EARLY SCREENING OF ALZHEIMER DISEASE UTILIZING MACHINE LEARNING APPROACH - AN OVERVIEW

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Abstract— ***The application of Machine Learning within the field of diagnosis is increasing gradually. This can be contributed primarily to the development within the classification and recognition systems utilized in disease diagnosis which is in a position to supply data that aids doctors in early detection of fatal diseases and therefore, increase the survival rate of patients significantly, In this paper the diagnosis of Alzheimer's disease (AD) or mild cognitive impairment (MCI) has attracted the attention of researchers during this field due to the rise within the occurrence of the diseases and therefore the need for early diagnosis. Unfortunately, the character of the high dimension of neural data and few available samples led to the creation of a particular computer diagnostic system. Machine learning techniques, especially deep learning, have been considered as a useful tool in this field. Analyzing magnetic resonance imaging (MRI) is a common practice for Alzheimer's disease diagnosis in clinical research. Detection of Alzheimer's disease is found by the similarity in Alzheimer's disease MRI data and standard healthy MRI data of older people. Recently, advanced deep learning techniques have successfully demonstrated human-level performance in numerous fields including medical image analysis. We propose a deep convolutional neural network for Alzheimer's disease diagnosis using brainMRI data analysis. While most of the prevailing approaches perform binary classification, our model can identify different stages of Alzheimer's disease and obtains superior performance for early-stage diagnosis. The objective of this research study is to introduce a computer-aided diagnosis system for Alzheimer's disease detection using machine learning techniques.***

Keywords: Machine Learning, Alzheimer's disease (AD), Magnetic Resonance Imaging (MRI), Neural Data, Convolutional Neural Network (CNN).

I.INTRODUCTION

Alzheimer's disease (AD) is the most prevailing sort of dementia. It destroys brain cells causing people to lose their memory, mental functions and skill to continue daily activities. Initially, Alzheimer's disease affects a part of the brain that controls language and memory. As a result, AD patients suffer from amnesia, confusion and difficulty in speaking, reading or writing. They often forget about their life and may not recognize their family members. Pathologically it is caused because of intracellular neurofibrillary tangles and extracellular amyloid protein and results in the deposition of plaques which obstruct the communication between the nerve cells resulting in this neurodegenerative disease. Brain Magnetic Resonance Imaging (MRI) has enabled non-invasive investigation of AD-related changes in the brain. Early detection is critical for effective management of Alzheimer's disease (AD) and screening for Mild Cognitive Impairment (MCI) is common practice [1]. Among several techniques that are applied to assessing structural brain changes on Magnetic Resonance Imaging (MRI), Convolutional Neural Network (CNN) has gained popularity in automated feature learning with the utilization of a spread of multilayer perceptron.

Machine learning is being widely used in various medical fields. Advances in medical technologies have given access to better data for identifying symptoms of various diseases in early stages. Alzheimer's disease is a chronic condition that leads to degeneration of brain cells leading to memory enervation. The aim of this paper is making use of machine learning algorithms to process this data obtained by neuroimaging technologies for detection of Alzheimer's in its primitive stage.

II. STAGES OF ALZHEIMER'S

Alzheimer's has mostly severe physical and psychological effects on the person with Alzheimer's and his family. Alzheimer's normally starts with a slow progression and gets worse increasingly as time progresses. At the beginning of this disease, the first symptom that appears is memory loss. In the advanced stages, Alzheimer's symptoms become more serious [2]. Alzheimer's disease typically progresses slowly in three general stages: early, middle and late.

A. Early-stage Alzheimer's (mild)

In the early stage of Alzheimer's, a person may function independently. He or she may still drive, work and be part of social activities. Despite this, the person may feel as if he or she is having memory lapses, such as forgetting familiar words or the location of everyday objects. Symptoms may not be widely apparent at this stage, but family and close friends may take notice and a doctor would be able to identify symptoms using certain diagnostic tools, Common difficulties include:

- Problems in remembering new facts
- Having difficulty performing tasks in social or work settings.
- Forgetting material that was just read.
- Losing or misplacing a valuable object.
- Experiencing increased trouble with planning or organizing.

B. Middle-stage Alzheimer's (moderate)

Middle-stage Alzheimer's is typically the longest stage and can last for many years. As the disease progresses, the person with Alzheimer's will require a greater level of care. During the middle stage of Alzheimer's, the dementia symptoms are more pronounced. The person may confuse words, get frustrated or angry, and act in unexpected ways, such as refusing to bathe. Damage to nerve cells in the brain can also make it difficult for the person to express thoughts and perform routine tasks without assistance. Symptoms, which vary from person to person, may include:

- Being forgetful of events or personal history.
- Feeling moody or withdrawn, especially in socially or mentally challenging situations.
- Being unable to recall information about themselves like their address or telephone number, and the high school or college they attended.
- Requiring help choosing proper clothing for the season or the occasion.
- Having trouble controlling their bladder and bowels.
- Experiencing changes in sleep patterns, such as sleeping during the day and becoming restless at night.
- Showing an increased tendency to wander and become lost.
- Demonstrating personality and behavioral changes, including suspiciousness and delusions or compulsive, repetitive behavior like hand-wringing or tissue shredding.

C. Late-stage Alzheimer's (severe)

In the final stage of the disease, dementia symptoms are severe. Individuals lose the ability to respond to their environment, to carry on a conversation and eventually, to control movement. They may still say words or phrases, but communicating pain becomes difficult. As memory and cognitive skills continue to worsen, significant personality changes may take place and individuals need extensive care.

- Require around-the-clock assistance with daily personal care.
- Lose awareness of recent experiences as well as of their surroundings.
- Experience changes in physical abilities, including walking, sitting and eventually, swallowing.
- Become vulnerable to infections, especially pneumonia.

The person living with Alzheimer's may not be able to initiate engagement as much during the late stage, but he or she can still benefit from interaction in ways that are appropriate, like listening to relaxing music or receiving reassurance through gentle touch.

Fig 1: Stages in Alzheimer's disease (AD)

III. SCREENING ALZHEIMER'S DISEASE BY USING MACHINE LEARNING

The application of machine learning in a healthcare context is digital diagnosis. ML can detect patterns of certain diseases within patient electronic healthcare records and inform clinicians of any anomalies. Detection of Alzheimer's disease (AD) is still not accurate until a patient reaches a moderate AD stage. The major challenge in this discussion is the high dimension with the small number of samples in the analysis of brain images. Therefore, machine learning and in their outline, deep learning, has achieved a lot of success. Machine learning methods can overcome these issues[4]. Recently, physicians are using brain MRI for Alzheimer's disease diagnosis. A large number of research works focused on developing advanced machine learning models for AD diagnosis using MRI data [6], the Convolutional Neural Network (CNN) have demonstrated excellent performance in the field of medical imaging, i.e., segmentation, detection, and classification. So, recently researchers have started using CNN models for AD and other brain disease diagnosis.

IV. MAGNETIC RESONANCE IMAGING (MRI)

The primary role of MRI in the diagnosis of Alzheimer disease is the assessment of volume change in characteristic locations which can yield a diagnostic accuracy of up to 87%, Unfortunately, such volume loss is not apparent early in the course of the disease. A classic magnetic resonance imaging (MRI)-based automated AD diagnostic system has mainly two building blocks feature/biomarker extraction from the MRI data and classifier based on those features/biomarkers. there is a significant connection between the changes in brain tissues connectivity and behavior of AD patient, The changes causing AD due to the degeneration of brain cells are noticeable on image from different imaging modalities, e.g., structural and functional magnetic resonance imaging (sMRI, fMRI), Positron Emission Tomography (PET), Single Photon Emission Computed Tomography (SPECT) and Diffusion Tensor Imaging (DTI) scans. Several researchers have used these neuroimaging techniques for AD Diagnosis [3]. In neuroimaging, the main task is labeling anatomical structures in magnetic resonance imaging (MRI) brain scans with accuracy. For clinical decision-making, regional volume measurement is important, as well as accurate segmentation. Therefore, neuroimaging makes an optimistic prognosis more likely, and assessments by structural MRI (sMRI).

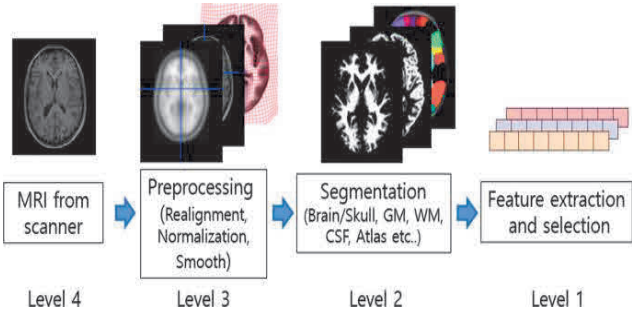

Fig 2: Image classification

V. CONVOLUTIONAL NEURAL NETWORK

An automated image recognition method, the CNN has attracted widespread research attention with tremendous success in recent years. A convolution layer in the CNN model is typically composed of two segments: Feature Extraction and Feature Mapping. This unique network structure can effectively reduce the complexity of feedback neural networks, which characterizes the CNN model. With the CNN, each input image is passed through a series of convolution layers: filtering layers (kernels), pooling layers, and fully connected layers (FCs).[5] CNNs can directly accept images data as input, utilize spatial

information embedded in adjacent pixels, and effectively reduce the number of model parameters by using local receptive fields, weights sharing, and subsampling. When a CNN model is trained with MRI slices, image features can be automatically retrieved, eliminating the need for manual selection of features for the learning process.

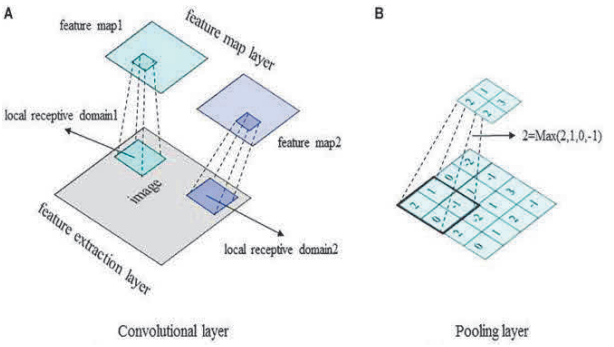

Fig 3: CNN Layer classification

These are the core layers of this class of networks. The convolutional layer obtains its output by applying the convolutional operation with different trainable kernels to the entire input, using a sliding window method to produce several feature maps containing different characteristics of the input marked in the feature extraction layer. The pooling layer segments the image into slices along with these above layers, then the CNN classification is described as:

$$C(n)=(\sum i=1kIn+i\cdot f(n)) +b$$

Where *I* is the input channel, *f* the filter, *k* the size of the filter, and *b* the bias.

VI. PROPOSED MODEL

The proposed model can classify different stages of Alzheimer's disease and outperforms the of-the-shelf deep learning models. The primary contributions are threefold:

1. It proposes a deep Convolutional Neural Network that can identify Alzheimer's Disease and classify the current disease stage.
2. The proposed network learns from a small dataset and still demonstrates superior performance for AD diagnosis.
3. It presents an efficient approach to training a deep learning model with an imbalanced dataset.

The input MRI is an image classifier which identifies the level of stages, the proposed model is a 2D architecture devising an approach to convert the input data to 2D images. For each MRI data, the image slices will be then created from three physical planes of imaging: axial or horizontal plane, coronal or frontal plane and sagittal or median plane.

VII. CONCLUSION

The efficient approach to AD diagnosis using brain MRI data analysis. While the majority of the existing research works focuses on binary classification, this model provides significant improvement for multi-class classification. The Proposed network can be very beneficial for early-stage AD diagnosis. Though the proposed model has been tested only on AD dataset it has been diagnosed with other sets of classifiers, as the proposed approach has strong potential to be used for applying CNN into other areas with a limited dataset. In future, we plan to evaluate the proposed model for different AD datasets and other brain disease diagnosis.

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