PERFORMANCE ANALYSIS OF A VISUAL SALIECNY-GUIDED MODEL FOR BLIND IMAGE QUALITY ASSESSMENT (VBIQA)

QUAH SWEE LIIN

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

PERFORMANCE ANALYSIS OF A VISUAL SALIENCY-GUIDED MODEL FOR BLIND IMAGE QUALITY ASSESSMENT (VBIQA)

QUAH SWEE LIIN

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 Visual Saliency-guided Model for Blind Image Quality Assessment (VBIQA)

Sesi Pengajian : 2018/2019

Saya QUAH SWEE LIIN 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)

Alamat Tetap: No 18, Tingkat Merbau 2, Bagan Ajam, 13000 Butterworth, Pulau Pinang.

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

Tarikh : 17/12/18

Tarikh : 17/12/2018

*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 Visual Saliency-guided Model for Blind Image Quality Assessment (VBIQA)" is the result of my own work except for quotes as cited in the references.

Signature : .....

Author : Quah Swee Lin

Date : 17/12/18

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	:	REDZUAN ABDUL MANAP .....
Date	:	17/12/2018 .....

DEDICATION

To my beloved mother and father

ABSTRACT

The project focuses on image quality assessment (IQA), especially in the problems of predicting the quality of an image blindly or in the absence of the information of reference images and types of distortion present in the image. Nowadays, IQA is integrated in various range of applications such as compression, transmission, restoration, etc. Over the last decade, there are rapid growth in developing blind image quality assessment (BIQA) approaches and various models have been introduced. Previous BIQA models often extract handcrafted quality predictive features from randomly sampled image patches. The extracted features are then used to learn their quality prediction model. This approach, however, ignore a human visual system (HVS) property that can have major impact to overall perceptual image quality. The property, referred to as visual attention, shows that the viewer may be more likely to detect distortions in highly salient regions, as compared to regions of low saliency. Thus, this project aims to incorporate this property into a BIQA model by utilising an image's saliency map to guide the model sampling process instead of sampling randomly. A new BIQA model that correlated highly with human judgements of quality is developed at a level that is competitive to the previous BIQA models.

ABSTRAK

Projek ini memberi tumpuan kepada penilaian kualiti imej (IQA), terutamanya dalam permasalahan ramalan kualiti imej tanpa menggunakan maklumat tentang imej rujukan dan jenis gangguan yang terdapat dalam imej tersebut. Pada masa kini, IQA digunakan dalam pelbagai aplikasi seperti pemampatan, penghantaran, pemulihan dan lain-lain. Sepanjang dekad yang lalu, terdapat pertumbuhan pesat dalam pembangunan kaedah penilaian kualiti imej tanpa imej rujukan (BIQA) dan pelbagai model telah diperkenalkan. Model BIQA yang telah diperkenalkan sebelum ini sering menggunakan ciri-ciri ramalan kualiti buatan tangan yang dihasilkan daripada sebahagian gambar secara rawak. Ciri-ciri yang dihasilkan ini digunakan untuk mempelajari model kualiti ramalan. Walau bagaimanapun, pendekatan ini telah mengabaikan satu aspek sistem visual manusia yang boleh memberi kesan besar kepada keseluruhan persepsi kualiti imej, iaitu perhatian visual. Unsur perhatian visual, menunjukkan bahawa penonton mungkin lebih cenderung untuk mengesan pencemaran dalam kawasan yang lebih mendapat perhatian, berbanding dengan kawasan yang kurang diberikan perhatian. Oleh itu, projek ini bertujuan untuk mengintegrasi unsur perhatian visual ke dalam model dengan menggunakan peta kadar perhatian dalam sesuatu imej dalam membimbing proses persampelan imej tersebut. Satu model baru yang berkorelasi tinggi dengan penilaian kualiti manusia telah diperkenalkan dan mampu bertanding dengan model lain.

ACKNOWLEDGEMENTS

In performing this final year project (FYP), I had received help and guidance from some respected people, who deserve my greatest gratitude. I would like to express any deep gratitude to Dr. Redzuan Bin Abdul Manap, my respected supervisors, for his great monitoring, patient guidance, enthusiastic, encouragement and useful critiques throughout this FYP project. His willingness to spend his time so generously is very much appreciated.

In addition, I also grateful to Dr. Hazli Rafis Bin Abdul Rahim, the coordinator of this FYP. I am thankful and indebted to him for sharing his expertise, valuable guidance and encouragement to us.

Finally, I would like to thanks to my roommate, coursemate and everyone who involved with this FYP report. Thanks to all the people for their direct or indirect help to me in completing my project. I also would like to express my apology that I could not mention each of you personally.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

This project is generally about developing a computer algorithm that can mimic the human visual system in predicting the quality of an image. This chapter introduces the background information related to the project and the reason of developing it. Sections included in this chapter are the background and research work of Image Quality Assessment (IQA), problem statement, objectives, scopes of the project and the outlines of the report.

1.1 Background of Project

Nowadays, lots of information often appear in the form of visual signals, i.e. digital images that can be found everywhere in our daily life. Normally those images have to

go through some processes before being delivered to the end-users, which are the human observer. The quality of those images often will be degraded where the original information of the images is being disturbed as they are subjected to some distortions such as blocking and white noise, etc. during the processing stages such as image acquisition[1][2], transmission[1][2][3] and compression[3], etc. For instance, in image acquisition, acquiring image directly in digital format will result in image quality degradation as the mechanism (imaging sensors) for gathering data can introduce noise. During transmission, there will be some noises and interferences in the transmission channel that may corrupt the image and causes degradation in image quality. Besides that, in image compression, lossy compression method causes blurring and ringing effects on the compressed image resulting in quality degradation.

Image Quality Assessment (IQA) is the process or method to measure the quality of the perceived image using quality metrics. Therefore, IQA can act as one of the crucial parts in image processing applications to maintain, control and enhance the images' quality[4] before delivering them to the end-users. Generally, the image quality can be assessed using two methods, which are the subjective IQA method and the objective IQA method. Subjective IQA approach can be considered as a traditional and standard method where the evaluation of image quality is based on human observation mechanism that considers human visual system (HVS). In this approach, a differential mean opinion score (DMOS) is often used to represent the perceived quality metric for the image. This kind of method is truly definitive but impractical in real-world applications as the experiment is time-consuming, expensive and difficult to design. However, it is often used to create the image quality database that can provide groundtruth in developing or evaluating any objective IQA method. There are several standard IQA databases such as LIVE[5], CSIQ[6] and etc. that contain the

reference images, its distorted images based on several type of distortions and their associated DMOS values.

In contrast, an objective IQA method can automatically provide the quality measurement for the perceived image by using a computational model. Thus it is highly desired and leading to many research activities on developing objective IQA models that correlate well with HVS. The objective IQA models have great potential in wide range of real-world applications especially in network visual communication applications. For instance, delivery of image and video content over the wired or wireless network often degrades the visual content quality during lossy compression and transmission, thus a network video server can use the objective quality metric to monitor the quality degradation to optimize streaming resource allocations. Besides that, in image acquisition system, an objective quality metric can be used to monitor and automatically adjust the system itself to obtain the best quality of image data.

Objective IQA approach can be divided into three categories[4][7] depending on the availability of the reference (undistorted) image's information: full-reference (FR) IQA, reduced-reference (RR) IQA and no-reference (NR) IQA or blind IQA (BIQA). In FR-IQA models, the entire information of reference image is available for predicting the quality of the distorted image. The simplest and oldest FR-IQA approaches are mean square error (MSE)[4] and peak signal-to-noise ratio (PSNR)[4]. MSE acts as a quality measure by comparing the distorted image and undistorted image spatially to provide a quantitative score that describes the level of distortion between them. However, they have been criticized for its poor correlation with HVS[4][8]. Therefore, over the years, more advanced FR-IQA approaches have been proposed to overcome the problem of poor correlation with HVS based on various aspects such as HVS, image structure and image statistics. Several FR-IQA models

such as MS-SSIM[9], SSIM[10], FSIM[11], GMSD[12], SR-SIM[13] and VSI[14] have achieved high correlation with HVS.

However, in many real-world visual applications, the reference image may not exist and only the distorted image is available. Due to this kind of problem, over the last decade, there has been an increasing interest in developing the BIQA models, which can predict the quality of distorted image without the availability of reference image. BIQA models are highly desired since it is sustainable, reliable and convenient in practice. In addition to FR IQA and BIQA models, RR-IQA model is lied between the FR-IQA and BIQA models as only partial information of reference image is required and used for image quality prediction. The models that are developed based on RR-approach often convert the spatial image into transform domains such as discrete wavelet transform (DWT)[15][16] or discrete cosine transform (DCT)[17] to model the natural image statistic.

BIQA models reported in literature range from distortion-specific (DS) metric to non-distortion-specific (NDS) metric. DS BIQA models work for only specific applications as they only measure the quality of images with one specific distortion such as Joint Photographic Experts Group (JPEG), JPEG200 and etc. For instances, model in [18] can only evaluate the quality of image compressed by JPEG while model in [19] is designed to estimate the quality of image distorted by JPEG2000 blindly. On the other hand, NDS BIQA approach is known as universal approach and works for general purpose applications as it can assess more than one type of distortions such as JPEG, JPEG2000, blur, and etc. without any prior knowledge of the distortion types. Thus, many researches focus on NDS BIQA approach since it is a general-purpose

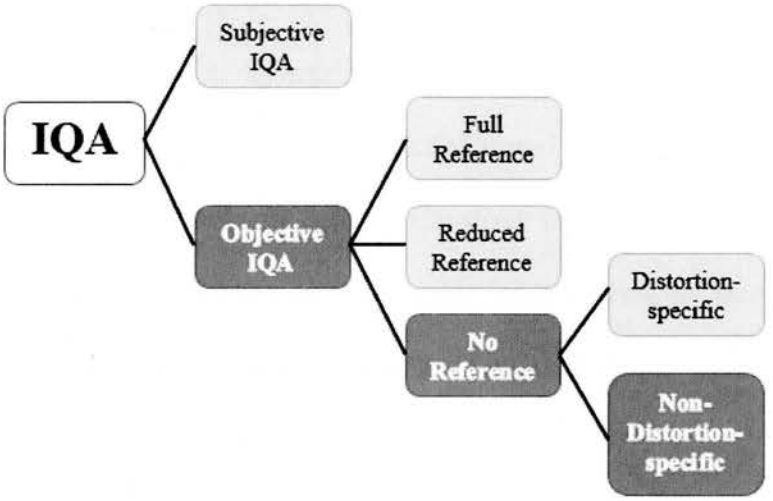

Figure 1.1: Image quality assessment categories

approach and more generally applicable in real life. Currently, most of NDS BIQA approaches focus on extracting discriminative features that contain information about image quality from the distorted image. Then, the extracted features will be used as an input to the regression algorithms to learn the mapping between the features and image quality.

A summary of IQA categories is shown in Figure 1.1, where the related IQA problems studied in this project are highlighted.

1.2 Problem Statements

Over the last decade, there are rapid growth in developing BIQA approaches whereby various BIQA models have been introduced. However, these models still have limitations. The previous NDS BIQA models such as CBIQ[20], CORNIA[21] and IQF-CNN[22], employ random sampling technique for patch extraction process, then extract quality predictive features from the sampled image patches and use the features to learn their quality prediction model. This approach, however, ignores one

human visual system (HVS) property that has major impact to overall perceptual image quality. The property is referred to as visual attention. There are significant current research[13][14][23][24] on the impact of visual attention for IQA. It shows that the viewer are more likely to detect distortions in highly salient regions, as compared to regions of low saliency. Thus, this project aims to incorporate this property into a BIQA model by utilizing an image's saliency map to guide the model's sampling process instead of random sampling.

1.3 Objectives

The main aim of this study is to develop a computer algorithm that can mimic the human visual system in predicting quality of an image. Thus, this study embarks on the following objectives, which are: -

1) To construct a visual saliency map for an image whereby the map is then used to guide the sampling process of image patches.
2) To extract relevant quality predictive features from the sampled image patches.
3) To develop a quality prediction model through support vector regression (SVR) utilizing the extracted features.
4) To analyze the model's performance through comparison with several available BIQA models in terms of prediction accuracy and generation capability as well as computational requirements.

1.4 Scopes of the Project

The scopes of the project are as follows:

1) The proposed project focused on developing the non-distortion specific BIQA model since most of the time, the reference image will not be available and the prior knowledge about the type of distortions present in the distorted image is unknown. Thus, the proposed project is more sustainable, reliable and generally applicable in real life.
2) To guide the image patches' sampling process, three simple priors for saliency detection (SDSP) proposed in [25] were used to develop the image's visual saliency map. This saliency detection approach has considered three important human visual system properties, which is the human behavior that tends to detect salient objects in an image, likely to pay more attention on the center of image and more attracted to warm colors than cold colors.
3) Gabor filter was used to extract features from the sampled image's patches. The Gabor based features can represent the texture information of an image. Since texture is an important property that consistent with the HVS, the choice of Gabor features was deemed appropriate for the project.
4) Support vector regression (SVR) with radial basic function (RBF) kernel was chosen for regression. Since the model depends on a huge number of features that encode the image quality degradation factor, a simple regression technique such as SVR can be utilized to learn the mapping between features and image quality.
5) Only the LIVE database[5] was used during the training and the testing of the proposed model.

6) Spearman rank-order correlation coefficient (SROCC), Pearson linear correlation coefficient (PLCC) and root mean square error (RMSE) were the chosen performance metrics to evaluate the model.

1.5 Report Outline

The report is divided into five chapters. Chapter 1 introduces the motivation behind the project and its background information that include some general information and research works on IQA, problem statement, project's objectives and the scopes of the project.

Chapter 2 discusses the literature review on existing objective IQA models, which related to the project especially the Non-Distortion-Specific (NDS) BIQA models and objective IQA models that adopt visual attention property.

Chapter 3 describes the methodology used for the project, including the flow of the project development, the theory and the concept regarding the method used in each development stage, implementation of the model and the standard performance metrics chosen for the performance evaluation of the proposed project's model.

Chapter 4 presents the findings, analysis and discussion of the developed model including the experimental setup for training and testing the model. The performance of the model is evaluated by comparing the obtained results with several previous IQA models' result in term of accuracy, generalization and speed performance.