UNIVERSITI PUTRA MALAYSIA

IMAGE COMPRESSION BASED ON REGION OF INTEREST FOR COMPUTERIZED TOMOGRAPHY IMAGES

TARIK FARAJ ALI IDBEAA

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By

TARIK FARAJ ALI IDBEAA

Thesis Submitted to the School of Graduate Studies, University Putra Malaysia in Partial Fulfillment of the Requirements for the Degree of Master of Science

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To my parents, wife, daughter,
Brothers and sister

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in partial fulfilment of the requirements for the degree of Master of Science.

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Chairman: Abdul Rahman Ramli , Ph.D.

Faculty : Engineering

The use of computers for handling image data in the healthcare is growing. The amount of data produced by modern image generating techniques, such as Computed Tomography (CT) and Magnetic Resonance (MR), is vast. The amount of data might be a problem from a storage point of view or when the data is sent over a network. To overcome these problems data compression techniques adapted to these applications are needed.

Many classes of images contain some spatial regions which are more important than other regions. Compression methods which are capable of achieving higher reconstruction quality of important parts of the image have been implemented. For medical images, only a small portion of the image might be diagnostically useful, but the cost of wrong interpretation is high. Algorithms which deliver lossless compression within the regions of interest (ROI), and lossy compression elsewhere

in the image, might be the key to providing efficient and accurate image coding to the medical community. In this thesis both of compression techniques (lossy and lossless) of medical images using the JPEG algorithm (DCT), will be discussed.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains.

IMEJ PEMAMPATAN BERASASKAN BAHAGIAN YANG MENARIK UNTUK IMEJ TOMOGRAFI BERKOMPUTER

Oleh

TARIK FARAJ ALI IDBEAA

Mac 2003

Pengerusi: Abdul Rahman Ramli , Ph.D.

Fakulti : Engineering

Penggunaan komputer untuk mengendalikan data imej di dalam penjagaan kesihatan sedang berkembang. Jumlah data yang dihasilkan oleh teknik moden timbulan imej, seperti CT dan MR, sangat besar. Jumlah data mungkin menjadi suatu masalah daripada segi penyimpanan atau bila data dihantar menerusi sesuatu rangkaian. Untuk mengatasi masalah ini, teknik pemampatan data digunakan.

Banyak kelas imej mengandungi beberapa buah kawasan lapang yang mana lebih penting berbanding dengan kawasan lain. Kaedah pemampatan yang boleh mencapai kualiti pembinaan semula yang lebih tinggi telah dilaksanakan. Bagi imej perubatan, mungkin sebahagian kecil imej sahaja berguna untuk diagnosis, tetapi harga bagi salah tafsiran sangat tinggi. Algoritma yang mana menyampaikan pemampatan tanpa hilang dalam kawasan yang menarik (ROI), dan pemampatan hilang lain tempat di dalam imej, mungkin menjadi kunci untuk membekalkan

gambaran asal dan tepat kepada masyarakat perubatan. Dalam tesis ini kedua-dua teknik pemampatan (hilang dan tanpa hilang) dilaksanakan dan dibincangkan ke atas imej-imej perubatan yang menggunakan algoritma JPEG (DCT).

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I would like to express my appreciation to Dr. Abdul Rahman Ramli during this work . His patience and guidance have been invaluable to me. Without the time he has invested brainstorming ideas and discussing results, this project would never have gotten off the ground. However, this is not the most important thing he has done for me. Usually, I see him demonstrating a love for teaching and learning. He has supported me in every way through both the easy and the difficult times. I count myself fortunate to have known and worked with Dr. Abdul Rahman Ramli.

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LIST OF ABBREVIATIONS

MR	Magnetic Resonance
CT	Computerized Tomography
ROI	Region Of Interest
CR	Compression Ratio
MAE	Maximum Absolute Error
ACC	American College of Cardiology
ACR	American College of Radiology
NEMA	National Electrical Manufacturers Association
SNRs	Signal-to-Noise Ratios
PSNR	Peak Signal-to-Noise Ratio
MSE	Mean Square Error
DPCM	Differential Pulse Code Modulation
MF	Multiplier Factor
EPIC	Efficient Protocol Independent Compression
ROC	Receiver Operating Characteristic
DEI	Displacement Estimated Interframe
BPE	Bit-Plane Encoding
MAR	Multiplicative Autoregression
RLE	Run-Length Encoding
DCT	Discrete Cosine Transforms
DWT	Discrete wavelet transform
VQ	Vector quantization
SVQ	Scalar-Vector Quantizes

VLC-ECSQ	Variable Length Code - Entropy Coded Scalar Quantization
HVS	Human Visual System
CU	Coding Unit
RMSE	Root mean square error
ACR-NEMA	American College of Radiology - National Electric Manufacturers Association
DICOM	Digital Imaging and Communications in Medicine
ISO	International Organization of Standardization
PACS	Picture Archiving and Communication Systems
RIS	Radiology Information System
NLIVQ	Non-linear interpolative vector quantization
HIS	Hospital Information System
SS	Scheduling System
JPEG	The Joint Photographic Expert Group
ISDN	Integrated Services Digital Network
APMAR	Adaptive predictive multiplicative autoregressive
ACC-NEMA	American College of Cardiology - National Electric Manufacturers Association

CHAPTER I

INTRODUCTION

1.1 Introduction to Medical Image Compression

Today a lot of hospitals handle their medical image data with computers. The use of computers and a network makes it possible to distribute the image data among the staff efficiently. As the health care is computerized new techniques and applications are developed, among them the Magnetic Resonance (MR) and Computerized Tomography (CT) techniques. MR and CT produce sequences of images (image stacks) each a cross-section of an object. The amount of data produced by these techniques is vast and this might be a problem when sending the data over a network. To overcome this, image data have to be compressed. For two-dimensional data there exist many compression techniques such as JPEG, GIF and the new wavelet based JPEG2000 standard. All of the schemes are used for two-dimensional data (images) and while they are excellent for images, they might not be that well suited for compression of three-dimensional data such as image stacks.

The easy, rapid, and reliable digital transmission and storage of medical and biomedical images would be a tremendous boon to the practice of medicine. Patients in rural areas could have convenient access to second opinions. Patients readmitted to hospitals could have earlier imaging studies instantly available. Rather than waiting for others to finish with hardcopy films, medical and surgical teams collaborating on patient care could have simultaneous access to imaging studies on monitors throughout the hospital. This long-term digital archiving or rapid transmission is prohibitive without the use of image compression to reduce the file sizes. For example, a single analog mammogram might be digitized at 4096 x 4096 pixels x 16 bpp. This file would be over 33 megabytes (MB). In lossless compression, the original image is exactly recoverable from the compressed format; with lossy coding, it is not, but vastly greater compression is achieved.

However, lossy schemes are viewed with suspicion by many members of the medical and scientific community; image alteration might entail loss of diagnostic or scientific utility. Many physicians feel they cannot trust lossy compression which mostly delivers exquisite quality and yet which can, without warning, introduce medically unacceptable artifacts into the image. After segmenting an image into regions (either automatically or manually) it is possible for a compression algorithm to deliver different levels of reconstruction quality in different spatial regions of the image. One could accurately (losslessly) preserve the features needed for medical diagnosis or for scientific measurement, while achieving high compression overall by allowing degradation in the unimportant regions.

In radiology, the discussion of image compression often divides into three separate uses: compression before primary diagnosis (for rapid transmission), compression after primary diagnosis (for long-term archiving), and compression for database browsing (where progressivity would be useful)(Jacob and Pamela, 1996). Compression occurring before primary diagnosis is the most controversial use of lossy compression. However, it might prove useful in cases where the interpreting radiologist is at a remote site and lossless compression cannot be used. For example, the patient's situation might require such rapid action that the time for lossless transmission of original images cannot be countenanced, or the bandwidth for real-time lossless video transmission might not be available.

Compression after primary diagnosis might be useful for long-term digital archiving. Here it is easy to imagine how region-based coding might play a role, since the primary interpretation of a film can perhaps be used for providing the region segmentation. A third use of compression is for providing progressive transmission capabilities when receiving images over a network. With progressive coding, image quality incrementally improves as more bits arrive.

Early versions of an image can be good enough to show that the image is not of interest; transmission can then be `nipped in the bud.' Progressive codes can be designed to be eventually lossless, so that if the user waits long enough (e.g., 30 seconds) the image will be exactly equal to the original, but over the short term (e.g., 0.5 seconds) the image would already be useful version more rapidly. As an example, Figure 1.1 shows an MR brain scan with cancerous tumors circled. Following its use in primary diagnosis, this image could be compressed so as to perfectly preserve this region.

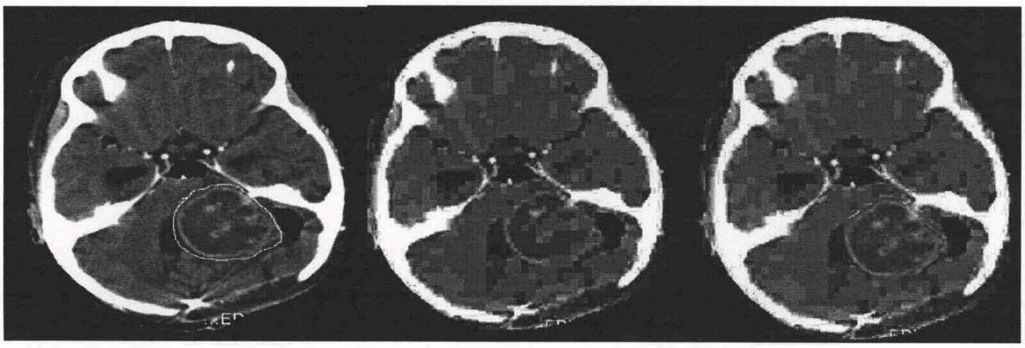

Figure 1.1: (a) MR brain scan with tumors (circled) ,(b) MR brain scan compressed by a factor of 100:1 , (c)compressed scan with circled region shown at original accuracy.

Allowing graceful degradation in the rest of the image could yield high compression. The original image has a grayscale resolution of 8 bits per pixel (bpp); Figure 1.1b shows it compressed to 0.08 bpp. Figure 1.1c shows an example, in which the compressed image has the circular tumor region at original quality, and it represents what one might wish to obtain from a regionally lossless scheme. This image is suitable for comparison and still provides dramatically higher compression than can be achieved by schemes which are lossless everywhere.

1.2 Objectives

This thesis presents a solution method to medical image compression that aims to achieve a good quality for the area that contains important information while achieving a higher compression for unrequired regions. Regions are compressed using a lossless technique; while the latter regions are compressed using a lossy technique .Lossless compression reproduces the original image exactly, unlike lossy compression which trades off higher compression with slight reproduction errors. The objectives of this thesis are:

1. To implement a lossless technique for medical image compression for the ROI.
2. To investigate the effects of the multiquantization to the image.
3. To display the result of the image and evaluate the performance of selected algorithm.