DEVELOPMENT OF 3D IMAGE VIZUALIZATION AND DIAGNOSIS SYSTEM FOR STROKE PATIENTS BASED ON MAGNETIC RESONANCE IMAGING

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Special dedicated to my parents for their priceless support and generous prayers

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ABSTRACT

Magnetic Resonance Imaging (MRI) uses magnetic fields and radio waves to produce high quality images of the body. This imaging technique is non-radioactive and pain free technique for visualizing and detecting brain lesion without any human involvement. It gives the detailed information regarding the abnormal tissue. The objective of this project is to estimate the detail parameters for features extraction for stroke lesion, to identify the types of stroke lesion using classification process, to visualize the stroke lesion in 3 dimensional (3D) view and to verify the performances of the technique. In this project, the image that captured by MRI will be used as the database for classification process. The region of interest (ROI) is analyzed by taking statistical calculation to obtain the value of features extraction. The different statistical values of abnormalities are classified using rule based classification technique. It will show the characterization of the ROI of different types of stroke, acute or chronic stroke. After classification is done, the performances of the system are verified to ensure the expected results are achieved. The performances of this classification system are accuracy, sensitivity and specificity. After that, 3D images of the stroke lesion are visualized. The results demonstrate that 90% accuracy has been achieved for acute stroke. This will help the physicians in analyzing the brain stroke accurately and efficiently. Finally, the Graphical User Interface (GUI) was developing to make the system more attractive and used friendly.

ABSTRAK

Pengimejan magnetik resonan (MRI) menggunakan medan magnet dan gelombang radio untuk menghasilkan imej yang berkualiti tinggi badan. Teknik pengimejan ini bukan radioaktif dan kesakitan teknik percuma untuk menggambarkan dan mengesan lesi otak tanpa penglibatan manusia. Ia memberikan maklumat yang terperinci mengenai tisu yang tidak normal. Objektif projek ini adalah untuk menganggarkan parameter terperinci untuk ciri-ciri perahan strok lesi, untuk mengenal pasti jenis strok lesi menggunakan proses pengelasan, untuk menggambarkan lesi strok dalam 3 pandangan dimensi (3D) dan untuk mengesahkan prestasi teknik. Dalam projek ini, imej yang ditangkap oleh MRI akan digunakan sebagai pangkalan data untuk proses pengelasan. Rantau kepentingan (ROI) dianalisis dengan mengambil pengiraan statistik untuk mendapatkan nilai berprestij pengekstrakan. Nilai-nilai statistik yang berbeza keabnormalan dikelaskan menggunakan teknik pengelasan peraturan berasaskan. Ia akan menunjukkan kepada pencirian ROI jenis strok, akut atau strok kronik. Selepas pengelasan dilakukan, prestasi sistem disahkan untuk memastikan hasil yang diharapkan tercapai. Prestasi sistem klasifikasi ini adalah ketepatan, kepekaan dan kekhususan. Selepas itu, imej 3D lesi strok adalah digambarkan. Keputusan menunjukkan bahawa 90% ketepatan telah dicapai untuk strok yang tenat. Ini akan membantu pakar perubatan dalam menganalisis strok otak tepat dan efisien. Akhir sekali, grafik antara pengguna (GUI) telah membangun untuk membuat sistem yang lebih menarik dan mesra pengguna.

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μ	-	Mean
σ	-	Standard deviation

LIST OF ABBREVIATIONS

DICOM	-	Digital Imaging and Communications in Medicine
DWI	-	Diffusion-Weighted Imaging
GUI	-	Graphical User Interface
MRI	-	Magnetic Resonance Imaging
ROI	-	Region Of Interest

CHAPTER 1

INTRODUCTION

This chapter will explain about project background, problem statement, objectives and scopes of project. It also explains about thesis methodology and organization of chapter.

1.1 Project background

Magnetic Resonance Imaging (MRI) is a medical imaging technique used in radiology to visualize internal structures of organ tissue in detail. It is widely used for brain disease diagnosis. MRI can create more detailed images of human brain than any possible devices such as Computer Axial Tomography (CAT). An MRI scanner is a device in which a patient lies within a large, powerful magnet where the magnetic field is used to align the magnetization of some atomic nuclei in the body or brain, and radio frequency magnetic fields are applied to alter the alignment of this magnetization with hydrogen atom in tissue molecules [1].

Stroke occurs when blood vessels bringing oxygen and nutrient to the brain burst or clogged by a blood clot or any other particles [2]. Due to loss of oxygen, nerve cells in the affected brain area are not able to perform basic functions which lead to the death of the brain tissue which results in brain damage. The ischemia or infarct can be caused by blood clotting (thrombosis, arterial embolism), or hemorrhage caused by bleeding, which both require opposite treatments. Key diagnosis and treatment planning is obtained from MRI sequences including DWI, contrast enhanced perfusion weighted imaging (PWI) and pre/post-contrast MR angiography (3D MRA). The most important goal of acute stroke imaging is to assess early signs of acute stroke and to rule out hemorrhage. Moreover, it is to assess tissue with risk of dying if ischemia continues [2].

In this project, brain MRI images are analyzed to develop a brain MRI classification system. This project aim is to estimate the detail parameters for features extraction for stroke lesion, to identify type of stroke lesion using classification process, to visualize the stroke lesion in 3D view and to verify and evaluate the performance of the technique. Types of diseases are acute stroke and chronic stroke.

1.2 Problem statement

Accurate diagnosis of stroke lesion is difficult, only a professional neuroradiology can confirm the assessment. It can often be difficult for clinicians to precisely assess the lesion on the basis of radiographic appearance due to overlap intensity and features of different types of lesion. Different types of lesion need different type of treatment. This process is performed visually by trained radiologists with a significant degree of precision and accuracy. Accurate segmentation is still a challenging task because of the variety of the possible shapes, locations and image intensities of various types of problems and protocols. For example, brain stroke

segmentations in conventional MRI performed by experts have approximately 14–22% differences [3]. The process is time consuming, not quantitative and certain conditions need to be calculated.

Accurate automated segmentation technique in brain imaging is desirable to allow interpretation of lesion structures in MRI. Accurate assessment of brain stroke is vital for determining treatment and prognosis. Any difficulty may necessitate more invasive examinations such as tissue biopsy, resulting in additional complications. However, classification of brain stroke is currently still based on histological examination of tissue samples through biopsy [4]. It is difficult to differentiate many brain strokes because of the mimic to another type of lesion which resulted in complicated imaging investigations [4]. Therefore, radiologists are continuously seeking for greater tools to ease the diagnosis. Thorough studies on the brain stroke and its characteristic on DWI are required prior to enhance the classification accuracy. Furthermore, in most settings the task is performed on a 3D data set by labelling the stroke slice-by-slice in 2D, limiting the global perspective and potentially generating sub-optimal segmentations.

1.3 Objective

The objectives of this project are:

1. To estimate the detail parameters for features extraction for stroke lesion.
2. To identify the types of stroke lesion using classification process.
3. To visualize the stroke lesion in 3D view.
4. To verify and evaluate the performance of the developed system.

1.4 Scope of project

Scope of the project is to be determined so that the main objective and goal can be achieved. The scopes of this project are listed as below:

1. This project analyses stroke lesion in brain based on DWI for acute and chronic stroke.
2. Rule-based classifier is used due to its simplicity to design a multi-class classification.
3. The effectiveness is verified based on overall accuracy, sensitivity and specificity.
4. The analysis and simulation are done by using Matlab software. This research does not include any clinical representation, patient history, histological findings or present solution of the lesion.

1.5 Thesis Methodology

1. Literature Review

   Research and collect the information of brain stroke, MRI brain image, MRI, DWI and 3D image. The sources are based on journals, internet resources and books.

2. Data collection

   The type of clinical brain images that acquired at two different institutions which are Universiti Kebangsaan Malaysia Medical Centre (UKMMC) and Kuala Lumpur General Hospital (GHKL) are stored in DICOM (Digital Imaging and Communications in Medical) format.

3. Pre-processing Stage

Pre-processing will be applied to original image. It consists of three steps which are image normalization, background removal and enhancement.

4. Segmentation

Segmentation purpose is to obtain the Region Of Interest (ROI). This process are done manually using hand free tool from MATLAB software.

5. Features extraction stage

Features extraction process is to obtain the information from ROI image. This process was done using first order statistical approach.

6. Classification stage

Rule-based classifier is developed for classifying of the brain lesions into their types of neurological disorders.

7. Classification performance

Evaluation of the performance for both segmentation and classification techniques to show the efficiency of the proposed method

8. 3D Developing

Images are stored in DICOM format will be developed in 3D images.

9. Software Development

System on displaying the brain stroke tissues image will be developing by using MathWorks and Graphic User Interface.

10. Verification

Evaluate and verify the performance of technique in term of effectiveness and efficiency.

1.6 Organization

This report contains five chapters. Chapter one describes about introduction of the project background, problem statement of the project, the objectives of the project, the scope of the project, thesis methodology and organization of the report.

Chapter two is a literature review about the brain stroke. This chapter review of human brain and type of brain disease. It also reviews on Magnetic Resonance Imaging (MRI) and Diffusion-Weighted Magnetic Resonance Imaging (DW-MRI).

Chapter three explains the methodology of the project. From ROI, the methods for features extraction and classification are described in details to classify two types of lesions. The theory of the performance analysis and evaluation are also included and describe briefly in this chapter. After that, brain image is constructed in the 3D image. The flow chart of the project as is explained in this chapter.

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

CHAPTER 2

LITERATURE REVIEW

Chapter two is the literature review of the project. In this chapter, the human brain and type of disease which is acute stroke and chronic stroke are explained. It also explain about magnetic resonance imaging(MRI), diffusion-weighted magnetic resonance imaging (DWI) and graphical user interface (GUI) are explained. It will explain in detail based on various journals, books and internet resources.

2.1 The Human Brain

The brain is the organ that defines a human being as a self and differentiates the human from other animals by its ability to perform higher-order cognitive functions that enable thoughts, emotions, memories, and dreams. Unlike any other organ in the human body, the brain has a multi layered protection and defense mechanism that keeps foreign substance away and maintains a delicate system that ensures a homeostatic milieu. The composition of the brains has 4 major parts which are brain stem, cerebellum, diencephalon and cerebrum. The cerebrum is the largest

part of the brain and it is divided into right and left halves known as cerebral hemisphere. It is divided into four lobes, which are frontal, parietal, temporal and occipital.

The cerebrum consists of grey and white matter tissue and cerebral spinal fluid (CSF) in its cavity and it can be affected by brain disease or lesions [5]. The brain is protected by cranial bones and cranial meanings. It is the control centre for regulating sensation, correlating them with one another and stored information making decisions and taking actions. It is also the centre of intellect, emotions, behaviour and memory. Besides, the different regions of the brain are specialized for different function. Different parts of the brain also works together to complete a certain shared function [5].

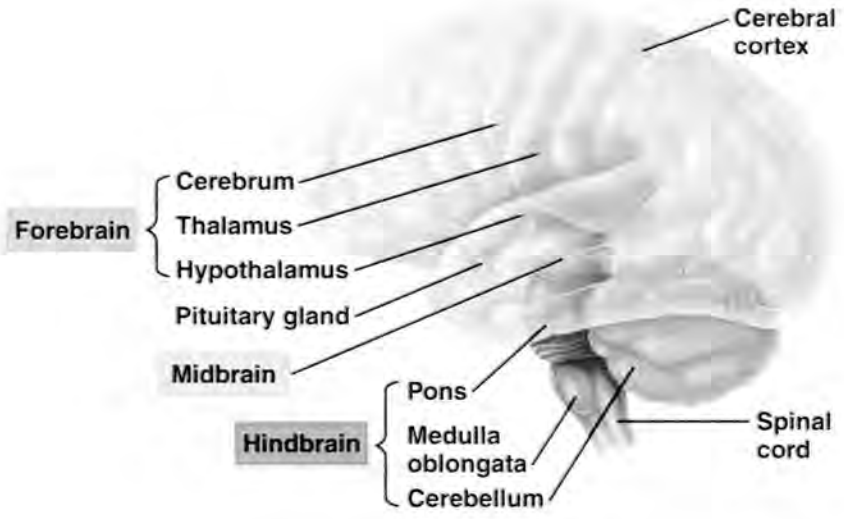

Figure 2.1: Brain image [6]