



UNIVERSITI PUTRA MALAYSIA

**IMAGE COMPRESSION BASED ON REGION OF INTEREST FOR
COMPUTERIZED TOMOGRAPHY IMAGES**

TARIK FARAJ ALI IDBEAA

FK 2003 7

**IMAGE COMPRESSION BASED ON REGION OF INTEREST FOR
COMPUTERIZED TOMOGRAPHY IMAGES**

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**

March 2003



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 certify that an Examination Committee met on 20th March 2003 to conduct the final examination of Tarik Faraj Ali Idbeaa on his Master of Science thesis entitled “Image Compression Based on Region of Interest for Computerized Tomography Images” in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

Shattri Mansor, Ph.D.
Associate Professor,
Faculty of Engineering,
Universiti Putra Malaysia.
(Chairman)

Abdul Rahman Ramli, Ph.D.
Faculty of Engineering,
Universiti Putra Malaysia.
(Member)

Veeraraghavan Prakash, Ph.D
Faculty of Engineering,
Universiti Putra Malaysia.
(Member)

Roslizah Ali, M.S.
Faculty of Engineering,
Universiti Putra Malaysia.
(Member)



GULAM RUSUL RAHMAT ALI, Ph.D.
Professor / Deputy Dean,
School of Graduate Studies,
Universiti Putra Malaysia.

Date: 20 APR 2003

The thesis submitted to the Senate of Universiti Putra Malaysia has been accepted as fulfillment of the requirement for the degree of Master of Science. The members of the Supervisory Committee are as follows:

Shattri Mansor, Ph.D.

Associate Professor,
Faculty of Engineering,
Universiti Putra Malaysia
(Chairman)

Abdul Rahman Ramli, Ph.D.

Faculty of Engineering,
Universiti Putra Malaysia
(Member)

Veeraraghavan Prakash, Ph.D

Faculty of Engineering,
Universiti Putra Malaysia
(Member)

Roslizah Ali, MS.

Faculty of Engineering,
Universiti Putra Malaysia
(Member)



AINI IDERIS, Ph.D.

Professor / Dean
School of Graduate Studies,
Universiti Putra Malaysia.

Date: **12** JUN 2003



DECLARATION

I hereby declare that the thesis is based on my original work except for equations and citations, which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.



(TARIK FARAJ ALI IDBEAA)

Date: 24.04.2003

TABLE OF CONTENTS

	Page
DEDICATION	ii
ABSTRACT	iii
ABSTRAK	v
ACKNOWLEDGEMENTS	vii
APPROVAL	viii
DECLARATION	x
LIST OF TABLES	xiv
LIST OF FIGURES	xvi
LIST OF ABBREVIATIONS	xix
CHAPTER	
I. INTRODUCTION	1
Introduction to Medical Image Compression	1
Objectives	4
Thesis Organization	5
II. LITERATURE REVIEW	6
Image Compression in Healthcare	6
Radiology	6
Cardiology	7
Medical Image Distortion And Quality	8
Image Quality Measurements	8
Image Artifacts	9
The Human Visual System	11
Medical Image Standards	11
DICOM (Digital Imaging and Communications in Medicine)	12
PACS (Picture Archiving and Communication System)	12
JPEG (Joint Photographic Expert Group)	13
EPIC Compression Algorithm	15
APMAR Model for Medical Image Compression	16
Storing Medical Image	17
Regions Fundamentals and Segmentation	19
Regions with Different Encoding Methods	20
Regions for Motion Compensation	21
Regions with Different Quality Levels	22
Region of Interest Based Compression of Medical Images	22
Segmentation Using Morphology	24
Region of Interest (ROI) Based Compression System	25
Medical Image Data Formats	28
Image Data Compression Schemes	29
Lossless Image Compression	30
Lossy Compression	33



Coding Techniques	36
Huffman Coding	36
Runlength Coding	36
Arithmetic Coding	37
Entropy Coding (Lempel – Ziv)	37
Delta Encoding	37
Lossless Differential Pulse Code Modulation	38
Block-Coding / Pixel Block Compression	38
Area Coding	38
Lossy Differential Pulse Code Modulation	39
Truncation Coding	39
Lossy Pixel Block-Coding	40
Vector Quantization	40
Fractal Image Compression	41
DCT – Based Transform Coding	41
Wavelet – Based Image Compression	42
Compression Of Digital Medical Images	42
Compression Of Digital Medical Images Due to the Classification Of the Image Bit Plane	43
Adaptive Compression Of Digital Medical Images With out loss Of Information	45
JPEG – 2000 Standards	49
Structure of the Standard	50
Summary	53
III. METHODOLOGY	54
Introduction	54
Compression Efficiency	55
Mathematical Evaluation	55
Choosing Software Tool	56
System Methodology	57
Reading Gray Level Medical Images	57
Select the Region of Interest	59
Lossy Compression	60
Lossless Compression	70
Combine Results	76
Store the Compressed Image	76
IV. RESULTS AND DISCUSSION	76
Introduction	76
Medical Image Compressed in A case of ROI size (101x101)	79
Quantization Multiplier Factor = 2	79
Quantization Multiplier Factor = 5	82
Quantization Multiplier Factor = 10	85
Quantization Multiplier Factor = 20	87
Quantization Multiplier Factor = 40	89
Medical Image Compressed in A case of ROI size (51x51)	92
Quantization Multiplier Factor = 2	92
Quantization Multiplier Factor = 5	95
Quantization Multiplier Factor = 10	97



Quantization Multiplier Factor = 20	99
Quantization Multiplier Factor = 40	102
V. CONCLUSION AND RECOMMENDATIONS	113
Conclusion	113
Recommendations	115
REFERENCES	116
BIODATA OF THE AUTHOR	123



LIST OF TABLES

Table		Page
4.1	Lossless regions of interest results with size (101 x 101)	81
4.2	Lossy compression results without ROI (101 x 101) and MF = 2	81
4.3	Final output compressed image with (101 x 101) lossless region of interest and MF = 2	82
4.4	Lossy compression results without ROI (101 x 101) and MF = 5	84
4.5	Final output compressed image with (101 x 101) lossless region of interest and MF = 5	84
4.6	Lossy compression results without ROI (101 x 101) and MF=10	86
4.7	Final output compressed image with (101 x 101) lossless region of interest and MF = 10	86
4.8	Lossy compression results without ROI (101 x 101) and MF=20.	88
4.9	Final output compressed image with (101 x 101) lossless region of interest and MF = 20	88
4.10	Lossy compression results without ROI (101 x 101) and MF=40.	90
4.11	Final output compressed image with (101 x 101) lossless region of interest and MF = 40	90
4.12	Lossless regions of interest results with size (51 x 51)	94
4.13	Lossy compression results without ROI (51 x 51) and MF = 2	94
4.14	Final output compressed image with (51 x 51) lossless region of interest and MF = 2	95
4.15	Lossy compression results without ROI (51 x 51) and MF = 5	97
4.16	Final output compressed image with (51 x 51) lossless region of interest and MF = 5	97
4.17	Lossy compression results without ROI (51 x 51) and MF = 10	99
4.18	Final output compressed image with (51 x 51) lossless region of interest and MF = 10	99



4.19	Lossy compression results without ROI (51 x 51) and MF = 20	101
4.20	Final output compressed image with (51 x 51) lossless region of interest and MF = 20	101
4.21	Lossy compression results without ROI (51 x 51) and MF = 40	103
4.22	Final output compressed image with (51 x 51) lossless region of interest and MF = 40	103



LIST OF FIGURES

Figure		Page
1.1	An MR brain scan with cancerous tumors circled	03
2.1	JPEG encoder and decoder block diagrams	14
2.2	Encoder of the APMAR	17
2.3	A schematic of ROI	19
2.4	Reconstruct CT slices with the original images	23
2.5	Segmenting the colon from the CT data set	25
2.6	Block diagram of the ROI based compressor	26
2.7	ROI based compression results with block size 16x16	27
2.8	ROI based compression results with block size 8x8	27
2.9	Image compression schemes	29
2.10	A general block diagram of DPCM	32
2.11	A block diagram of the predictive 2-D MAR method	32
2.12	Lossy image compression scheme	34
2.13	Fractals in image	41
2.14	Test images on which the algorithm „classification of the bit plane is applied	44
2.15	Shows a flow diagram of the adaptive compression of digital medical images	47
2.16	Three test images divided in three different classes (K1,K2 and K3) after applying the classification algorithm	48
2.17	Block diagram of the JPEG2000	51
3.1	General Methodology form	54

3.2	Flowchart of the encoding process	58
3.3	Flowchart of the decoding process	59
3.4	Flowchart of Lossy encoder	61
3.5	Noise reduction	64
3.6	Flowchart of Lossy Decoding	68
3.7	Flowchart of lossless	71
4.1	Original medical images	78
4.2	The compressed ROI for the three images (Brain, Abdomen, and Chest) with size of (101 x 101)	79
4.3	The three compressed images with (101 x 101) Lossless compressed region of interest and MF=2	80
4.4	The three compressed images with the lossless Compressed region of interest and MF= 5	83
4.5	The three compressed images with (101 x 101) lossless compressed region of interest and MF= 10	85
4.6	The three compressed images with (101 x 101) lossless compressed region of interest and MF=20	87
4.7	The three compressed images with (101 x 101) lossless compressed region of interest and MF=40	89
4.8	MSE against Multiplier factor values for CT brain, chest and abdomen images with out ROI (101x101)	91
4.9	PSNR against Multiplier factor values for CT brain, chest and abdomen images with out ROI (101x101).92	91
4.10	The compressed ROI for the three images (Brain, Abdomen, and Chest).	92
4.11	The three compressed images with (51 x 51) lossless compressed region of interest and MF = 2.	93
4.12	The three compressed images with (51 x 51) lossless compressed region of interest and MF = 5.	96
4.13	The three compressed images with (51 x 51) lossless compressed region of interest and MF = 10.	98



4.14	The three compressed images with (51 x 51) lossless compressed region of interest and MF=20.	100
4.15	The three compressed images with (51 x 51) lossless compressed region of interest and MF=40.	102
4.16	MSE against Multiplier factor values for CT brain, chest and abdomen images with out ROI (51x51).	104
4.17	PSNR against Multiplier factor values for CT brain, chest and abdomen images.	104
4.18	Compression ratio against ROI size for CT brain, abdomen and chest images.	105
4.19	Image file size (KB) against MF for CT brain, abdomen and chest Image with ROI size of (101x101)	106
4.20	Image file size (KB) against MF for CT brain, abdomen and chest Image with ROI size of (51x51)	107
4.21	Image intensity variance against MF for CT brain, abdomen and chest Images with ROI size (101x101)	108
4.22	Image intensity variance against MF for CT brain, abdomen and chest Images with ROI size (51x51)	109
4.23	Comparison of PSNR value between ROI, rest of the image and final compressed image with MF =2 and ROI (101x101)	110
4.24	Comparison of PSNR value between ROI, rest of the image and final compressed image with MF =40 and ROI (101x101)	110
4.25	Comparison of PSNR value between ROI, rest of the image and final compressed image with MF =2 and ROI (51x51)	111
4.26	Comparison of PSNR value between ROI, rest of the image and final compressed image with MF =40 and ROI (51x51)	112



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.

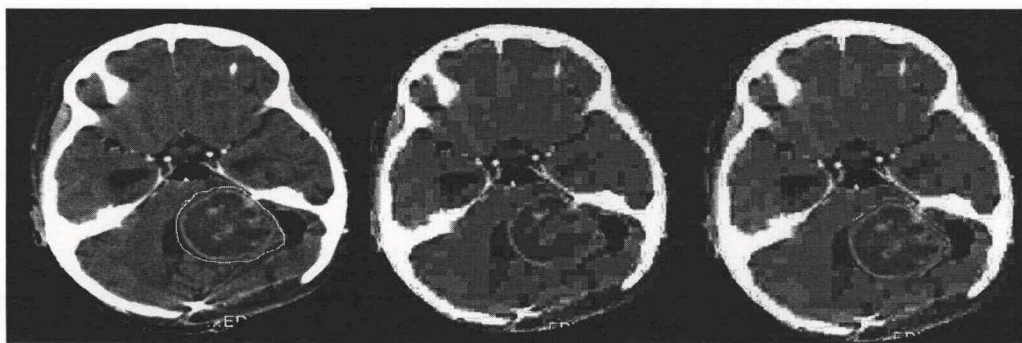


Figure 1.1: (a) MR brain scan with tumors (circled) ,(b) MR brain scan compressed by a factor of 100:1 , (c)compressed scan with circled region shown at original accuracy.

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.