COMPUTER AIDED DIAGNOSIS FOR STROKE PATIENTS BASED ON DIFUSSION-WEIGHTED MAGNETIC RESONANCE IMAGES

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This Report Is Submitted In Partial Fulfillment Of Requirements For The Bachelor Degree Of Electronic Engineering (Industrial Electronic)

FACULTY OF ELECTRONICS ENGINEERING AND COMPUTER ENGINEERING

JUNE 2016

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN

PROJEK SARJANA MUDA II

Tajuk Projek : COMPUTER AIDED DIAGNOSIS FOR STROKE PATIENTS BASED ON DIFUSSION-WEIGHTED MAGNETIC RESONANCE IMAGES

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Specially dedicated to:

My parents for their priceless supports and generous prayers.

ACKNOWLEDGEMENT

Firstly, I am grateful to Allah s.w.t, the most gracious and most merciful for His blessing, grace and guidance in order for me to complete this final year project.

I would like to dedicate this thesis to my beloved parents, Mr. Mohd Noor Bin Mohd Shariff and also Mrs. Normala Binti Isa, who have always been there for me and have been helpful and supportive. It is with my deepest gratitude and warmest affection that I dedicate this thesis to my Supervisor, Dr. Norhashimah Binti Mohd Saad, who has been a constant source of knowledge and inspiration and also to Dr. Mohd Juzaila Bin Abdul Latif from FKM UTeM. Appreciation dedicated to both my seminar panel PSM Dr. Khoo Chin Foon and Mrs. Norbayah Binti Yusop.

I would also like to dedicate this thesis to postgraduate students Ayuni Fateeha Binti Muda and also ADSP Lab members who helped me with this project. Last but not the least I would like to convey my grateful appreciation to my dear family and friends for their unceasing love and encouragement throughout the duration of my study. I have met such inspiring people along this incredible journey.

Thank you.

ABSTRACT

Stroke is a disease that occurs when a blood clot blocks an artery or a blood vessel breaks, interrupting blood flow to an area of the brain. Diffusion-weighted magnetic resonance imaging is increasingly having an important role in the diagnosis of stroke diseases. This medical imaging technique provides higher pathologic or lesion contrast for early stroke detection based on diffusion of water molecules in brain tissues. Key diagnosis and treatment planning is obtained from DWI, in order to assess early signs of acute stroke and to rule out hemorrhage. The major trouble with medical segmentation is the accurate segmentation in improving the treatment and diagnosis of disease due to use of medical imaging techniques. Image segmentation becomes challenging and complex task because of the usual medical image has unknown noise and inhomogeneity. The brain image segmentation is a complicated and challenging task that its precise segmentation is extremely important for detecting stroke. Within this context, this study proposes a technique for automatically detect stroke lesions of acute stroke and chronic stroke. An analytical framework of the stroke lesions consists of three stages which are pre-processing, segmentation, and performance evaluation. For segmentation process, fuzzy C-means integrated with correlation template are proposed to segment the lesion region. The algorithm performance was then evaluated using Jaccard index and Dice index. The results are 0.75 and 0.52 for average Jaccard index acute stroke and chronic stroke respectively.The average Dice index acute stroke and chronic stroke is 0.84 and 0.53 respectively. This method can be used to segment the lesions for acute stroke precisely but not too accurate for chronic stroke.

ABSTRAK

Strok adalah penyakit yang berlaku apabila darah beku menyekat arteri atau saluran darah pecah, mengganggu aliran darah ke kawasan otak. Pengimejan magnetik resonan pemberat-resapan semakin mempunyai peranan yang penting dalam diagnosis penyakit strok. Teknik pengimejan perubatan menyediakan patologis atau lesi yang lebih tinggi untuk mengesan strok awal berdasarkan resapan molekul air dalam tisu otak. Perancangan diagnosis dan rawatan utama diperolehi daripada DWI untuk menilai tanda-tanda awal strok yang teruk dan untuk menolak pendarahan. Masalah utama dengan segmen perubatan adalah segmen yang tepat dalam meningkatkan rawatan dan diagnosis penyakit kerana penggunaan teknik pengimejan perubatan. segmen imej menjadi tugas yang mencabar dan kompleks kerana imej perubatan biasa mempunyai bunyi yang tidak diketahui dan ketakhomogenan. Segmen imej otak adalah satu tugas yang rumit dan mencabar yang segmen tepat adalah sangat penting untuk mengesan strok. Dalam konteks ini, kajian ini mencadangkan satu teknik untuk mengesan secara automatik lesi strok pada strok akut dan strok kronik. Satu rangka kerja analisis daripada lesi strok terbahagi kepada tiga tahap iaitu pra-pemprosesan, pembahagian, dan peningkatan imej. Untuk proses segmen, *Fuzzy C-means* bersepadu dengan templat korelasi dicadangkan untuk segmen rantau lesi. Prestasi algoritma kemudian dinilai dengan menggunakan indeks *Jaccard* dan indeks *Dice*. Keputusan adalah 0.75 dan 0.52 untuk purata indeks *Jaccard* masing-masing strok akut dan strok kronik .Purata indeks *Dice* strok akut dan strok kronik masing-masing ialah 0.84 dan 0.53. Kaedah ini boleh digunakan untuk segmen lesi strok yang akut dengan tepat tetapi tidak terlalu tepat untuk strok kronik.

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B0	=	Magnetic Field Strength
b	=	Diffusion Gradient
S0	=	Intensity signal
δ	=	Gradient time
G	=	Strong Gradient
γ	=	Gamma
ε	=	Termination criteria

LIST OF ABBREVIATION

ADC	=	Apparent Difussion Coefficient
ADSP	=	Advance Digital Signal Processsing
AO	=	Area Overlap
AVM	=	Arteriovenous malformation
CSF	=	Cerebrospinal Fluid
CT	=	Computed Tomography
DCM	=	Dicom
DWI	=	Diffusion Weighted Imaging
FCM	=	Fuzzy C-Means
Fmri	=	Functional Magnetic Resonance Images
GM	=	Grey Matter
GUI	=	Graphical User Interface
MRA	=	MR Angiography
MRI	=	Magnetic Resonance Image
PET	=	Positron Emitted Tomography
PWI	=	Perfusion Weighted Imaging (PWI)

ROI = Region of interest

UTeM = Universiti Teknikal Malaysia Melaka

WM = White matter

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CHAPTER I

INTRODUCTION

1.1 Project Background

Stroke is a neurological disease which affects vessels that supply blood to the brain. Nowadays, stroke is a common disease that's been known among the community. According to the stroke news issue reported by National Stroke Association of Malaysia (NASAM) in 2015, stroke is a second major cause of death in Malaysia [1].Futhermore 1 of 6 Malaysians average at risk of having stroke.

An accurate diagnosis of stroke lesion is extremely important for its treatment and diagnosis. In recent years, computed tomography (CT) has been proven to be an effective imaging modality in the detection, staging, treatment planning, and follow-up of brain lesions. Today, magnetic resonance imaging (MRI) is primilary accepted as the method of choice in most situations where a radiologic investigation of brain lesions is required.

Advanced MRI techniques such as diffusion-weighted magnetic resonance imaging (DWI) images may unveil information on the initial location of the early detection of brain lesion. Because of the advent of this technique in clinical MRI units, recent studies have highlighted the clinical value of DWI images in stroke lesion. DWI has been accepted as the most accurate technique for early detection and diagnosisof stroke lesion. This imaging technique provides high lesion contrast for the lesion compared to other MRI sequences [2].DWI measures diffusion of water molecules within the tissue structure on a pixel basic. Tissues in which water diffusion is reduced can therefore be readily detected as a hyperintense area on DWI images, which has become the hallmark of detection of recent stroke lesion.

In this study, the DWI image will be analyzed to develop stroke lesion detection based on image processing technique. The analysis will involve the preprocessing stage and segmentation algorithms. The image pre-processing stages are applied to the DWI image for image normalization, background removal and image enhancement. Fuzzy C-means and correlation template will be implemented in the segmentation process. The performance of the stroke lesion using DWI image will be verified. A computer aided system for thedetection and segmentation of stroke lesion based on DWI will be developed.

1.2 Problem Statement

Recently we often hear many news about stroke lesion among people. Early and accurate diagnosis of stroke lesion is vital for determining accurate diagnosis. However, the diagnosis is a very challenging task and can only be performed by specialists in neuroradiology. Lesion detection, segmentation or separation of specific ROI is a vital procedure for diagnosis. Computer aided surgery also requires prior analysis of lesion area inside the brain [3]. This process is a challenging process due to the complexity and large variations in the anatomical structures of human

brain tissues, the variety of the possible shapes, locations and intensities of various types of lesions.

MRI imaging is currently the method of choice for early detection of stroke lesion. However, the interpretation of MRI is largely based on radiologist's opinion. The task of manually segmenting stroke lesions from MRI imaging is generally time consuming and difficult. An automated segmentation method is desirable because it reduces the load on the operator and generates satisfactory results [4].Many professional radiology use manual segmentation and this take time for them to classify the type of the lesion. Not only that, not all hospitals have professional radiology and patient need to refer to another hospital. This action leads to the time taken from patient to know the disease that occurs in their brain.

1.3 Objective

The objectives of the project are as follows:

1. To analyze image analysis techniques of stroke lesion detection and segmentation based on DWI mages for computer aided diagnosis (CAD) system.
2. To evaluate the performances of the analysis techniques based on DWI for lesion detection and segmentation.

1.4 Scope of Project

There are several scopes in this project, which are:

1. This study analyzes two stroke lesion based on medical image data on DWI which is acute stroke and chronic stroke.

2. The DWI samples are using diffusion-weighted parameter of b1000. The diffusion coefficient of b0, b500 and apparent diffusion coefficient (ADC) image as well as conventional MRI such as T1, T2 and proton density images are not included in the analysis.
3. The main focus of this study concentrates on the automatic segmentation process of DWI lesions to accurately perform the region of interest (ROI). The technique used is fuzzy C-mean algorithm and correlation template method.
4. The performances of the technique are evaluated using Jaccard index and Dice index.
5. The analysis and simulation are done by using Matlab R2015b software. This research does not include any clinical representation, patient history, histological findings or present solution of the lesion.

1.5 Methodology

1. Literature review

   Review of human brain, magnetic resonance image (MRI) and diffusion-weighted imaging (DWI), stroke lesion diagnosis, segmentation methods in image preprocessing and analysis, region of interest (ROI) and graphical user interface (GUI) design in Matlab software. The sources are based on the journal, internet resources and books.

2. DWI image acquisition

   This study uses clinical DWI on real patients which is acquired at two different institutions which are Universiti Kebangsaan Malaysia Medical Centre (UKMMC) and Kuala Lumpur General Hospital (GHKL) using 1.5 Tesla MRI scanners (Siemens Magnetom Avanto). All samples have been verified and confirmed by neuroradiologists. Images are stored in Digital Imaging and Communications in Medicine (DICOM) format. The acquisition parameters used time echo (TE), 94 ms; time repetition (TR), 3200 ms; pixel

resolutions, 256 × 256; slice thickness, 5 mm; gap between each slice, 6.5 mm; diffusion weighting gradient known as b value, 1000 s/mm2 and total number of slices, 19.

3. Pre-processing stage

   Pre-processing consists of three types which are image normalization, background removal and enhancement.

4. Manual segmentation by radiologists

   Manual segmentation is done by the neuroradiologists using free hand. The data set was then transferred to the Matlab software.

5. Segmentation algorithm

   The process of the segmentation algorithm is by using fuzzy C-means algorithm and correlation template method.

6. Performance evaluation

   The segmentation method of the fuzzy C-means will be compared with the manual segmentation for the performance of both methods.

1.6 Thesis Organization

This thesis contains of five chapters. Chapter one describes about introduction, problem statement, objective and scope that described the reasons for developing this project, thesis methodology and organization of the thesis.

Chapter two is the literature review about the human brain, magnetic resonance image (MRI) and diffusion-weighted imaging (DWI), stroke lesion diagnosis, segmentation methods in image preprocessing and analysis, region of interest (ROI) and graphical user interface (GUI) design in Matlab software.