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INFLUENCE OF ALZHEIMER'S DISEASE DIAGNOSE FOR USING MRI IMAGES

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ABSTRACT

With millions of victims and a heavy financial and logistical strain on healthcare systems throughout the globe, Alzheimer's disease (AD) is a major public health concern. To effectively intervene and control the condition, an early and precise diagnosis is essential. An advanced system for automating the detection of Alzheimer's disease using MRI image processing is the focus of this research, which takes a close look at its design and execution.

This study explores the possibilities and threats of developing an accurate and efficient automated Alzheimer's disease diagnostic tool by combining cutting-edge image processing methods with machine learning algorithms and artificial intelligence (AI), which has demonstrated encouraging outcomes in medical diagnostics.

The study's first portion delves into the present state of Alzheimer's disease diagnosis, highlighting the shortcomings of conventional procedures and the urgent need for new approaches. Traditional techniques of diagnosis, which mainly include clinical evaluations and neuropsychological tests, may be somewhat laborious, prone to subjectivity, and could not always provide precise findings, particularly when the condition is in its early phases.

There are now more ways than ever before to identify and track neurodegenerative diseases because to medical imaging technology, especially magnetic resonance imaging (MRI). Yet, healthcare providers may incur resource costs and potential interobserver heterogeneity when they manually analyze MRI results.

KEYWORDS: Alzheimer's Disease Diagnose, MRI Images, artificial intelligence, MRI image, magnetic resonance imaging

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INTRODUCTION

AD can be considered as one of the rapidly growing disease in India. Memory loss is the main symptom of the disease. There is no cure exists, but medication and management strategies may temporarily improve symptoms. New techniques have been evolving day by day to detect AD automatically from MRI. Researchers have been trying to explore new, fast and accurate techniques in the last few decades to detect AD automatically. This chapter has focussed on related works reported in literature and theoretical backgrounds that have been explored in the present study. An image carries the information of more than words. Information perceived by human being from an image always get highest preference among the other information for decision making. Last few decades image processing and its applications are rapidly developed in different research areas and gets tremendous importance. The improvement of different imaging techniques has also given helping hand to the enormous growth of image processing. Medical image processing becomes apparent research area of digital image processing along its growth. It is the research area where information retrieved from the medical image is used to diagnose health condition of an individual as normal or have some diseases. Most of the disease of human being occurs inside the body such as brain tumour, Alzheimer's disease, breast cancer, lung cancer, heart diseases etc. With the use of medical image processing it becomes possible to diagnose and treat these diseases effortlessly. The centre of interest of present research work is on Alzheimer's disease (AD). Alzheimer's is one type of brain disease. A medical imaging technique that produces the image of inside of human body mainly includes x-ray, computed tomography, ultrasound, magnetic resonance imaging, positron emission tomography. The selection of medical imaging technique depends on the circumstance of the patient. For example if a patient has some bone problem then it is suggested to take x-ray of the particular body part of the patient. The present research work focuses on magnetic resonance image processing for diagnosis of Alzheimer's disease.

ALZHEIMER'S DISEASE

Dr. Alois Alzheimer first described about the Alzheimer's disease (AD) in 1906. AD is the most common and uncured brain disease that has been affecting more than 1 million people per year in India ([4], [5]). It is a neurodegenerative disease. It starts

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slowly but progressively gets worse over time. AD causes the brain cells and their interconnections to degenerate and die. It mainly causes problems with human memory system. The first symptom of AD can be difficulties in remembering things, as the degeneration of brain cells progresses with the disease, more symptoms can be noticed like- changes in mood and personality, problems in communication, difficulties in remembering name of known people or place or recent events. In severe case, AD makes people unable to complete their day to day task by themselves. They completely become dependable to other person. The early symptoms of AD are often ignored as normal sign of aging, as brain changing that occurs due to normal aging causes occasional problems with memory. But it is very important to diagnose AD at an early stage so that progression of the disease can be reduced in time. There is no cure for AD but progression of brain damage can be reduced or stop if diagnosed at early stage.

The causes of AD are not clearly understood till now. But there are some factors that researchers have found that originates high risk of AD [5]. Those are as follows.

Age: AD is found as a disease of older people. It mainly occurs at the age of 65 or older. AD may also effects people younger than 65, but that percentage is very less.

Family member: If someone in family (parents or siblings) have AD then he/she is more likely to develop AD.

Genetics: The APOE-e4 gene is found as the most common gene associated with AD.

Mild cognitive impairment: Mild cognitive impairment related to memory problems, always has the increased risk of developing AD.

Cardiovascular disease: The cause of cardiovascular disease may also be the cause of developing AD. The brain performs its functions properly when the heart pumps the blood to the brain. So they are interrelated.

Brain injury: Any brain injury can lead to develop AD.

The stages of AD can be categorized into three categories [5]. The time and symptoms of each stage may vary from person to person. The stages of AD are as follows.

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Mild (early stage): In mild stage, a person may face problems in remembering familiar words or location of important objects but can perform everyday work independently.

Moderate (middle stage): In moderate stage symptoms of AD becomes more prominent than mild. At this stage, a person can face more difficulties in day to day life, like – face problem in paying bills, difficulty in remembering events and even own address or telephone number, confusion about what day it is, becomes moody, change in personality and behaviour and often withdrawn from social activities.

Severe (late stage): At this stage symptoms of AD becomes so much severe that a person needs help to perform daily activities. The person becomes unable to communicate, sit, walk, and give respond to the surrounding environment and also becomes vulnerable to infections.

The diagnosis process of AD includes –

- Study of family medical history
- Neurological exam
- Cognitive test to evaluate memory and thinking
- Blood test
- Brain imaging

It is required to diagnose AD as early as possible so that one can get all the benefits of available treatments and can enhance the quality of life and also get opportunities to receive support services. Although there is no cure for AD as the damage of brain cell is irreversible, there are medications available that can help to improve the AD symptoms. Proper support system can also help the person to improve the quality of life and increase life span.

AD mainly causes death of nerve cells and tissues of brain which makes the brain shrink. Human brain is the most powerful and central organ of human nervous system. Human brain has three parts – cerebrum, cerebellum and brainstem [5]. Cerebrum is the largest part of brain and uppermost region of central nervous system. This is the part of brain which is responsible for remembering, thinking, problem solving, controlling emotions, hearing, vision etc. The cerebrum is divided into two hemispheres, left hemisphere and right hemisphere. It mainly contains cerebral cortex that is the gray matter outer layer of cerebrum. The cortex contains billions of neurons that are

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arranged in specific layers. Below the cortex are long nerve fibres that are axons that connect brain areas to each other called white matter. Gray matter loss of cerebral cortex has been found as a predictive marker for AD detection. The cerebrum also contains many subcortical structures such as hippocampus, basal ganglia. The cerebrum is further divided into four lobes- frontal, temporal, occipital and parietal.

Temporal lobe of cerebrum is the part of brain that is mainly and early affected by AD, but degeneration also spreads into the other lobes with the progression of the disease. Cerebellum is the structure that is located under the cerebrum and is responsible for coordination of movements and balance. Brainstem is located under the cerebrum and in front of cerebellum that connects the brain to the spinal cord and is responsible for many automatic functions such as digestion, breathing, heart rate, body temperature etc. Among these three parts of brain, cerebrum is the part that is mainly affected due to AD. Figure 1 has depicted the different parts of a normal human brain.

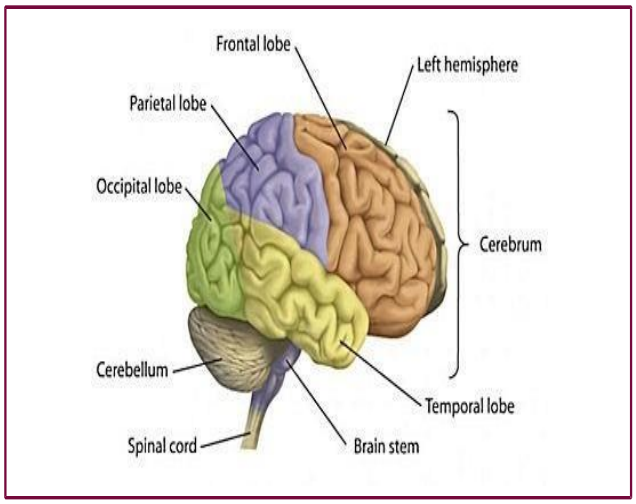

Figure 1- Different parts of a Normal Human Brain

The neuron is the basic working unit of the brain that is designed to transmit information to other nerve cells. Neurons consist of cell body, an axon and dendrites. They transmit information to each other across a tiny gap between them called synapse. A neuron has many extensions called dendrites which are responsible for picking up messages from other nerve cells.

The messages are then processed in the cell body and important messages are passed to the end of the axon, where neurotransmitters cross the synapse and pass on the message to the other nerve cell. Figure 2 shows a picture of neuron. The tissues of AD brain have many fewer nerve cells and synapses than a normal brain. From research on AD it has been revealed

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that plaques and tangles are main cause of death of brain cells and tissues.

Plaques are abnormal clusters of protein fragments; build up in the spaces between nerve cells. The plaques are composed of beta-amyloid which is a protein fragment that affects the functions of surrounding brain cells. The regions of brain that are more susceptible to develop plaques include hippocampus which is responsible for memory function. The damage of this region always reflects symptoms of AD in a person. Tangles are made up of twisted strands of another protein. Tangles destroy the transport system of nutrients among the neurons and prevent the ability of neurons to work together. Plaques and tangles spread through the cortex as the AD progresses.

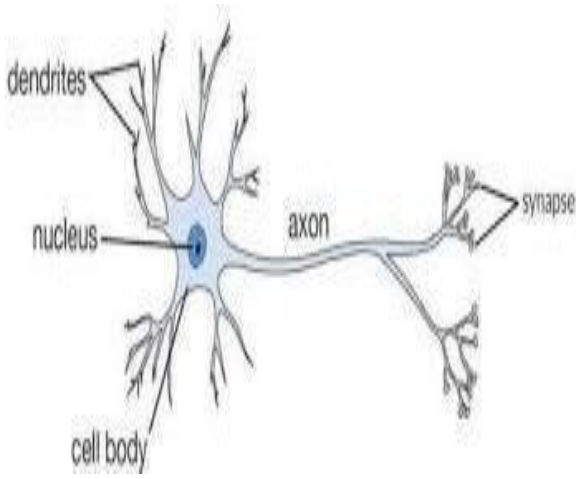

Figure 2 Structure of a Neuron

In initial stage of AD, plaques and tangles are formed in areas of brain related to memory, thinking and planning, and the related structures are – hippocampus, amygdala, cingulated gyrus etc. As the disease progress the formation of plaques and tangles spreads to the other areas of brain that are related to speaking and understanding speech. In the last stage the spreading is so much that it damage the whole cortex almost. According to current developments and clinical research predictive biomarkers of AD, that is found important in AD diagnosis from literature are-

- Atrophy of whole brain

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- Atrophy of hippocampus
- Size and shape of hippocampus
- Medial temporal lobe atrophy
- Cerebral atrophy
- Enlargement of the temporal horns
- Enlargement of third and lateral ventricles
- Atrophy of entorhinal cortex
- Size of amygdala
- Size of cingulate gyrus
- Size of caudate nucleus

Figure 3 has depicted the common structures of brain that are affected by AD considering coronal view of MRI [11].

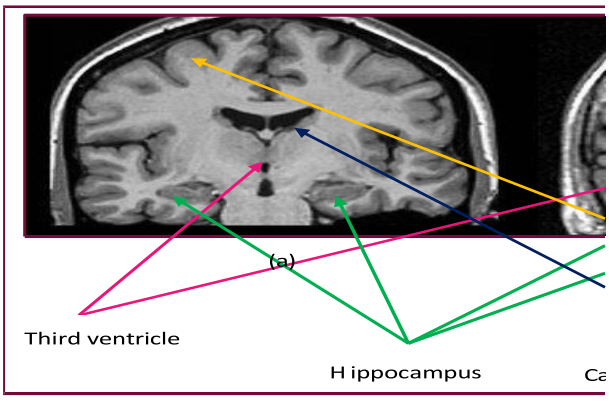

Figure 3 Common structures of brain affected by AD in coronal (a) Normal, (b) ADMRI

CHALLENGES

- Human brain is a very complex non-linear structure. It requires correct and detail knowledge about the anatomy of brain to work on it.
- Variation in size and shape of brain is a challenge to work on it.
- We cannot have the normal and AD image for the same patient.
- Intensity inhomogeneity of MRI.
- It also requires basic knowledge on radiology to understand the MRI images.

CONCLUSION

The findings of the present research work of analysis and detection of Alzheimer's disease from MRI images has been included in this study. Different features have been extracted from MRI considering the whole brain as region of interest and also considering hippocampus as a region of interest. The different features that have been considered for experiment includes cortical thickness, perimeter of brain, hole size of brain, boundary distance, atrophy of hippocampus, shape of hippocampus and fusion feature. Details of these features have been discussed in the study. These extracted features have been analyzed with GRBF kernel SVM and k-NN classifiers.

The classification results have been discussed in details in the study. Among these features cortical thickness, atrophy of hippocampus, shape of hippocampus and fusion features have given good classification accuracy with both the considered classifiers.

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