AN ENHANCEMENT- BASED LOSSLESS COMPRESSION FOR MAMMOGRAM IMAGES USING DIFFERENTIAL PULSE CODE MODULATION

By

Reem Mohamed Abd El-Aziz Kord

A Thesis Submitted to the
Faculty of Engineering at Cairo University
In Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
In
Biomedical Engineering and Systems

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Under the Supervision of

Prof. Dr. Manal Abdel Wahed Abdel Fatah
Professor of Biomedical Engineering
Systems and Biomedical Engineering Department
Faculty of Engineering, Cairo University

Dr. Heba Mahmoud Afify
Lecturer at Biomedical Engineering
Systems and Biomedical Engineering Department
Faculty of Engineering, MTI University

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Approved by the
Examining Committee

_____
Prof. Dr. Manal Abdel Wahed Abdel Fatah (Thesis Main Advisor)
- Systems and Biomedical Engineering Department, Cairo University

_____
Prof. Dr. Mohamed Emad Mousa Rasmy (Internal Examiner)
- Systems and Biomedical Engineering Department, Cairo University

_____
Prof. Dr. Ahmed Farag Seddik (External Examiner)
- Systems and Biomedical Engineering Department, Helwan University

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
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2019

Engineer's Name: Reem Mohamed Abdel Aziz Kord
Date of Birth: 7/9/1991
Nationality: Egyptian
E-mail: Eng.reem.kord@gmail.com
Phone: 01099516177
Address: Group 61, Madinaty, New Cairo

Registration Date: 1/10/2014
Awarding Date: …./…./2019
Degree: Master of Science
Department: Biomedical Engineering and Systems

Supervisors:

Prof. Dr. Manal Abd El-Wahed Abdel Fatah
Dr. Heba Mahmoud Afify (Systems and Biomedical Engineering Department, MTI University)

Examiners:

Prof. Dr. Ahmed Farag Seddik (External Examiner)
Systems and Biomedical Engineering Department, Helwan University
Prof. Dr. Mohamed Emad Mousa Rasmy (Internal Examiner)
Prof. Dr. Manal Abdel Wahed Abdel Fatah (Thesis Main Advisor)

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An enhancement- based compression for mammogram images using differential pulse code modulation

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Mammography images compression; Image enchantment; Histogram equalization (HE); Top-hat filtering; Differential pulse code modulation (DPCM).

Summary:

Mammogram images are important documents as they play an important role in early detection of breast cancer. They are high-resolution and large size images which require specific computing facilities to process them. Moreover, transmitting these images over computer networks can be difficult and might require image compression. Therefore, a reduction stage is an important stage in most mammography-based systems. In this study; we employ new compression technique that is based on image enhancement, Haar wavelet transform and compression by differential pulse code modulation (DPCM). Several methods with different parameters have been used for image enhancement and performance evaluation, which will be explained in details later within the thesis.

Disclaimer

I hereby declare that this thesis is my own original work and that no part of it has been submitted for a degree qualification at any other university or institute.

I further declare that I have appropriately acknowledged all sources used and have cited them in the references section

Name: Date:

Signature:

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All praise is due to Allah, Most Merciful, and the Lord of the Worlds, Who taught man what he knew.

First of all, special thanks go to Prof. Dr. Manal Abd El-Wahed for providing me with the opportunity of working under her supervision in my post graduate studies in which I have gained useful experience. I would like also to thank Dr. Heba Mahmoud Afify, who has not been only providing me an experienced guidance; but she has also been giving me support and always giving me the confidence and enthusiasm to go on. They have given useful advice throughout my work on topics both related and unrelated to research. The many interesting discussions we had were both productive and enjoyable. They have shown me more patience than I deserved.

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List of Symbols and abbreviations

ACOG	American College of Obstetrics and Gynecology
AEC	Automatic Exposure Control
BI-RADS	Breast Imaging Reporting and Data System
BSE	Breast Self-Exam
CAD	Computer Aided Detection
CBE	Clinical Breast Examination
CC	Cranio-Caudal
CDF	Cumulative Distributive Function
CESM	Contrast Enhanced Spectral Mammography
CR	Compression Ratio
DBT	Digital Breast Tomosynthesis
DCIS	Ductal Carcinoma In Situ
DCT	Discrete Cosine Transform
DDSM	Digital Database for Screening Mammography
DPCM	Differential Pulse Code Modulation
ED	Edge Detection
FBB	Fixed Block Based
HE	Histogram Equalization
HT	Haar Transform
MIAS	Mammography Image Analysis Society
MLO	Mediolateral Oblique
MRI	Magnetic Resonance Imaging
MSE	Mean Square Error
OE	Object Extraction
PACS	Picture archiving and communication system
PDF	Probability Density Function
PEIPA	Pilot European Image Processing Archive
PSNR	Peak Signal to Noise Ratio
ROI	Region Of Interest
SE	Structuring Element
USPSTF	U.S Preventive Services Task Force

Abstract

The development of digital mammography imaging has led to high quantity of data required to represent modern images. This requires large disk space for storage, and long time for transmission over computer networks, and these two are relatively expensive. These factors prove the need for images compression.

Image compression addresses the problem of reducing the amount of space required to represent a digital image yielding a compact representation of an image, and thereby reducing the image storage/transmission time requirements. The key idea here is to remove redundancy of data presented within an image to reduce its size without affecting the essential information of it.

This study presents a compression algorithm that is based on image enhancement, Haar wavelet transform and differential pulse code modulation (DPCM) to optimize the compression of 50 mammography images, each having a resolution of 1024*1024 pixels with 8 bits/pixel. Image enhancement is implemented by two techniques; histogram equalization (HE) and top-hat filtering. The performance of compressed images is measured by compression ratio (CR), mean square error (MSE), peak signal to noise ratio (PSNR), and time consumption. This proposed algorithm is compared with the existing ones and is found to achieve better compression ratio than the others by providing 7.76 of CR.

Chapter 1 : Introduction

Breast cancer disease appears when cells in the breast start to grow out of control. The survival rate and the disease prognosis differ greatly on the cancer stage. When early detected, the treatment is more efficient, because the evolution into a more severe stage is avoided, which implies less mortality risk. Recently, the American Cancer Society (ACS) recorded about 266,120 new cases of invasive breast cancer that are predicted to be diagnosed and about 40,920 cases that are predicted to die in the United States [1]. It was found that the incidence rate of breast cancer is estimated about 1 in 8 women with 12.4%. This also means that there is a 7 in 8 chance woman will not have the disease.

Breast cancer can be detected through imaging exams as mammography, ultrasonography, magnetic resonance imaging, where mammography is the most common exam. Mammography is a non-invasive breast exam that can detect characteristic breast cancer lesions. Adding tomosynthesis to mammography leads to an increase in the cancer detection rate and a decrease in the recall rate overall [2].

Medical imaging has become an indispensable tool in clinical practice. Studies have shown links between the use of medical imaging exams and declines in mortality, reduced need for exploratory surgery, fewer hospital admissions, shorter hospital stays, and longer life expectancy [3]. As a result, the utilization of medical imaging has risen sharply during the early part of the last decade.

In a modern hospital, Picture Archiving and Communication Systems (PACS) handle the short- and long-term storage, retrieval, management, distribution, processing, and presentation of these large datasets. Data compression plays an important role in these systems. Since the earliest days of PACS, compression of medical images has been anticipated and novel compression techniques have been proposed before standardized compression approaches were available [4]. However, proprietary compression techniques greatly increase the cost and effort required to migrate data between different systems, and interoperability and compatibility of these systems necessitate the use of standards for digital communications [5].

With the increasing utilization of medical imaging in clinical practice and the growing dimensions of data volumes generated by various medical imaging modalities, the storage of digital medical image data sets requires data compression.

This chapter intends to explain the size problem of mammogram images, the objective of the proposed thesis, a literature review of the related work as well as the organization of the thesis.

1.1. Problem Definition

The upgrowth of medical imaging and the demand for storing large amount of digital images encouraged the development of compression applications that is to access the speed and accuracy in image sharing, transmission, and retrieval [6]. The digital mammogram image occupies a size between 8 MB and 55 MB [7] which is associated with breast cancer screening program. The compression of mammogram images remains a challenging problem as the amount of data to be stored is huge and should be taking into account the details of cancer regions or micro-calcifications for the radiologist.

This thesis exploits the success of an integrated approach to compress the mammogram images by choosing various combinations of bands. In addition, the contribution of this study is to determine the relationship between the applied image compression algorithms and the digital image processing techniques, including enhancement that is used for image explanation as well as improved diagnosis.

1.2. Thesis Objective

Image compression is an area of research that has many applications spanning different technological fields; among the most important of these fields is that of mammogram images compression.

The following are the main objectives of the proposed algorithm:

- The main goal of the algorithm is to reduce the storage quantity as much as possible without any loss of information. The algorithm must achieve lossless compression where mammogram images carry important information for clinical research. Lossless is used in cases where it is important that the original and the decompressed data be identical, or where deviations from the original data could be deleterious.

- The algorithm should be flexible, in that it should allow any mammogram images to be accessed.

- Speed of the algorithm is an important issue because algorithm is expected to be fast in all of its operations.

- Extensibility should be a key feature of this algorithm, as the number of mammogram images is growing.

- The algorithm should include essential parameter for evaluating the process of compression such as size of mammogram images that depend on the available memory space.

This thesis is divided into three phases as shown in figure 1.1. Phase I, we try to enhance the mammogram images by two different methods in order to get a high

resolution and high contrast images. Phase II and III, we try to find a good solution to compress mammogram images in less time and less space.

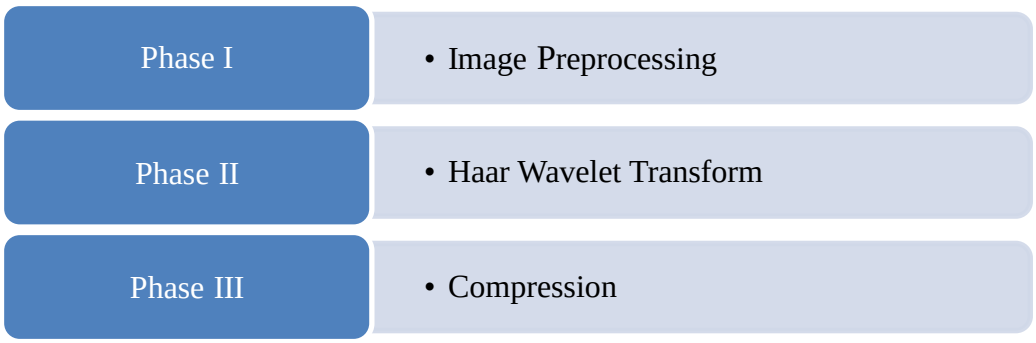

Figure 1.1: The three phases of the used algorithm

Compression is important application in medical images that helps in health and medical fields. The goal of compression and decompression of mammogram images is easy used to assist researchers in their decision making and avoid errors in diagnosis and the selection of treatment.