AUTOMATED BRAIN IMAGE SEGMENTATION

SYAHIRAH HUSNA BINTI UDA ZAHLI

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Sesi Pengajian :

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ABSTRACT

This project is about image segmentation application to automatically segment the Magnetic Resonance Imaging (MRI) brain image using thresholding and fuzzy c-means (FCM) methods. Conventional method of brain MRI segmentation is done manually by neuro-radiologists which are time consuming and have significant differences between expertises. Therefore, automatic segmentation would serve as second option with neuro-radiologists. The objective of the project is to analyze the automated brain MRI image segmentation by using thresholding and FCM clustering. Thresholding technique identifies a region based on the pixels with similar intensity values and provides boundaries in images that contain solid objects on a contrast background. This technique gives binary output image from a grey scale image. FCM is an iterative process. The iteration is being repeated until a set point called the threshold is reached or the process stops when the maximum number of iterations is reached. The steps include in the project are pre-processing, segmentation (thresholding and FCM) and performance analysis. FCM method is more accurate compare to the thresholding which the percentage of accuracy is 45.45% compare to 37.50 %.

ABSTRAK

Projek ini adalah mengenai aplikasi penggunaan imej segmentasi automatic yang bertujuan untuk membahagikan imej otak pengimejan resonans magnetik (MRI) menggunakan teknik „thresholding‟ dan „fuzzy c-means(FCM)‟. Secara konvensional proses segmentasi dilakukan secara manual oleh neuro- radiologi yang memakan masa dan mempunyai perbezaan yang signifikan di antara pakar. Oleh itu, segmentasi automatik akan menjadi pilihan kedua oleh neuro- radiologi . Objektif projek ini adalah untuk menganalisis segmen secara automtik menggunakan imej otak MRI dengan menggunakan teknik „thresholding‟ dan „FCM‟. Teknik „thresholding‟ mengenal pasti kawasan berdasarkan piksel dengan nilai-nilai keamatan yang sama dan menyediakan sempadan dalam imej yang mengandungi objek padu pada latar belakang kontras. Teknik ini memberikan imej output binari dari imej skala kelabu. FCM adalah satu proses yang berterusan. Lelaran ini diulangi sehingga titik set dipanggil ambang dicapai atau proses itu berhenti apabila bilangan maksimum lelaran dicapai. Langkah-langkah yang termasuk dalam projek itu adalah pra- pemprosesan , segmentasi („thresholding‟ dan „FCM‟) dan analisis prestasi. Kesimpulannya, kaedah FCM adalah lebih tepat berbanding dengan „thresholding‟ yang peratusan ketepatan adalah 45.45 % berbanding dengan 37.50 %.

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LIST OF ABBREVIATION

MRI – Magnetic Resonance Imaging

DW-MRI – Diffusion Weight Magnetic Resonance Imaging

FCM – Fuzzy C-Means

DWI - Diffusion Weighted Imaging

WM – White matter

GM – Grey Matter

CSF – Cerebrospinal Fluid

LIST OF APPENDIX

NO. **TITLE**

CHAPTER 1

INTRODUCTION

1.1 Project Background

This project is about image segmentation application in medical imaging which aims to segment the MRI brain image using thresholding and fuzzy c-means methods. Image segmentation is very important in medical field. In brain magnetic resonance imaging (MRI), it is been used to detect the brain tissues abnormality, which is the key for diagnosis treatment and planning. The brain tissues that involve in brain image segmentation are white matter (WM), grey matter (GM) and cerebrospinal fluid (CSF) [1]. The changes in the composition of these tissues area used to determine classification of brain disease such as tumours and stroke. The objective of this project is to design automated brain MRI image segmentation by using fuzzy C-means (FCM) clustering method and thresholding segmentation. The technique will be tested on brain MRI. The goal is to analyse the most accurate technique that can separate, cluster and extract the brain tissue types and abnormalities structures in MRI images.

Thresholding method identifies a region based on the pixels with similar intensity values. This technique provides boundaries in images that contain solid objects on a contrast background. This technique gives binary output image from a grey scale image. The main limitation for image segmentation based on thresholding is that only two classes are generated and it cannot be used for multi-channel images [1].To get the desired segmented output we can select either any one or combination of methods based on the application.

Fuzzy c-means (FCM) image segmentation clustering algorithm has been commonly use in medical field but the standard FCM algorithm is sensitive to noise. To overcome the problem a modified FCM algorithm is used by incorporating the spatial neighbourhood information into the standard FCM algorithm and modifying the membership weighting of each cluster. The thresholding is the most simple and commonly used method in image segmentation to detect the contour of the tumour in brain. Therefore, at the end of project we will conclude which methods can produces higher accuracy result.

1.2 Problem Statement

The process of brain MRI segmentation is done manually by neuro-radiologists. The process is time consuming not quantitative, not accurate and have significant differences between expertises. Therefore, radiologists are continuously seeking for computerized tools to ease their diagnosis. Automatic segmentation would serve as compliment and second option with neuro-radiologists. This project will be able to increase the accuracy and performance analysis of MRI brain image segmentation. There are many image segmentation techniques in this field but there is no perfect accuracy. Researchers are continuously seeking for better and improvement technique form the existed techniques. The purpose of the project is to design a method for brain MRI image segmentation that can produce the most accurate performance analysis. Thus, this project can help radiologists to ease their diagnosis. This project also gives benefits for the researcher in this field.

1.3 Objectives

The objective of this project:

1. To design method for brain MRI image segmentation.
2. To analyze the automated brain MRI image segmentation by using modified fuzzy C-means (FCM) clustering method and thresholding segmentation.
3. To analysis which method will produce the more accurate result.

1.5 Scope of Project

The scope of the project is as following:

1. Type of image use is brain diffusion-weighted MRI (DW-MRI).
2. The brain image is focus on normal, tumour and stroke patients.
3. This project concentrates on the process of segmentation and detection of the abnormalities.
4. MATLAB software will be used to develop the algorithms.

1.6 Methodology

1) Literature Review

   Research and information collections of MRI brain image, thresholding method, fuzzy c-means and manual segmentation. The sources are based on journals, internet resources and books.

2) Data collection and pre-processing

   The type of image been used in DCIM. Pre-processing consists of three steps which are normalization, background removal and gamma-law transformation.

3) Manual segmentation by radiologists

   Manual segmentation is done by the radiologists using free hand. The dataset then was transfer to the MATLAB.

4) Design thresholding method

Thresholding method identifies a region based on the pixels with similar intensity values.

5) Design FCM method

FCM method is based on iterative process.

6) Verify the performance of both methods.

Compare the thresholding and fuzzy c-means method with the manual segmentation by the neuro radiologists.

1.6 Thesis Organization

This report contains five chapters. Chapter one describe about introduction of brain image MRI segmentation using FCM and Thresholding techniques, problem statement of the project, objective of the project, the purpose of the project that describe the reason for developing this project, scope of the project and organization of the report.

Chapter two is literature review about the brain image MRI segmentation. This chapter review on previous research about the topic related to the project. Various methods and approaches that related to the project is discussed and reviewed.

Chapter three explains the methodology of the project. This project will used thresholding and fuzzy c-means algorithms techniques. The flow chart of the project and the algorithms use is explained in this chapter.

Chapter four is about results of the MATLAB simulation and discussion regarding the results. Lastly, chapter five will conclude the project findings and recommendation for the further study.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Chapter two is the literature review of the project. In this chapter MRI brain image, brain image segmentation process and the proposed method used are explained in details based on various journals, books and internets resources.

2.2 Neuroimaging

Neuroimaging falls into two categories which are structural and functional imaging. Structural imaging deals with the structure of the brain while functional imaging used to diagnose metabolic diseases and lesions on a finer. There are many brain imaging techniques such as Computed Axial Tomography (CAT), diffuse optical imaging (DOT), Event-related optical signal (EROS), Magnetic resonance imaging (MRI), functional magnetic resonance imaging (fMRI), Magneto encephalography(MEG), positron emission tomography (PET) and Single-photon emission computed tomography (SPECT)[2]. The advantage of MRI is to detect water molecules. In the brain 70% of brain tissues are water. In this research we specified into MRI imaging technique.

2.3 Brain and Its Function

The function of brain is it controls the heart rate, respiratory rate, blood pressure, Autonomic nervous system, Endocrine system, Sensory-motor integration, Intelligences, memory and Consciousness. There are four main regions of the brain which are cerebral hemispheres (left and right), diencephalon, brain stem (Midbrain, Pons, and Medulla oblongata) and cerebellum. White matter is located external and grey matter is centrally located in the brain. There's an additional layer of grey matter internal to the white matter in the cerebrum and cerebellum which is called cortex. Ventricles are CSF filled cavities (the things in blue) situated deep inside the brain. There are two lateral ventricles that have anterior, posterior and inferior horns. The interventricular foramen connects the lateral ventricles and the third ventricle. The cerebral aqueduct connects the third and fourth ventricles together. The fourth ventricle has a few holes called apertures, named by their relative positions, such as the lateral aperture and median aperture. The two lateral apertures provide a conduit for cerebrospinal fluid to flow from the brain's ventricular system into the subarachnoid space. Figure 2.1 show the brain and its part.

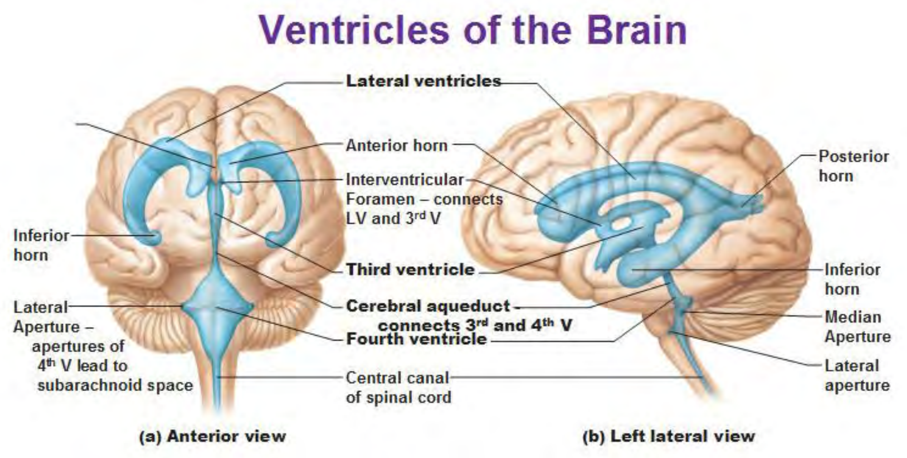

Figure 2. 1: Brain and Its Parts[3]

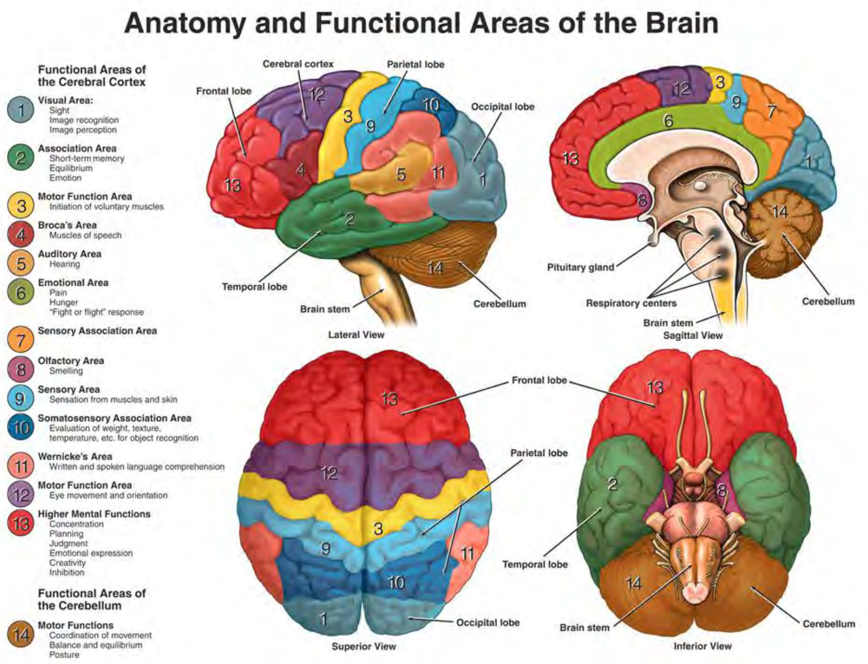

Figure 2. 2:Brain and Functional Areas [3]

Figure 2.2 show that brain and functional areas. White matter is a component of the central nervous system consists mostly of glial cells and myelinated axons that transmit signals from one region of the cerebrum to another and between the cerebrum and lower brain centers. White matter affects how the brain learns and functions, acting as a relay and coordinating communication between different brain regions. The white matter is white because of the fatty substance (myelin) that surrounds the nerve fibers (axons). This myelin is found in almost all long nerve fibers, and acts as an electrical insulation. This is important because it allows the messages to pass quickly from place to place. Grey matter (or gray matter)is a major component of the central nervous system, consisting of neuronal cell bodies, neuropil (dendrites and myelinated as well as unmyelinated axons), glial cells (astroglia and oligodendrocytes) and capillaries [4].

Grey matter contains numerous cell bodies and relatively few myelinated axons, while white matter is composed chiefly of long-range myelinated axon tracts and contains relatively very few cell bodies. Grey matter contains most of the brain's neuronal cell bodies which includes regions of the brain involved in muscle control, and sensory perception such as seeing and hearing, memory, emotions, speech, decision making, and self-control. 20 % of all oxygen taken in by the body will goes to brain and 95% of that go into the grey matter. Figure 2.3 shows the location of white matter and grey matter of the brain.

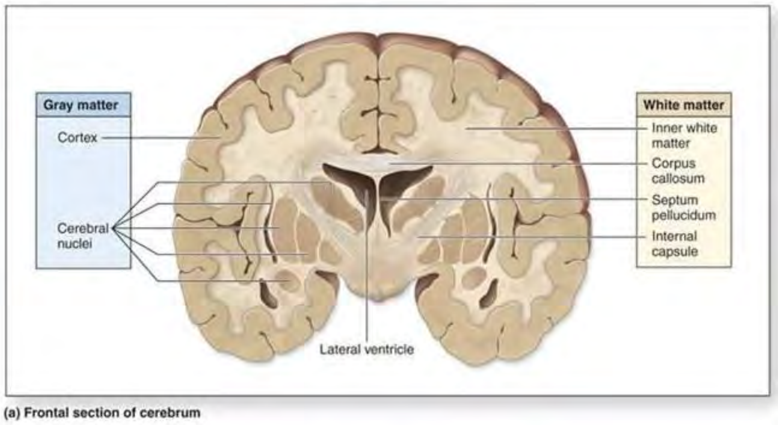

Figure 2. 3: White Matter and Grey Matter of Brain

Cerebrospinal fluid (CSF) is a clear, colourless liquid that is found in the brain and spinal cord. Primary function of CSF is to act as a cushion to the brain within the skull and serve as a shock absorber for the central nervous system. CSF also circulates nutrients and chemicals filtered from the blood and removes waste products from the brain. Examining the fluid can be useful in diagnosing many diseases of the nervous system [5].

2.4 Magnetic Resonance Imaging (MRI)

MRI is based on the principles of nuclear magnetic resonance (NMR). NMR is a technique that provides information about properties of materials. It was developed by Bloch and Purcell in the 1940’s. In the 1970's Paul Lauterbur, Ray Damadian, and Peter Mansfield began to use the principles of NMR in MRI as an imaging modality in the head, spine and body. MRI produces images of high spatial resolution (mm) with good soft tissue contrast that has made it useful for detection of diseases [6]. MRI scanners use strong magnetic fields and radio waves to form images of the body. Unlike the computed tomography (CT) scan or conventional X-ray, MRI does not use radiation. MRI measures the water content in tissues for both normal tissue and abnormal tissue. MRI uses a powerful magnetic field that:

1) Makes the hydrogen protons in water molecules line up in the direction of the magnetic field.

2) Once the hydrogen protons have been lined up, radio waves are used to knock them out of line.

3) When the radio waves are stopped, the protons relax back into line. As they relax, the protons release resonance signals that are transmitted to a computer.

Figure 2.4 show the MRI scanner while Figure 2.5 shows the MRI scanner cutaway. The most commonly use types of MRI scans are the T1-weighted scan and the T2-weighted scan to measure the relaxation time in different ways. Then computer programs will translate these data into cross-sectional pictures of the water in human tissue. Because the layer of myelin that protects nerve cell fibers is fatty, it repels water. In the areas where the myelin has been damaged by MS, the fat is stripped away. With the fat gone, the area holds more water, and shows up on an MRI scan as either a bright white spot or a darkened area depending on the type of scan that is used. Few examples of MRI scan been used is T1-weighted, T2-weighted and FLAIR. These are the most commonly scan used in clinical care.

Figure 2. 4: MRI Scanner