IMAGE QUALITY ANALYSIS

SHANKAR A/L KRISHNAN

This project is submitted in partial fulfilment of
The requirements for the degree of Bachelor of Engineering with Honours
(Electronic and Computer Engineering)

Faculty of Engineering
UNIVERSITI MALAYSIA SARAWAK
2009

UNIVERSITI MALAYSIA SARAWAK

R13a

BORANG PENGESAHAN STATUS TESIS

Judul: **IMAGE QUALITY ANALYSIS**

SESI PENGAJIAN: 2008/2009

Saya **SHANKAR A/L KRISHNAN**
(HURUF BESAR)

mengaku membenarkan tesis * ini disimpan di Pusat Khidmat Maklumat Akademik, Universiti Malaysia Sarawak dengan syarat-syarat kegunaan seperti berikut:

1. Tesis adalah hakmilik Universiti Malaysia Sarawak.
2. Pusat Khidmat Maklumat Akademik, Universiti Malaysia Sarawak dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Membuat pendigitan untuk membangunkan Pangkalan Data Kandungan Tempatan.
4. Pusat Khidmat Maklumat Akademik, Universiti Malaysia Sarawak dibenarkan membuat salinan tesis ini sebagai bahan pertukaran antara institusi pengajian tinggi.
5. ** Sila tandakan (✔) di kotak yang berkenaan

☐	SULIT	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972).
☐	TERHAD	(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/ badan di mana penyelidikan dijalankan).
☑	TIDAK TERHAD	

Disahkan oleh

(TANDATANGAN PENULIS) (TANDATANGAN PENYELIA)

Alamat tetap: 12, SS4/21, 47301

PETALING JAYA, SELANGOR MRS. KURYATI KIPLI
Nama Penyelia

Tarikh: 13 APRIL 2006 Tarikh: 13 APRIL 2006

CATATAN * Tesis dimaksudkan sebagai tesis bagi Ijazah Doktor Falsafah, Sarjana dan Sarjana Muda.
** Jika tesis ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh tesis ini perlu dikelaskan sebagai SULIT dan TERHAD.

This Final Year Project attached here:

Title : Image Quality Analysis

Student Name : Shankar A/L Krishnan

Matric No : 15207

has been read and approved by:

_____ _____

Mrs. Kuryati Kipli Date

(Supervisor)

Dedicated to my loved ones and the pursuit of knowledge.

ACKNOWLEDGEMENT

I would like to express my gratitude to my supervisor, Pn. Kuryati Kipli, who took every effort to guide me every step of the way, to the technicians who helped me make the most out of the lab equipment in UNIMAS, to all my friends who willingly provided advice and research materials, and to my family for being supportive of my endeavours.

I truly enjoyed working with everyone who contributed and my work is as much theirs as it is mine.

ABSTRAK

Analisis kualiti imej sedang menjadi semakin penting dalam era digital masakini. Objektif utama analisis kualiti imej adalah untuk mengkaji kualiti imej dan seterusnya merekabentuk kaedah untuk menilai tahap kualiti sesuatu imej dengan cekap dan cepat. Projek ini bertujuan untuk mengkaji kaedah subjektif dan objektif menilai kualiti imej di samping mengaitkan keputusan setiap kaedah objektif kepada keputusan kaedah subjektif. Tiga kaedah objektif telah dipakai untuk projek ini, iaitu, algoritma Indeks Kualiti yang direkabentuk oleh Zhou Wang dan Alan C.Bovik, sistem blok PSNR yang direkabentuk sendiri, dan algoritma mengira Purata Ralat Dikuasadua (PRD). Justeru itu, pengetahuan yang lebih mendalam tentang kriteria yang diperlukan untuk merekabentuk sesuatu kaedah baru untuk menilai tahap kualiti imej telah didapati. Data daripada projek ini juga menjelaskan kaedah objektif yang mana adalah paling sesuai untuk menilai jenis penghamparan kualiti imej yang bagaimana. Akhir sekali, segala unjuran daripada projek ini telah dipergunakan untuk merekabentuk satu prototaip kaedah objektif menilai tahap kualiti imej yang berdasarkan rangkaian neural yang berpotensi untuk menjadi lebih cekap dari segi perlaksanaannya daripada segala kaedah objektif yang dipakai dalam projek ini setakat ini kalau dikaji dengan lebih teliti sebagai projek baru.

ABSTRACT

Image quality analysis is becoming more and more important in this digital age. The main objective of image quality analysis is to study the quality of images and develop methods to efficiently and swiftly determine the quality of images. This project aims to study subjective and objective assessment methods of image quality as well as to draw correlations between each objective assessment and the subjective assessment. Three objective assessment methods were used in this project, the Quality Index algorithm developed by Zhou Wang and Alan C. Bovik, the Peak Signal-to-Noise Ratio (PSNR) Block-Set, and the Mean Squared Error (MSE) calculating algorithm. By doing so, a better understanding of what is actually required to develop an efficient image quality assessment method was gained. The resulting data also indicated what type of objective assessment was most suitable for which type of impairment imposed upon an image. Finally, the conclusions of this study were used to develop a prototype of a neural network based image quality assessment method that could be further enhanced as part of a further study to eventually develop an objective image quality analysis method that has a higher correlation to the subjective assessment method compared to the other objective assessment methods employed throughout this project.

LIST OF CONTENTS

CONTENT			PAGE
ABSTRAK			**i**
ABSTRACT			**ii**
LIST OF CONTENTS			**iii**
LIST OF FIGURES			**vii**
LIST OF TABLES			**x**
LIST OF ABBREVIATIONS			**xi**
CHAPTER 1	**INTRODUCTION**		
1.1	Overview		1
1.2	Scope of Research		3
1.3	Objectives		4
1.4	Problem Statement		5
1.5	Outline of Project Report		7
CHAPTER 2	**LITERATURE REVIEW**		
2.1	Introduction		8
2.2	Objective Assessment		9
	2.2.1	Objective Image Assessment	9
	2.2.2	Objective Video Assessment	10
2.3	Subjective Assessment		12

2.4 Quality Scaling 14

2.5 Image File Formats 15

2.6 Image Degradation 17

2.7 Edge Detection 20

2.8 Digital Quality Metrics 20

2.9 MATLAB® Software 25

CHAPTER 3 METHODOLOGY

3.1 Introduction 27

3.2 Preparing the Sample Images 29

3.2.1 Objectives 29

3.2.2 Procedure 29

3.2.2.1 Reference Image and Closed Images 30

3.2.2.2 Dilated Images 31

3.2.2.3 Eroded Images 33

3.2.2.4 Gaussian-Noising 35

3.2.2.5 Opened Images 36

3.2.2.6 Salt and Pepper Noising 38

3.2.2.7 Multiplicative Noising 39

3.2.2.8 File Format Conversion 41

3.2.2.9 Filtered Images 42

3.3 Conducting the Subjective Assessment 51

3.3.1 Procedure 51

3.4 Determining the Image Quality Analysis Using the Universal Quality Index Algorithm 54

3.4.1 Procedure 54

3.5 Determining the PSNR between the Reference Image and the Sample Image 56

3.5.1 Procedure 56

3.6 Determining the MSE between the Reference Image and the Sample Image 58

3.6.1 Procedure 58

CHAPTER 4 RESULTS AND DISCUSSION

4.1 Overall Assessment Results 60

4.2 Statistics of the Subjective Assessment 64

4.3 Correlation of the Objective Assessments to the Subjective Assessment 66

4.4 Data Trends of the Objective Assessments against the Subjective Assessment 68

4.5 Category-Specific Correlation of the Objective Assessments to the Subjective Assessment 71

4.6 Discussion 73

4.6.1 Preface 73

4.6.2 Subjective Assessment Results 73

4.6.3 Correlations of the Objective Assessments to the Subjective Assessment 78

4.6.4 Examining the Data Trends to Validate Correlation Results 81

CHAPTER 5 CONCLUSION AND RECOMMENDATION

5.1 Conclusions 88

5.2 Recommendation 90

REFERENCES 92

Appendix A: Evaluation Forms from the Subjective Assessment 96

Appendix B: Quality Index Algorithm 99

Appendix C: MSE Calculating Algorithm 102

LIST OF FIGURES

FIGURE		PAGE
3.1	Flowchart of Methodology	28
3.2	Reference Image	31
3.3	Closed Image 1	31
3.4	Closed Image 2	31
3.5	Closed Image 3	31
3.6	Dilated Image 1	32
3.7	Dilated Image 2	32
3.8	Dilated Image 3	33
3.9	Eroded Image 1	34
3.10	Eroded Image 2	34
3.11	Eroded Image 3	34
3.12	Gaussian Noised Image 1	35
3.13	Gaussian Noised Image 2	35
3.14	Gaussian Noised Image 3	36
3.15	Opened Image 1	37
3.16	Opened Image 2	37
3.17	Opened Image 3	37
3.18	Salt & Pepper Noised Image 1	38
3.19	Salt & Pepper Noised Image 2	38
3.20	Salt & Pepper Noised Image 3	39

3.21	Multiplicatively Noised Image 1	40
3.22	Multiplicatively Noised Image 2	40
3.23	Multiplicatively Noised Image 3	40
3.24	lenacolor.bmp	41
3.25	lenacolor.jpg	41
3.26	lenacolor.tif	42
3.27	Averaged Image	43
3.28	Circularly Averaged Image	44
3.29	Gaussian Filtered Image	45
3.30	Laplacian Filtered Image	46
3.31	LoG Filtered Image	47
3.32	Lens Motion Approximated Image	48
3.33	Prewitt Filtered Image	49
3.34	Contrast Enhanced Image	50
3.35	Sobel Filtered Image	51
3.36	PSNR Block-Set	57
3.37	Simplified PSNR Block-Set	57
4.1	Data Trend of Standard Deviations of the MOS Results	66
4.2	Data Trend of Normalized MOS vs. QI	68
4.3	Data Trend of Normalized MOS vs. QI (Gray-Scaled Set)	69
4.4	Data Trend of Normalized MOS vs. PSNR (divided by a factor of 10)	69
4.5	Data Trend of Normalized MOS vs. PSNR (Grayscaled-Set) (divided by a factor of 10)	70
4.6	Data Trend of Normalized MOS vs. MSE (divided by a factor of 1000)	70

4.7 Points of Interest in Figure 4.1 77

4.8 Points of Interest in Figure 4.2 83

4.9 Points of Interest in Figure 4.4 84

4.10 Points of Interest in Figure 4.6 85

LIST OF TABLES

TABLE		PAGE
2.1	Image File Formats	17
3.1	Definitions of Opinions	52
3.2	Evaluation Table	53
3.3	PSNR Block Functions	58
4.1	Subjective Assessment and Quality Index Assessment Results	61
4.2	Subjective Assessment, PSNR Block-set and MSE Results	63
4.3	Standard Deviations and Confidence Intervals of Each MOS Reading	65
4.4	Pearson Product Moment Correlation, r, of Subjective vs. Objective Assessment Results	67
4.5	Pearson Product Moment Correlation Coefficient of Category Specific Subjective vs. Objective Assessment Results	72
4.6	Standard Deviations of the Knowledgeable Group's Opinion Scores and of the Entire Group's MOS	75
4.7	Approximate Correlation Percentages of each Assessment	79

LIST OF ABBREVIATIONS

MPEG	-	Motion Picture Expert Group
PQA	-	Picture Quality Analysis
MATLAB	-	Matrix Laboratory
CSF	-	(Count) State Flow
SNR	-	Signal to Noise Ratio
MSE	-	Mean Squared Error
HVS	-	Human Visual System
JPEG	-	Joint Photographic Expert Group
PNG	-	Portable Network Graphics
PDF	-	Portable Document Format
TIFF	-	Tagged Image File Format
MAC	-	Macintosh
PC	-	Personal Computer
PCM		Pulse-Code Modulation
PSNR	-	Peak Signal to Noise Ratio
QI	-	Quality Index
Q	-	Quality
FIR	-	Finite Impulse Response
MOS	-	Mean Opinion Score
LoG	-	Laplacian of Gaussian
OS	-	Opinion Score

CRT	-	Cathode-Ray Tube
LCD	-	Liquid Crystal Display
RGB	-	Red, Green, Blue
r	-	Pearson Product Moment Correlation
SVD	-	Singular Value Decomposition

CHAPTER 1

INTRODUCTION

1.1 Overview

Image Quality Analysis is the science of analysing, then comparing the characteristics and features of an image with reference to another image of predetermined/preset standards [1]. Its purpose is to gauge how the sample image measures up to the reference image.

The history of image analysis stemmed from the need to create catalogues due to the growing volume of images in archives around the world. The earliest form of image analysis was purely visual and was based on grouping together images that had similar features and characteristics. However, these methods were no longer feasible once the size of the image collection became too large. The issue of grouping the images was resolved but a new issue, recalling a certain image, became more and more tedious [2]. With modern computing, image cataloguing and indexing was made easier by using the processing capabilities of computers.

Most previous research in image quality analysis employed different methodologies. Thus, various image quality analysis methods will be examined in

Chapter 2, Literature Review. For example, the fingerprint image quality analysis by Lim E. et al., (2004), employed mathematical operators in the form of filters and classifiers [1].

Research conducted in [3], placed emphasis on the error sensitivity with full-reference method as well as outlining image quality assessment algorithms and video quality image algorithms as well as a section on a method that simulates the human visual cortex. The study also includes validation of an objective test result, storage of reference material for objective tests and refining quality metrics (standards) for an objective test [3].

In addition, research done in [4], outlines the difference in quality between various video formats, namely, Windows Media Video, (Motion Picture Experts Group) MPEG-1, and MPEG-2. The research was focused on Multi Frame Rate Encoding of images and the effect of such encoding and the frame rates, bit rates and sizes of the videos. [4]

A technical paper [5], states the working capabilities of the Picture Quality Analysis (PQA) 200 tool by Tektronix. In summary, the data proves that the depreciation in image quality due to compression can be detected by the use of the PQA tool by Tektronix. It is a purely objective approach to image quality analysis. Various types of image flaws are outlined and defined such as blocking, smearing, edge busyness, error blocks, mosquito noise and quantization noise. The studies conducted show good correlation between results of the PQA and subjective image quality analysis results.

Voran S.D et al., in [6], performed an objective video quality assessment system that emulates the human visual cortex. Results from this research have also been compared to subjective image analysis results that were recorded as part of the research. The subsequent results of both methods were then compared to provide validation of results for the objective video quality assessment system that was designed [6].

With regards to the experimental procedure, the use of the various functions available in the MATLAB image processing toolbox and MATLAB Video and Image Processing Block-set as well as the basic functions of MATLAB itself are considered to be a vital part of this project.

Studying human bias and human assessment of image quality presents a unique opportunity to collect data that will enable future research to be performed on developing alternative objective assessment methods that are sturdier, more reliable, and more accurate than the objective assessment methods employed in this project.

1.2 Scope of Research

The scope of this project is defined largely by the key objective of the research, to determine correlations between objective and subjective image quality analysis results. This project aims to verify which method has the best correlation characteristics. In order to achieve that, a number of objective assessments will be conducted and compared to a corresponding subjective assessment. Thus, the

subjective assessment will become a standard or benchmark of the actual quality of the image. Thus, all objective tests that are performed can be evaluated fairly. Once the complete results are out, it should reflect how valid a certain objective test actually is and in addition, considering how much effort is needed to conduct it, the practicality of the test can also be assessed.

Defining the benchmark of quality for the experiments is a must. A benchmark is a reference standard to which all obtained results will be compared against. It is important to have a uniform reference standard to determine correlations between the various assessment results. The matter of how many reference pictures to be used and the manner of comparing the results will be discussed further in chapter 3, Methodology.

1.3 Objectives

Based on summaries of current research, it can be stated that the premise of this project is to perform objective and subjective image quality analysis and to research several image altering techniques and their effects on assessment methods of the images. To achieve this, there will be experimentation. Four assessments will be modelled, three objective and one subjective, to generate data to be interpreted.

The objectives of this research are;

a.) To design assessments to be conducted and analyse the results to investigate the correlation characteristics between objective image quality analysis and subjective image quality analysis.

b.) To determine the best method of image analysis in certain circumstances based upon conditions and parameters that will be studied during the course of this project.

c.) To study image altering techniques.

d.) To draw correlations between objective and subjective image quality assessment results as well as to determine the probable causes of any discrepancies in the correlation of the final results.

e.) To gain hands-on experience of using MATLAB for digital image processing.

1.4 Problem Statement

With regards to the quality of an image, there are several processes that images generally undergo in many circumstances such as transmission, compression, and conversion. Such processes tend to alter the appearance and, subsequently, the quality of the image itself. For instance, due to the way certain equipment generate

images, it is almost unavoidable to end up having digital images that are very large in size [2]. Also, images that are available in a physical format such as X-ray slides and photographs will decay with time and can be preserved into the form of digital images. Thus compression and conversion, respectively, are employed.

There are numerous applications to this project that can be derived as a result of images being altered due to digital processes. Firstly, as elaborated in the introduction, digital image manipulation is a process that is unavoidable due to the fact that it is not cost efficient to digitally store certain image formats from a lack of hard disk space as well as to preserve physical images. Unfortunately, these processes alter the quality of images. Thus, image quality analysis measures should be employed to determine the usability of images after they have undergone any kind of manipulation, for example, transmission or conversion.

Therefore, studying the various approaches to image quality analysis will provide information on what method of image quality assessment can be efficiently employed under which circumstances.

Drawing a proper correlation between any given objective method of image quality analysis and a subjective method will determine the reliability of the given objective method. Most digital image analysis processes try to simulate the human visual cortex as it is a known fact that the human eye remains a very superior judge of image quality. For example, if the computer says the image is of a good quality, and a human says it is of a bad quality, the image will most likely be scrapped.

Therefore, the computer's reliability and accuracy will be considered low if there is a poor correlation between its results and the human eye's judgment.

1.5 Outline of Project Report

In summary, the outline of this project is as follows, the Introduction chapter elaborates the general ideas and concepts that will be explored throughout the project. The Literature Review chapter, Chapter 2, elaborates various possible methodologies and their outcomes that could be used for this project. The Methodology chapter, Chapter 3, elaborates the actual procedures that were executed throughout the project. The Results and Discussion chapter, Chapter 4, elaborates the outcomes of the methodology and the discussion and conclusion chapter elaborates the justifications of the results as well as discussing the analysis of every major result of the project. Finally, the Conclusion and Recommendation chapter, Chapter 5, highlights every major conclusion drawn from the results and discussion chapter as well as elaborates a recommendation for a prototype image quality analysis method.