The normal pressure hydrocephalus health and social care essay

CHAPTER 1

Introduction

Human brain is the most complex structure in the human body. Brain is the most challenging organ in the human body for the physicians to understand and treat. It is made up of more than 100 billion nerves that communicate through trillions of connections called synapses. It plays an important role in every human activity. Any minute change in the human brain affects the person to a greater extent. Any injury to brain, deformities, tumors or disease affects the brain tissues. There are many diseases which affect the brain and are related to memory. One of the diseases is dementia.

Dementia

Generally memory related diseases are termed as dementia. There are many types of dementia and an overview of them is presented below.

Creutzfeldt-Jakob disease (CJD)

It is also referred as ‘ Mad Cow Disease’. The infectious agents named prions cause CJD. CJD affects adults in the age group of 40-60. During corneal transplantation there is a possibility for this disease to be transmitted through infected medical equipment. There is a rapid progression for this type of dementia. This may cause problems like less attention, low concentration. Also there may be some problems related to appetite, vision and coordination.

Head Trauma

A single major head injury or repeated head injuries cause this type of dementia. The impact of the disease depends on the position and the severity of the injury. This type of dementia results in amnesia and memory loss. Mostly this dementia is found to affect young males who are engaged in risk-taking behaviors. This may also cause irritability, attention problems, depression, apathy and other personality changes.

Huntington's Disease

This disease affects cognition, emotion and movement. It is an inherited disease. It is most commonly found in children before 4 years of age and elders above 85 years of age. Difficulty in retrieval of memories, executive functioning problems and impaired judgment are symptoms of this type of dementia. Delusions and hallucinations may occur when the disease becomes severe. Lewy Body DiseaseIn some brain cells the protein alpha synuclein may deposit inside. This leads to this type of dementia. Perception, thinking and behavior are impaired by this deposit, called as Lewy bodies. There may be a fluctuation in alertness and severe problems in sleep. A vivid visual hallucination is also a symptom of this dementia.

Normal Pressure Hydrocephalus

The cerebrospinal fluid may increase abnormally in the brain's cavities, resulting in pressure on the brain. People affected by this dementia have problems with walking and balance and also impaired bladder controlParkinson's DiseaseParkinson's disease is related with the problems in the movement. The balance and motor skills may be affected by this

disease. This disease mostly affects cognitive functioning. People may suffer from depression, difficulty in memory retrieval and executive functioning problems. Pick's DiseaseIt is the frontotemporal dementia and affects the frontal and temporal lobes of the brain. This disease is most commonly found in people of 50-60 years of age. It results in personality changes, deterioration of social skills and lack of empathy and emotion. The affected person may become apathetic or agitated in its advanced stage. Vascular DementiaThis type of dementia is due to impaired blood flow to the brain. This is becsuse there may be complete blockage or narrowing of the blood vessels in the brain. This dementia can result from several small strokes, diabetes or hypertension. Wernicke-Korsakoff SyndromeWernicke-Korsakoff syndrome results from a thiamine deficiency (Vitamin B1). Severe alcoholism, general malnutrition or the effects of chemotherapy are the sources for this disease. This type of dementia causes communication problems and severe memory impairment. The confusion, apathy and hallucinations may also result because of this syndrome. Alzheimer DiseaseAlzheimer's disease (AD) is a disorder which is irreversible and progressive and the neurons (brain cells) deteriorate. This results in the loss of cognitive functions such as memory, pattern reocognition. It also affects the judgement and reasoning and movement coordination. The condition predominantly affects the cerebral cortex and hippocampus. There will be a lose mass and shrink (atrophy) of these components as the disease advances. All memory and mental functioning may be lost in advanced stages of the disease. The proportional cases of various dementia is given in Table 1. Table 1. Proportional cases of various dementia

Dementia

Proportion

Alzheimer’s disease (AD)50-75%Vascular dementia (VaD)20-30%Fronto-temporal dementia (FTD)5-10%Dementia with Lewy Bodies (DLB <5%From the above table it is clear that the dementia due to AD has the highest proportion. So a study has been made on AD to identify the causes, detection,

Alzheimer Disease (AD)

Life expectancy being increased, elderly people are facing many issues and one among them is dementia. AD is considered to be the most common form of dementia. Till now, there is no cure for this disease. It may cause death when it becomes severe. It was first described by the German Psychiatrist and neuropathologist named Alois Alzheimer in the year 1906. Some problems such as confusion, trouble with language, irritability and aggression, mood swings, and long-term memory loss are the symptoms of this disease. It mostly affects the old age people at the age group of above 60. AD is the common cause of dementia. Nearly 26. 6 million people lived with AD in 2006 in the world. It is also estimated that it may increase to nearly 100 million by 2050[1]. The cause and progression of Alzheimer disease are not well understood. Research on this disease indicates that it is related with plaques and tangles within the brain. In the cerebral cortex and certain sub cortical regions, there may be a loss of neurons and synapses and this leads to gross atrophy of the affected regions. The temporal lobe, parietal lobe, parts of the frontal cortex and cingulated gyrus are suffered with deterioration. From the research it is found that the people affected by

AD lose some part of memory and forget things frequently compared to normal aging people. The patients lose the thinking ability, reasoning and language skills when the disease progresses. AD patients, if treated in the early stage, the need for health care would be reduced. AD has been a hot research topic currently, and a lot of funding and resources are invested not only for detecting the disease but also for predicting the development of the disease which may help to get treatment at the earliest.

Economic impact

The cost of caring for AD patients is increasing day by day at the international level. To care a loved one with AD, it can cost thousands of dollars. So nearly hundreds of billions of dollars are needed to care for this type of patients. It may become one of the most expensive disease in the history. Currently in America 15 million people provide 210 billions of dollars for dementia patients. For this year it is estimated in America that it may cost 200 billion dollars in addition to 140 billion dollars to Medicare and Medicaid. Currently 5. 1 million Americans are affected by AD [2].

Challenge of Dementia in India

Aging is a human phenomenon. It has a great impact on economically backward countries such as Asia, Latin America and Africa. In India the population is growing rapidly. This requires meeting the needs of the older people which is more challenging and an urgent one. As per the 2001 Census [3] India has more than 70 million people are above 60 years of age. This age group is 7. 5% of the total population in 2001, is expected to increase in the coming decades. This may be doubled in every 5 years with the proportional increase in people affected with dementia. Hence, India is

expected to be the country with the largest numbers of old age people with this problem. The evidence on dementia pervasiveness in India has increased during the last 10 years considerably. Over 3. 7 million people among whole population are affected by dementia in our country. It is expected to double by 2030 without any doubt. The number of people affected by AD and other dementias is increasing over years. In 2025, UK is projected to have 1 million people with dementia (Dementia UK Report, 2007). Based on the current estimation, India has more than 3 million and may overtake USA by 2015[4]. The Alzheimer's and Related Disorders Society of India (ARDSI) had been formed and they initiated awareness programmes in 1993 for addressing this growing problem in India. ARDSI tries to increase the awareness of dementia among public in affiliation with the Alzheimer's disease International (ADI). They are involved in care and rights of persons with dementia and their families.

Causes for AD

Depression

People who suffer from depression have the possibility of developing AD according to the study [5]. This study was conducted on 486 people at the age group of 60 - 90 with no dementia. Among them, 134 people had experienced depression in some way and they had sought medical advice. All the people taken for the study were followed for six years. During that period 33 people were affected with Alzheimer's disease. The possibility to develop AD was 2. 5 times more for the people who faced depression. The risk was even higher for people who had faced depression before the age of 60. It was four times more likely to develop Alzheimer's for these people

compared to those with no depression. There is also another theory saying that depression affects two areas of the brain, the hippocampus and the amygdale leading to the loss of cells, which then contributes to Alzheimer's disease.

Loss of brain cells in hippocampus

According to the study [6], the loss of brain cells available in the hippocampus region of the brain are expected to develop dementia in those people.

A drop in spinal fluid level

A team at Washington University School of Medicine in St. Louis developed a timeline for this disease [7]. They found that a drop in spinal fluid level, is the key ingredient of Alzheimer’s brain plaques. This can be detected even 25 years before the anticipated age of onset. 15 years before the occurrence of the memory problems itself the plaques in the brain become visible. Some of the other symptoms are the increased levels of a protein (tau) in the spinal fluid and the shrinkage of some parts of the brain. They also become evident at around the same time.

Detection of AD

Symptoms

The cells in the hippocampus , degenerate in the early stages of AD and the memory begins to fade. On progress of the disease, more nerve cells die which results in the changes in behavior like wandering and agitation. There is also some degradation in the individual’s ability of performing the routine tasks. When this AD, spreads through the outer layer of the brain (cerebral

cortex), language is impaired. The judgment also declines and emotional outbursts can occur. Finally the affected person lose the ability of recognizing faces and communication. They are also unable to control the bodily functions. Hence they require constant care. In Alzheimer's disease, the sulci, (grooves or furrows) in the brain are widened which is very much noticeable. There is also overall shrinkage in brain tissue which could be clearly seen. There is also considerable shrinkage of the gyri (the well-developed folds of the brain's outer layer). The ventricles, or chambers within the brain which contain cerebrospinal fluid, are noticeably enlarged in size in addition to the above symptoms. Figure 1 shows the brain in normal and AD condition. The left hand side represents cross section of a normal brain and the one on the right side represents a brain with Alzheimer's disease. Figure 1. Healthy vs AD brainMany of the previous research analysis have shown the relationship between the size of the hippocampus and diseases such as epilepsy, Alzheimer’s, and schizophrenia [8, 9, 10]. It is also proved that any person with the above listed diseases has a smaller size of hippocampus compared with a normal person. So it is evident that the reduction of hippocampus is one of the important biomarker for the detection of AD and Schizophrenia. Hence it is important for the clinician and medical practitioner to measure the size and shape of the hippocampus accurately, to study the relationship between the hippocampus and certain pathological conditions. In addition to this, there is also clinical interest to measure the size of hippocampus with reliable automatic techniques.

Need for hippocampus segmentation

Life expectancy is increasing in today's modern world. Dementia is becoming an important issue among the elderly people of age of 60 years and above. Alzheimer's disease (AD) is a common cause of dementia. One obvious symptom of Alzheimer's disease is that people suffering from Alzheimer's disease lose some part of memory and forget things much more frequently than normal people below 60 years of age. On progression of this disease, the patients lose the ability of thinking, reasoning and language skills. AD patients are not only suffering from the disease but also relying on others for their daily health care to lead a normal life. Recently, Alzheimer's disease has been a hot research topic. Lots of funding and resources have been invested in this area not only for detecting the disease in patients but also for predicating disease development to let patients get treatment as early as possible. The HC is the main area affected by AD. There is a shrinkage in this region which is one of the biomarker found in the early stage and can help to control the effect of AD. To diagnose, or control and monitor dementia related diseases, an image of the HC is needed.

Imaging modalities

Medical imaging plays an important role in diagnosing various diseases, injuries, deformities, etc. that occur in organs of human body in the day-to-day life. For viewing the organs in the human body many imaging modalities are used. There are many popular imaging techniques such as X-rays, computed tomomgraphy (CT), single photon emission computed tomography (SPECT), magnetic resonance imaging (MRI), and positron emission tomography (PET) to quote a few. These modalities are non-destructive and

non-invasive which makes them advantageous to diagnose internal organs of the human. MRI is so popular than other because of its resolution and no ionization characteristics. The basic principle, merits and demerits of some of the popular modalities are discussed here.

X-ray

X-radiation containing x-rays is a type of electromagnetic radiation. It was found in 1895 by Wilhelm Conrad Roentgen. The X-rays having photon energies greater than 5-10 KeV (less than 0. 2-0. 1 nm wave length) are termed as hard x-rays and the rays having lesser energy levels are called as soft x-rays. The patient’s part (which is to be diagnosed) is placed before x-ray detector and then it is illuminated with a short x-ray pulse. Then the corresponding part can be imaged. Bones contain a large amount of calcium. Due to its relatively high atomic number, it absorbs x-rays efficiently. This results in reduction of the amount of x-rays reaching detector in the places of shadow of bones, thereby making them clearly visible to the human eye on the radiograph. It is useful in the detection of pathology of skeletal system. But the ionizing radiation is harmful to living tissue.

Computed Tomography (CT)

The CT was found by Sir Godfrey Hounsfield in 1970. The x-ray beam is initially passed through the patient. Each structure present in the exposed region attenuates x-ray beam differently. The difference depends on individual densities. The radiation received by the detector varies according to these densities. This density information is then transferred from detector finally to CT computer. There this information is reconstructed into a cross-sectional image by computer. The main advantage is that it has the ability to

resolve small objects in an image. It can also differentiate small density differences in an image. But the x-rays used here is harmful to the living tissue. There are many applications of CT and to quote a few it is used in the detection of disease such as thyroid disorders, brain disorders, tumors, lymphatic system and inflammation.

Single Photon Emission Computed tomography (SPECT)

It is one type of nuclear imaging. This technique shows the flow of blood to tissues and organs efficiently. The radio isotopes emitting single γ-ray per nuclear disintegration are used by SPECT. One or more gamma cameras are used to produce images. These cameras rotate around the human body completely with 360 for sampling photons from human body. The special features of SPECT are that different regions of different functions show more contrast than planar scintigraphy. It provides better spatial localization. There is also an improvement in detection of abnormal function. The quantification is also improved. There are also some disadvantages such as poor spatial resolution. It founds its application in detecting diseases namely Cerebral glioma, Cardiovascular defects, breast cancer, haemangioma, hepatic tumour and neuroblastoma.

Positron Emission Tomography (PET)

This system uses the tracers which generate positron decay. Two photons are produced in two opposite directions by the positron decay at a time. Special coincidence detection circuitry is used by this system, to detect two photons which are in opposite directions simultaneously and then captures projections on many directions. Some of the special features of PET are the improved image quality, improved sensitivity, ability to acquire shorter scans

with similar SNRs (Signal – to – noise ratios) and the capability to perform multiple scans of a patient at different fields of view in a reasonable time. It also provides improved temporal resolution. PET is applied especially to detect defects related to breast and chest.

Objective of the thesis

To study the HC, segmentation of HC from MRI is needed. We developed seven nearly automatic methods to segment Hippocampus from the MRI of human head scans. People who have lost brain cells in the hippocampus area of the brain are more likely to develop dementia, according to the study [11]. In this study 64 people affected with AD, 44 with mild cognitive impairment (which is memory problem preceding AD), and 34 in normal condition (with no memory or thinking problem) were taken for analysis. MRI scans were taken for all the participants at the beginning of the study. Then again MRI were performed at an average of a year and a half at later of that. During that time, 23 of the people with mild cognitive impairment were affected with Alzheimer's disease. Three of the healthy participants were also under this case. During the beginning and end of the study, a the researchers measured the volume of the whole brain as well as the hippocampus region and calculated the rate of shrinkage in the brain over that time. The people who had smaller hippocampal volumes and higher rates of shrinkage had the possibility to develop dementia two to four times compared to others with larger volumes and a slower rate of atrophy. Currently, a lot of research is going on regarding the segmentation and measurement of hippocampus region. Researchers are trying to find typical feature for the hippocampus which is consistent with AD. There is a demand for the development of

automatic diagnosis method. Full segmentation of the hippocampus is required to measure the size or volume of the hippocampus. The segmentation of the hippocampus is necessary to estimate the volume. The advent of Magnetic Resonance Imaging (MRI) and subsequent development in application environments have increased the need for a powerful tool to segment the hippocampus automatically and reliablyIn earlier days, hippocampus appearing in MRI is segmented manually and using that, other computations like volume were done. Manual segmentation needs a expert and take few hours to segment the Hippocampus. Further, the segmentation is operator dependent. To get more accurate results and to reduce the time taken for segmenting Hippocampus nearly automatic methods were developed. Even though there are many methods an improved, quicker, less complex and reliable method is clearly desirable for segmentation of hippocampus is necessary. The main motivation for this work is to develop an automated hippocampus segmentation methodology using watershed, artificial intelligence techniques and atlas based techniques and also to assess its performance in comparison to the gold standard technique of manual tracing. In order to segment the hippocampus the anatomy of brain and hippocampus should be understood. Though several methods have been developed to segment Hippocampus, all of them need human intervention to segment Hippocampus. It is because the structure of the Hippocampus is very complex surrounded by a large number of tissues. Hence research and development of algorithms is needed to segment Hippocampus automatically. In this thesis, seven methods have been developed to segment Hippocampus. The remaining part of the thesis is organized as followsIn Chapter 2, we present the literature survey on various methods

used for segmenting HC from MRI. In this chapter we also present a brief analysis of different types of segmentation tools , their advantages and limitations. In chapter 3, we present the anatomy of Human Brain and the structure and function of Hippocampus. In chapter 4, we present the basic principles involved in MRI. We also focus on the tissue characteristics vs Imaging characteristics (T1 and T2) and the various types of MRI are discussed. The different orientations are presented and the advantages of MRI had been highlighted. In chapter 5, we present the basic image segmentation techniques. In this chapter we present an overview of the image fundamentals. Followed by that, we present the detailed description about the basic segmentation methods used in our research work, such as Watershed method, Knowledge Based Segmentation and Atlas Based Segmentation techniques. In chapter 6, we present our first method, titled " A Novel Method for Segmentation of the Hippocampus (NMSH), which segments the hippocampus from a single slice of a brain MRI in sagittal orientation. Then we extended this method and present it as our second method titled as " An Approach for Relatively Automated Hippocampus Segmentation (ARAHS)" which can segment the hippocampus from the five slices. We then present our third segmentation method titled " Segmentation of the Hippocampus Based on Watershed Algorithm" (SHBWA). This segments the hippocampus from the coronal orientation of the MRI of human head scans. The 3rd method (SHBWA) is further improved and present it as our 4th method titled " A Novel Method for Segmentation of the Hippocampus Based on Watershed Algorithm"(NMSHBWA). This method segments the left hippocampus and right hippocampus alone without any non-HC. In chapter 7, we present our 5th method which works on the axial

view of the high resolution brain MRI titled " Hippocampus Segmentation based on Priori Shape Model with Region Growing From High-Resolution MRI Of Post-Mortem Samples" (HSPSMRGPS) to segment the left hippocampus. In chapter 8 we present our 6th method which works on the axial view of the high resolution brain MRI titled " A Simple Automatic Tool For Segmenting the Right Hippocampus from Mid-Slices of Brain MRI" (SATSRHMBM) to segment the right hippocampus. In chapter 9, we present our eighth method, titled " A Semi-Automatic Atlas-Based Method for Segmentation of the Hippocampus from the mid slices of brain MRI" (SAABMSH) to segment the right and left hippocampi from the mid slices. In chapter 10 we conclude by presenting the summary of our findings as well as the future directions of the research.