CHAPTER 1

INTRODUCTION

1.1 Study Overview

Cutting-edge technologies in health care segment is entirely dissimilar from any other industry. Due to the innovation in image collecting devices, the data is tremendously huge that is demanding and exciting for image investigation. This development in medical images and methodologies needs widespread efforts by radiologists and medical practitioner to handle huge amount of image data. Artificial Intelligence (AI) consists of Machine Learning (ML) techniques along with Deep Learning (DL) approaches can automate the diagnosis process which is complex and handle other issues related to the medical data. The evolution of AI in the field of imaging has enhanced clinical outcomes like speeding up the scan duration, creating accurate diagnoses and simplifying the medical imaging process. Medical experts interpret the medical image data which is complex and subjective by applying AI approaches. Hence, an AI based architecture is required to optimize the medical images by performing image segmentation, classification and discovering several diseases at the primary stage.

In this present study, the focus is on the brain neuron images in classifying Alzheimer's Disease (AD) stages, which aids neurologists to understand complex changes in the brain. The goal is to use brain imaging analysis to diagnose AD early. Millions of elderly people worldwide suffer from AD, a deteriorating brain disease caused by brain cell degeneration that impairs memory and intellectual function. In 1906, AD was titled after Dr. Alois Alzheimer who observed few significant alterations in the patient's brain nerves who had discomfort from psychological ailments like undergoing memory loss, communication difficulties, unfamiliar manners, etc. (Lane et al., 2018). When the patient expired, Dr. Alzheimer examined the patient's brain and recognized numerous abnormalities. AD is a permanent brain ailment that steadily wear away thinking and memory skills which finally disturbs

even the basic tasks (Sengoku 2020). In the mid-60s age, AD symptoms like memory loss appears along with other symptoms like i) unable to perform easy tasks, ii) trouble in solving simple problems, iii) personality and mood changes like isolating from family and friends, iv) written or spoken communication issues, v) misperceptions related to people, places and events, vi) visual deviational issues like misunderstanding images and videos (DeTure MA & Dickson DW 2019). These conditions are complex that influences the affected individual along with their family and friends.

Neuroimaging method aids to measure the abnormal changes in the brain images by examining the stand-in markers. Hence, a technique to measure the abnormal changes in the brain is required. An effective neuroimaging tools like Computer Tomography (CT), Magnetic Resonance Imaging (MRI), Positron Emission Tomography (PET) and Single Photon Emission Computerized Tomography (SPECT) aids in finding changes in the brain due to neurodegenerative ailments. These diverse imaging techniques aids in envisioning the functional structures and detecting precise changes and anomalies in the brain. Compared to other neuroimaging tools MRI is better and widely used for AD analysis (Arora et al., 2022).

For analyzing the medical images and discovering neurological ailments like AD computational techniques like ML and DL are popular in the recent times. The memory and cognitive functions are affected in AD which is the reason for dementia in older population. These computational techniques use algorithms to analyze the brain images to classify patterns and features related to AD. SVM, Bayesian classifier, DT and KNN classifiers are common classifiers to categorize the brain images effectively based on the features set. These algorithms aids to classify the individuals with AD or forecast the development of the disease at a later stage. Among the characteristics taken from the brain images of regular and irregular categorization are neuron loss and white matter shrinkage. Finally, the classification findings are used to grade the brain images and accuracy, precision, recall and F1-score metrics are determined. Based on their neurological characteristics, AD images are categorized into various phases. Hence, there is a need for a more accurate AD diagnosis.

The present work emphases on refining the classification performance of AD stages, resulting in more accurate diagnosis. This chapter initiates with a detailed description of the human brain anatomy, a brief about dementia, AD, followed by a detailed explanation about the symptoms of AD, stages of AD and AD diagnosis classification, impact and challenges present in AD diagnosis. ML and DL models for AD analysis are discussed. The chapter successively defines the problem statement, research objectives, and contributions. The chapter closes with the framework of this thesis.

1.2 Human Brain Anatomy

One of the human body's most complex organs is the brain which aids in controlling the thoughts, emotions, thinking, breathing, viewing, learning, sensing, motor functioning, body temperature, hunger and each process that controls our body. The human brain weighs nearly 3 pounds and it consists of 60% fat, and in addition to water, salts, carbohydrates, protein etc. It is an intricate neurological structure comprising more than 100 billion neurons, blood vessels and cells. The nervous system consists of neurons, where each neuron connects with the other neurons with countless number of connections. These neurons aids in communicating with different human body parts.

The components of the human brain are forebrain, midbrain and hindbrain. The forebrain, which is composed of the cerebrum and its supporting structures, is the largest and most developed area of the brain. The thalamus, cerebrum, and hypothalamus are the components of the forebrain. The tegmentum, cerebral peduncles, and colliculi are the components of the midbrain. The tasks like eye movement, reflex activities and voluntary motions are regulated by the midbrain which is situated at the brainstem’s top. The parts of the hindbrain are spinal cord’s upper part, brain stem and cerebellum.

The vital tasks like breathing, heart rate are regulated by the hindbrain. The anatomy of human brain are shown in Figure 1.1.

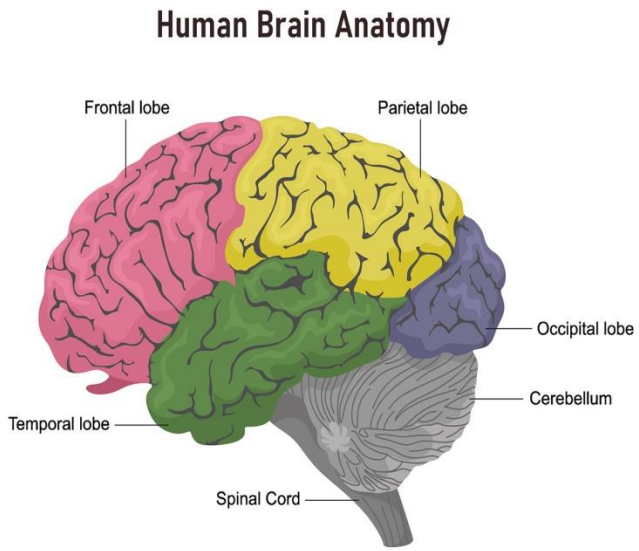

Figure 1.1 Anatomy of human brain

There are two parts of the brain's central nervous system: the gray matter and the white matter. The duskier and outer region of the brain is denoted as gray matter while the lighter and inner region of the brain is denoted as white matter. On the other hand, white matter is located outside the spinal cord and gray matter is located inside. The rounded neuron somas found in the central cell body make up the gray matter. Axons, which are lengthy stems that link neurons, make up the white matter. The axons are enfolded in myelin. The gray matter is mainly accountable for handling and understanding information. The white matter is accountable for transmitting the information to additional parts. Neuronal anatomy in the human brain are shown in Figure 1.2.

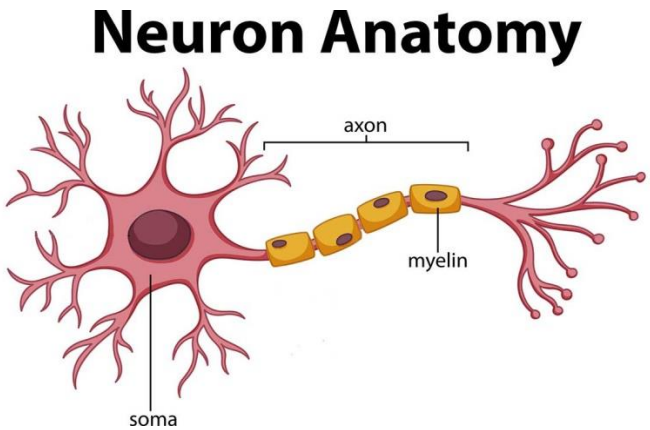

Figure 1.2 Neuronal anatomy in the human brain

The human brain's four lobes—temporal, parietal, frontal, and occipital—as well as the cerebrum, cerebellum, and brainstem are shown in the subsection that follows.

The Cerebrum

It is the foremost part in the brain covering several bends and features. The surface areas of the cerebral cortex found in the left and right cerebral hemispheres are referred to as grey matter. It is used to form neuron cell bodies and are responsible for intellect actions, emotions and memory functions. The right hemisphere is responsible for structural thinking and the left hemisphere is responsible for intellectual thoughts and speech.

The Cerebellum

It is the supreme part of the hindbrain which is present in the brain's lower rear side below the occipital lobe. It is responsible for all body movements and withstand the balance amidst all body movements. The cerebellum manages this motor information with the aid of the cerebral cortex. The pace and posture of moving people is maintained by the musculoskeletal components in the body. Along with the cognitive actions like language, responses and attention it controls the fear, emotions, balance and physical movement (Shebiah RN et al., 2019, March).

The Brainstem

It is the last part of the human brain which is present in the brain's bottom part that connects brain and spinal cord. A Cerebrospinal Fluid (CSF) guards the brain but still the brain is vulnerable to injuries and different neurological ailments. The different aspects for brain ailments are hereditary, neuron degeneration diseases, painful injuries, and irregular and unexpected neuron cells growth. Brain tumors occur when there is an unexpected neuron growth. The other brain ailments occur due to brain injuries, blood clots and shocks that affect the cells and nerves in the brain. The brain cell's death causes neurodegenerative diseases like Pakinson's, AD and Huntington's (Pinto and De Carvalho 2008).

The frontal lobes

It is the major brain lobe in the human body located directly behind the forehead. The brain's front part is the frontal lobes accountable for choice creation and problem resolving skills. The information from the other lobes and the body's activity commands are gathered with the aid of the motor cortex present in the frontal lobes. When the frontal lobe is injured, the emotions, activities and the behaviors are affected (Dworkin and Kennedy 2018).

The parietal lobes

It is located in between frontal and occipital lobes which is situated at the brain's center. Its present near the skull's base at the temporal lobes called as the neocortex. It coordinates all the sensual information gathered from different human body parts. It is responsible to maintain the relationship between visual and spatial processing along with the enhanced understanding ability. When the parietal lobe is injured, there is a difficulty in storing the verbal words, linguistic, and controlling the eyeball movements (Coslett and Schwartz 2018).

The occipital lobe

It is the fourth and the final lobe of the cerebrum, which is small that makes up the brain's caudal region. It understands visual information and consists of visual cortex.

The temporal lobe

t is the most vital part which is present in the brain's bottom. It aids in thinking and storing along with audio observation, language, physical inputs and memory are managed by temporal lobe. When the temporal lobe is injured, issues related to speech delivery, hearing, visual and language are affected (Betts et al., 2022).

1.3 Alzheimer's Disease

Dementia, AD basics, its symptoms, phases, classification, diagnosis of AD, its effects, and difficulties in diagnosing AD are covered in this section.

In general, dementia denotes a collection of ailments that disturbs a person's thinking, reasoning, personality, memory, mood and conduct. Dementia is not defined as

a particular disease but a person's mental function. The daily life of a person is affected when there is a deterioration in mental functions. Nearly, 50% of the older population above 85 years of age have dementia. Recent medications aids to decelerate the mental degeneration. The degeneration in mental functions severely interface with the daily activities of a person. Two or more complications such as coordination, memory, mood, behavior and reasoning are affected. In the older population dementia is not a health concern. Many cognitive insufficiencies that are severe which affects the daily actions, defines this clinical condition. The shortages include memory loss and other cognitive disorder like agnosia, apraxia, aphasia etc. When someone has dementia, their brain's decision-making, learning, and memory regions are impacted. When dementia happens to older people often then it's caused by AD. An amalgamation of numerous factors is related to this matter in science and health. There is a need to recognize prophylactics to minimize the risk or interval the start. There is growing evidence that caffeine use can reduce the incidence of AD or postpone its onset. Studies shows that intake of caffeine/coffee guards against Mild Cognitive Impairment (MCI) and AD (Heidari and Gobato 2019).

AD is an unbearable and progressive brain complaint that disturbs lots of people around the globe. The utmost cause of dementia, were a collection of symptoms hinder a person's capability to perform day-to-day activities. A condition which is complex that impacts that individual, their friends and family (DeTure and Dickson 2019). The precise cause of AD is not discovered but it's believed that numerous reasons contribute to its growth (Killin et al., 2016). These reasons comprise age, head injury, genetics, heart diseases and lifestyle reasons like exercise and diet (Huang and Mucke 2012). In many cases, AD is a result of a combination of these reasons. One of the assured feature of AD is growth of abnormal protein deposits in the brain called as amyloid plaques (Lehericy et al., 1994). The occurrence of plaques disturbs the nerve cell's steady operation, causing a decline of cognitive capabilities. The protein tangles in the brain named as tau build-up and injury the nerve cells further resulting in a deterioration in cognitive function seen in AD. The AD signs progresses gradually as the time goes on, there is a decline in daily activities like behavior, mood changes, disorientation and memory loss. The neural

damage is spread to the cerebral cortex and other brain areas (Mueller et al., 2010). These symptoms become severe over the time and the person experience problems related to movement, coordination, and difficulty in communicating. In the advanced stage, brain atrophy occurs and the affected person requires fulltime assistance to take care of the daily activities. The figure 1.3 shows normal brain and AD brain differences along with the vital components of the brain for AD diagnosis.

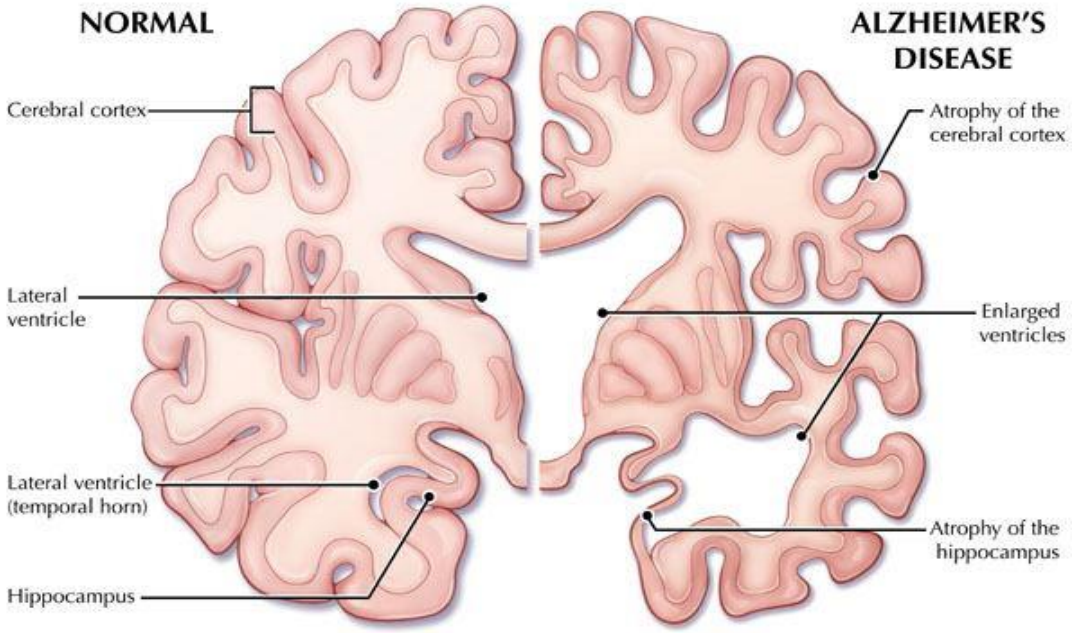

Figure 1.3 Difference between the normal and AD brain and its components

1.3.1 Symptoms of AD in human brain

The symptoms of AD to consider are hippocampal volume, ventricles size and cortex thinning. The vital part of the human brain is hippocampal volume which is accountable for forming long and short term memories and navigation (Anand and Dhikav 2012). The hippocampus is the primary area in the brain that gets affected due to AD and other kinds of dementia. The reason for amnesia and incapability to form new memories are the damage in hippocampus region (Bright et al., 2006). The neural death occurs when there is an amyloid plaques between neurons and tau protein in the neurofibrillary region which blocks the nerve signals. The nerve damage from the

hippocampus region spreads and affects the grey and white matters with respect to shrinkage (Bobinski et al., 1999). The ventricles size of the brain is inflated with disease development by reduction of the brain cortex. The gaps in the brain are rapidly filled by CSF. The volume of CSF is measured which specifies AD severity (Niemantsverdriet et al., 2017). The thinning of cortex is another symptom were the cerebral cortex near the hippocampus is thick at the early stage of the disease. Later, it starts swelling and atrophy occurs throughout the brain structure leading to AD. Hence, the brain structural features are considered as a biomarker of disease.

1.3.2 Stages of AD in human brain and its classification

There are four stages of AD development: mild, moderate, severe, and early. Depending on how severe it is, each stage has a unique set of symptoms. Based on the symptoms, one can forecast the current stage of AD. For few individuals the early stage can prolong for more than 10 years even before the symptoms to begin. The prodromal stage of AD is the mild stage. Since there is now no treatment to reverse AD, early and accurate diagnosis is essential. An early diagnosis of AD is classified as MCI. Early diagnosis is vital for treating individuals with prodromal stage. The severe stage is known as AD, were the individual is completely transformed and is suffering from memory loss and experiencing difficulties to perform daily activities. The complete brain shrinks which is pathologically known as brain tissue atrophy. The vital brain areas and the neocortex have a high multiplication of neurofibrillary plaques and tangles. Individuals at this stage needs assistance to perform simple activities like walking, eating talking and the reflexes also slows down as the infection develops (Porsteinsson et al. 2021).

In order to classify AD using brain images, structural imaging methods such as Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) are utilized to determine the size, location, and creation features of the brain image (Ledig et al., 2018). They are categorized as AD (stage 3), CN, MCI (stage 1), and mild (stage 2). To ascertain whether brain cells in different classifications—such as CN, MCI, moderate, and AD—are inconsistent, image processing technologies are utilized. Standard classifiers are used by researchers to analyze the tissue changes in the brain neuron images (Fung et al., 2019). Images are processed properly to identify the vital bio-markers of AD. Later, the

classification aids to identify whether the individual has normal cognitive brain or affected with MCI/AD. The CN human brain's MRI is shown in Figure 1.4. An MRI of a human brain with MCI is shown in Figure 1.5. The MRI of a human brain with AD is shown in Figure 1.6.

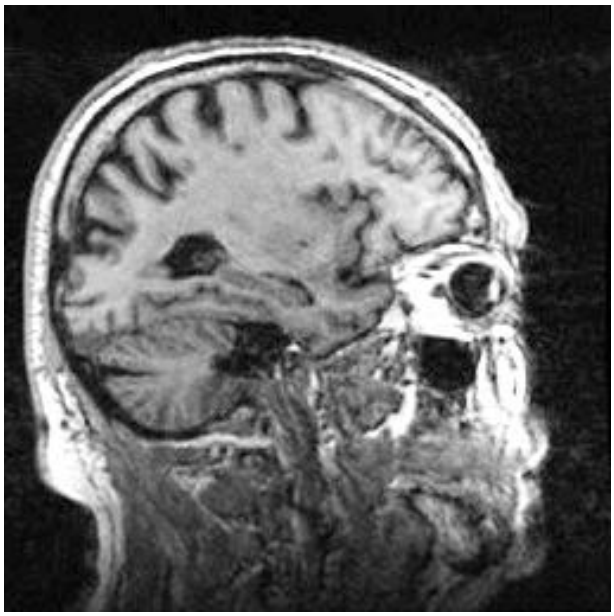

Figure 1.4 MRI of human brain with CN

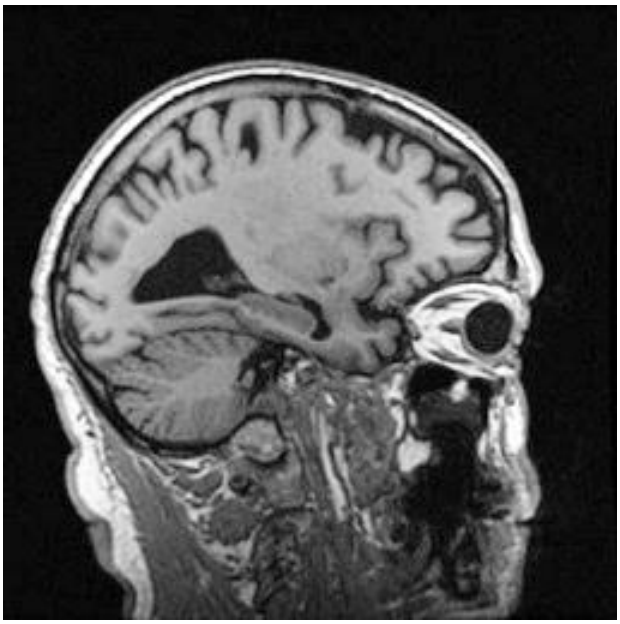

Figure 1.5 MRI of human brain with MCI

Figure 1.6 MRI of human brain with AD

1.3.3 Diagnosis of AD and its types

There are various approaches and there is no single approach to diagnosis whether an individual is affected by AD or not. Medical physicians like neuropsychologists, neurologists, etc. use various techniques and tools for diagnosing AD. The AD diagnosis techniques are given below:

i) Medical history examination: The patient's medical history especially neurological ailment history such as cognitive and behavioral changes are analyzed. Experts analyses the present and the past ailments and medications taken by the patient. Other family members history related to AD or other neurological complaints are also addressed (Burns and Iliffe 2009).

ii) Physical examination: Experts during physical examination looks for issues related to the diet, nutrition, blood pressure levels, body temperature, pulse, heart and lung health, blood and urine profile, overall assessment and type of medication assessment. These tests aids in finding the health issues related to dementia (Porsteinsson et al. 2021).

iii) Neurological examination: Experts during neurological examination looks for issues other than AD such as minor or major strokes, brain tumors, brain fluid buildup and other conditions related to muscle tone, muscle strength, eye movement, speech, memory and thinking declination (Huff et al., 1987).

iv) Mental status examination: Experts during mental status examination looks for problem solving capabilities, memory and mental status assessment. Tests related to overall sense of a person such as whether the person knows the current date and time, simple calculations, can the person follow instructions and remember short word lists (Grossman and Irwin 2016).

v) Mini mental state examination and cognitive tests: A health expert asks the patient a set of questions related to intellectual abilities. The examination is a 30 point test. A patient is assessed based on the score obtained. If a patient scores 20-24 points it shows mild dementia, 13-20 points shows moderate dementia and points less than 12 shows serious dementia AD (Kukull et al.,1994). The cognitive tests are related to memorizing and repeating the names of common objects.

vi) Mood assessment: Experts check for a person's sense of happiness along with their mental health to identify mood disorders and depression caused by memory issue, lack of curiosity and other symptoms which are similar to dementia (Cummings et al.,1995).

vii) Brain imaging: Structural imaging is commonly used for AD diagnosis. Its used to screen other ailments that are similar to AD. Tumors, minor or major strokes, fluid buildup, severe head damages are discovered using structural brain imaging (Johnson et al., 2012).

1.3.4 Impact of AD

A neurological ailment that develops over time. Few of the symptoms are reasoning, memory and behavioral issues. The impact it creates for that particular individual and their friends and family are terrific. The impacts of an AD are given below:

i) Memory loss: An individual is struggling to remember things and remember recent event happenings.

ii) Difficulty with everyday chores: An individual is struggling to do routine tasks like cooking, cleaning, managing finance etc.

iii) Communication difficulties: An AD patient might struggle to express their feeling verbally and trouble related to understanding things.

iv) Mood and behavior changes: An AD patient will experience anxiety, depression, impatient and other aggressive behavior changes.

v) Loss of independence: An AD patient will be dependent on others for performing basic activities like eating, bathing, dressing etc.

vi) Caregiver burden: An AD patient will have an impact on the care givers, family members. They may suffer from emotional, physical and financial tension.

1.3.5 Diagnosis challenges

An automated diagnosis procedure has several problems related to diagnostic process, which lead to incorrect diagnosis that can affect the patient's current status. Hence, it is critical and vital to analyses the issues faced by an automated AD diagnosis system (Hu et al., 2023). Before the system design and implementation there are many challenges related to data, training and testing. They are listed below:

i) Data challenges: There is dataset scarcity, because collecting available medical data is a challenging task. The dimension of a MRI 2D image will be a high dimensional dataset which is challenging to handle. Noisy labels in an open source medical dataset is another challenge. Class imbalance is another challenge because ML algorithms provide equal priority to all classes. When the dataset is large with equal subjects count in each class, then it's challenging due to data scarcity.

ii) Training challenges: During pre-processing, the constraints related to the MRI data such as noise removal, reorientation, registering etc. During feather selection, there are difficulties related to different features and selecting the correct region of interest. In the ML model, hyper parameter tuning related to

number of layers, number of iterations, activation function selection, optimizer selection and terminating criteria are the another challenges.

iii) Testing challenges: A suitable data with all possible variations that should match the real-time scenarios are the biggest challenge related to selecting the correct data. During the evaluation phase, the performance metrics should be applied to the testing data and should be compared with the recent approaches is a huge challenge.

All these challenges are addressed for an efficient AD classification.

1.4 Computational models for AD analysis

In the recent times, clinical examination has advanced in numerous directions such as image capturing, amalgamation, augmentation, segmentation, and visualization. Medical imaging apparatus has advanced imaging principles which can capture various images of cells, organs and tissues that assists doctors in diagnosing medical ailments. Numerous image databases are obtained as a result of advancements in medical image capturing equipment. Advanced computational techniques aids to enhance the accuracy of medical image analysis. There is a need for automated and self-learning models for processing and classifying the medical images.

This section discusses computational models like ML and DL for classifying AD disease. In the evaluation model, a brain cell picture is analyzed to predict the phases of AD. The computational assessment model automatically classifies the normal and abnormal brain neuron images. The image processing is applied to MRI at different phases like preprocessing, feature extraction, segmentation, and classification. These phases ease automation process and aids to classify the MR images of brain. This study aims in engaging ML and DL models to classify several brain neuron images.

1.4.1 Machine Learning

ML have developed swiftly in the medical imaging domain. ML techniques abstract information from the images and characterizes information effectively. ML is the method of learning from the previous experience (Kaushik et al., 2017). Here the

experience consists of features of data occupied in the machine. The machine recognizes any new pattern then the new data is considered as a feature value (Lahmiri and Shmuel 2019). The ML model assists medical professionals to diagnosis and predict the different stages of diseases and avoid them. These models improve the understanding ability of medical professionals and researchers by analyzing the general variations of the disease. ML techniques consist of conventional algorithms without learning model like Neural Network (NN), KNN, SVM, DT, Neuro Evolution of Augmenting Topologies (NEAT), Bootstrap Aggregating (BAGGING) etc.

1.4.2 Deep Learning

Image classification issues can be solved effectively using DL techniques by training the model by using an interpreted image dataset. It can be applied to classify new unnoticed images for detecting the object, segmentation etc. for DL models. DL techniques consist of algorithms with learning model like Convolutional Neural Network (CNN), Recurrent Neural Network (RNN) etc. Out of these DL algorithms CNN is best suitable for image classification because it can achieve high accuracy in numerous image classifications. The reason to use CNN is its ability to identify the local patterns inside an image along with the spatial relationship amidst these patterns. The architecture of CNN consists of convolutional layers (CL), pooling, activation function, fully connected layer (FCL), hidden layers and softmax function for classification process (Dey et al., 2019; Chevtchenko et al., 2018). Figure 1.7 illustrates the CNN architecture. The steps involved in creating a CNN model are given below:

i) At the initial stage, learning model needs a set of images.

ii) Creating a model with several layers of neural network like CL, pooling FCL.

iii) Training the model with several input images, the model iterates to modify the learning parameters.

iv) Model is evaluated by providing new test datasets to validate its performance.

v) The model is saved and loaded to classify photos from various datasets after it has been trained and verified.

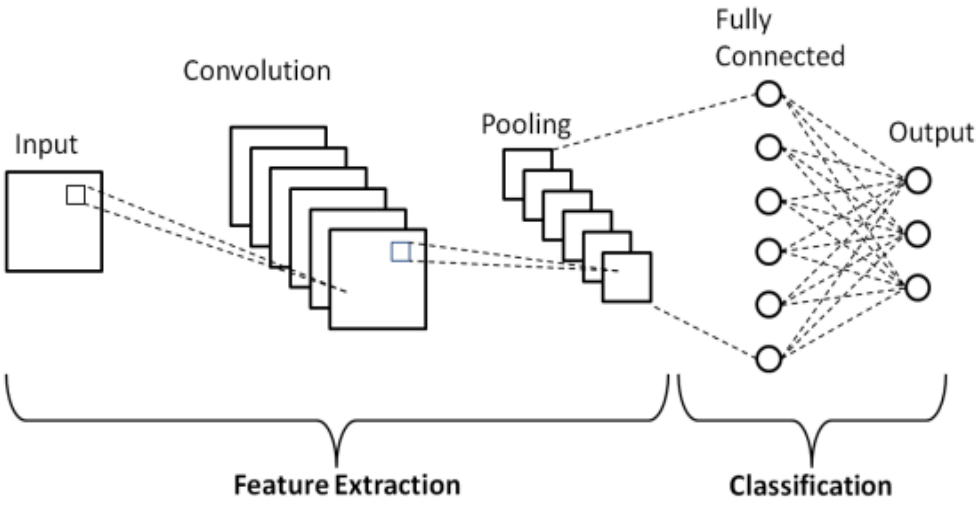

Figure 1.7 Basic Architecture of Convolutional Neural Network

1.5 Problem Statement

Globally every year there is a rise in the patient count affected with dementia. AD causes dementia in adults and is now the next foremost reason of death worldwide. Cognitive functioning issues in older adults are affected by AD. The person's ability is affected which is a challenging to perform the daily routine tasks. There is a lack of awareness related to cognitive damage and dementia precaution. AD can cause destructive impact on social and economic status. Early stage AD diagnosis can lead to a good life with sound mental health. This research emphasis on early detection and classification of AD in older adults which aids to increase the patient maintenance and their life time.

Advanced medical imaging practices, particularly in the brain neuron images, support the neurologist in choosing suitable treatment plan, discovering anomalies present in the human brain. Innovative and computationally progressive methods for brain neuron image analysis are required to create qualitative valuations in AD classification. The identification of AD from brain neuron images involves a computerized system to categorize the neuron images. Hence, an automated system to categorize AD at an early stage through organized screening procedure is mandatory to provide a more accurate diagnosis.

1.6 Research Objectives

The research objectives are listed below.

Primary Objective: To enhance the classification performance of AD using enhanced Machine Learning and Deep Learning approaches based on an ensemble classification framework.

Secondary Objectives:

- To create a medical image preprocessing framework that eradicates noises in the brain neuron MRIs by applying various de-noising filters to enhance the image deviations and to attain upgraded classification performance.
- To segment the process of skull removal from the brain neuron image by applying thresholding methods to obtain a perfect image of the brain structure. This process aids to simplify the classification accuracy.
- To enhance the feature extraction performance by applying CNN-based methods which increase the classification performance accuracy.
- To forecast and categorize the AD stages using hybrid ensemble classification algorithms for effective classification.

1.7 Research Significance

Certain significant contributions in this research are deliberated in brief.

- Image pre-processing is carried out in two phases: de-noising and segmentation
    - Initially, various filtering techniques such as Weiner, Weighted median and adaptive are applied to remove noise in neuron MRI. Then, a hybrid de-noising technique for the brain neuron images is proposed by combining Adaptive Filter (AF) and Hampel Identifier (HI) along with the soft and hard thresholding. The proposed hybrid Adaptive Hampel Identifier Filter (AFHI) method effectively handles the various levels of Gaussian noise present in the corrupted grayscale images.

  - Secondly, segmentation is performed in this phase by applying adaptive noise filtering techniques to the neuron image. Here, image segmentation is performed for effective skull stripping operation by applying techniques like region growing technique, histogram based thresholding in Discrete Wavelet Transform (DWT) and Fuzzy c-means clustering are performed. The proposed hybrid segmentation technique named Threshold DWT based using Fuzzy Set Theory (TDWT_FST) performs fuzzy edge detection and morphological operations.

- To address the imbalance problems, a transfer learning approach is used for feature extraction. An AlexNet model for feature extraction, initial layer is transferred, and the CNN features are extracted. This process aids to identify AD at an early stage.
- Classification is carried out from the extracted features using ML algorithms like DT, KNN, SVM, Neuro Evolution of Augmenting Topologies (NEAT), and BAGGING for AD stage classification. In this study, two hybrid classification techniques are proposed.
  - The first hybrid classification technique combines BAGGING and NEAT approaches to classify brain neuron images.
  - The second hybrid classification technique combines BAGGING and SVM approaches to classify brain neuron images.
- The proposed hybrid techniques are endorsed on benchmark datasets: ADNI and OASIS.

1.8 Thesis Framework

The thesis's framework is set out as follows.

An overview of dementia, AD basics, its symptoms, stages, and categorization is provided in Chapter 1 on human brain structure. The diagnosis of AD, its effects and difficulties, and ML and DL models for AD analysis are covered. The problem statement, study objectives, and research importance are all clearly explained. In Chapter 2, a

comprehensive literature review linked to the preprocessing phase, AD disease classification, and various methods are discussed.

In Chapter 3, describes the complete research procedure involved in this study. It briefs all the proposed methods in this study. The pre-trained AlexNet structure which is a CNN based method, system configuration, dataset description, AD levels and dataset distribution based on the different levels are described.

In Chapter 4, the image preprocessing techniques for denoising the neuron image, histogram-based methods and segmentation techniques are discussed.

In Chapter 5, discusses the proposed CNN based method for feature extraction which uses the transfer learning method. A detailed discussion about AlexNet model for feature removal which is a CNN based method.

In Chapter 6, discusses the proposed hybrid BAGGING_SVM classification framework for classifying the neuron images.

In Chapter 7, discusses the proposed hybrid BAGGING_ NEAT classification framework for classifying the neuron images.

The study's conclusion and recommendations for future improvements are given in Chapter 8.

1.9 Summary

This chapter briefs about the sketch of the study explains human brain anatomy along with an explanation of the various parts of the brain like cerebrum, cerebellum, brainstem and the four lobes such as temporal, parietal, frontal and occipital. A synopsis of AD is given, along with information on its symptoms, stages, diagnosis, effects, difficulties in diagnosing AD, and ML and DL techniques for AD analysis. The problem statement, research objectives, and research significance are explained. Finally, the thesis framework is presented.