

**UNIVERSITI TEKNOLOGI MARA**

**CHARACTERIZATION OF DIGITAL  
INTRA-ORAL DENTAL  
RADIOGRAPHS BASED ON IMAGE  
ENHANCEMENT ALGORITHMS  
(IEAs).**

**SITI ARPAH BT AHMAD**

Thesis submitted in fulfillment  
of the requirements for the degree of  
**Doctor of Philosophy**

**Faculty of Electrical Engineering**

September 2017

## ABSTRACT

The advancement in medical imaging modality has made it possible to produce many types of digital medical images. However, many of these images suffer from low contrasts and noise which make it difficult to identify disease characteristics. Furthermore, the quality and properties of the final display of medical images are often inadequate for diagnostic purposes. Currently limited work has been done in enhancing the pathological features to detect and interpret abnormalities that are required to clearly diagnose dental diseases. Low contrasts in medical image leads to disagreement and might cause misdiagnosis and differential diagnosis. Dentists come from different background in terms of experience, place of study, method of practices and emotional quotient. These are some of the factors that may cause difference of opinion among dentists. The onset of digital imaging modality has made it possible to apply image processing algorithms to overcome the short comings of medical images such as noise, blurring and low contrast. This involves changes in appearance of the original image. The acceptance of dentists towards these changes are subjective thus may result in variation of opinion. To identify the most appropriate appearance of image which is subjectively agreeable to the dentists is the initial stage towards determining the characteristic required in the objective measurement. Therefore, this research focuses on identifying objective measurements based on dentists' subjective evaluation on abnormalities in jaw area. The methodology consists of three phases; image processing experimental design, subjective evaluation and objective evaluation. Theses phases formed a new subjective-objective based image enhancement (SOIE) framework. Image processing experimental design consists of designing three sharpening and AHE based image enhancement framework namely SAHE, SMAHE and SCLAHE. The subjective evaluation involved the analysis of dentists' subjective evaluation on the images. The validation study consists of performing pilot study to validate the dentist's evaluation between two places. Then, more images are collected and produced 2464 raw evaluation of the intra-oral dental radiographs. Results from pilot study and literature review reveal the existing issue of disagreement among the dentists' evaluation. Thus, this work investigates the role of sharpening and AHE based image enhancement in reducing variability among the evaluation. New rule using existing standard deviation ( $std = 0$ ) is utilized to determine the dentists' decision on the image quality and detected abnormalities. In addition, dentists' subjective evaluation variability issues are investigated based on supervised, non-supervised method and questionnaire viewing approach; twin-view approach versus random approach. Results show SCLAHE is able to champion in reducing the variability of subjective evaluation. Supervised twin-view approach produced consistent evaluation. The objective evaluation stage measured the enhanced images using Contrast Improvement index (CII), Signal to Noise Ratio (SNR) and Root Mean Squared Error (RMSE). The final lists of images with abnormalities are presented as a new abnormality matrix in table form, to characterize the intra-oral dental radiographs abnormalities. In conclusion, this work successfully characterized the abnormalities of the intra-oral dental images in the form of abnormality matrix based on the SOIE framework.

## ACKNOWLEDGEMENT

Firstly, Alhamdulillah, thanks to Allah for giving me the opportunity to embark on my PhD and for completing this lengthy and challenging journey successfully. My gratitude goes to my first supervisor, Prof Dr Hj Mohd Nasir bin Taib, my second supervisor, Dr Haslina Bt Taib, my co-researchers; Dr Noor Elaiza A.Khalid and Dr Rohana Ahmad and my colleagues; Pn Rozita Yunos, Pn Noorhayati Mohamed Noor, Pn Zarina Zainol, Dr Zalilah Abd Aziz, Dr Marina Yusoff, Mohd Faisal Ibrahim, Dr Mohd Izani Mohamed Rawi and Dr Shuzlina Abd Rahman. I also want to express my appreciation to all the dentists and staff from Faculty of Dentistry UiTM and School of Dental Sciences, USM. They are Dr. Azmeel Mazlee Anuar, Dr Firdaus Hanapiah, Dr Nik Mohd Mazuan B. Nik Mohd Rosdy, Dr Zurairah Berahim and Dr Kasmawati @ Norhidayati Mokhtar, Mr Mohd Aziz Farhan Rosli and Dr Rabiha Binti Alawi. Friends from Advanced Signal Processing Research Group(ASPRG); Prof Madya Zunairah Hj Murat, Dr Hezri Fazalul Rahim, Dr Nurlaila Ismail, Dr Mahfuzah Mustafa, Dr Mohamed Faiz Mohamed Said, Dr Siti Zura A.Jalil @Zainuddin, Dr Rozita Jailani, Dr Isnii Sofiah and all other ASPRG members. Special thanks also to friends from faculty of Computer and Mathematical Science and Faculty of Electrical Engineering, UiTM Shah Alam for all the supports and assistance.

Finally, this thesis is dedicated to my family members; my beloved husband, Ahmad Safuan Mokhtar, my loving mother, Amina M Sutan dan all my four cute children; Nursakinah, Nursufiah, Abu Zar and Abu Hakim. This piece of victory is dedicated to all of you. Alhamdulillah.

# TABLE OF CONTENTS

	<b>Page</b>
<b>CONFIRMATION BY PANEL EXAMINERS</b>	ii
<b>AUTHOR'S DECLARATION</b>	iii
<b>ABSTRACT</b>	iv
<b>ACKNOWLEDGEMENT</b>	v
<b>TABLE OF CONTENTS</b>	vi
<b>LIST OF TABLES</b>	xiii
<b>LIST OF FIGURES</b>	xv
<b>LIST OF SYMBOLS</b>	xx
<b>LIST OF ABBREVIATIONS</b>	xxi
<b>CHAPTER ONE: INTRODUCTION</b>	
1.1 Research Background	1
1.2. Problem Statement	2
1.3. Objective of the Research	3
1.4. Scope of Research	3
1.5. Significance of the Research	4
1.6. Organization of the Research Thesis	6
<b>CHAPTER TWO: LITERATURE REVIEW</b>	
2.1 Introduction	8
2.2. Radiographs issues	9
2.2.1. Noise	10
2.2.2. Low Contrast	11
2.2.3. Blurring	12
2.2.4. Overlapping	12
2.3. Periapical Diseases	13
2.3.1. Anatomy	14
2.3.2. Symptoms and radiographic appearance	15

# CHAPTER ONE

## INTRODUCTION

### 1.1 RESEARCH BACKGROUND

The advancement of information and communication technology has greatly influenced a whole lot of other progresses. In dentistry, one area that is gaining rapid growth is in the area of early and or non-invasive diagnosis. Image enhancement techniques have gradually been shown to improve dental radiographs [1–7]. Many techniques such as high pass and contrast enhancement had been applied to dental radiographs [1–4][8-9]. Some of these techniques are available as built in software provided by x-ray machine vendors such as Digora for Windows [1], Photoshop 8.0 [2] and Trophy Windows [3]. Algorithm such as Sliding window adaptive histogram equalization (SWAHE) [4] and frequency domain algorithms [8] also provide successful enhancements. High pass filters that have been used are shadow [1] and sharpening [1][9]. Other contrast enhancement variations are adaptive histogram equalization (AHE) [2], bright contrast enhancement [3] and pseudo-coloured with brightness-contrast adjustment [3]. Negative or inversion algorithms have been used to test the effect of brightness changes in dark region of images [1] [3].

The dental anatomical structures that had been investigated are the upper and lower jaw [1–4][8-9]. The focus areas studied are around upper and lower jaw such as around palatal, distal and mesial [1-2]. The areas around the teeth (molar and bicuspid) [3-4] and tooth supporting structure such as periodontal ligament space (PDLs) [1][4] and lamina dura (LD) [2-3] also are the main interest of the investigations. These researches correlate the abnormality pathologies which are periapical radiolucency, widen periodontal ligament space (PDLs) and loss of lamina dura (LD). These pathologies are the symptom for the existence of periapical disease [10]. This disease is one of the common diseases in dentistry that occurs at the apices of the teeth. Its diagnosis is particularly valuable to enable the clinician to provide immediate and appropriate dental treatment [10]. Frequently encountered periapical diseases are granulomas and cysts that appear at the jaw. Other lesions, including nondontogenic and malignancies, are also