FPGA IMPLEMENTATION ON MRI BRAIN CLASSIFICATION USING SUPPORT VECTOR MACHINE

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ABSTRACT

The field of medical imaging gains its importance with in crease in the need of automated and efficient diagnosis in a short period of time. Brain images have been selected for the image references since injuries to the brain tend to affect other organs. Magnetic Resonance Imaging (MRI) is an imaging technique that has been playing an important role in neuroscience research for studying brain images. The classifications of brain MRI data as normal and abnormal are important to prune the normal patient and to consider only those who have the possibility of having abnormalities or tumor. An advanced kernel based techniques such as Support Vector Machine (SVM) for the classification of volume of MRI data as normal and abnormal will be deployed. Image processing tasks are computationally intensive due to the vast amount of data that requires the processing of more than seven million pixels per second for typical images sources. To keep up with this, a careful and creative data management must be provided. Field Programmable Gate Array (FPGA) is one of the alternatives that offer custom computing platform, sufficiently flexible and fast enough for new algorithms to be implemented on existing hardware

ABSTRAK

Bidang pengimejan perubatan telah menjadi bidang yang sangat penting seiring dengan keperluan dalam diagnosis secara automatic dan cekap dalam tempoh yang singkat. Imej otak telah dipilih sebagai imej rujukan kerana; kecederaan pada otak boleh memberi kesan kepada sebahagian besar organ-organ manusia. Pengimejan resonan bermagnetik *(MRI)* adalah satu teknik pengimejan yang telah memainkan peranan yang penting dalam penyelidikan sains saraf. Pengkelasan imej otak MRI sebagai normal dan tidak normal adalah sangat penting untuk mengurangkan bilangan pesakit normal dan hanya memberi tumpuan kepada pesakit yang berkemungkinan mempunyai ketidak normalan atau wujudnya ketumbuhan. Satu teknik maju berdasarkan *kernel* seperti Mesin Vector Sokongan *(SVM)* digunakan untuk mengkelaskan isipadu data MRI sebagai normal dan tidak normal. Pemprosesan imej boleh dikhususkan dengan menggunakan komputer. Antara sebabnya ialah jumlah data yang sangat banyak memerlukan pemprosesan lebih daripada 7 juta pixel per saat untuk satu sumber imej. Bagi mengekalkan kadar data ini, satu pengurusan data yang terperinci mesti digunakan. *Field Progammable Gate Array (FPGA)* adalah salah satu alternatif yang berasaskan kehendak pengguna. Ia sangat fleksibel di mana algorithm yang baru boleh digunakan terhadap perkakasan, dan pemprosesan yang sangat cepat.

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LIST OF ABBREVIATIONS

AWGN	-	Additive White Gaussian Noise
AMDI	-	Advanced Medical and Dental Institute
ANN	-	Artificial Neural Network
ASICs	-	Application Specific Integrated Circuits
CPLD	-	Complex Programmable Logic Devices
CT	-	Computed Tomography
CEM	-	Constrained energy minimization
DAUB-4	-	Daubechies-4
DSP	-	Digital Signal Processing
DWT	-	Discrete Wavelet Transform
DDR	-	Double-Data Rate
EDS	-	Embedded Development Suite
EM	-	Expectation-Maximization
FPGA	-	Field Programmable Gate Arrays
FLAIR	-	Fluid Attenuated Inversion Recovery
GPP	-	General Purpose Processor
GRE	-	Gradient Echo
GUI	-	Graphic User Interface
GM	-	Gray Matter
WM	-	White Matter
CSF	-	Cerebral Spinal Fluid
K-NN	-	K-Nearest Neighbors
MRI	-	Magnetic Resonance Imaging
MMU	-	Memory Management Unit

MPU	-	Memory Protection Unit
MDTS	-	Multidimensional Time Series
NMR	-	Nuclear Magnetic Resonance
OSP	-	Orthogonal Subspace Projection
PCI	-	Peripheral Component Interconnect
PCA	-	Principal Component Analysis
PLD	-	Programmable Logic Device
PLI	-	Programming Language Interface
QDR	-	Quad Data Rate
SOM	-	Self Organization Map
SNR	-	Signal To Noise Ratio
SE	-	Spin Echo
SVM	-	Support Vector Machine
TPM-s	-	Tissue Probability Maps
VHDL	-	Very High Description- hardware Language

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Medical Imaging techniques such as Computed Tomography (CT), Magnetic Resonance Imaging (MRI) and mammogram are used to scan and analyze the presence or absence of tumor in a patient [1]. MRI is a scanning device that uses magnetic fields and computers to capture images of the brain on film. It does not use x-rays. It provides pictures from various planes, which permit doctors to create a three-dimensional image of the tumor if present. MRI detects signals emitted from normal and abnormal tissue, providing clear images of most tumors [2]. It has become a widely-used method of high quality medical imaging, especially in brain imaging where soft tissue contrast and non-invasiveness are clear advantages. MRI is examined by radiologists based on visual interpretation of the films to identify the presence of abnormal tissue. Brain images have been selected as an image reference for this research because the injuries to the brain almost always affect other organs. The brain controls and coordinates most movement, behavior and homeostatic body functions such as heartbeat, blood pressure, fluid balance and body temperature. It is also responsible for cognition, emotion, memory, motor learning and other sorts of learning.

The classification of brain MRI data as normal and abnormal is important since it can save lives [24]. The shortage of radiologists and the large volume of MRI to be analyzed make such readings labor intensive and cost expensive. Hence there is a need for automated system for analysis and classification of such medical images. In dealing with human life, the results of human analysis involving false negative cases must try to be avoided. A double reading of medical imaging could lead to better tumor detection but this is costly. The idea of using Programmable Logic Device (PLD) is an option to overcome the disabilities. PLDs are invented to address the inefficiencies of implementing logic using memories [4]. They can implement wide functions efficiently (functions with many input variables) and since their logic is programmable; it can be defined by the user and programmed on the desktop. Two major types of programmable logic devices are Field Programmable Gate Arrays (FPGAs) and Complex Programmable Logic Devices (CPLDs). FPGA is a general structure that allows very high logic capacity. Whereas CPLDs feature logic resources with a wide number of inputs (AND planes), FPGAs offer more narrow logic resources and a higher ratio of flip-flops to logic resources than do CPLDs.

1.2 Objective of the research

In this project, we will study, develop and implement an automated system for analysis and classification. The objective of the system is to reduce as much as possible human error and the time consumed in interpreting the image. By accomplishing this project, we hope that it will contribute to the research area not only in engineering but also in medical field. As technologies grow, we are switching to FPGA which is increasingly used as an implementation platform for image processing applications. FPGA has been chosen because of the some advantages given by this chip:

i) fast (to become faster it is possible to design the algorithm in parallel
ii) smaller than a PC for hardware design
iii) low on power consumption in comparison with a PC

1.3 Problem Statement

Manual, or even semi-automatic, classification performed by a trained expert is labor-intensive (hence impractical for processing large amounts of data), highly subjective, and non-reproducible (35). Fully automatic, robust tissue classification is required for the quantitative analysis of MRI data from large-scale (150 - 1000 subjects), possibly multi-site clinical trials or research projects. The MRI intensity scale has no absolute, physical meaning: the image values and contrast are dependent on the pulse sequence, and other variable scanner and post-processing parameters. Thus, the ability of a tissue classification method to automatically adapt to a new MRI dataset is especially important when the data is collected at multiple sites or with several different MRI scanners. An aspect that is often ignored by brain MRI classification schemes is how to adapt to a new MRI dataset in a fully automated manner. Some researchers have addressed this issue:

- The use of stereotaxic space tissue probability maps (a probabilistic brain atlas) for automating supervised classification algorithms was originally pro-posed by [33], and subsequently used by [35].
- Automatic implementations of the popular Expectation-Maximization (EM) statistical classification scheme were proposed by [43] and by [37,38] These methods use a probabilistic brain atlas to initialize, and also to constrain, the iterative EM process.

However these methods can fail for “a typical" brain scans (significantly different from the atlas), such as child brains, or brains with large pathological abnormalities. All these classification methods start by spatially registering the subject's MRI to the probabilistic atlas using a linear (rigid body) transformation. Work quite recently presented by [78] showed that using elastic (non-linear) registration of the subject to the atlas can improve the performance of Van Leemput's method. However, as of this writing these results are preliminary and comprehensive validation is still pending. The contribution of this project is a way to develop an automated system for a classification procedure using wavelet as input to support vector machine. Using of an FPGA as a reconfigurable hardware could increase the ability of system performance.

1.4 Scope of the research

The data is taken from Advanced Medical and Dental Institute (AMDI). From the data, we study and analyze the difference between normal and abnormal MRI brain images. Other images technique such as image de-noising, noise filtering and wavelet transform are also applied to the images using Matlab 2009. Then, the output from the Matlab procedure will be used as the input for classification. The classification of images using Support Vector Machine (SVM) will involve both in Matlab and Visual C ++. The next and final stage is implementing NIOS II to enable the C programs to be embedded into FPGA chips on DE2 board as reconfigurable hardware.

1.5 Dissertation Layout

This is structured as follows. Chapter 1 begins with the introduction of this project. Chapter 2 outlines the literature review of the related work in the area of medical imaging, brain MRI classification and FPGA implementation. Chapter 3 focuses on the image processing of brain MRI and implementation on reconfigurable hardware. In Chapter 4, we will mention the methodology of the project, where it discusses in detail the stages of each process included in the image processing method, classification and algorithm implementation on FPGA using NIOS II processor. Chapter 5 will discuss the result gained in every stage of this project. Chapter 6 will explain the conclusion and future work that could be undertaken to further improve of this project.