	4

Image **Convolved Feature**

Figure 2.10: 3×3 Output matrix

ReLU Layer:

ReLU stands for Rectified Linear Unit. The layer applies the function $f(x) = \max(0, x)$ to all of the values in the input volume. In basic terms, this layer just changes all the negative activations to 0. This layer increases the nonlinear properties of the model and the overall network without affecting the receptive fields of the convolution layer.

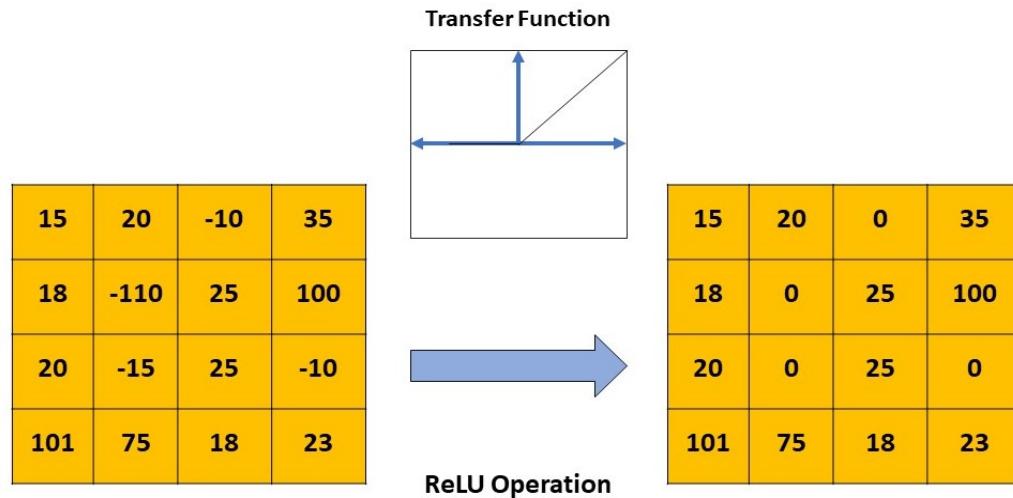


Figure 2.11: Relu

Pooling Layer:

The pooling layer replaces the output of the network at certain locations by deriving a summary statistic of the nearby outputs. This helps in reducing the spatial size of the representation, which decreases the required amount of computation and weights. The pooling operation is processed on every slice of the representation individually.

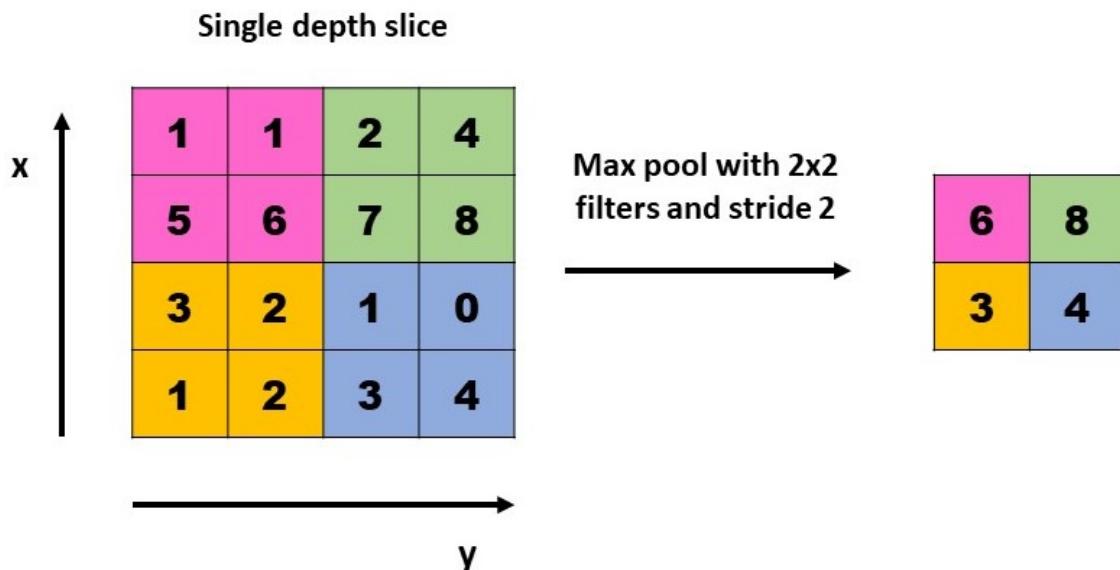


Figure 2.12: Max Pooling

Fully connected Layer:

Neurons in this layer have full connectivity with all neurons in the preceding and succeeding layer as seen in regular FCNN. This is why it can be computed as usual by a matrix multiplication followed by

a bias effect. The FC layer helps map the representation between the input and the output. Fig 2.13 shows a FC layer obtained after flattening the pooling layer.[?].

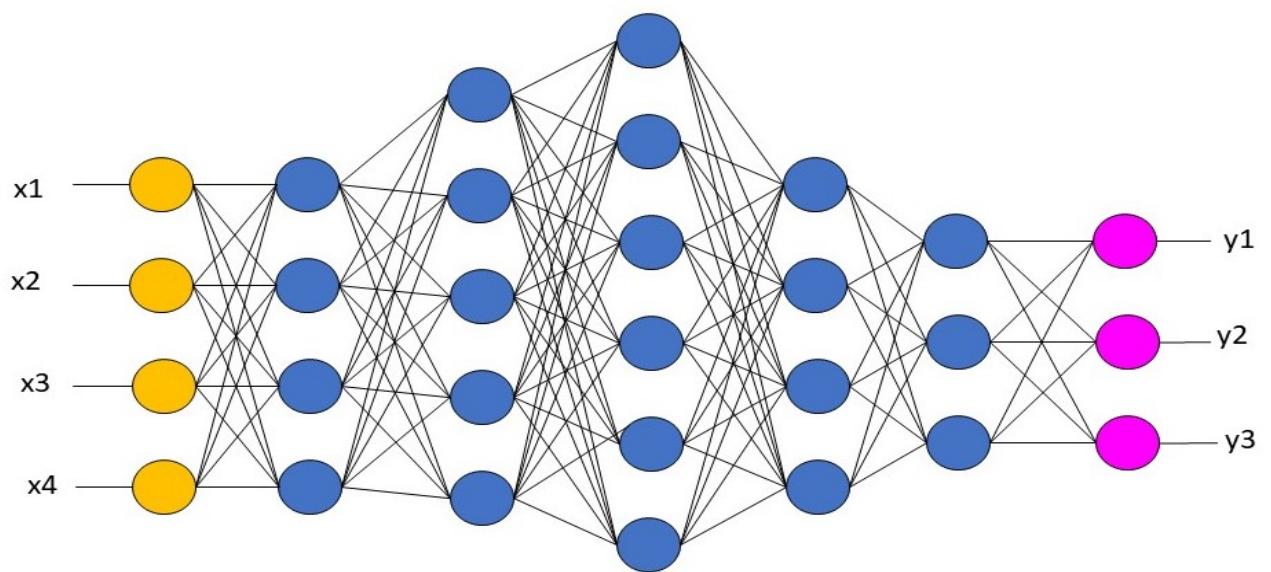


Figure 2.13: Fully Connected layer

In figure 2.13, the feature map matrix will be converted as vector (x_1 , x_2 , x_3 , ...). With the fully connected layers, we combined these features together to create a model. Finally, we have an activation function such as softmax or sigmoid to classify the outputs as cat, dog, car, truck etc.,

2.3 Related Work (Comparative study of 5 research papers)

Table 2.1: Related Work

Sr. No.	Paper Name	i/p and o/p	Algorithm used	Accuracy	Issues
1	A segmentation technique to detect AD using image processing	MRI scans of Brain only focussing on Hippocampus	Watershed algorithm used to identify the Hippocampus region	83	The gray and white matter could not be distinguished properly
2	An intelligent Alzheimer's disease diagnosis method using unsupervised feature learning[?].	MRI scans of Brain (ADNI dataset)	A two-stage learning method has been used. Sparse filtering is done in the first stage and SoftMax regression is applied to the learned features in the second stage.	98.7	Larger input dimension is causing to spend more time for the method
3	Brain MRI analysis for AD diagnosis using an ensemble system of deep Convolutional Neural Networks	MRI scans of Brain (OASIS dataset) 416 subjects aged 18-96	Three deep convolutional neural networks (Convolution, batch normalization, rectified linear unit, pooling are the layers used)	77	Since the network used is a very deep NN, so without a large dataset, training process would not work correctly
4	Applying Convolutional Neural Networks for Pre-detection of AD from Structural MRI data	MRI scans of Brain (ADNI dataset)	Application of CNN	96	Extended ROI performance decreases as edge detection algorithm removes white and grey matter details from brain image
5	Detection of AD from MRI using Convolutional NN with Tensorflow	MRI scans of Brain (OASIS and ADNI dataset)	(Convolutional layer handles image filtration, pooling layer deals with reducing sample size)	90	Use of outdated APIs, expensive GPUs/Cloud instances. Efficient data wrangling was required

Chapter 3

Proposed System

3.1 Problem Statement

Our system will detect presence of Alzheimer's disease from MRI scans of the patient's brain. It will be fed with a trained model for the same. MRI scans will be uploaded by a doctor on a website (User Interface). The system will give results accordingly. The system will also be facilitated by a doctor verification option (only if required).

3.2 Scope

The scope of the project involves detection of Alzheimer's disease by the application of Deep Learning algorithm. It starts with determining an algorithm that will provide maximum possible accuracy and will minimize the need to verify obtained results. It then focuses on dataset analysis i.e. determining number of dataset parameters and then proceeds to pre-processing of this data which will in turn be fed into the Deep Learning model created. The project is worked upon with an intention of making a contribution towards medical welfare. All the work is planned to be done in the course of one year.

3.3 Proposed System

The aim is to develop a system that will take in the Brain MRI scan of a person and detect the presence of Alzheimer's Disease. The system will classify the Brain MRI scans into two categories, namely CN (Cognitively Normal) which describes the brain of a person who is completely free from the disease and AD (Alzheimer's Disease) which describes the brain of a person that suffers from a major cognitive decline. AD is when the patient totally loses his/her ability to respond to the environment.

The brain being a complex organ makes it difficult to classify CN and AD from an MRI scan. The plan therefore is to work on data before feeding it into the system model. This will not only ease the classification job but also will help improve the accuracy.

The system proposes a deep learning model which will be trained using brain MRI scans belonging to the two categories i.e. AD or CN.

The data being used to train the system consists of brain MRI scans of patients of ages ranging from under 2 to over 85. This data is in the NIfTI format.

The pre-processed images will be fed to the Convolution Neural Network model for training and classification purpose. The Convolution Neural Net-

work consists of a Convolution layer, Activation layer and a Pooling layer. Various filters will be applied to the input images in the Convolution layer. ReLU activation layer will be used to train the network faster without making a significant difference to the accuracy. Then a pooling layer will be applied to the outputs generated by the activation layer. The function of Pooling layer is to progressively reduce the spatial size of representation to reduce the number of parameters and computation in the network. Finally, a Fully Connected Layer will be used to bind the layers together and carry out the training process smoothly.

Chapter 4

Alzheimer's Disease Detection System

4.1 Image pre-processing

Image pre-processing is the term used for operations on images at the lowest level of abstraction. The aim of pre-processing is an improvement of the image data that suppresses undesired distortions or enhances some image features relevant for further processing and analysis task. Pre-processing of Brain MRI scans was the primary step in this project. The scans initially obtained were of bad quality. Also, studies suggested that effects of Alzheimer's can be observed by studying the grey matter present in these MRI scans. The grey matter hence needed to be separated from rest of the scan. The term taken into consideration here was Image Segmentation which will be explained in the following section.

4.1.1 Image Segmentation

Image segmentation is one of the most important tasks in medical image analysis and is often the first and the most critical step in many clinical applications. In brain MRI analysis, image segmentation is commonly used for measuring and visualizing the brain's anatomical structures, for analyzing brain changes, for delineating pathological regions, and for surgical planning and image-guided interventions [4].

The goal of image segmentation is to divide an image into a set of semantically meaningful, homogeneous, and non overlapping regions of similar attributes such as intensity, depth, color, or texture. The segmentation result is either an image of labels identifying each homogeneous region or a set of contours which describe the region boundaries.

Fundamental components of structural brain MRI analysis include the classification of MRI data into specific tissue types and the identification and description of specific anatomical structures. Classification means to assign to each element in the image a tissue class, where the classes are defined in advance. The problems of segmentation and classification are interlinked because segmentation implies a classification, while a classifier implicitly segments an image. In the case of brain MRI, image elements are typically classified into three main tissue types: white matter (WM), gray matter (GM), and cerebrospinal fluid (CSF). The segmentation results are further used in different applications such as for analyzing anatomical structures, for studying pathological regions, for surgical planning, and for visualization. Fig 4.1 below shows A brain MRI scan before segmentation. Fig 4.2 next to it shows the separated tissues obtained after segmentation.

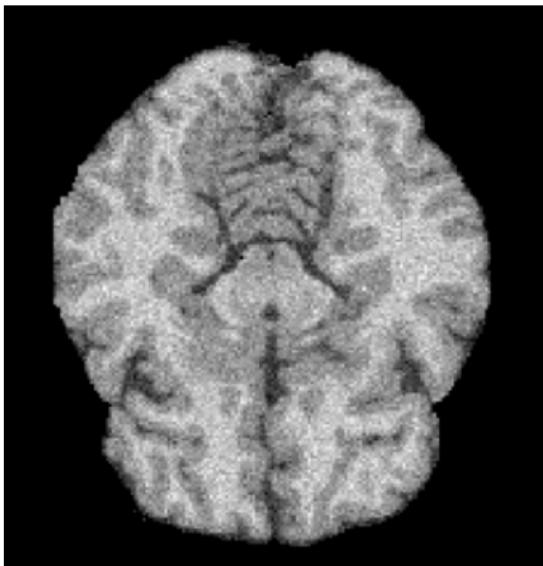


Figure 4.1: Before Segmentation

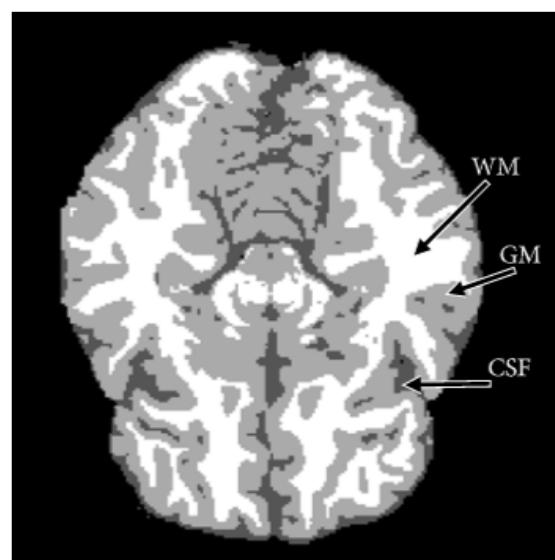


Figure 4.2: After Segmentation

Image segmentation can be performed on 2D images, sequences of 2D images, or 3D volumetric imagery. The data used in this project involved 3D MRI scans. In such a situation, segmentation occurs in a series of MRI images. Each image “slice” is segmented individually in a “slice-by-slice” manner. This type of segmenting 3D image volumes often requires a post-processing step to connect segmented 2D slices into a 3D volume or a continuous surface. Furthermore, the resulting segmentation can contain inconsistencies and non-smooth surface due to omitting important anatomical information in 3D space. Therefore, the development of 3D segmentation algorithms is desired for more accurate segmentation of volumetric imagery[5].

4.1.2 Statistical parametric mapping (SPM)

SPM (Statistical Parametric Mapping) refers to the construction and assessment of spatially extended statistical processes used to test hypotheses about functional imaging data. It is usually used to identify regionally specific effects (e.g., brain activations) in neuroimaging data to characterize functional anatomy and disease-related changes.

Statistical analysis of imaging data corresponds to inverting generative models of data. These ideas have been instantiated in software that is called SPM. The software helps in analysis of brain imaging data sequences. The sequences can be a series of images from different cohorts, or time-series from the same subject. The current release is designed for the analysis of fMRI, PET, SPECT, EEG and MEG.

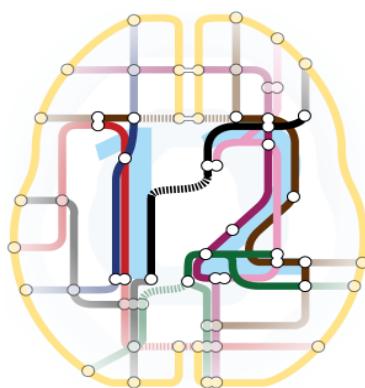


Figure 4.3: SPM12

Current version: SPM12

The current version is SPM12 (Fig 4.3), released 1st October 2014 and last updated 13th January 2020. This provides a major update to the SPM software, containing substantial theoretical, algorithmic, structural and interface enhancements over previous versions.

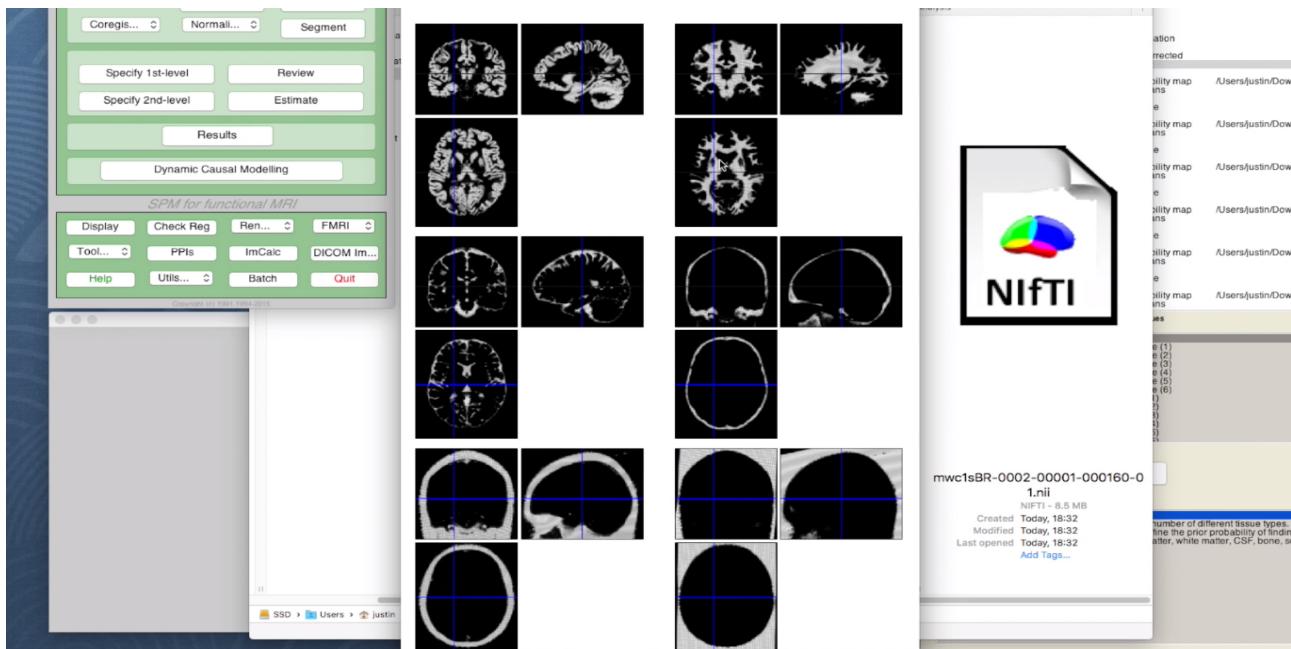


Figure 4.4: Image Segmentation using SPM 12 tool in MATLAB-I

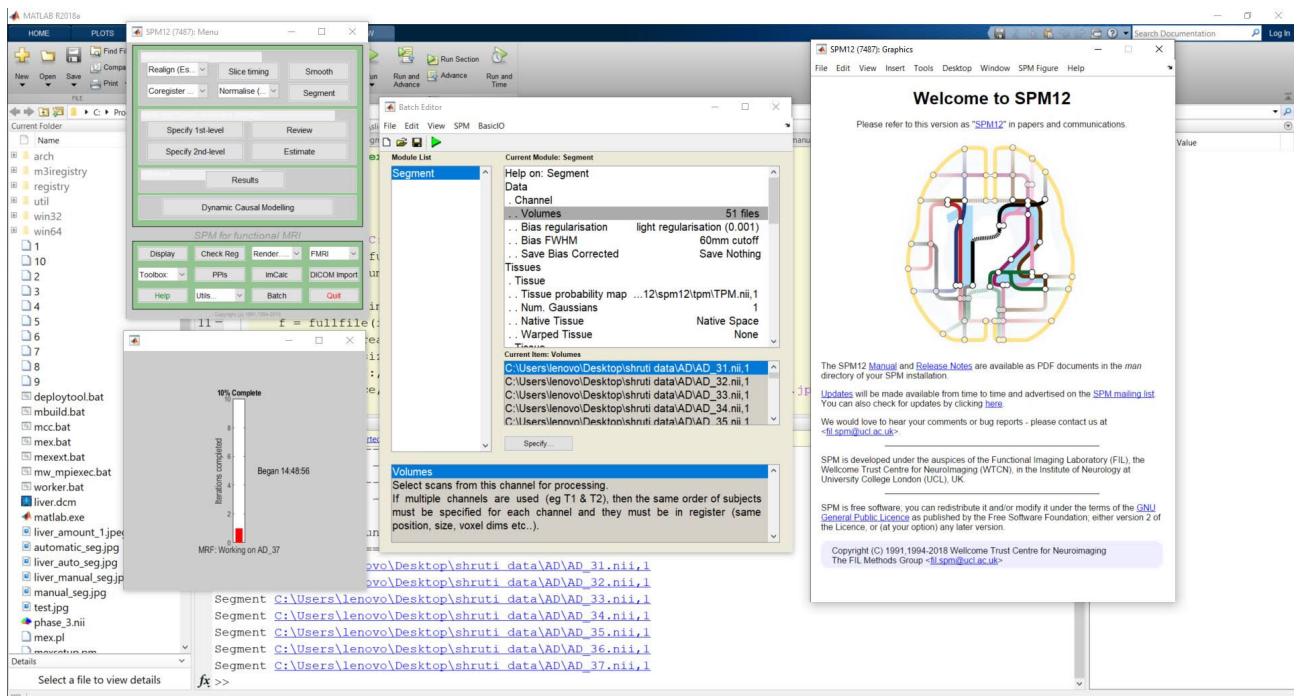


Figure 4.5: Image Segmentation using SPM 12 tool in MATLAB-II

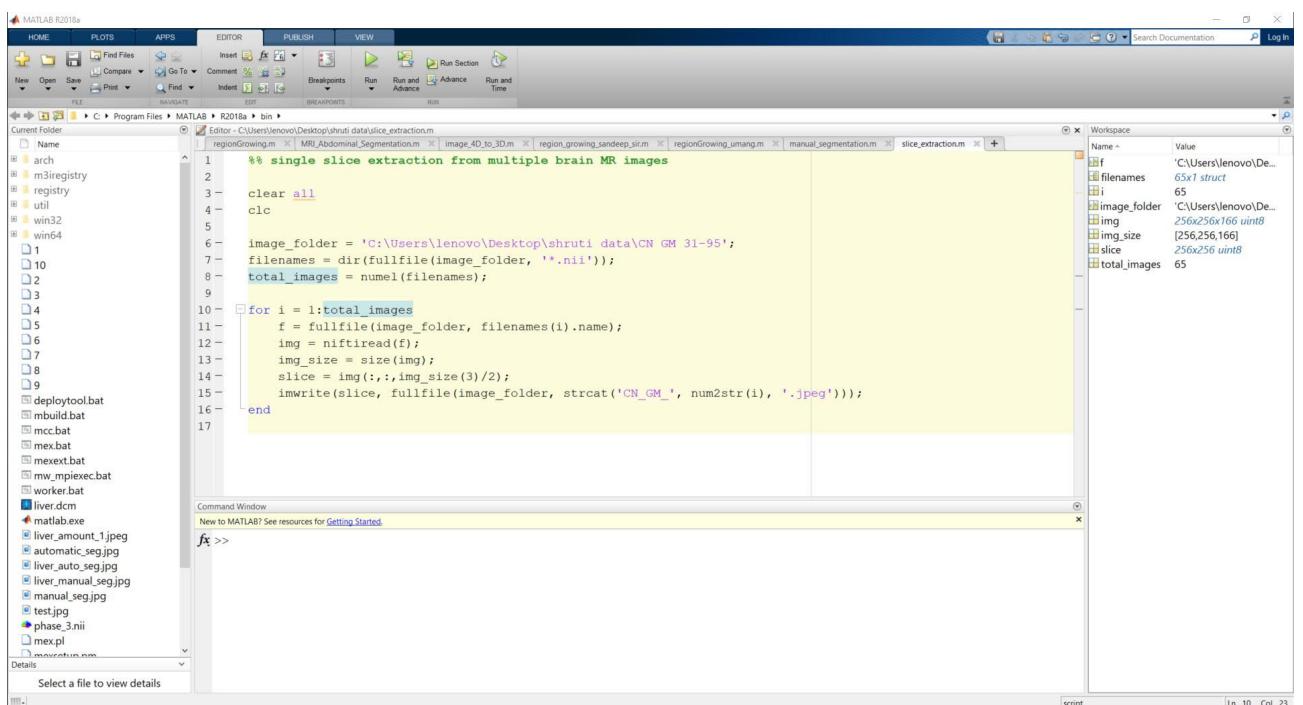


Figure 4.6: Conversion from nii to jpeg format post Segmentation in MATLAB

4.2 Convolution Neural Network Model

4.2.1 Training Model

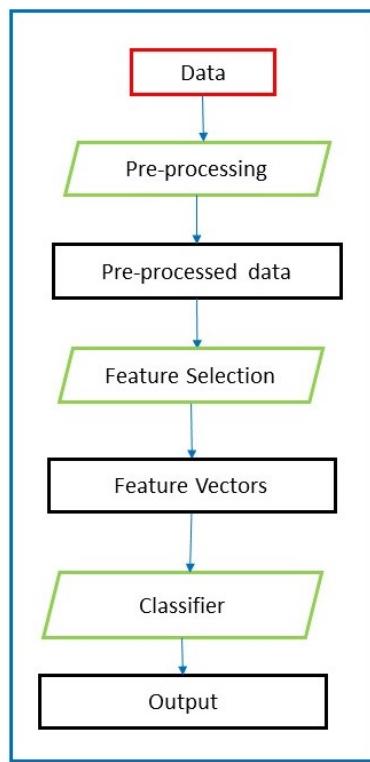


Figure 4.7: Block diagram of Training Model & Parameters

Fig 4.2 below represents the flow of the training process of this project. It starts with data pre-processing stage. The images used were in NII format. These images were then converted to JPEG format for easy classification. The feature vectors from these images were obtained.

A feature vector is a vector that contains information describing an object's important characteristics. In image processing, features can take many forms. A simple feature representation of an image is the raw intensity value of each pixel. However, more complicated feature representations are also possible. The classifier will be trained with the help of the feature vector.

4.2.2 System Model

The model used in this project (See Fig 4.8) is a Convolutional Neural Network (CNN) model. It can be explained as below:

1. Initially, we have the input layer. The layer acquires input image data and reshapes image into single dimension (also called Feature Vector).

E.g. If the image is of size 64 x 64, it will convert it into an array (4096,1). This is because $64 \times 64 = 4096$.

2. Next is the Convolution Layer. This layer helps in the extraction of image feature.
3. Following Convolution is the Pooling Layer. This layer reduces the spatial volume of the input image after convolution.
4. Fully Connected Layer is the final layer of the network. This layer connects a layer to another layer.
5. Output layer is the final layer of the model. It generates the predicted values.

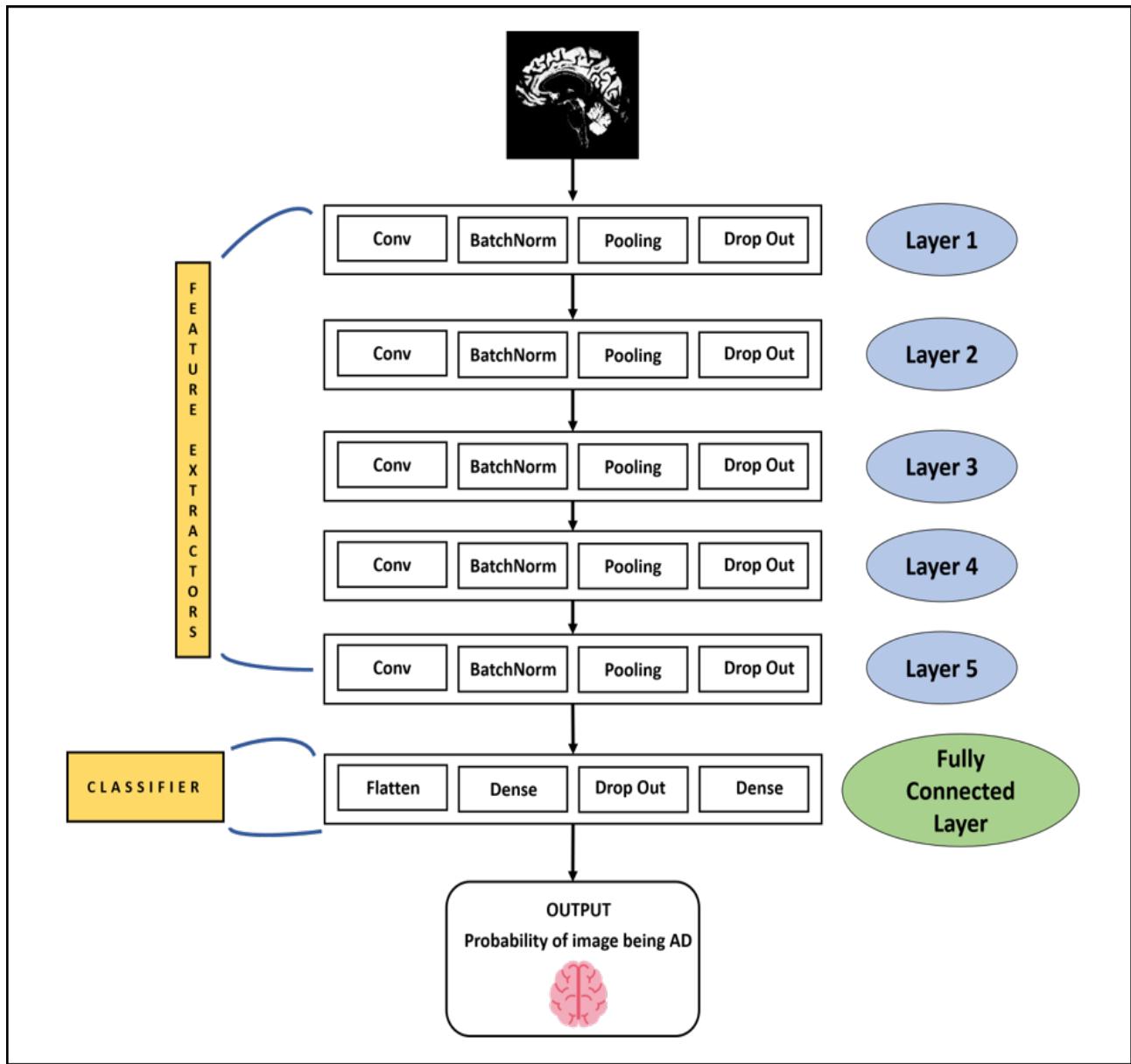


Figure 4.8: Block Diagram: CNN Sequential Model

Fig 4.8 represents the Convolutional Neural Networks (CNN) model used in this project. A Convolutional Neural Network (CNN) is a feed-forward artificial neural network inspired by animal visual cortices, it is designed for visual imagery. CNNs have been applied in many practical fields, such as pattern recognition, vocal recognition, natural language processing, and video analysis. In CNNs, the most significance features are weight sharing and hierarchical connections with automatic self-training. The network above consists of 5 Feature Extraction layers and a classifier at the end which generates the final output. Feature extraction starts from an initial set of measured data. It then builds derived values or features intended to be informative and non-redundant. This involves dimension-

ality reduction. When the input data is given to the extractor, it gets transformed into a reduced set of features (also named a feature vector). Determining a subset of the initial features is called feature selection. The Feature extraction layer consists of Convolution Layer, Batch Normalization Layer, Pooling and Drop Out Layer respectively.

1. Conv: This layer is responsible for extracting features of the input image. This is done by detection of features of the image by passing a filter over the image. The image matrix (with pixel values in cells) and the filter matrix are taken together and their dot product is performed so as to get what is called the Feature Map.
2. BatchNorm: This layer is responsible for standardizing the input given to the layer for each mini-batch. The layer stabilizes the learning process, thereby reducing the number of training epochs required to train the deep network.
3. Pooling: This is another building block of CNN model. Its function is to progressively reduce the amount of parameters and computation in the network. This layer operates on each feature map independently. The approach used in this project is map pooling.
4. Drop Out: This layer protects the model from overfitting. Dropout works by randomly setting the outgoing edges of hidden units (neurons that make up hidden layers) to 0 at each update of the training phase.

The first Feature extraction layer helps filter a few parameters (say lines and corners). The grey matter extracted from MRI scan of the brain is a very small area and hence difficult to classify as the features are compact and very difficult to identify. In order to identify these features more clearly, the model needs to go in depth and filter the image. This is the reason why 5 feature extractors have been used in the model. The uneven patterns in the brain are more easy to detect if we go deeper into the neural network and train the images.

Next is the Classifier or Fully Connected Layer. The classifier consists of Flatten, Dense, Drop Out and Dense again respectively.

1. Flatten: This is a layer between the Convolutional and Fully Connected Layer. It transforms a 2 dimensional matrix of features into a vector that can be fed into a fully connected neural network classifier.
2. Dense: Dense is another term for Fully Connected. It facilitates sparse training. Sparse training regularises the model.

3. Drop Out: It prevents the model from overfitting.
4. Dense: This last dense training restores the pruned weights, increasing the model capacity without overfitting. This is the reason why classification result improves while training with more data overtime.

Model: "sequential_5"		
Layer (type)	Output Shape	Param #
conv2d_21 (Conv2D)	(None, 126, 126, 8)	224
batch_normalization_22 (BatchNormalization)	(None, 126, 126, 8)	32
max_pooling2d_19 (MaxPooling)	(None, 63, 63, 8)	0
dropout_22 (Dropout)	(None, 63, 63, 8)	0
conv2d_22 (Conv2D)	(None, 61, 61, 16)	1168
batch_normalization_23 (BatchNormalization)	(None, 61, 61, 16)	64
max_pooling2d_20 (MaxPooling)	(None, 30, 30, 16)	0
dropout_23 (Dropout)	(None, 30, 30, 16)	0
conv2d_23 (Conv2D)	(None, 28, 28, 32)	4640
batch_normalization_24 (BatchNormalization)	(None, 28, 28, 32)	128
max_pooling2d_21 (MaxPooling)	(None, 14, 14, 32)	0
dropout_24 (Dropout)	(None, 14, 14, 32)	0
conv2d_24 (Conv2D)	(None, 12, 12, 64)	18496
batch_normalization_25 (BatchNormalization)	(None, 12, 12, 64)	256
max_pooling2d_22 (MaxPooling)	(None, 6, 6, 64)	0
dropout_25 (Dropout)	(None, 6, 6, 64)	0
conv2d_25 (Conv2D)	(None, 4, 4, 128)	73856
batch_normalization_26 (BatchNormalization)	(None, 4, 4, 128)	512
max_pooling2d_23 (MaxPooling)	(None, 2, 2, 128)	0
dropout_26 (Dropout)	(None, 2, 2, 128)	0
flatten_4 (Flatten)	(None, 512)	0
dense_7 (Dense)	(None, 512)	262656
batch_normalization_27 (BatchNormalization)	(None, 512)	2048
dropout_27 (Dropout)	(None, 512)	0
dense_8 (Dense)	(None, 2)	1026
<hr/>		
Total params: 365,106		
Trainable params: 363,586		

Figure 4.9: CNN Model Layers

Fig 4.8 gave a pictorial representation of the system model used in this project. Fig 4.9 shows the actual architecture of the system. The model by nature is Sequential. Sequential Model is nothing but a linear stack of the layers explained above.

The columns in the figure are Layer type, Output Shape and Parameters respectively.

1. Layer type shows the transition from one layer to other as the image is passed on through the network.
2. Output Shape shows gradual reduction in matrix size due to dot product performed at the Convolution (Conv) layer.
3. Parameters shows the sum of weights/biases in the neural network.
The weights on Convolution Layers get added up eventually and that is how we obtain the number of trainable and non-trainable parameters. Trainable parameters refer to the number of weights which will be updated in the network. Non-trainable parameters are the weights that need to be kept constant while training. The value is 0 in this case.

The figure provides the architecture which is built in the beginning. Images from the data frame will be loaded into the the model while training. Training is carried out in Epochs. One epoch means that each sample in the training data set has had an opportunity to update the internal model parameters. An epoch is comprised of one or more batches. Before training, parameters such as earlystop, learning rate reduction and callbacks are adjusted to avoid overfitting. This is done by stopping the number of epochs after a particular number.

4.2.3 Testing Model

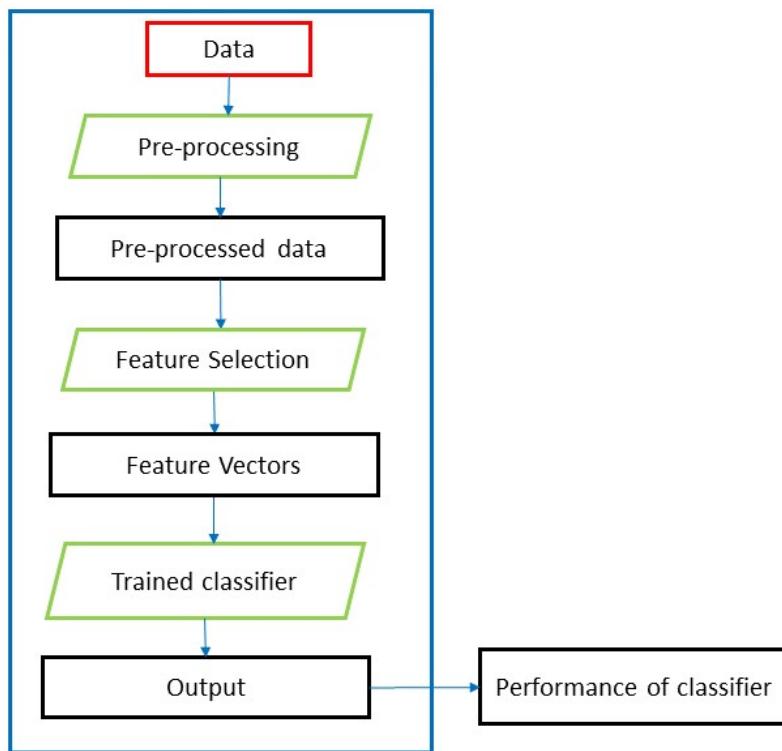


Figure 4.10: Block diagram of Testing Model

Fig. 4.3 represents the flowchart of the testing model. It begins with pre-processing of the testing data set images which are in NII format. These images are converted into JPEG format. The next step is extracting feature vectors from these processed images which will be fed into the trained CNN model. The model will then classify the image based on comparison to the trained data set.

4.3 Mini Mental State Exam (MMSE)

Also known as Folstein Test, it is a set of 30 questions that doctors and other healthcare professionals commonly use to check for cognitive impairment (problems with thinking, communication, understanding and memory).

The doctor might perform the MMSE if there is a reason to suspect you may be confused, such as after a head injury or during a sudden episode of illness such as an infection. It is also sometimes used as part of the process for determining if someone has dementia.

The MMSE can be used to assess several mental abilities, including:

- short and long-term memory

- attention span
- concentration
- language and communication skills
- ability to plan
- ability to understand instructions

The MMSE test takes about 5 to 10 minutes and consists of a series of tasks such as:

- memorising a short list of objects and then repeating the list back
- writing a short sentence that is grammatically correct, such as "The dog sat on the floor"
- correctly identifying the current day of the week, followed by the date, the month, the season and the year

The maximum score for the MMSE is 30. A score of 25 or higher is classed as normal. If the score is below 25, the result is usually considered to be abnormal (indicating possible cognitive impairment). Impairment may be classified as follows:

Table 4.1: Interpretation of MMSE

Method	Score	Interpretation
Single Cutoff	<24	Abnormal
Range	<21	Increased odds of dementia
	>25	Decreased odds of dementia
Education	21	Abnormal for 8th grade education
	<23	Abnormal for high school education
	<24	Abnormal for college education
Severity	24-30	No cognitive impairment
	18-23	Mild cognitive impairment
	0-17	Severe cognitive impairment

Chapter 5

Design Of the System

5.1 Requirement Engineering

5.1.1 Software Development Life Cycle Model

STAGE 1: Planning and requirement analysis

As Doctors face difficulty to find out whether a patient has AD or not, the system was planned to detect Alzheimer's disease using a deep learning algorithm as it is more reliable and gives appropriate result. The main goal for the system was to identify or to detect whether the patient is suffering from AD or not. The stakeholders are those who developed the system. As it is implemented further, then the doctors are the stakeholders as they can take benefit of the system for better results. There was a discussion with the doctor regarding the system as to add more details to the system as per their requirements.

STAGE 2: Designing Project Architecture

The system consists of two different parts. The MMSE Test shows at what stage of AD the patient is at. The MRI scan shows the result of Whether the patient is suffering from AD or CN. The Detection of AD and CN happens using CNN(Convolution Neural Network).

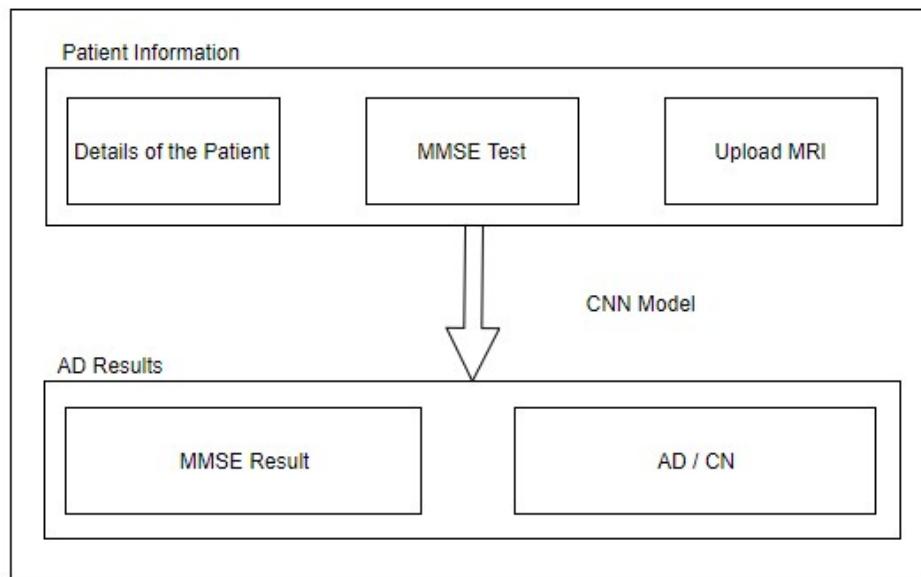


Figure 5.1: Architecture Diagram

STAGE 3: Development and Programming

The system is developed using the CNN(Convolutional Neural Network) algorithm of Deep learning. The programming language by which

the system is developed was python using libraries such as keras, tensorflow and tkinter. The system developed contains a training as well as testing model where NIfti (Neuroimaging Informatics Technology Initiative) images are trained and suitable for testing. These images are preprocessed using MATLAB where the SPM12 toolkit was used. The preprocessed images help in giving out a better accuracy and the system becomes more reliable.

STAGE 4: Testing

Testing of the system is a very important part as the life of the patients is at risk. Testing involves whether the correct disease is been predicted by the system or not. There are three various types of testing performed on the system for better results, which are Unit Testing, Integration Testing and Black-Box Testing. Testing helps in improving the system and makes the patients trust on the system.

STAGE 5: Deployment

The system is going to be deployed by the doctors as they get the whole package of detecting Alzheimer's Disease using MMSE test and MRI Scan Detection. The effort taken by the doctors reduce and there is less time consumption, so that the doctors can get appropriate result and start the diagnosis and treatment of the patient as early as possible. This System will be used to earn profits and also help patients at the same time.

The software development model used in the system is V-model. Since in the system testing and verification takes place simultaneously. Every time while testing, input MRI scan given to the system is stored in the database, and added to the training data set in order to improve the accuracy of the system.

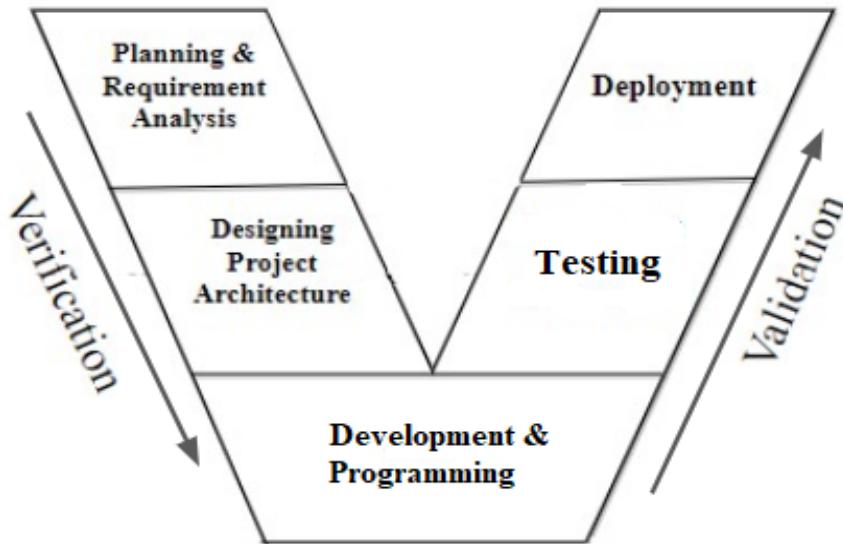


Figure 5.2: SDLC Model

The system needs to be tested because life of the patient is at risk. The V Model is perfect of this kind of system where the validation and verification of the system matters the most.

5.1.2 Requirement Analysis

5.1.2.1 Use Case diagram

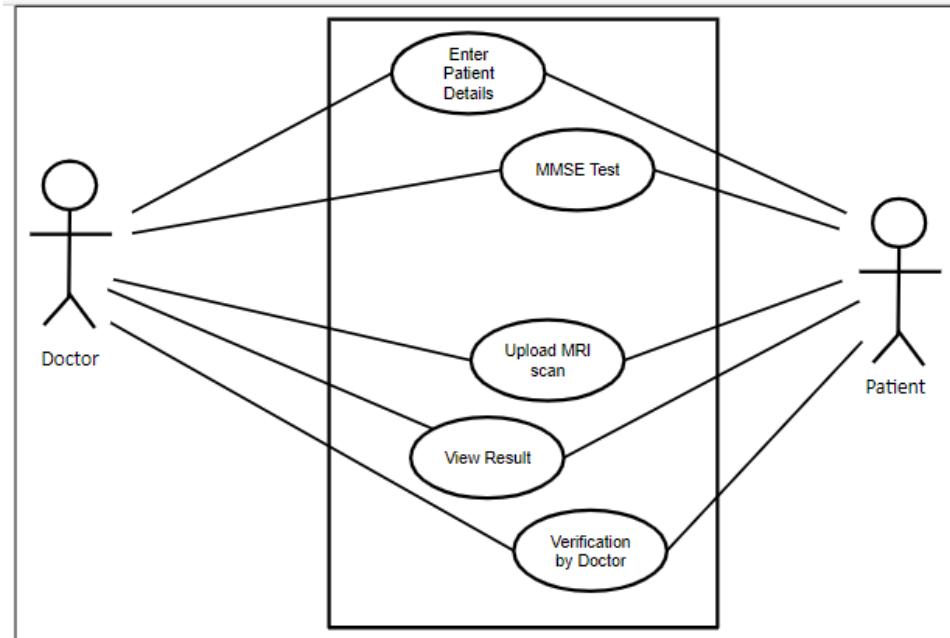


Figure 5.3: Use Case Diagram

5.1.2.2 Hardware and software requirement

Hardware Requirements:

- Intel Pentium IV Processor or above
- RAM 6GB and above
- HDD Memory 20GB and above
- Internet Connectivity

Software Requirement:

- Anaconda (spyder) version 2019.03
- MRIcron
- Keras
- TensorFlow
- Tkinter
- MATLAB version above 2017b
- SPM 12 Toolkit

5.2 System architecture

5.2.1 UI/UX diagram

The GUI for this project has been developed using Tkinter. Python offers multiple options for developing GUI . Out of all the GUI methods, tkinter is the most commonly used method. It is a standard Python interface to the Tk GUI toolkit shipped with Python. Python with tkinter is the fastest and easiest way to create the GUI applications.

The Fig 6.1 shows the page where the doctor can fill the general information of a patient. The general information contains the name, date of birth, gender, height, weight, phone number and email address of a patient. After getting this information, the patient is asked to give an MMSE Test.

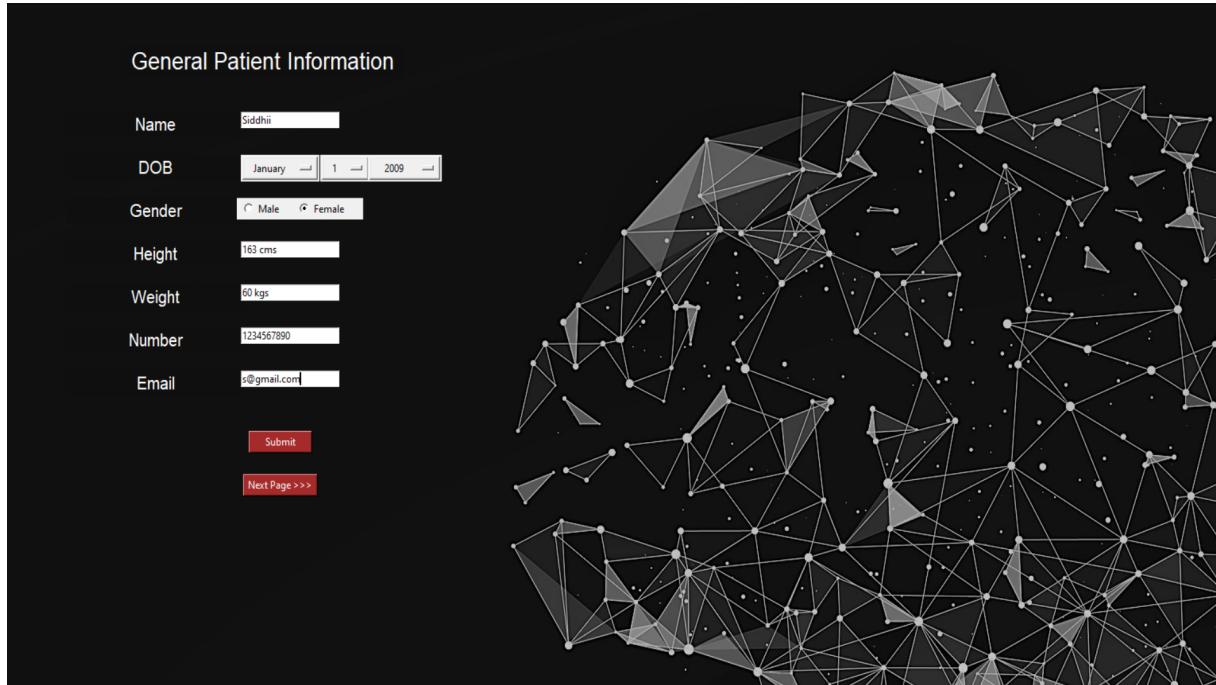
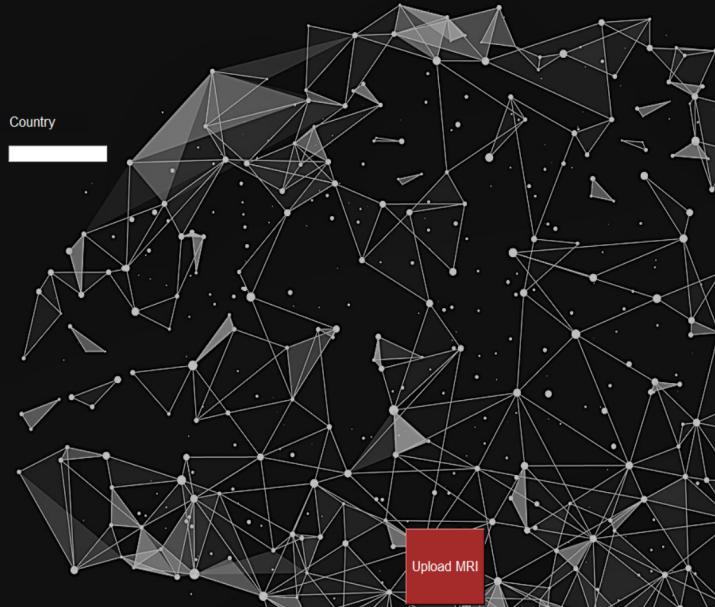


Figure 5.4: Patient Registration

The Mini-Mental State Exam (MMSE) is a widely used test of cognitive function among the elderly; it includes tests of orientation, attention, memory, language and visual-spatial skills. Fig 6.2 shows some of the questions asked in the test. The user (Doctor in this case) will enter and submit the answers spoken by participant (patient). The maximum marks that can be scored are 30. In general, participant scoring below education-adjusted cut-off scores on the MMSE may be cognitively impaired.

If a participant scores between 0-18, he/she may have severe cognitive impairment. If the score is between 19-23, he/she may have mild cognitive impairment else the participant has no cognitive impairment. The Fig 6.3 is an example that shows the result after all the entries are analysed in the test.

Mini Mental State Exam

1. What year is it?	<input type="text"/>	
2. What season is it?	<input type="text"/>	
3. Where are we now?	City <input type="text"/> State <input type="text"/> Country <input type="text"/>	
4. Count backwards from 100 from sevens	Done? <input type="radio"/> Yes <input type="radio"/> No	
5 Repeat the phrase	Done? <input type="radio"/> Yes <input type="radio"/> No	
6. Guess the 2 objects	<input type="radio"/> Correct <input type="radio"/> Incorrect	
7. Repeat the 3 words I told you in the beginning	<input type="radio"/> Correct <input type="radio"/> Incorrect	
8. Take a paper with your right hand, fold it in half, put in on the table.	Done? <input type="radio"/> Yes <input type="radio"/> No	
9. Close your eyes	Done? <input type="radio"/> Yes <input type="radio"/> No	
10. Make up and write a sentence	<input type="radio"/> Correct <input type="radio"/> Incorrect	
11. Copy this picture shown to you	<input type="radio"/> Correct <input type="radio"/> Incorrect	

Get Score **Upload MRI**

Figure 5.5: Mini Mental State Examination (MMSE)

Mini Mental State Exam

1. What year is it?	<input type="text" value="2020"/>	
2. What season is it?	<input type="text" value="summer"/>	
3. Where are we now?	City <input type="text" value="mumbai"/> State <input type="text" value="maharashtra"/> Country <input type="text" value="india"/>	
4. Count backwards from 100 from sevens	Done? <input type="radio"/> Yes <input type="radio"/> No	
5. Repeat the phrase	Done? <input type="radio"/> Yes <input type="radio"/> No	
6. Guess the 2 objects	<input type="radio"/> Correct <input type="radio"/> Incorrect	
7. Repeat the 3 words I told you in the beginning	<input type="radio"/> Correct <input type="radio"/> Incorrect	
8. Take a paper with your right hand, fold it in half, put in on the table.	Done? <input type="radio"/> Yes <input type="radio"/> No	
9. Close your eyes	Done? <input type="radio"/> Yes <input type="radio"/> No	
10. Make up and write a sentence	<input type="radio"/> Correct <input type="radio"/> Incorrect	
11. Copy this picture shown to you	<input type="radio"/> Correct <input type="radio"/> Incorrect	

Get Score **The score is 19 /30. The patient has MILD COGNITIVE IMPAIRMENT** **Upload MRI**

Figure 5.6: Result of MMSE

The doctor then needs to upload the brain MRI scan of that patient. The MRI scan will be given as an input to our model. Fig 6.4 shows the file that is selected in order to upload. Fig 6.5 shows the path of the image on the screen for the Doctor to verify using our system. After this, the button PREDICT is clicked to display the output.

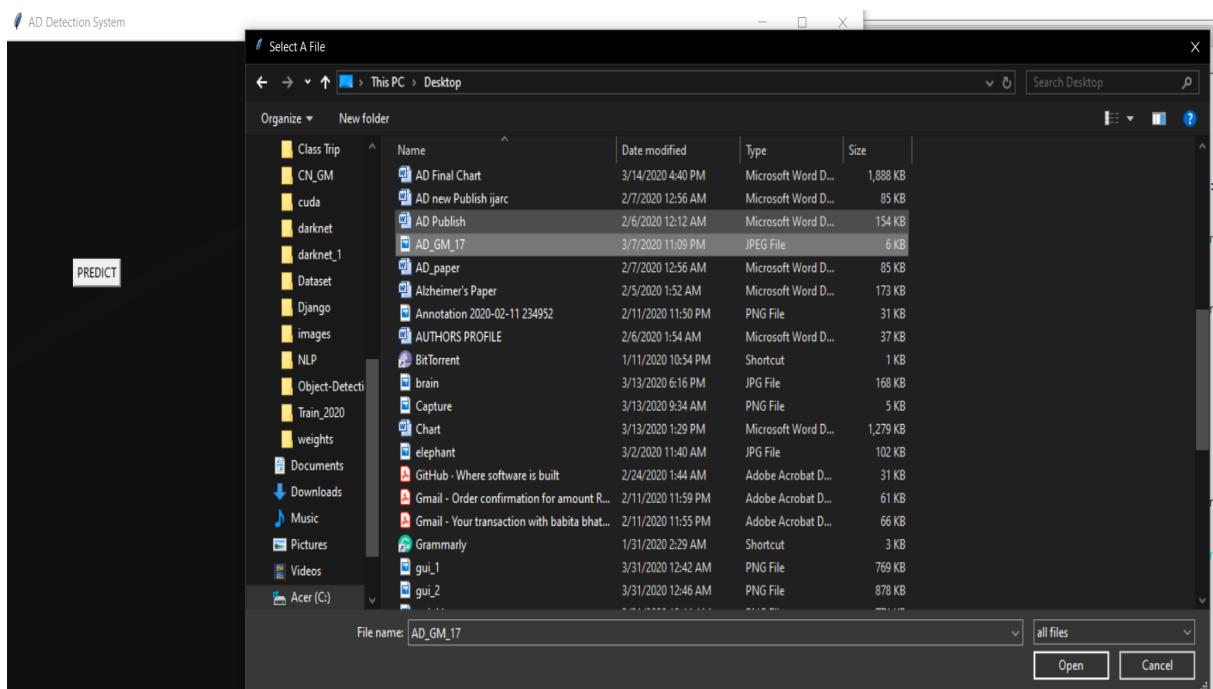


Figure 5.7: Uploading an MRI Scan Image



Figure 5.8: Show the uploaded image

The model, along with other images, predicts the class of the given input images. The class can be either AD or CN, where AD means Alzheimer's Disease and CN means Cognitive Normal. In Fig 6.6, the output of the class can be seen in the square brackets next to the filename.

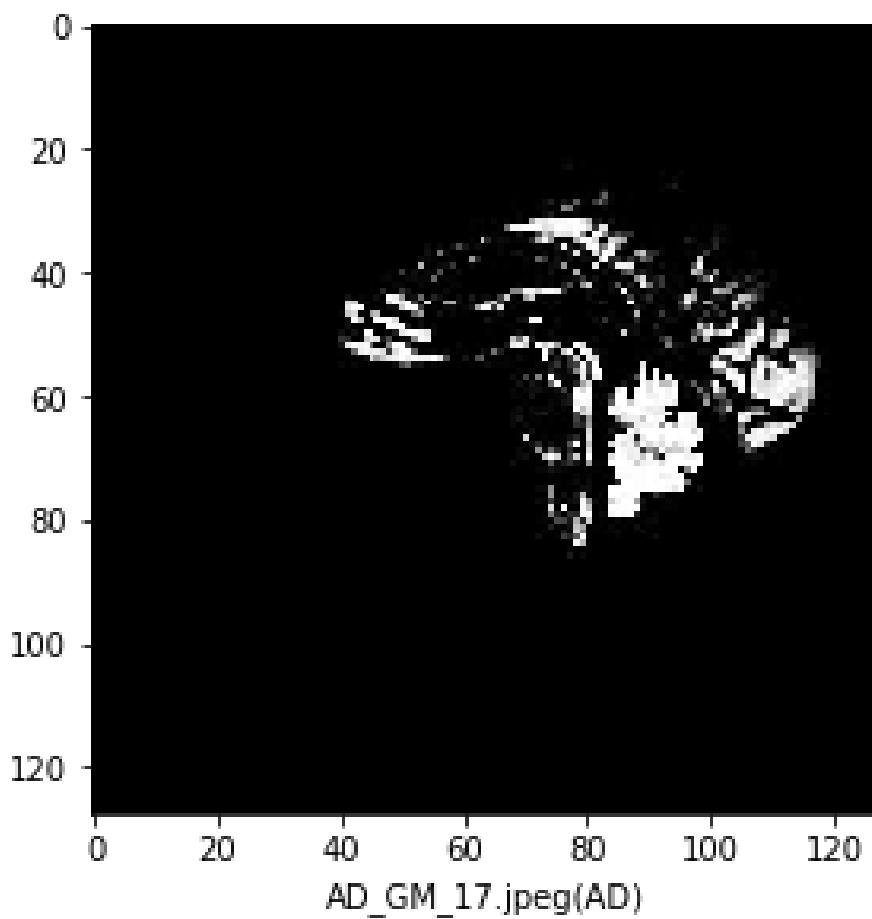


Figure 5.9: Prediction

5.3 Sample Code (of imp part/ main logic)

```
filenames = os.listdir("/content/drive/My Drive/Data/Train")
categories = []
for filename in filenames:
    category = filename.split('_GM')[0]
    if category == 'AD':
        categories.append(1)
    else:
        categories.append(0)
print(categories[80:100])
df = pd.DataFrame({
    'filename': filenames,
    'category': categories
})
```

Figure 5.10: Data Preparation

```
print(df.head())
print(df.tail())

      filename  category
0   AD_GM_1.jpeg       1
1   AD_GM_16.jpeg      1
2   AD_GM_12.jpeg      1
3   AD_GM_18.jpeg      1
4   AD_GM_15.jpeg      1
      filename  category
175  CN_GM_87.jpeg     0
176  CN_GM_85.jpeg     0
177  CN_GM_88.jpeg     0
178  CN_GM_90.jpeg     0
179  CN_GM_9.jpeg       0
```

Figure 5.11: Displaying Data in Data Frame

```
from keras.models import Sequential
from keras.layers import Conv2D, MaxPooling2D, Dropout, Flatten, Dense, Activation, BatchNormalization

model = Sequential()

model.add(Conv2D(8, (3, 3), activation='relu', input_shape=(IMAGE_WIDTH, IMAGE_HEIGHT, IMAGE_CHANNELS)))
model.add(BatchNormalization())
model.add(MaxPooling2D(pool_size=(2, 2)))
model.add(Dropout(0.25))

model.add(Conv2D(16, (3, 3), activation='relu'))
model.add(BatchNormalization())
model.add(MaxPooling2D(pool_size=(2, 2)))
model.add(Dropout(0.25))

model.add(Conv2D(32, (3, 3), activation='relu'))
model.add(BatchNormalization())
model.add(MaxPooling2D(pool_size=(2, 2)))
model.add(Dropout(0.25))

model.add(Conv2D(64, (3, 3), activation='relu'))
model.add(BatchNormalization())
model.add(MaxPooling2D(pool_size=(2, 2)))
model.add(Dropout(0.25))

model.add(Conv2D(128, (3, 3), activation='relu'))
model.add(BatchNormalization())
model.add(MaxPooling2D(pool_size=(2, 2)))
model.add(Dropout(0.25))
|
model.add(Flatten())
model.add(Dense(512, activation='relu'))
model.add(BatchNormalization())
model.add(Dropout(0.5))
model.add(Dense(2, activation='softmax'))

model.compile(loss='categorical_crossentropy', optimizer='rmsprop', metrics=['accuracy'])

model.summary()
```

Figure 5.12: Building CNN model

```
from keras.callbacks import EarlyStopping, ReduceLROnPlateau

earlystop = EarlyStopping(patience=10)

learning_rate_reduction = ReduceLROnPlateau(monitor='val_acc',
                                             patience=2,
                                             verbose=1,
                                             factor=0.5,
                                             min_lr=0.00001)

callbacks = [earlystop, learning_rate_reduction]

df["category"] = df["category"].replace({0: 'CN', 1: 'AD'})

print(df.head())
print(df.tail())

      filename category
0   AD_GM_1.jpeg    AD
1   AD_GM_16.jpeg   AD
2   AD_GM_12.jpeg   AD
3   AD_GM_18.jpeg   AD
4   AD_GM_15.jpeg   AD
      filename category
175  CN_GM_87.jpeg    CN
176  CN_GM_85.jpeg    CN
177  CN_GM_88.jpeg    CN
178  CN_GM_90.jpeg    CN
179  CN_GM_9.jpeg     CN
```

Figure 5.13: Setting parameters to prevent overfitting

```

epochs=3 if FAST_RUN else 50
history = model.fit_generator(
    train_generator,
    epochs=epochs,
    validation_data=validation_generator,
    validation_steps=total_validate//batch_size,
    steps_per_epoch=total_train//batch_size,
    callbacks=callbacks
)

Epoch 1/50
9/9 [=====] - 5s 558ms/step - loss: 1.4232 - acc: 0.4984 - val_loss: 0.8391 - val_acc: 0.5333
Epoch 2/50
9/9 [=====] - 3s 316ms/step - loss: 1.2894 - acc: 0.5165 - val_loss: 0.8549 - val_acc: 0.5238
Epoch 3/50
9/9 [=====] - 3s 314ms/step - loss: 1.1972 - acc: 0.5324 - val_loss: 1.0187 - val_acc: 0.5714
Epoch 4/50
9/9 [=====] - 3s 317ms/step - loss: 1.3253 - acc: 0.4602 - val_loss: 0.9581 - val_acc: 0.5667
Epoch 5/50
9/9 [=====] - 3s 329ms/step - loss: 1.2294 - acc: 0.4889 - val_loss: 0.8526 - val_acc: 0.4762

Epoch 00005: ReduceLROnPlateau reducing learning rate to 0.000500000237487257.
Epoch 6/50
9/9 [=====] - 3s 292ms/step - loss: 1.3691 - acc: 0.4546 - val_loss: 1.1085 - val_acc: 0.4762
Epoch 7/50
9/9 [=====] - 3s 333ms/step - loss: 1.1793 - acc: 0.5926 - val_loss: 0.8400 - val_acc: 0.5667

Epoch 00007: ReduceLROnPlateau reducing learning rate to 0.000250000118743628.
Epoch 8/50
9/9 [=====] - 3s 303ms/step - loss: 1.1672 - acc: 0.5123 - val_loss: 0.7070 - val_acc: 0.6667
Epoch 9/50
9/9 [=====] - 3s 300ms/step - loss: 0.9008 - acc: 0.5803 - val_loss: 1.0251 - val_acc: 0.4762
Epoch 10/50
9/9 [=====] - 3s 312ms/step - loss: 1.1607 - acc: 0.5016 - val_loss: 0.9815 - val_acc: 0.4667

Epoch 00010: ReduceLROnPlateau reducing learning rate to 0.000125000059371814.
Epoch 11/50
9/9 [=====] - 3s 308ms/step - loss: 1.1606 - acc: 0.5165 - val_loss: 0.6782 - val_acc: 0.6667
Epoch 12/50

```

Figure 5.14: Training

5.3.1 Block Diagram

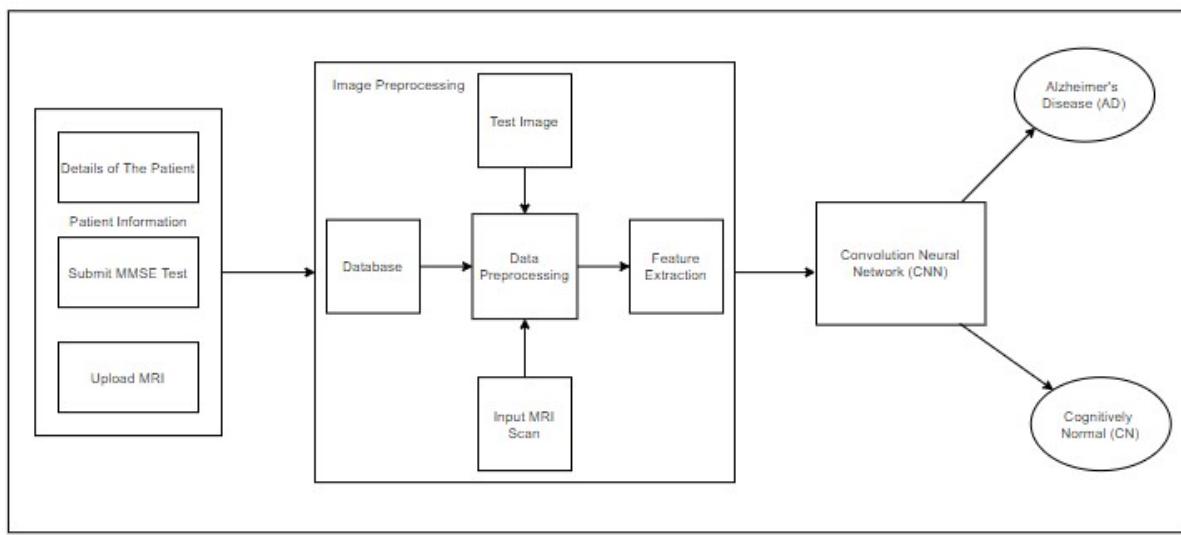


Figure 5.15: Block Diagram

Chapter 6

Result and Discussion

6.1 Testing

Testing of our model was done by providing 10 images to the CNN model after training. The graph as shown in Fig 6.1 shows the result that was predicted by the model. The values on x-axis can either 0 or 1, where 0 denotes class CN and 1 denotes the class AD. The y-axis denotes the number of images. The 10 images consisted of 8 images of AD and 2 images of CN. But, from the figure we can see that all the images were classified as AD.

Fig 6.2 shows the prediction done on a single image. The '1' in the bracket after the filename denotes its class, which here is AD.

The accuracy after training the model with 90 images of AD and 90 images of CN was 63%.



Figure 6.1: Result visualization

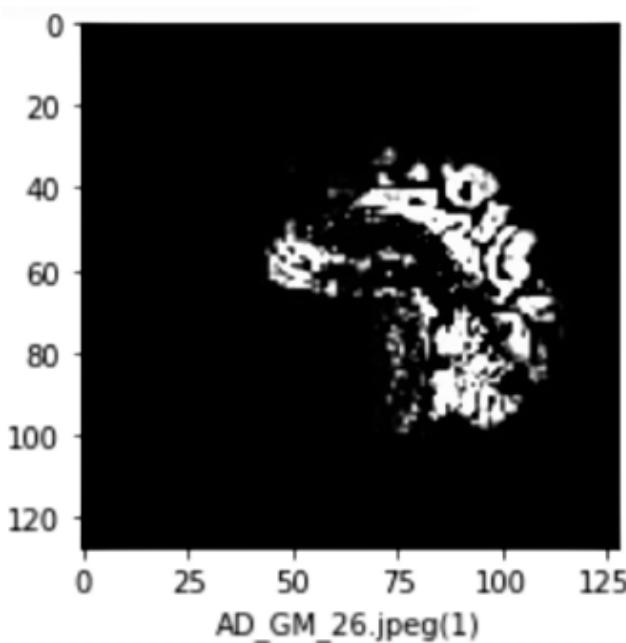


Figure 6.2: Result with predicted image

6.1.1 Unit Testing

Unit Testing is a level of software testing where individual units/components of a software are tested. The purpose is to validate that each unit of the software performs as designed. A unit is the smallest testable part of any software. It usually has one or a few inputs and usually a single output.

For unit testing of our model, we tested whether the layers of the CNN model that we created were connected properly to each other or not. The result of this test was a success as the network was properly created.

6.1.2 Integration Testing

Integration Testing is a level of software testing where individual units are combined and tested as a group. The purpose of this level of testing is to expose faults in the interaction between integrated units. Test drivers and test stubs are used to assist in Integration Testing.

For integration testing, we combined two units of the system. The first was the User Interface and the second one was the prediction model. The User Interface was properly able to accept the image given as an input to the model. Then, the model predicted the class and the result was displayed as expected. Thus, the result of this test was a success.

6.1.3 Black Box Testing

Black Box Testing, also known as Behavioral Testing, is a software testing method in which the internal structure/design/implementation of the item being tested is not known to the tester. These tests can be functional or non-functional, though usually functional.

For Black box testing of our system, we tested our model by providing inputs, which were MRI scans of AD affected patients and verifying the outputs against the expected outcome. The outcome of this test was a success.

Table 6.1: Testing of inputs with their respective outputs

Description of Input	Correct Results	Out of
Input of only AD images	10	10
Input of only CN images	7	10
Mixture of AD and CN	8	20

Chapter 7

Conclusion & Future Scope

The report describes an Alzheimer's Disease Detection System using Deep Learning. It covers different domain techniques used while carrying out the system development.

Starting with the literature survey, it shows a comparative study of different algorithms used while attempting to build a similar system. It then describes the work done on data before feeding it into the training model. This was nothing but pre-processing of the brain MRI scans which was done using SPM12 tool in MATLAB. Pre-processing involved segmentation of the scans. The result obtained was middlemost slice of every scan with the grey matter separated from it.

Followed by pre-processing was Convolutional Neural Network (CNN) model implementation. The model consists of several layers whose functionalities were explained in this report.

Followed by data pre-processing was development of system design. This included engineering behind the project which focused on the Development Model, Project Architecture, Requirement Analysis, Hardware and Software requirements.

Last but not the least are relevant images and screenshots which depict the flow and working of our system. These include an MMSE along with an MRI upload screen for the user to detect the presence of Alzheimer's Disease in a person from MRI scan and a couple of memory questions.

Overall, the report provides details of such a system that can be used by Doctors to check whether a person is suffering from Alzheimer's Disease or not. The system aims to reduce Doctor efforts generating accurate results.

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Appendix A : Timeline Chart

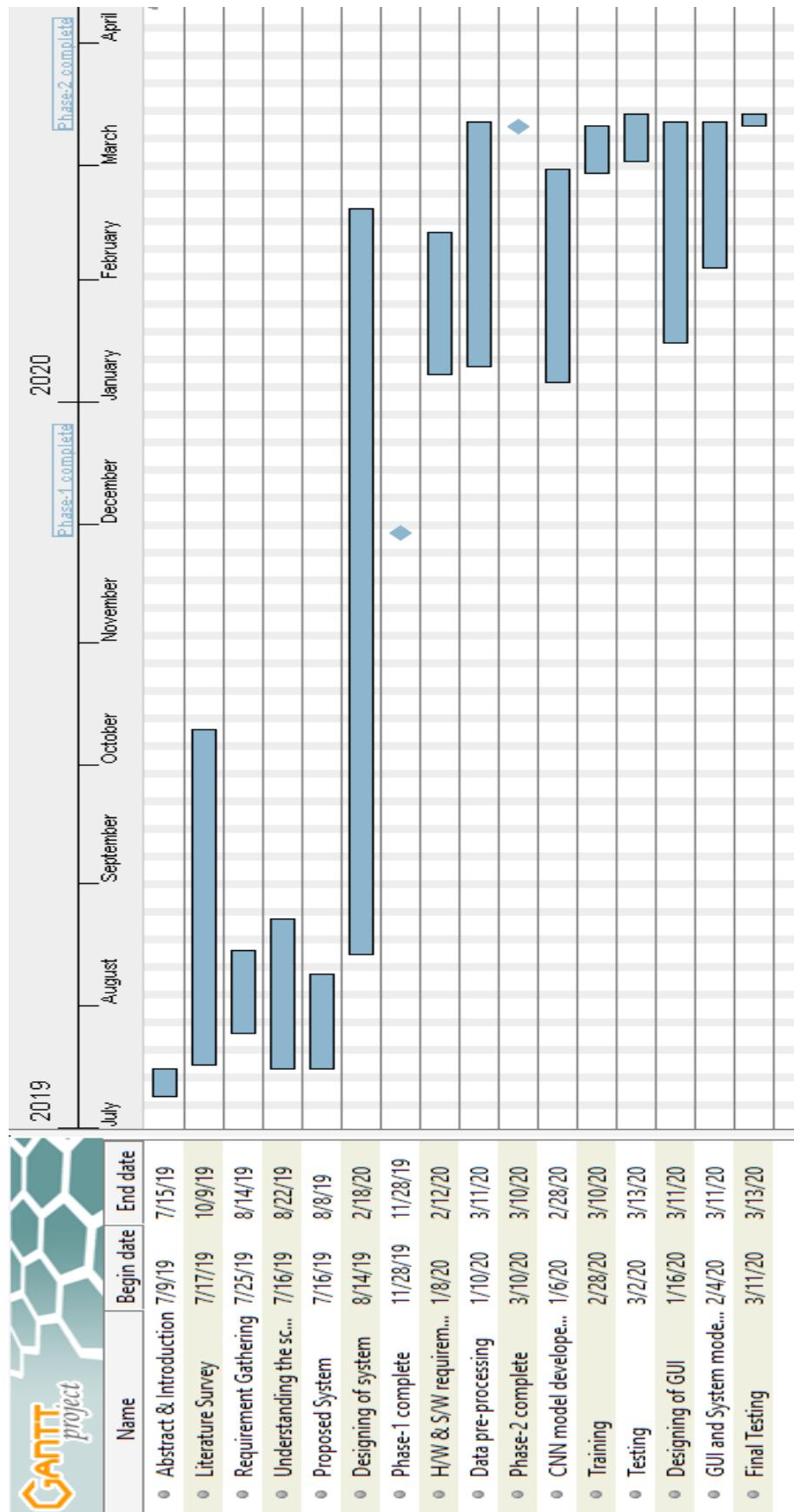


Figure 7.1: Gantt Chart

Appendix B : Interaction with Domain Experts

MEETING WITH PSYCHIATRIST

Alzheimer's is a disease of the brain where the CSF atrophy in the brain is reduced. The brain becomes weak and it cognitively starts to decline every function of the body. In the psychological analysis first the MMSE (Mini-mental state exam) is conducted where the patient is asked a few questions and based on his/her score a CDR (Clinical Dementia Rating) is generated. Based on the CDR score a psychometric evaluation is done.

When treating the patient psychologically, it is made sure that the patient is suffering from Alzheimer's or any other disease because the patient who visits the doctor is aged so the memory loss may be due to health issues or various other factors.

The brain may also contain other chemicals which may or may not affect the Alzheimer's Disease. Mainly hydrocephalus can be the issue for weakening of the brain. It becomes very difficult to think under such circumstances.

Patients generally don't have 100% pure AD. These patients could have other health issues like diabetes, hypertension, blood pressure, etc. which may cause ischemic changes in the brain leading to vascular cause of dementia. So memory loss could be because of these reasons too. So it becomes difficult for the doctor to find out the reasons behind memory loss. Vascular Dementia also has a similar kind of symptoms and treatment facilities, but diagnosis may differ as in vascular dementia there is a blood clot that happens in the brain so this leads to irregular blood flow. There are genetic markers in the human body which may also lead to AD in an early age.

AD is not just forgetfulness of things it is a serious disease in the brain. The doctors find it difficult to differentiate between brain tumors and Alzheimer's. They both have similar symptoms and in cases such as this taking an MRI scan becomes mandatory.

While treating for AD, there are tests for B12 and thyroid so that they can see and reversible changes. If they see no reversible changes can be done then psychologically the patient is treated. But before that, a psychological education is given to the family where the family is been prepared that the patient is not going to be like before he/she is going to be difficult to handle and they may face many problems with them. Medicines are used just to delay the process of complete memory loss. The psychologist just gives medicines like melatonin for sleep, anti psychotics for brain stability, etc. just to make the patient stable.

The patient suffering from AD has lucid bits of memory where there are gaps between the things they remember and what they forget. The orientation of the brain changes. The patients who take the MRI scans are not so common as it is expensive. Patients who take the MRI are at an early stage or a later stage. AD is easier to detect at an later stage as the shrinkage and atrophy is visible.

MEETING WITH RADIOLOGIST

The brain consists of atrophy, and it helps to figure out whether the patient is suffering from AD or not. Not many patients take an MRI scan of the brain as it is expensive. Some patients who are able to afford these only take the scan. After the MMSE test result, many of the doctors are confident that the patient is suffering from Alzheimer's or not, But by taking the MRI it helps in figuring out that it is just due to abnormality in the brain or some other health problems.

MRI scan is used to differentiate between the cognitively normal stage and Alzheimer's disease. In the MRI scan of the brain, the image consists of gray matter which is used to determine the abnormality in the brain. While detection of Alzheimer the size of the brain decreases, but it depends on the type of dementia. The MRI image is in grayscale, so the CSF is which is used to identify is black in color. Due to AD, there is shrinkage in the brain and the CSF is more visible so the black area is more prominent.

Appendix C : Publication Details

Name of the Paper: Proposed System for Detection of Alzheimer's Disease

Journal Name: International Journal of Advanced Research in Computer Science

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