Faculty of Electronic and Computer Engineering

BRAIN LESION SEGMENTATION AND CLASSIFICATION USING DIFFUSION-WEIGHTED IMAGING (DWI)

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DECLARATION

I declare that this thesis entitle "Brain Lesion Segmentation And Classification Using Diffusion-Weighted Imaging (DWI)" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in the candidature of any other degree.

Signature : .....

Name : AYUNI FATEEHA BINTI MUDA

Date : .....

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Master of Science in Electronic Engineering.

Signature : .....

Name : DR. NORHASHIMAH BINTI MOHD SAAD

Date : .....

DEDICATION

To my beloved family especially my husband; Mohd Hafiz Bin Sulaiman ,my mother; Rohani Binti Abd Rahman, my late father; Muda Bin Jusoh, my father and mother in law; Saliah Binti Ghani and Sulaiman Bin Liudin and my siblings; Norliza Binti Muda, Mohd Nazroi Shukri, Normuslim, Nor Armiza, Adly Hisham, Mohd Aiman and Aishah Masturah, Nurul Asyikin, Mohd Yazid and Nurul Amirah Nadhira.

ABSTRACT

Research and development of brain detection and diagnosis system for brain disorder based on Magnetic Resonance Imaging (MRI) have become one of the most common interest in the past few years. Out of various MRI techniques, Diffusion-Weighted Imaging (DWI) remains the most accurate technique for early detection and discrimination of several brain lesions such as stroke. This study proposed the image analysis technique for automatically segmenting and classifying abnormal lesion structures from DWI. Four lesions namely acute stroke, chronic stroke, solid tumor and necrosis were analyzed. The proposed analysis framework were pre-processing, segmentation, features extraction and classification. Four different segmentation techniques were proposed based on Thresholding with Morphological Operation (TMO), Fuzzy C-Means (FCM), Fuzzy C-Means with Active Contour (FCMAC) and Fuzzy C-Means with Correlation Template (FCMCT) to segment the lesion's region. Next, the statistical parameters from spatial and wavelet transforms were extracted from the Region of Interest (ROI) as features. These features were classified using a rule-based classifier for automatic classification. The results indicate that FCMCT offered the best performance for Jaccard Index, Dice Index, False Positive Rate and False Negative Rate which were 0.6, 0.73, 0.19 and 0.2 respectively. The overall accuracy, sensitivity and specificity for the classification were 89 %, 86 % and 96 %. In conclusion, the proposed hybrid analysis has the potential to be explored as a computer-aided tool to detect and diagnose of human brain lesion.

ABSTRAK

Sejak beberapa tahun ini, pembangunan dan penyelidikan tentang pengesanan dan diagnosis otak untuk kecacatan otak berdasarkan pengimejan magnetik resonan (MRI) telah menjadi salah satu kepentingan. Salah satu diantara teknik MRI ialah Pengimejan magnetik resonan pemberat-resapan (DWI) kekal teknik yang paling tepat bagi pengesanan awal dan diskriminasi beberapa lesi otak seperti strok. Kajian ini mencadangkan satu teknik untuk mengsegmenkan dan mengkelaskan struktur lesi yang tidak normal daripada DWI. Empat lesi yang dikenali lesi tumor, strok akut, strok kronik dan nekrosis telah dianalisis. Analisis rangka kerja yang dicadangkan adalah pra-pemproses, pengsegmenan, pengekstrakan ciri dan pengkelasan. Empat teknik pengsegmenan yang berbeza telah dicadangkan berdasarkan pengsegmenan iaitu teknik ambang dengan operasi morfologi (TMO), fuzzy C-means (FCM), fuzzy C-means dengan kontur aktif (FCMAC) dan fuzzy C-means dengan template kolerasi (FCMCT) untuk mengsegmen kawasan lesi. Kemudian, parameter statistik daripada ruang dan ubahan wavelet diekstrak daripada kawasan yang terpenting (ROI) sebagai ciri-ciri. Ciri-ciri ini telah dikelaskan dengan menggunakan pengelas yang peraturan untuk pengelasan automatik. Keputusan menunjukkan bahawa FCMCT mempunyai prestasi yang terbaik untuk segmentasi berdasarkan Jaccard indeks, Dice Indeks, kadar positif salah (FPR) dan kadar negatif salah (FNR) masing –masing iaitu 0.6, 0.73, 0.19 dan 0.2. Keseluruhan kejituan,sensitiviti dan spesifisiti untuk pengkelasan adalah 89 %, 86 % dan 96 %. Sebagai kesimpulannya, analisis hybrid yang dicadangkan mempunyai potensi untuk diterokai sebagai alat bantuan komputer untuk mengesan dan mengdiagnosis lesi otak manusia.

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2-D	-	Two-Dimensional
AO	-	Area Overlap
BW Area Opened	-	Binary Area Open
CAD	-	Computer-Aided Diagnosis
CSF	-	Cerebral Spinal Fluid
CT	-	Computed Tomography
CWT	-	Continuous Wavelet Transform
Dev	-	Deviation
DICOM	-	Digital Imaging And Communications In Medicine
DNNs	-	Deep Neural Network
DTI	-	Diffusion-Tensor Imaging
DWI	-	Diffusion-Weighted Imaging
Entr	-	Entrophy
FCM	-	Fuzzy C-Means
FCMAC	-	FCM With Active Contour
FCMCT	-	FCM With Correlation Template
FN	-	False Negatives
FNR	-	False Negative Rate
FP	-	False Positive

FPR	-	False Positive Rate
GHKL	-	Kuala Lumpur General Hospital
GM	-	Gray Matter
MRI	-	Magnetic Resonance Imaging
NMR	-	Nuclear Magnetic Resonance
PPUKM	-	Pusat Perubatan Universiti Kebangsaan Malaysia
RF	-	Radio Frequency
ROI	-	Region Of Interest
STIR	-	Short-TI Inversion Recovery
SVM	-	Support Vector Machine
TE	-	Echo Time
TMO	-	Thresholding With Morphological Operation
TN	-	True Negative
TP	-	True Positive
TR	-	Repetition Time
UKMMC	-	Universiti Kebangsaan Malaysia Medical Centre
WHO	-	World Health Organization
WM	-	White Matter