PERFORMANCE ANALYSIS OF A SPATIAL DOMAIN BASED MODEL FOR BLIND IMAGE QUALITY ASSESSMENT

NURIN INSYIRAH AMANINA BINTI MOHAMAD NOR AZAM

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

PERFORMANCE ANALYSIS OF A SPATIAL DOMAIN BASED MODEL FOR BLIND IMAGE QUALITY ASSESSMENT

NURIN INSYIRAH AMANINA BINTI MOHAMAD NOR AZAM

This report is submitted in partial fulfilment of the requirements for the degree of Bachelor of Electronic Engineering with Honours

Faculty of Electronic and Computer Engineering
Universiti Teknikal Malaysia Melaka

2018

UNIVERSITI TEKNIKAL MALAYSIA MELAKA
FAKULTI KEJUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek : Performance Analysis Of A Spatial Domain Based Model For Blind Image Quality Assessment

Sesi Pengajian : 2018/2019

Saya NURIN INSYIRAH AMANINA BINTI MOHAMAD NOR AZAM mengaku membenarkan laporan Projek Sarjana Muda ini disimpan di Perpustakaan dengan syarat-syarat kegunaan seperti berikut:

1. Laporan adalah hakmilik Universiti Teknikal Malaysia Melaka.
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan laporan ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan (✓):

☐ **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) (COP DAN TANDATANGAN PENYELIA)

DR. REDZUAN BIN ABDUL MANAP
Senior Lecturer
Faculty Of Electronic & Computer Engineering
Universiti Teknikal Malaysia Melaka (UTeM)
Hang Tuah Jaya
76100 Durian Tunggal, Melaka

Alamat Tetap: Lot 11632 RPT Haji Tahir, 35350 Temoh Perak

Tarikh : 19 Disember 2018 Tarikh : 19 Disember 2018

*CATATAN: Jika laporan ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali tempoh laporan ini perlu dikelaskan sebagai SULIT atau TERHAD.

DECLARATION

I declare that this report entitled "Performance Analysis Of A Spatial Domain Based Model For Blind Image Quality Assessment" is the result of my own work except for quotes as cited in the references.

Signature : ....

Author : NURIN INSYIRAH AMANINA BINTI MOHAMAD NOR AZAM

Date : 9/01/2019

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 Bachelor of Electronic Engineering with Honours.

Signature : ....

Supervisor Name : REDZWAN ABDUL MANAF

Date : 17/12/2018

DEDICATION

Special dedication to my beloved family, Allahyarham Mohamad Nor Azam bin Hassan and Rozita binti Zainal Abidin. Their encouragement and guidance has always be an inspiration to me along this journey of education.

ABSTRACT

This project focuses on image quality assessment (IQA), especially in the problems of estimating the quality of an image blindly or without the presence of reference information. Previous blind IQA (BIQA) models often utilize transform-based quality predictive features to perform their quality prediction. This approach, however, can be computationally expensive due to the need of image transformation process. This project attempts to alleviate this by developing a transform free BIQA model that operates on the image spatial domain. The model use generalized Gaussian distribution (GGD) and asymmetric generalized Gaussian distribution (AGGD) statistical parameters as quality predictive features. The project involves extracting relevant quality predictive features from the image's spatial domain, developing a quality prediction model through support vector regression (SVR) utilizing the extracted features and analyse the model's performance through comparison with several available BIQA models in terms of prediction accuracy, generalization capability as well as computational requirement.

ABSTRAK

Projek ini memberi tumpuan kepada penilaian kualiti imej (IQA), terutamanya dalam permasalahan penilaian kualiti sesuatu gambar tanpa kehadiran maklumat rujukan . Model penilaian kualiti imej tanpa rujukan (BIQA) terdahulu menggunakan ciri ramalan kualiti berasaskan transformasi untuk menilai kualiti sesuatu gambar. Pendekatan ini boleh dianggap mahal dan rumit kerana memerlukan proses transfomasi imej. Projek ini cuba mengatasi masalah tersebut dengan membangunkan model BIQA tanpa tranfomasi dimana ia beroperasi dalam domain spatial imej. Ia menggunakan parameter statistik "generalized Gaussian distribution (GGD)" dan "asymmetric Gaussian generalized (AGGD)" sebagai ciri ramalan kualiti. Projek ini melibatkan kerja-kerja mengekstrak ciri ramalan kualiti yang relevan dari domain spatial sesuatu imej, membangunkan model ramalan kualiti melalui "support vector regression (SVR)" menggunakan ciri-ciri yang diekstrak dan menganalisis prestasi model tersebut melalui perbandingan dengan beberapa model BIQA yang ada dari segi ketepatan ramalan, keupayaan generalisasi serta keperluan pengkomputeraan.

ACKNOWLEDGEMENTS

In the name of Allah, the Most Gracious and the Most Merciful. First of all, I thank Allah for giving me strength, opportunity and patience to complete this final year project. I take this opportunity to express my deepest gratitude and special thanks to my supervisor, Dr. Redzuan bin Abdul Manap who in spite being extraordinarily busy with his duties, took time to hear, guide and teach me during the project. Last but not least, I would like to dedicated my appreciation to my beloved parents Allahyarham Mohamad Nor Azam bin Hassan and Rozita binti Zainal Abidin, family members, Zaidatul Naziyah binti Hassan and Raja Nur Izzati binti Raja Razak and friends for their moral, financial and relentless support to me to get through this journey. Allah is the All-Knowing. Thank you very much for the wonderful hands.

TABLE OF CONTENTS

Declaration	
Approval	
Dedication	
Abstract	**i**
Abstrak	**ii**
Acknowledgements	**iii**
Table of Contents	**iv**
List of Figures	**vii**
List of Tables	**x**
List of Symbols and Abbreviations	**xii**
List of Appendices	**xiv**
CHAPTER 1 INTRODUCTION	**1**
1.1 Introduction	1
1.2 Problem Statement	3
1.3 Objectives	4
1.4 Scope of Project	4

1.5 Report Layout 5

CHAPTER 2 BACKGROUND STUDY **6**

2.1 Introduction 6

2.2 Natural Scene Statistic (NSS) Based Model 7

2.2.1 Transform-based Approach 7

2.2.2 Transform-free Approach 9

2.3 Learning Based Model 11

2.3.1 General Learning Based Approach 11

2.3.2 Codebook Based Approach 11

2.3.3 Summary of Related BIQA Models 12

CHAPTER 3 METHODOLOGY **15**

3.1 Introduction 15

3.2 Methodology Flow Chart 15

3.3 General Framework for The Proposed Model 17

3.3.1 Normalization 18

3.3.2 Feature Extraction 21

3.3.3 Database Construction 30

3.3.4 Regression and Optimal SVR Parameter Setting 30

3.3.5 Training and Testing Procedure 31

3.3.6 Performance Analysis 32

CHAPTER 4 RESULTS AND DISCUSSION **33**

4.1 Introduction 33

4.2 Result Analysis 33

4.2.1 Database Construction 33

4.2.2 Calling and Displaying Image in MATLAB 36

4.2.3 Feature Extraction 37

4.2.4 Optimal SVR Parameters 39

4.2.5 Train-test Partition 39

4.2.6 Performance Evaluation On The LIVE Database 40

CHAPTER 5 CONCLUSION AND FUTURE WORKS **49**

REFERENCES **51**

APPENDICES **55**

LIST OF FIGURES

Figure 3.1 : Project methodology flow chart 17

Figure 3.2 : The model framework 17

Figure 3.3 : Steps to calculate MSCN coefficients 18

Figure 3.4 : Visualization of MSCN Coefficient Computation 18

Figure 3.5 : Scatter plot between neighboring values of (a) original luminance coefficient and (b) MSCN coefficient 20

Figure 3.6 : Effect of normalization procedure. (a) Original image $\boldsymbol{I}$. (b) Local mean field μ. (c) $\boldsymbol{I} -$ μ. (d) Local variance field $\boldsymbol{\sigma}$. (e) MSCN coefficients ($\boldsymbol{I} -$ μ$\boldsymbol{\sigma}$) 21

Figure 3.7 : Distribution of MSCN coefficients for a natural image and its distorted versions 22

Figure 3.8 : (a) 2D scatter between shape and scale parameter for GGD and (b) 3D scatter plot between shape, left scale, right scale for AGGD 24

Figure 3.9 : Four orientations' pairwise products computation 25

Figure 3.10 : Distribution of paired products of MSCN coefficients of a natural undistorted image and various distorted versions of it. (a) Horizontal. (b) Vertical. (c) Main-diagonal. (d) Secondary-diagonal. 26

Figure 3.11 : Correlation between the extracted features and DMOS for different distortion 29

Figure 4.1 : Initial database of one type of data 35

Figure 4.2 : The final constructed database 35

Figure 4.3 : Code to call image in MATLAB 36

Figure 4.4 : Code to display an image in MATLAB 36

Figure 4.5 : Example of image displayed in MATLAB 37

Figure 4.6 : Example of extracted features' value of 15 images (15 row) 37

Figure 4.7 : Features' value after scaling for SVR learning process 38

Figure 4.8 : Generating non-overlap random train-test partition based on a total number of reference image 40

Figure 4.9 : Median SROCC and LCC across 1000 train test combinations on the LIVE IQA database 42

Figure 4.10 : Median RMSE across 1000 train test combinations on the LIVE IQA database 43

Figure 4.11 : Median SROCC for different distortions in the LIVE IQA database 44

Figure 4.12 : Median LCC for different distortions in the LIVE IQA database 46

Figure 4.13 : Median RMSE for different distortions on the LIVE IQA database 48

LIST OF TABLES

Table 2.1 : Summary of several BIQA models related to this project 13

Table 3.1 : List of extracted features and their computational methods 29

Table 4.1 : Feature extraction computation time 38

Table 4.2 : Median SROCC and LCC across 1000 Train Test Combinations on the LIVE IQA Database 42

Table 4.3 : Median RMSE across 1000 train test combinations on the LIVE IQA database 43

Table 4.4 : Median SROCC across 1000 train test combinations for different distortions on the LIVE IQA Database 44

Table 4.5 : SROCC standard deviation across 1000 train test combinations for different distortion on the LIVE IQA database 45

Table 4.6 : Median LCC across 1000 train test combinations for different distortions on the LIVE IQA database 46

Table 4.7 : LCC standard deviation across 1000 train test combinations for different distortions on the LIVE IQA database 47

Table 4.8 : Median RMSE across 1000 train test combinations for different distortions on the LIVE IQA Database 47

LIST OF SYMBOLS AND ABBREVIATIONS

AGGD	:	Asymmetric Generalized Gaussian Distribution
BIQA	:	Blind Image Quality Assessment
BIQI	:	Blind Image Quality Index
BLIINDS	:	Blind Image Integrity Notator using (DCT) Statistics
BRISQUE	:	Blind/Referenceless Image Spatial Quality Evaluator
CORNIA	:	Codebook Representation for No-Reference Image Assessment
DIIVINE	:	Distortion Identification-based Image Verity and Integrity Evaluation
DMOS	:	Difference Mean Opinion Score
DS	:	Distortion-Specific
FF	:	Fast-fading
GB	:	Gaussian Blur
GGD	:	Generalized Gaussian Distribution
GM-LOG	:	Gradient magnitude-Laplacian of Gaussian
GRNN	:	General Regression Neutral Network
IQA	:	Image Quality Assessment
LCC	:	Pearson's (Linear) Correlation Coefficient
MSCN	:	Mean Subtracted Contrast Normalized

NDS	:	Non Distortion-Specific
NIQE	:	Natural Image Quality Evaluator
NSS	:	Natural Scene Statistic
RMSE	:	Root Mean Square Error
SROCC	:	Spearman's Rank Ordered Correlation Coefficient
SVM	:	Support Vector Machine
SVR	:	Support Vector Regression
VBIQA	:	Visual Saliency – Guided Model for Blind Image Quality Assessment
WN	:	White Noise

LIST OF APPENDICES

APPENDIX A : Coding To Save All The Image As Image.mat Form 55

APPENDIX B : Coding For Calling Image 56

APPENDIX C : Coding For Feature Extraction 57

APPENDIX D : Coding For Scale Feature Extraction 58

APPENDIX E : Coding For Create The Database Of The Image 59

APPENDIX F : Coding For Cross-Validation 60

APPENDIX G : Coding To Get Overall Data 63

APPENDIX H : Coding To Test One Image 66

CHAPTER 1

INTRODUCTION

1.1 Introduction

In recent years, advances in innovation have allowed for pictures and videos to be captured effortlessly and efficiently, stored, compressed, transmitted and displayed on the range of digital devices such as HD screen. With the ubiquitous use of digital images, it is necessary for researcher to have proficient and solid techniques to evaluate the quality of those images so that the end user will be presented with a satisfactory quality of experience (QoE). These techniques are normally referred as image quality assessment (IQA). The aim of IQA is to predict the quality of still image by generating prediction model that can mimic human quality perception.

A quality of an image represents the characteristic of the image that measure the visible degradations present in the image. The degradations of an image is present when the image lose its information due to the existence of distortion such as noise, blurring and etc. . In image processing, methods for evaluating the quality of an image can be categorized into two classes which are subjective and objective. For subjective IQA, quality is evaluated directly by human observers. This means human directly rates the quality of a sequence of images presented to them in some applications. However, this method is a difficult task, requires a lot of time and quite expensive thus making this method irrelevant and impractical in real world applications. In contrast, objective IQA normally involve developing computer model that automate the process of estimating quality of an image. The model is designed such that it should be in agreement with human perception. There are several models have been proposed for objective IQA depending on the availability of the original undistorted image. The models can be categorized into three which are full-reference IQA (FR-IQA), reduced-reference IQA (RR-IQA) and no-reference IQA (NR-IQA) or also known as blind IQA (BIQA). In FR-IQA, it requires the comparison between full information of the original image and the distorted image to predict the quality of image. Examples of FR-IQA models are feature similarity index (SSIM), multi-scale SSIM (MS-SSIM) and edge strength SSIM (ESSIM). In contrast to FR-IQA, RR-IQA performs quality assessment using only partial information of the original image. Instead of requires a full reference, only minimal set of reference image are extracted and then used with the distorted image to predict the quality of the image. However, both FR-IQA and RR-IQA are not practical for some applications where the availability of any original information may be impossible. For such cases, a BIQA model is preferred. With

BIQA model, it automatically assess the quality scores of an image without any reference to the original image.

In addition, BIQA models can be further categorized into two classes which are distortion-specific (DS) and non-distortion-specific (NDS) [1]. DS model is only capable of assessing the quality of images distorted by a particular distortion type, such as blockiness, ringing, blur or noise [2]. Meanwhile, NDS is more practical as it can estimate image quality regardless the kind of distortions like fast fading, blur, JPEG, JPEG2000 and white noise. NDS BIQA models can also be divided into two categories which are natural scene statistic (NSS) based and learning based. The NSS based approach designs the quality predictive features using prior knowledge of the image while the learning based approach uses features which are directly extracted from the image raw data. The NSS based approaches can be either transform-based or transform-free whereby transform-based requires the image to be transformed into frequency domain using wavelet transform, discrete cosine transform or contourlet transform. Transform-free does not require such operation.

1.2 Problem Statement

The interest of developing BIQA model is fast increasing in the last few years. Various BIQA models have been developed and proposed for image processing applications. For example, Blind Image Quality Index (BIQI) and Distortion Identification based Image Verity and Integrity Evaluation index (DIIVINE). These models frequently use transform-based quality predictive features to quantify the quality of an image. This approach, however, can be computationally expensive due to the need of image transformation process. To address this problem, one requires to try to develop BIQA model that can design quality predictive features without having to undergo the image transformation process.

1.3 Objectives

The aim of this project is to develop a transform-free BIQA model that operates on the image spatial domain in order to predict the quality of an image consistent with human perceptual measures. This aim can be achieved by fulfilling the following objectives :

1. To extract relevant quality predictive features from the image's spatial domain.
2. To develop a quality prediction model through support vector regression (SVR) utilising the extracted.
3. To analyse the model's performance through comparison with several available BIQA models in term of prediction accuracy, generalisation capability as well as computational requirements.

1.4 Scope of Project

This project only focus on developing BIQA model. FR-IQA and RR-IQA models are not covered in this project. The model proposed to be develop is based on NSS-based approach. Furthermore, the model is intended for NDS cases rather than DS. Features are designed using image information in the spatial domain without having to go transformation process. There are various learning techniques to develop quality prediction model. For example, simple linear regression, decision trees, support vector machine/regressor (SVM/SVR), neural network and deep learning. For this project, SVR is chosen to learn the model.