AUTOMATIC SEGMENTATION BASED HYBRID APPROACH FOR BRAIN MRI

Maulik Mangukiya 1, Ritika Lohiya 2

1 ME Student, I.T. Department, Silver Oak College of Engineering and Technology,

2 Assistant Professor, Computer Engineering Department, Silver Oak College of Engineering and Ahmadabad, Gujarat, India
Technology, Ahmadabad, Gujarat, India

ABSTRACT

It is accepted that the onset of disease starts almost decades before appearing clinical symptoms. Developing new pharmacotherapeutic trials need to evaluate the effect of therapy in disease progression and it is ascertained that Neuroimaging based on high quality MR images is a useful way of dealing with this challenge. Various processing methods have been used to diagnose Alzheimer's disease and evaluate strength of it in three major populations (AD, MCI and NC). Each of these methods has suggested that some anatomical structures or anatomically unspecified Regions of Interest (ROI) have been influenced by disease in various grades. This paper aims to survey the recent research in MRI Neuroimaging methods and evaluate the impact of various brain parts in AD diagnosing methods. A number of various regions in all of three main tissues (CSF, GM AND WM) suffer from the effects of disease. It is revealed that temporal lobe, hippocampus and cortex are the most important structures.

1.0 INTRODUCTION

Alzheimer is known as the most common form of dementia between people over 65 years old. There are more than 5 million people in the United States out of 26 million in the world afflicted by the Alzheimer's disease and its financial and psychological expenditures are on the rise continuously [1]. It is anticipated that the number of these people will be twice as now during next 20 years. Native Alzheimer's disease whittles some of capabilities starting with memorial and spreading to lingual, cognitive, behavioural and functional ones but that the onset of disease starts almost decades before appearing these symptoms [2]. Some common clinical tests such as Mini-Mental State Examination (MMSE) or Clinical Dementia Rating (CDR) have been used for diagnosing Alzheimer's disease. The need for finding some new methods for early diagnose of disease led to the definition of a new status named Mild Cognitive Impairment (MCI).

MCI is a transitional state in moving from NC to AD [3]. A person, who has MCI complains about some memory impairments but still can do his/her personal activities and cannot be classified as Alzheimer holder. It has been implied that MCI has 4-6-fold increased risk of converting to Alzheimer's disease beside normal populations and around 50% of them convert to Alzheimer's disease during a period of three years [1]. The need to diagnose Alzheimer's disease in the early stages seems to be crucial. It comes from the fact that pharmacotherapy treatments for preventing disease progression or at least decelerating it must be started as early as possible before widespread infestation of the brain. In addition, developments of new pharmacotherapy treatments need to monitor the influence of drugs in different parts of brain [4]. Diagnostics based on clinical symptoms is prone to error and their test-retest accuracy is very low [5]. The cause of this unreliability could be different educational level of subjects and their cognitive capabilities so that some people can cope with prodromal cognitive impairments. This makes the diagnostic results more confusing. On the other hand, the clinical symptoms of disease are mostly hidden by the late age of disease and appear only when the brain structures have been infested by the disease. It has been proved that histological and pathological onset of

disease starts 10-15 years before manifestation of clinical signals and these pathological symptoms seem to be useful for disease evaluation.

Neuroimaging methods are used for evaluating anatomical degenerations caused by disease. Different imaging modalities such as Positron Emission Tomography (PET) [6-8], Functional Magnetic Resonance Imaging (fMRI) [9-12] and also structural Magnetic Resonance Imaging (MRI) have been used in lots of previous works. Because of high availability, noninvasive nature and high quality, MR Images are suitable for identifying subtle differences in brain anatomies that occur due to the disease development and progression [13]. Finding a few quantitative measures to diagnose Alzheimer's disease and evaluate its progression is considered as objective in some of MRI processing methods. To this end, MR Images of some anatomical brain structures have been studied. In terms of the mass of invasion and its continuance, each of diverse tissues shows different discriminative power and accuracy. In the following, the major anatomical parts in each of three main brain tissues - Cerebrospinal Fluid (CSF),Gray Matter (GM) and White Matter (WM) – are described and their discriminative power in classifying subjects into different pairs of populations (AD vs. MCI, AD vs. NC, NC vs. MCI, MCI-MCI vs. MCI-AD) are evaluated. In other words, subjects supposed to be categorized into five different populations. Those who have their normal control (NC), suffer from mild cognitive impairments (MCI), felt in Alzheimer's disease, MCI subject who remain in MCI (MCIMCI) or MCI subjects who convert to AD (MCI-AD).
Clinical tests are the most common form of tests used for diagnosing Alzheimer's disease. The most commonly used test is MMSE. This examination is used to evaluate the capabilities of the subject under the test including orientation, memory, arithmetic, recall, naming and etc. Total maximum score of the test is 30 and it is assumed that everybody must normally score 26 or above [14-15]. Clinical Dementia Rating (CDR) is another test of this category. It characterizes six major abilities including memory, orientation, judgment & problem solving, community affairs, home & hobbies, and personal care. Its total maximum score is 3 and the minimum normal score for this test is assumed to be 2 [16]. In section 2, some of the most important parts of the brain are explained which are likely to be influenced by AD. They are categorized into their three major belonging tissues (CSF, GM and WM) and the influence of disease on them is investigated. Section 2.1 explores CSF structures, section 2.2 is about GM structures and 2.3 is focused on WM. Afterwards in section 3, evaluating methods are mentioned and discussed whether they are used for evaluating intergroup differences (e.g. difference between AD and MCI groups) or for classification of subjects (e.g. subjects which are classified as NC's or AD holders) which is an important factor in making it a clinically practical system and eliminating or reducing any human manual intervention. In section 4 the results of diagnostics which is done by various methods are compared and based on these comparisons, section 5 concludes which parts of brain are most important in diagnosing AD and in various grades of disease.

2.0 MAJOR TISSUES IN BRAIN MRI

Cerebrospinal fluid, gray matter and white matter are the major tissues which can be used to categorize brain parts into. This paper focuses on these tissues and investigates the impact of AD in each of them.

A.Cerebrospinal Fluid (Csf)

Cerebrospinal fluid or brain juice is the liquid part of the brain, which surrounds it and is located between brain and skull. This liquid is included in ventricle and Sulcus. Researches show that these two parts are influenced by AD. Effects of AD on these parts are mostly in the form of enlarging CSF area [17].

B.Ventricle

Empty spaces within the cerebral hemispheres and brain steam is called ventricle. These empty spaces are filled with CSF liquid and its volume change is an indicator for Alzheimer's disease. It has been revealed that entricle enlarges gradually in AD patients [18]; [5] and can be used as a marker of AD.

1. Sulcus Area

Sulcus or sulci are grooves or fissures of the brain, which are filled with CSF liquid like the ventricle. The volume of the liquid occupying the sulcus can be used as indicator of AD. There is no specific pattern of Sulcus network for all people and everybody has its own peculiar sulcus structure. But some of them are common to all people. Lateral sulcus is one of these common features in all people and volume of CSF inside it has been used as a biomarker in diagnosing AD patients [18]. Furthermore, circular sulcus of the insula and the volume of CSF inside it has pointed out good characteristics in evaluating AD [5].

C. Gray Matter (Gm)

Gray matter is one of two major tissues of the brain body (White Matter &Gray Matter). It consists of cell bodies of neural system in contrast to myelinated nerve fibers, which constitute the White Matter of the brain. Gray matter is degenerated by the AD in various parts of it and Neuroimaging research is focused mostly on this tissue.

2. Cortex Lobes

Four major lobes of cortex –frontal lobe, parietal lobe, temporal lobe, and occipital lobe- are gray matter structures which are interested in diagnosing AD. Volume of temporal lobe has been used as one of the most common discriminative measures for diagnosing AD. Results have revealed a prominent volume loss in MCI and AD holders regarding NC subjects [1, 4-5, 18-23]. This effect has been more eminent in the left side compared to the right side of temporal lobe [1]. In contrast with temporal lobe, volume loss in frontal and parietal lobes are subtle for both MCI and AD subjects with respect to NC [1]. The rate of atrophy in frontal and parietal lobes are almost the same [1] but in temporal lobe there are a noticeable volume loss for MCI and AD holders. It is implied that temporal lobe is more discriminative than the former ones in diagnosing AD and its power is more rousing in the left temporal lobe than the right one. Generally, occipital lobe does not show any considerable volume loss and there is some slight volume increase for MCI and especially for AD subjects [1]. But some of researches show that the regional volumetric measures of occipital lobe can be used in classifying subjects [4]. These ambiguities may arise because of the bias in datasets, preprocessing methods or the way of evaluating results.

3. Hippocampus

Hippocampus as a principTEXl part of temporal lobe has been mostly used for diagnosing AD [1, 5, 13, 20, 24-29]. Although the results show volume loss of hippocampus in MCI and especially AD subjects, but its volume loss is petty compared to that of temporal lobe as its inclusive global anatomical structure [1]. Left hippocampus show more discriminating power than the right one, as it was for the left side of temporal lobe too [1, 30].

4.Entorhinal Cortex

This brain structure is located close to hippocampus and is the main pre-processor and feeder of signals to it. With respect to its spatial location and adjacency to hippocampus, it seems to be one of the affected parts of the brain in AD. Investigations confirm this hypothesis and assert the differentiating power of it in evaluating group differences and diagnosing disease [4, 28, 31-33]. Some findings also show that Entorhinal cortex is the first anatomical structure which is influenced in MCI subjects even before hippocampus [34].

5. Cortical TicknessAnd Volume

Regional cortical thickness and its shape parameters can be used for differentiating AD, MCI and NC subjects [4, 35-39]. Cortical thickness and volume of cortex have a high discriminative power so that these can be used to avoid some sort of manual errors [4, 40-42]. It is implied that the volume of cortex is more definitive feature than its thickness and diagnostics using its volume are more accurate than those which are based on its thickness [40].

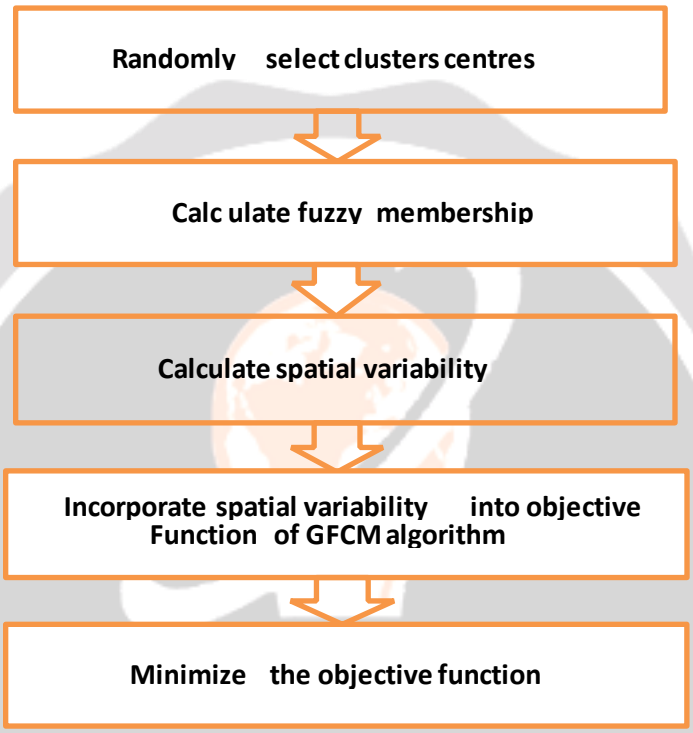
6. Other Region Of Interest (Roi) In Gray Matter

Whole brain has been investigated for finding influenced parts of the brain which can be used to evaluate disease progression [19, 43-44]. These discriminative parts of the brain do not necessarily follow the anatomical boundaries of brain structures and have to be specified by their specific boundaries. To classify subjects, some parts of the brain such as anterior cingulate gyrus extending towards the orbit frontal cortex as well as the sub cortical thalamic-basal ganglia brain areas have been used as well [19, 22]. Volume loss in some of gyries like insula-lingual gyri, parahippocampalgyrus, inferior, middle and superior temporalgyri, fusiform gyri, recentralgyri, inferior, middle and superior frontal gyri, lingual gyri [4, 31-32, 45] have been used to evaluate disease progression. Accordingly, atrophy rate in structures such as amygdala, putamen, temporal pole, frontal pole and some parts of cortex like anterior and posterior cingulate cortices, precuneus cortex, rbitofrontal cortices, isthmus of cingulated cortex [4, 20, 22, 31-32], frontal operculum, transverse temporal cortex, banks of superior temporal sulcus and bilateral accumbens [4], insula [20-21], connections between right frontal regions (inferior frontal, middle frontal and superior frontal gyri) to the substantianigra, right superior frontal gyrus to left medial orbitalgyrus connections and also connections between the caudate and substantianigra and between the right inferior frontalgyrus and right post central gyrus [45] indicate the differences between populations.

D.White Matter (Wm)

In addition to GM anatomies, WM volume is also tested for diagnosing Alzheimer's disease [1, 5, 46-48]. Temporal lobe WM atrophy can be used as a measure in evaluating AD progression [20]. Accordingly, parahippocampal WM and WM areas in regions with direct and secondary connections to the medial temporal lobe has signified a good definitive power in diagnosing AD [49]. It is revealed that white matter volume reductions also can be found predominant in some other areas like superior and inferior frontal gyrus, precentral gyrus, sub-gyrus in parietal lobe, temporal lobe, corpus callosum, inferior longitudinal fasciculus and cingulate fasciculus [50-51].

3.0 EXPERIMENTAL SETUP



Method:

Step 1: Read i/p images

Step 2: Pre- processing (convert into gray image)

Step 3: Apply GFCM algorithm

Step 4: calculate and monitor centroid of random generate centroid

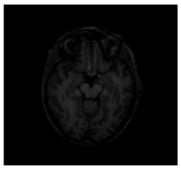
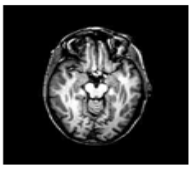
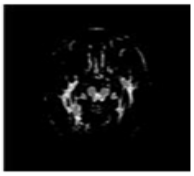
Step 5: For loop for counting membership of fuzzy

Step 6: Count maximum possibility function

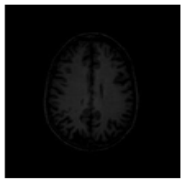
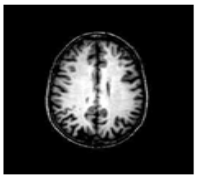
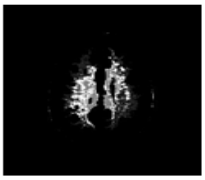
Step 7: Count Value of variability of spatial domain

Step 8: Incorporate spatial variability into objective function

Step 9: Minimize the objective function and then see output

Original image Enhanced image GFCM image

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Name of disease	Method	White Matter volume (%)	CSF volume for cortical region (%)
Control	FCM Proposed method	54.8 64.9	45.2 42.8
Alzheimer's disease	FCM Proposed method	56.5 58.4	43.5 44.7
Dementia	FCM Proposed method	57.1 47.4	42.3 51.2

From table we show that in diseased condition white matter is decreased. In existing method value of white matter is increased but proposed method can differentiate the disease by decrement in white matter. Csf volume in Cortical region is increased in diseased condition.

CONCLUSION:

Fuzzy c-means clustering, Geostatical possibilistic clustering and Geostatical Fuzzy c-mens clustering method are used for automatic detection of WMS in Brains of Elderly people. In these three GFCM clustering is quite efficient and accurate result compare to FCM & GPC. In future I will try to identify different diseases on different level and also calculate area of White matter segmentation.

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