

DEVELOPMENT OF BREAST CANCER DETECTION SYSTEM USING
DIGITAL IMAGE.

NORLAILAH BINTI LANISA

A report submitted in partial fulfilment of the
requirements for the award of the degree of
Bachelor of Electrical Engineering (Electronic)

Faculty of Electrical and Electronic
Universiti Malaysia Pahang

JUNE 2012

UNIVERSITI MALAYSIA PAHANG

BORANG PENGESAHAN STATUS TESIS♦

JUDUL: DEVELOPMENT OF BREAST CANCER DETECTION SYSTEM USING DIGITAL IMAGE

SESI PENGAJIAN: 2011/2012

Saya NORLAILAH BINTI LANISA (880405-49-5610)
(HURUF BESAR)

mengaku membenarkan tesis (Sarjana Muda/~~Sarjana~~ ~~Doktor Falsafah~~)* ini disimpan di Perpustakaan dengan syarat-syarat kegunaan seperti berikut:

1. Tesis adalah hakmilik Universiti Malaysia Pahang (UMP).
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan tesis 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)

Alamat Tetap:

PETI SURAT 1842,
91043 TAWAU,
SABAH.

(TANDATANGAN PENYELIA)

DR. KAMARUL HAWARI BIN GHAZALI
(Nama Penyelia)

- CATATAN:
- * Potong yang tidak berkenaan.
 - * Jika tesis ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali tempoh tesis ini perlu dikelaskan sebagai atau TERHAD.
 - * Tesis dimaksudkan sebagai tesis bagi Ijazah doktor Falsafah dan Sarjana secara Penyelidikan, atau disertasi bagi pengajian secara kerja kursus dan penyelidikan, atau Laporan Projek Sarjana Muda (PSM).

“I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Electrical Engineering (Electronic)”

Signature : _____

Name of Supervisor : DR. KAMARUL HAWARI BIN GHAZALI

Date : 21th JUNE 2012

I declare that this thesis entitled “Development of Breast Cancer Detection System Using Digital Image” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is concurrently submitted in candidature of any other degree.

Signature:.....

Name:

Date:

To my beloved family.

ACKNOWLEDGEMENT

In preparing this thesis, I was in contact with many people. In particular, I wish to express my sincere appreciation to my thesis supervisor, Dr. Kamarul Hawari Bin Ghazali, for his encouragement, guidance, advices, motivation, support, critics and friendship. Without all that, this thesis would not have been the same as presented here.

My fellow undergraduates' students should also be recognised for their support. Their ideas, views and tips are useful indeed in helping me completing this thesis. I am grateful also to all my family members for their support.

ABSTRACT

Breast cancer is one of the most common cancer affecting women around the world. Mammography is the most known and effective method to detect early signs of breast cancer. However, due to some weaknesses in mammography such as painful procedures and radiation, researches introduce another diagnosis method which is by analysing thermal image. The purpose of this project is to design a system to detect the signs shown in mammogram and thermal image using Image Processing Technique applied to MATLAB. Image processing techniques can be divided into several elements. The elements are image acquisition, image pre-processing, image processing, feature extraction, object classification and classification decision. Both type of images then analyse step by step according to the elements. Mammogram images are analyse using morphology technique before features extraction which then lead to the classification of the image into 3 classes ('Normal Fatty breast', 'Abnormal Fatty breast' and 'Glandular breast'). For thermal image, the distribution of heat around the breast will be the features extracted and analysed. The different range of heat in the image will be used to specify the possible area of cancer. This project also includes the construction of Graphical User Interface (GUI) so that the system is more users friendly.

ABSTRAK

Barah payudara adalah sejenis barah yang paling biasa dialami oleh ramai wanita di seluruh dunia. Teknik Mammografi adalah teknik yang paling kerap dilakukan dan dikatakan paling efektif dalam mengesan tanda-tanda awal barah payudara. Walaubagaimanapun, prosedur yang menyakitkan dan radiasi dikenalpasti sebagai kelemahan teknik mammografi sehingga menyebabkan para penyelidik memperkenalkan teknik diagnosis menggunakan imej suhu. Projek ini dilakukan dengan tujuan untuk mereka satu sistem menggunakan teknik pemprosesan imej pada MATLAB yang mampu mengesan tanda-tanda barah berdasarkan kepada imej mammografi dan imej suhu payudara. Teknik pemprosesan imej boleh dibahagikan kepada beberapa komponen. Komponen yang terlibat adalah pemerolehan imej, imej pra-pemprosesan, pemprosesan imej, pengekstrakan maklumat, pengelasan objek dan keputusan klasifikasi. Kedua-dua jenis imej kemudian dianalisis mengikut komponen. Imej mammogram dianalisis menggunakan teknik morfologi sebelum maklumat imej diekstrak untuk mengklasifikasi imej kepada 3 kelas yang berbeza ('Payudara Lemak Biasa', 'Payudara Lemak Abnormal' dan 'Payudara Kelenjar'). Bagi imej suhu, pengedaran haba di sekeliling payudara adalah ciri-ciri yang akan diekstrak dan dianalisis. Perbezaan haba dalam imej akan digunakan untuk menentukan kawasan yang berkemungkinan barah. Projek ini juga melibatkan pembinaan Graphical User Interface (GUI) untuk mewujudkan satu sistem mesra pengguna.

TABLE OF CONTENT

CHAPTER	TITLE	PAGE
1	INTRODUCTION	1
	1.1 Problem Statement	2
	1.2 Objectives	2
	1.2.1 Sub-Objective	3
	1.3 Project Scope	3
2	LITERATURE REVIEW	4
	2.1 Image Processing Technique	4
	2.2 Mammogram Image Analysis	6
	2.3 CAD system using Thermal Image	8
3	RESEARCH METHODOLOGY	10
	3.1 Image Acquisition	11
	3.1.1 System 1	11
	3.1.2 System 2	12
	3.1.3 System 3	12
	3.2 Image Pre-processing and Image Processing	14
	3.2.1 System 1	14
	3.2.2 System 2	15
	3.2.3 System 3	16
	3.3 Feature Extraction	17
	3.3.1 System 1	17
	3.3.2 System 2	18
	3.4 Image Classification	19
	3.4.1 System 1	19
	3.4.2 System 2	20
	3.4.3 System 3	21

4	RESULT AND DISCUSSION	22
4.1	Result for Mammogram Analysis	22
4.1.1	Result for ‘Normal Fatty breast’ images.	23
4.1.2	Result for ‘Abnormal Fatty breast’ images.	24
4.1.3	Result for ‘Glandular breast’ images.	25
4.1.4	Threshold value for classification between ‘Fatty breast’ and ‘Glandular breast’.	26
4.1.5	Threshold value for abnormalities detection for ‘Fatty Breast’ images.	27
4.1.6	Correlation between MIAS database result and analysis result.	28
4.1.7	Result for DDSM database image	28
4.2	Result for Thermogram Analysis	29
4.3	GUI	29
5	CONCLUSION	32
5.1	Future Recommendation	32
	REFERENCE	33
	APPENDICES	35

LIST OF TABLES

TABLE NO.	TITLE	PAGE
3.1	Sobel approximation to the derivatives.	15
4.1	Threshold value for classification.	26
4.2	Threshold value for classification.	27

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
1.1	Breast cancer.	1
3.1	Image processing main elements.	10
3.2	YSX0906 Digital Mammography X-ray Machine.	11
3.3	Mammogram image.	12
3.4	FLIR A615 infrared camera.	13
3.5	Thermal image of breast.	13
3.6	Image Pre-processing and Image Processing.	14
3.7	Image Pre-processing and Image Processing.	15
3.8	Image Pre-processing and Image Processing.	16
3.9	Feature extractions.	17
3.10	Feature extractions.	18
3.11	Graph number of pixel value versus image number.	19
3.12	Number of pixel value versus image number.	20
3.13	The possible abnormal cell was outlined.	21
4.1	Overall results.	23
4.2	Overall results.	24
4.3	Overall results.	25
4.4	Classification graph for breast type.	26
4.5	Classification graph for normalities type fatty breast.	27
4.6	DDSM database images result.	28
4.7	High Temperature detected after analysing thermal image.	29

4.8	GUI for CAD system.	29
4.9	‘Choose image’ button selected and its result.	30
4.10	‘Screening’ button selected and the result.	31
4.11	‘Detection’ button selected and the result.	32

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
A	Image Type and Normalities Based on MIAS database	35
B	Result for image type and normalities written in text file.	36
C	MATLAB source code for Classification between ‘Fatty breast’ image and ‘Glandular breast’ image.	40

CHAPTER 1

INTRODUCTION

Breast can be classified into 2 types due to its density which are ‘Fatty breast’ and ‘Glandular breast’. When the amount of fat tissues exceed the amount of fibro-glandular tissues, the breast can be classified as ‘Fatty breast’ and when the amount of fibro-glandular tissues exceed the amount of fatty tissues, the breast can be classified as ‘Glandular breast’. Breast cancer occurs when breast tissues grow, change and multiply rapidly without control which may form lump or mass of extra tissues as shown in Figure 1.1. These masses are called tumor and can be either cancerous (malignant) or non-cancerous (benign) [1].

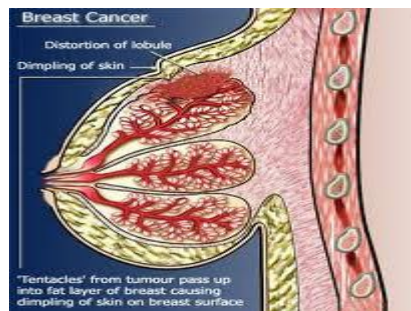


Figure 1.1 Breast cancer

Breast cancer is one of the most common cancers affecting woman and the most common source of death among middle aged women. Based on the World Health Statistics 2011 by Global Health Observatory (GHO), the mortality among female population all over the world cause by malignant neoplasma is about 11.81% and breast cancer are the highest with 15.80% compare to other types of cancer [2]. Successful treatment of breast cancer depends on early detection. Currently, two imaging method uses to detect masses are mammography and thermography.

1.1 Problem Statement

Mammography is a specific type of x-ray imaging that focusing on breast imaging. This process uses system with low dose x-ray, high contrast and high-resolution film [3]. However the accuracy in detecting the cancer based on mammogram image with bare eye by qualified personnel (radiologist) will be affected by poor mammographic image quality and fatigue radiologist. Radiologist misdiagnose 10-30% of the malignant cases due to the difficulty to maintain required attention level when reading large number of screening mammograms since most are free of cancerous features [1]. However, due to the invasive process of mammography, another method emerged as potential method to detect the early sign of breast cancer. The method is thermography.

Thermography is an imaging technique which shows temperature patterns at the surface of the breast. The heat patterns indicate the metabolic activity and vascular circulation in breast tissue which will be high at the surrounding area of cancerous tissue [4].

Due to the need of overcoming the problem that cause high rate of false positive and false negative detection, a Computer Assisted Detection (CAD) system is develop to provide assistant for clinician to identify cancerous tissue in mammogram and thermal image. The system will be design based on image processing technique on MATLAB platform.

1.2 Objectives

This project proposes to develop a system for breast cancer using image processing technique.

1.2.1 Sub-objective

The sub-objective for this project is as follow.

1. To classify type of breast and detect abnormalities of breast using mammogram image.
2. To study thermal image processing feasible to detect breast cancer.

1.3 Project Scope

The 150 breast mammogram images for this study are obtained from trusted online database (MIAS database) [11]. Breast thermal image with abnormalities obtain from 6 case studies by Pacific Chiropractic and Research Centre Infrared Imaging in California [4]. Both type of image analyse using Matlab software.

CHAPTER 2

LITERATURE REVIEW

Several researches have been done to develop CAD system to detect breast cancer. The references for this paper are taken from journal, books and conferences regarding the mammogram image and thermal image.

2.1 Image Processing Technique

Alasdair McAndrew (2004) entitlement, image processing is used to change the nature of an image to improve and enhance the image for human interpretation. Image processing also used to render image for machine perception. In his module, he explains on how to use matrix capabilities of MATLAB to investigate images and its properties. The image processing operations are explained in term of chapters. Image display chapter explain on how to use *imshow* function to display image and how spatial resolution and quantization affect the display and appearance of the image. Another chapter explain on point processing and the sub-chapter are arithmetic operation, histogram and thresholding. This sub-chapter discuss on how to modify image (enhance and blurring image) using MATLAB function that show how each operation work. For example, *imadjust* function which indicate histogram stretching is use to enhance image. The next chapter teach about spatial filtering. This chapter is also explaining on how to enhance and blurring image but using different operation. The operation discuss in this chapter is by filtering image using frequencies (low and high pass filter), Gaussian filter and non-linear filter. Types of noise, cleaning salt and pepper noise and cleaning Gaussian noise are explain in the

next chapter which is noise chapter. Noise is degradation in the image cause by image disturbance during transferring and during image acquisition. Cleaning noise is important to restore image to its original state and to analyse the image. The type of noise discuss in this module are salt and pepper noise and Gaussian noise. The image is filtered using *fspecial* function to clean up the noise. The next chapter explain one of the most useful information in an image which is edge. The uses of finding the edge are to measure size of the object, to isolate object from background, to recognise and classify object in the image. There are numbers of edge detection method discuss in this module such as Robert edge detection, Sobel edge detection and Prewitt edge detection. The module also discuss on topic morphology. Morphology is an operation in image processing to analyse shape in image. Morphology consist of many types of operations and some of it such as dilation, erosion, opening, closing, hit or miss transform, region filing and connected components are discuss in this module. Topic colour processing is discussed in the next chapter. In this chapter, the main topic discuss are what is colour mean in image processing, colour models, colour image in MATLAB, pseudo colouring and colour images processing . For example, to extract RGB component in RGB image, *imshow* function can be used. [17]

Marius Leordeanu et. al. (2011) entitlement, boundary detection is an important task when doing segmentation and recognition using vision system. Despite being one of the most important tasks to be done in image processing, there is no general formulation for boundary detection. This paper discusses on formulation and algorithm designed to detect different types of boundaries such as boundaries intensity, occlusion boundaries and specific boundaries for object. Based on their observation, boundary can be summarizing as a region that separates different image regions or a layer that coincide with boundaries in other layer. In this paper, author has designed two algorithms (Gb1 and GB2) and tested the algorithm to detect boundaries in static colour images, occlusion boundaries in video, occlusion boundaries in RGB-D video and boundaries from soft-segmentation. The result is the algorithm effectively and accurately detects boundaries of images use in the experiment. [18]

Hao Yuen Kueh et. al. entitlement, biological image contain a lot of patterns and objects which may convey information about biology mechanism. This tutorial

discusses the process to extract data from raw microscopic image using MATLAB. The advantages to extract and quantify objects and patterns using automated image analysis compare to manual methods of analysis is automated image analysis will provide unbiased approach to extract information from images and testing hypotheses. Automated system analysis also has advantages to facilitate the collections of large data collections for statistical analysis. The topics discuss in the first section of this tutorial are how to read, display, write and convert images. Besides that, the author also discuss on how MATLAB represent image and how to convert between different types of image. The second section discuss on contrast adjustment. As majority of biological image have low dynamic range and the features are difficult to be analysis, there is a need to enhance the appearance of the image by using different intensity transformation. This step may improve the performance of image segmentation algorithm and feature recognition. Next section discuss on spatial filtering technique. The filters explained are smoothing filters (average filter and Gaussian filter), edge detection filter (Prewitt filter and Sobel filter), Laplacian filter and median filter. Mathematical morphology which uses to extract features and components in images discussed on the next chapter. The operations are dilation, erosion, opening (erosion followed by dilation), closing (dilation followed by erosion), filling holes and clearing border objects. Image segmentation process to subdivide image into regions and images discuss in the next section. The quantitative information is processed and analysed using segmentation technique for extraction. The techniques of segmentation are edge detection and morphological watershed. This tutorial also discuss on analysis of dynamic and motion in biological images. The techniques use to visualize dynamical behaviour are kymographs (two-dimensional analog of times traces), difference images, maximum intensity projections, image cross-correlation and particle tracking. [19]

2.2 Mammogram Image Analysis

Jelene Bozek, Kresimir Delac and Mislav Grgic (2008) entitlement, mammography is the best method to detect early signs of breast cancer such as masses, calcifications, bilateral asymmetry and architectural distortion. However,

due to human limitation computer system have to take the major role in detecting abnormal tissue. The challenges that have been faced by the system are the wide range of abnormalities features and the indistinguishable from surrounding cell. Most of system developed involves algorithms which consist of two stages. The first stage is to detect suspicious lesion and second stage is to reduce the number of false positives. In BI-RADS system which discussed in this paper, the detected lesions are classified as masses, calcifications, architectural distortion and bilateral asymmetry. Masses are classified as benign or malignant based on density (fat containing, low density, isodense and high density), margins (circumscribed, microlobular, obscured, indistinct and spiculated) and shape (round, oval, lobular and irregular). Calcifications classified as benign, malignancy suspicious and malignancy highly suspicious based on the distribution of cluster, size, shape, and variability. For architectural distortion, the lesion classified as malignant when integrated with other lesion such as masses and classified as benign when scar and self-tissue damage due to trauma detected. Bilateral asymmetry analyse based on its texture, shape measurement, topology, brightness distribution, roughness, pattern assymetry and directionality. [3]

Ranjeet Singh Tomar et. al. (2009) entitlement that image processing techniques that been mention in their journal are more radiologist friendly. The system is designed using image processing technique on MATLAB. The techniques uses are edge detection and morphology. The detection process designed will start with detecting entire cell in the image, followed by filling gaps, dilating gaps, removing border, smoothing the objects, finding structures and lastly extracting large objects. For feature extraction to find the wanted area, 3 steps were suggested which were reduce uneven illumination, determine size distribution in Top-hat Image and calculate first derivatives. The result for feature extraction then plotted into graph to be analysing for classification. [6]

Hala Al-Shamlan and Ali El-Zaart (2010) entitlement, the features extraction in mammogram is an important key for early detection of breast cancer. In this study, they aim to determine the features extraction range. Before the range was determined, image pre-processing and image segmentation process applied to the images. Image pre-processing done to the image to suppress noise and improve the contrast of the image. Image segmentation is for detect the suspicious lesion. The

features used are based on three main categories; Geometric, Texture and Gradient features. For Geometric category, the features measured are area, perimeter and compactness [20]. Features in Texture category mostly obtain from image histogram. The features are mean, mean global area, mean local area, uniformity, standard deviations, smoothness, skewness, entropy, correlation and inverse. The last category is Gradient category. Features that classified under this category are Sobel-mean, Sobel-mean global area, Sobel-mean local area, Sobel-uniformity, Sobel-standard deviations, Sobel-smoothness, Sobel-skewness, Sobel-entropy, Sobel-correlation and Sobel-inverse. After applying up to 23 types of features extraction to 80 mammograms, they manage to obtain the range value for each feature extraction which may be used for further process in their breast cancer CAD system. [7]

2.3 CAD System Using Thermal Image

Monique Frize, Christophe Herry and Rober Roberge (2002) entitlement, the 3 technique in Head et al's methods [21]. The study shows the third method provided reliable result compare to the first and second method when applied to 9 patient's sample (6 with a diagnosis of normal and 3 with cancer). One of the analysis done is by increasing the threshold value in the methods and the result obtain are no false negatives or false positives on the sample. Therefore by looking at this preliminary result, they concluded future work should focus on improving third method to enhance thermogram diagnosis and decrease false negatives or false positives. [8]

V. Umadevi, S. V. Raghavan and Dr. Sandeep Jaipurkar (2010) entitlement, an interpretation system able to characterize thermography image as normal or required follow-up with clinician. The infrared cameras uses in this paper are Ti40FT from M/s Fluke Corp. and Varioscan-3021 ST from Jenoptik Laser. Software that integrated with the cameras to view images captured are SmartView for Ti40FT and IRBIS for Varioscan 3021-ST. The system discussed in this paper is Infrared Thermography Based Image Construction (ITBIC) system. This system consists of two main process, body boundary identification and highest temperature area extraction. This system will classify the image into normal case or follow-up case. When the system tested to 50 female volunteers, the system manages to characterize

and match the result to clinical finding. The system then interface with developed graphical user interface (GUI) to allow easier thermal image analysis by the radiologist or clinician. [9]

Pragati Kapoor and Dr. S. V. A. V. Prasad (2010) entitlement, image segmentation with automatic approach may improve the accuracy in earlier detection of breast cancer for thermography image. The methods outlined in this study are image segmentation and asymmetry analysis. One of the image segmentation process that use in this paper is edge detection which extract the boundaries of the breasts. The process also involving Hough transforms to extract the lower breast boundaries. Segmented classification done to classify each segmented pixel into a certain number of clusters. Lastly, diagnostic based on asymmetric analysing of the pixels in every cluster. The features uses in this paper for the diagnosis of image are skewness and kurtosis. [10]

CHAPTER 3

RESEARCH METHODOLOGY

This study will be using image processing main elements which are image acquisition, image pre-processing, image processing, feature extraction, object classification and classification decision as shown in Figure 3.1 for developing CAD system for mammograms and thermal images.

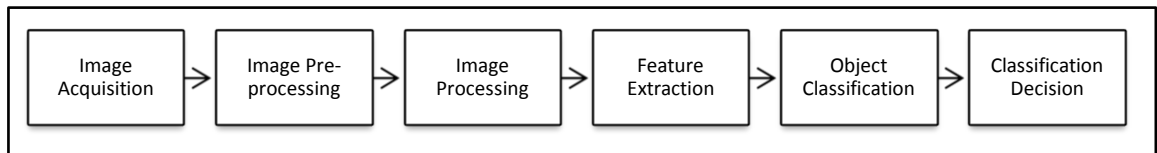


Figure 3.1 Image processing main elements

Image acquisition step involves the camera and its connection to the computer or processors. Computer or processors will receive the image in digital format. Image pre-processing step is a step to improve and enhance the image for processing step. Image processing step is a further step in analysing the image to obtain desired object. A lot of image processing techniques can be used in this step such as morphological processing, edge detection and compression. Feature extraction is where a set of desired features extracted from data pixels of the image which are good for classification. Object classification and classification decision are steps to make decision based on test and analysis done on the image [12]. The above methods is use to develop the following system;

1. System 1: Classification between ‘Fatty breast’ and ‘Glandular breast’.
2. System 2: Detection for abnormalities in type ‘Fatty breast’ images.
3. System 3: Detection of high temperature in thermal images.

3.1 Image Acquisition

3.1.1 System 1.

Mammogram image is obtained using mammogram machine. There are many types of mammogram machine and one of it is 'YSX0906 Digital Mammography X-ray System' manufactured by YSENMED from China as shown in Figure 3.2. The sizes of mammogram image that can be obtained using this machine are 18 x 24 cm or 24 x 32 cm. The C-arm of the machine can rotate between range $+180^\circ$ and -135° . The clinician is allowed to magnify the image with ratio from (1.4)/1 until (1.6)/1. The thickness of breast that can be compress from 0 mm until 268 mm with pressure range between 0 kg until 20 kg [13].



Figure 3.2 YSX0906 Digital Mammography X-ray Machine

In this study, The CAD system will be tested using 150 mammography images (65 'Fatty breast' image and 85 'Glandular breast' image). The digital mammography images acquired from online mammogram database (MAIS database). The image resolution of the image is 1024 x 1024 and in PGM (Portable Graymap) format. A sample of the database is shown in Figure 3.3.

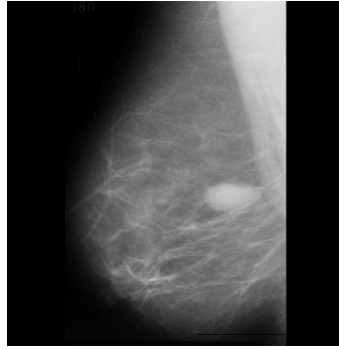


Figure 3.3 Mammogram image

3.1.2 System 2.

For detection for abnormalities, the system will test the 65 ‘Fatty breast’ mammography image that had been classified among the 150 mammogram images tested before. The digital mammography images acquired from online mammogram database (MAIS database). The image resolution of the image is 1024 x 1024 and in PGM (Portable Graymap) format.

3.1.3 System 3.

Thermal images of breast can be obtained using infrared camera. One type of camera that can be used is FLIR A615 manufactured by FLIR Systems, Inc. as shown in Figure 3.4. FLIR A615 is a perfect instrument for industries when the temperature changes over time is quiet fast. FLIR A615 also complies with standards like GigE Vision that allow this camera to interface using the Gigabit Ethernet communication protocol and fast image transfer using low cost standard cables even over long distances. This camera also complies with GenICam protocol which allows the camera to be use with third party software. Due to its compliance to standards, FLIR A615 is a Plug&Play device within 3rd parties Machine Vision softwares like NIs IMAQ Vision™ and the MVTecs Halcon™ software. By using this camera, image with resolution 640 x 480 pixels can be obtained [14].



Figure 3.4 FLIR A615 infrared camera.

For thermal image analysis, the system will test the 6 image at front position that taken from 6 case studies by Pacific Chiropractic and Research Centre Infrared Imaging website. The image resolution of the image is around 300 x 200 and in JPG (Joint Photographic Expert Group) format. A sample of thermal image is shown in Figure 3.5.1.

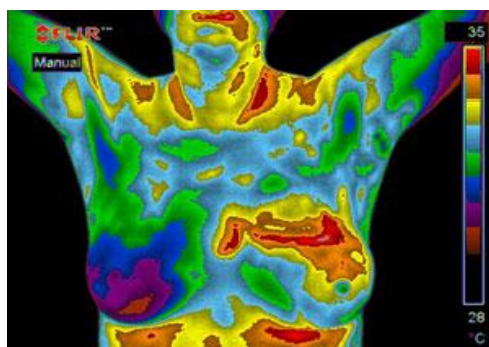


Figure 3.5 Thermal image of breast

3.2 Image Pre-processing and Image Processing

3.2.1 System 1.

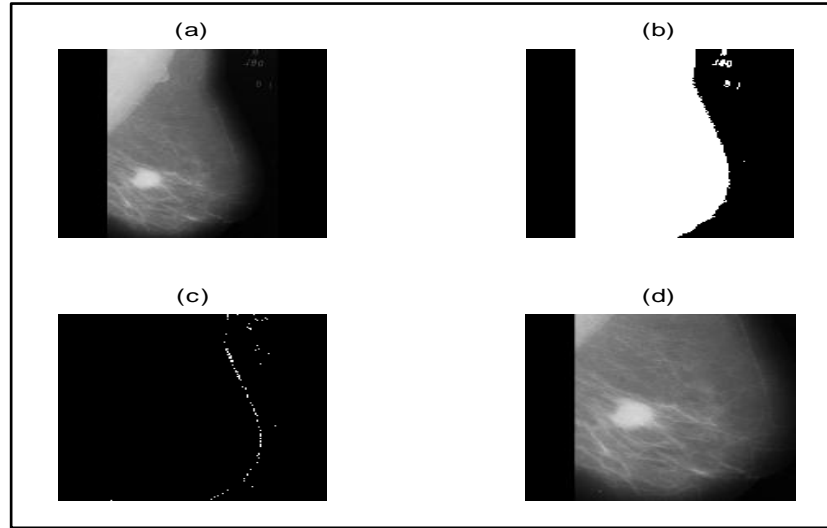


Figure 3.6 Image Pre-processing and Image Processing. (a) original image, (b) BW image, (c) *Sobel* gradient of (b), (d) Cropped image based on *Hough* parameter.

The original image (Figure 3.5.2(a)) is a grayscale image. The image then convert to BW (black and white) image (Figure 3.5.2(b)) using *im2bw* function. *im2bw* (*I*, *level*) function converts grayscale image to a binary image. The output image occur after replacing all pixels in the input image with luminance greater than level with the value 1 (white) and replaces all other pixels with the value 0 (black). The level for this function is between 0 and 1 which is relative to the signal levels possible for the image's class.

Then, the edge of the image is finding by using *Sobel* gradient as shown in Table 3.1. After *Sobel* gradient apply to image in Figure 3.5.2(b), image in Figure 3.5.2(c) obtained. By using this image, the parameters of *Hough* function and *Houghpeaks* function obtain in order to crop the image automatically and produce output image (Figure 3.5.2(d)). *Hough* (BW) computes the Standard Hough Transform (SHT) of the binary image. *Hough* function is used to detect lines in the image and generate Hough transform matrix. *Houghpeaks* function will locate peaks in the Hough transform matrix and this value will be used to crop the ROI (Region of Interest) of the image.

-1	-2	-1		-1	0	1
0	0	0		-2	0	2
1	2	1		-1	0	1

Table 3.1: Sobel approximation to the derivatives

3.2.2 System 2.

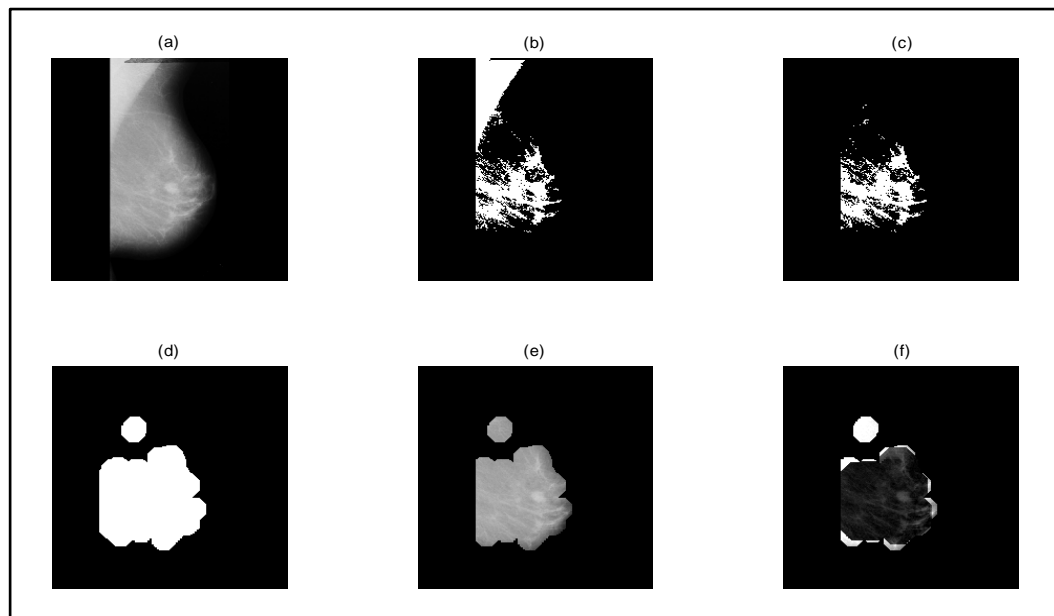


Figure 3.7 Image Pre-processing and Image Processing. (a) original image, (b) BW image, (c) *imclearborder* of image (b), (d) result after Morphological opening apply on image (c), (e) output image after multiplication between image (a) and (d), (f) sharpened image obtained by top-hat filtering and adjusting.

The image is crop to obtain new image with resolution 1001 x 1001 pixels. The images then change to BW using *im2bw* function (Figure 3.6(b)) before the noise removal function (*imclearborder*) use on the image (Figure 3.6(c)). *Imclearborder* function use to suppress structures that are lighter than their surroundings and that are connected to the image border. This step is to allow more accurate further analysis.

The image then process using morphological opening which consist of erosion followed by dilation (Figure 3.6(d)). *Imerode* function is an operation that

thins object in binary images based on structuring elements. *Imdilate* function is the opposite of *imerode* function. The structural elements which control these operations are created using *strel* function which consists of several shape and parameters to be chosen.

The image then multiply with original image using *immultiply* function to only shows the possible area of abnormalities as shown in Figure 3.6(e). Then, top-hat filtering performs on the image followed by *imadjust* function (Figure 3.6(f)). *Imtophat* function is use to perform top-hat filtering which will computes the morphological opening of the image and then subtracts the result from the original image. *Imadjust* function use to maps the intensity values of the original image to new values in output image such that 1% of data is saturated at low and high intensities of the original image. This increases the contrast of the output image.

3.2.3 System 3.

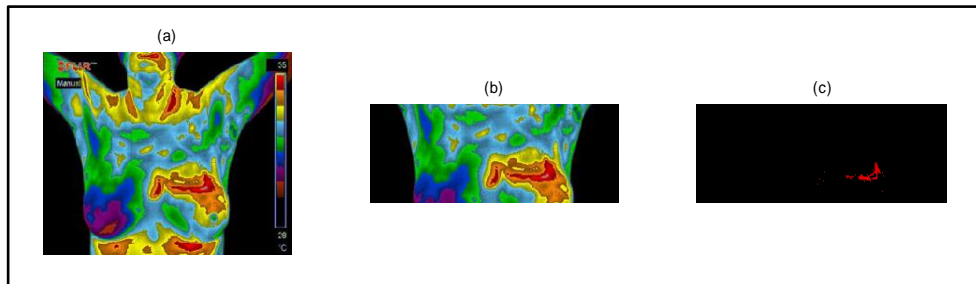


Figure 3.8 Image Pre-processing and Image Processing. (a) original image, (b) cropped image, (c) red colour area indicate high temperature area.

The image is crop using *imcrop* function to obtain only the breast area. The image will first process using threshold values that have been set. The threshold will detect the high temperatures which in this case indicate as red colour. The threshold value is shown in Table 3.2.

Colour	Digital Image Representation
Red	>170
Green	<50
Blue	<50

Table 3.2: Threshold value for colour processing

3.3 Feature Extraction

3.3.1 System 1.

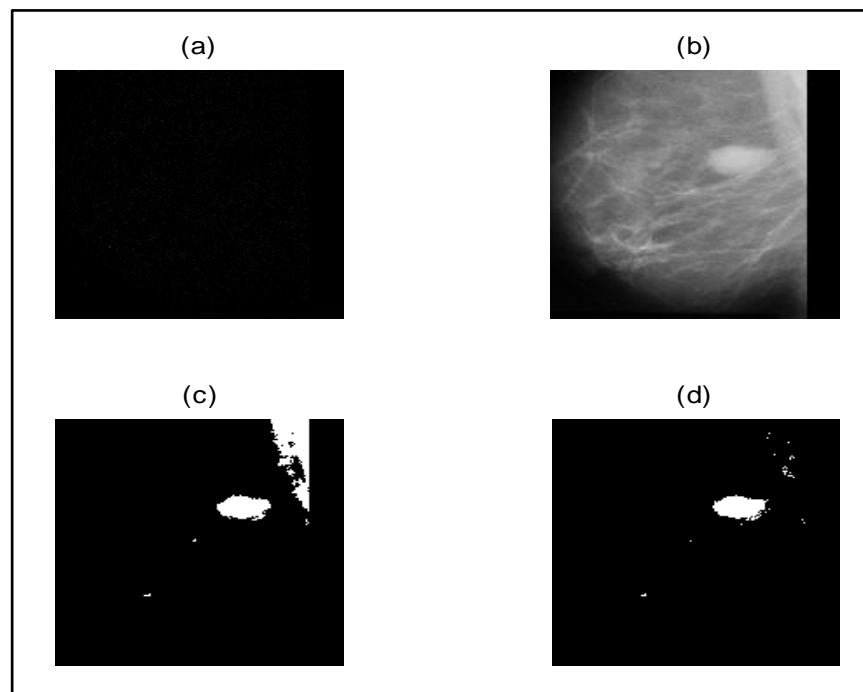


Figure 3.9 Feature extractions. (a) filtered cropped image (Figure 3.5(d)) using *Laplacian* filter, (b) sharpened image obtained by adding cropped image (Figure 3.5(d)) and (a), (c) BW image of (b), (d) clean image of (c).

The feature to be extracted is the number of tissue visible which in the BW image, the area shown in white colour. The number of tissues visible for ‘Glandular breast’ will be more than the number of tissues in ‘Fatty breast’ as ‘Glandular breast’ indicate dense breast and ‘Fatty breast’ indicate less dense breast. Therefore, to obtain the value to differentiate both type of breast, the image shown in Figure 3.5(d)

is filtered by *imfilter* function using *fspecial* function of *Laplacian* filter. *fspecial* function use to create a 3-by-3 two-dimensional filter of Laplacian operator. The shape of the filter control by alpha parameter and must be in the range 0.0 to 1.0. Then, the image is sharpened by using *imadd* function to produce image as shown in Figure 3.6(b). The sharpened image then convert to BW using specific level in *im2bw* function and the noise removed using *imclearborder* function to obtain clean image as shown in Figure 3.6(d).

3.3.2 System 2.

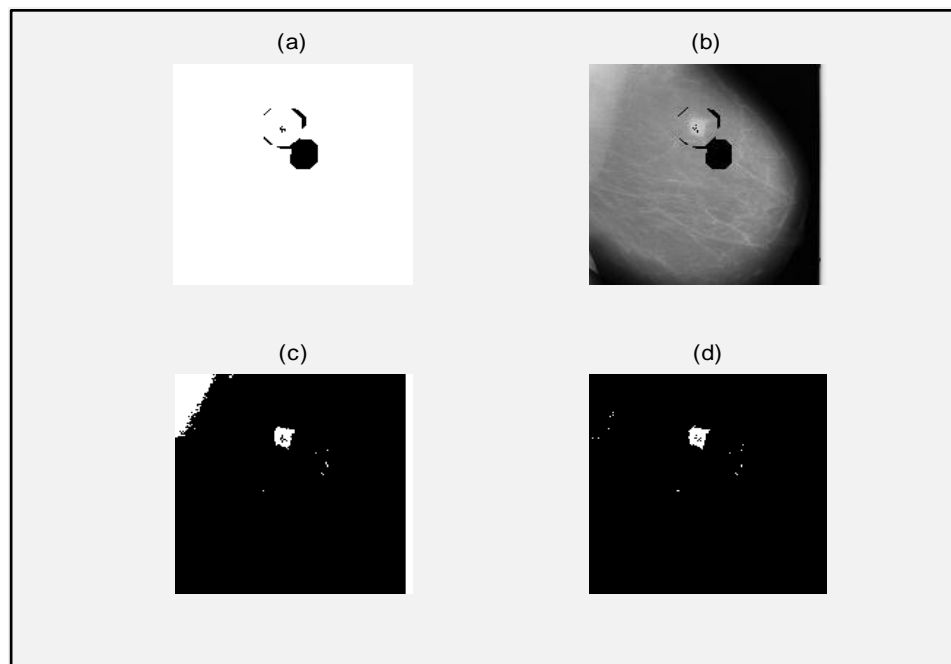


Figure 3.10 Feature extractions. (a) inverse image of output image in Image Processing process, (b) output image after multiplication between cropped image in Image Pre-processing process and (a), (c) BW image of (b), (d) clean image of (c).

The possible area of the tumour are the feature extracted to differentiate whether the image show ‘Normal Fatty breast’ or ‘Abnormal Fatty breast’. The complement of output image from Image Processing step are obtained (Figure 3.9(a)) before the image multiply with cropped image from Image Pre-processing using *immultiply* function to obtain image in Figure 3.9(b). Then, the BW image of Figure

3.9(b) obtain before noise removing by *imclearborder* function use on Figure 3.9(c) to extract feature in the image as shown in Figure 3.9(d).

3.4 Image Classification

3.4.1 System 1.

Image obtain from feature extraction step is in BW format therefore the pixel value for the image will only consist of number 0 and 1. In classification of ‘Fatty breast’ and ‘Glandular breast’, the number of pixel value is obtained using *sum* function. The number of pixel value for ‘Glandular breast’ will be more than the number of pixel value for ‘Fatty breast’.

The classification tool that will be use is linear classification tool and to obtain the threshold value for the classification, the number of pixel value for all 150 mammogram images plotted on the graph with axis as shown in Figure 3.10. X-axis in the graph will indicate the image number in the database and y-axis will indicate the number of pixel value of pixel number of the image. Threshold value is a value that differentiates both classes of ‘Fatty breast’ and ‘Glandular breast’.

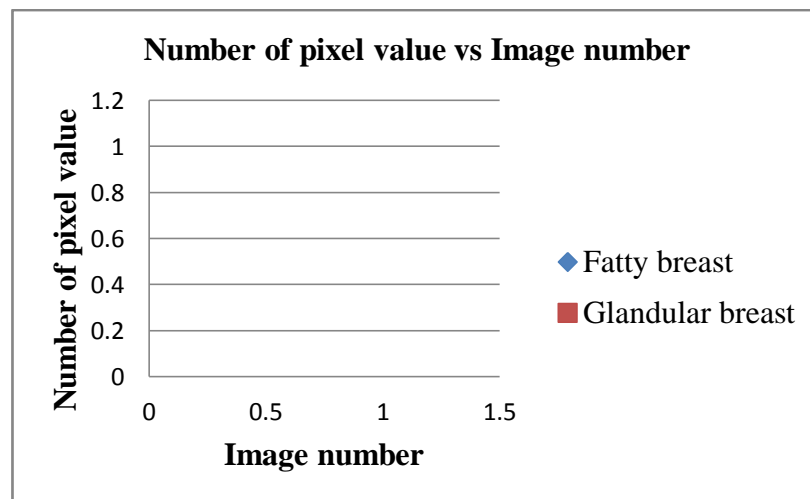


Figure 3.11 Graph number of pixel value versus image number

3.4.2 System 2.

Similar to the classification of ‘Fatty breast’ and ‘Glandular breast’, the detection for abnormalities in ‘Fatty breast’ image also use the number of pixel value 1 from the feature extraction output image. The number of pixel 1 for ‘Abnormal Fatty breast’ images will be more than the number of pixel value for ‘Normal Fatty breast’ images.

Linear classification tool also use as the classification tool for the detection and to obtain the threshold value for the classification, number of pixel value for all 65 ‘Fatty breast’ images divides by 10^4 are plotted on the graph with axis as shown in Figure 3.11. X-axis in the graph will indicate the image number in the database and y-axis will indicate the number of pixel value of pixel number of the image. Threshold value is a value that differentiates both classes of ‘Normal Fatty breast’ and ‘Abnormal Fatty breast’. Besides that, the abnormal area in the breast will be outlined on the image create by *bwperim* function as shown in Figure 3.12.

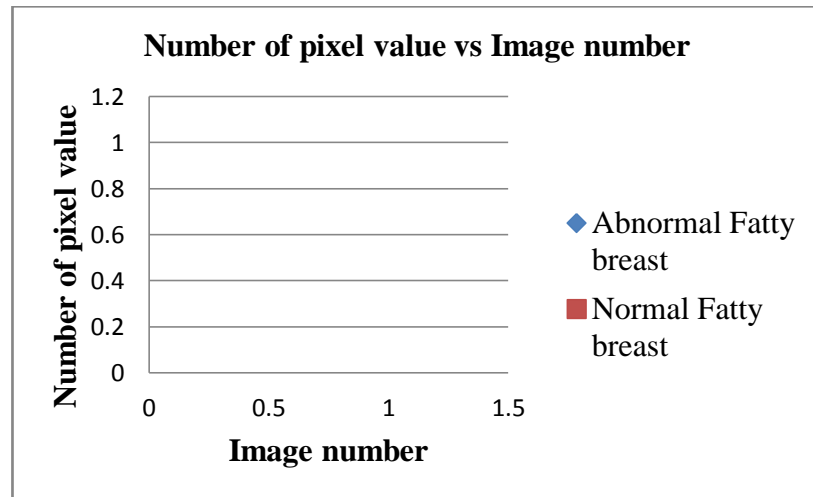


Figure 3.12 Number of pixel value versus Image number.

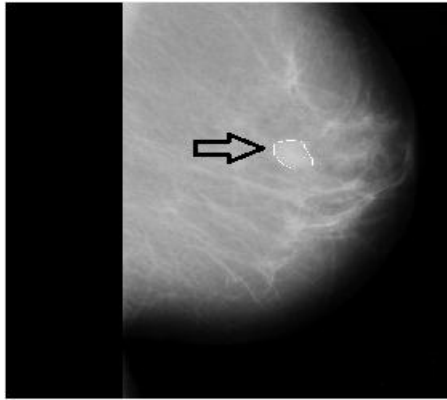


Figure 3.13 The possible abnormal cell was outlined.

3.4.3 System 3.

The decision for thermal image is by the visibility of high temperature area which on all 6 images the highest temperature is shown as red colour. The highest temperature is chosen to be visible in the final image because the possible cancerous area in breast thermal image is where the high temperature located.

CHAPTER 4

RESULT AND DISCUSSION

The result of the system can be divided into 2 parts which is for mammogram image and thermal image.

4.1 Results for Mammogram Analysis

In mammogram analysis, 2 classifications are done. The first classification is to differentiate between 'Fatty breast' type image and 'Glandular breast' type image. This classification is done to reduce misdiagnose by clinician due to the density of tissue which become noise in mammogram image. The dense tissues will reduce the penetration of x-rays through breast during screening process which then gives the same output image as when the x-rays penetrate through cancerous cell. Therefore, images which have lots of noise tissues classified as 'Glandular breast' type and images consist less noise tissues classified as 'Fatty breast' type. The classification is crucial to reduce misdiagnose of breast cancer.

The second classification is to detect any abnormalities in 'Fatty breast' type images. As 'Fatty breast' types consist less tissue, therefore the visibility of the cancerous cell in the images is high. This allows detection to be done on 'Fatty breast' type images.

4.1.1 Result for ‘Normal Fatty breast’ images.

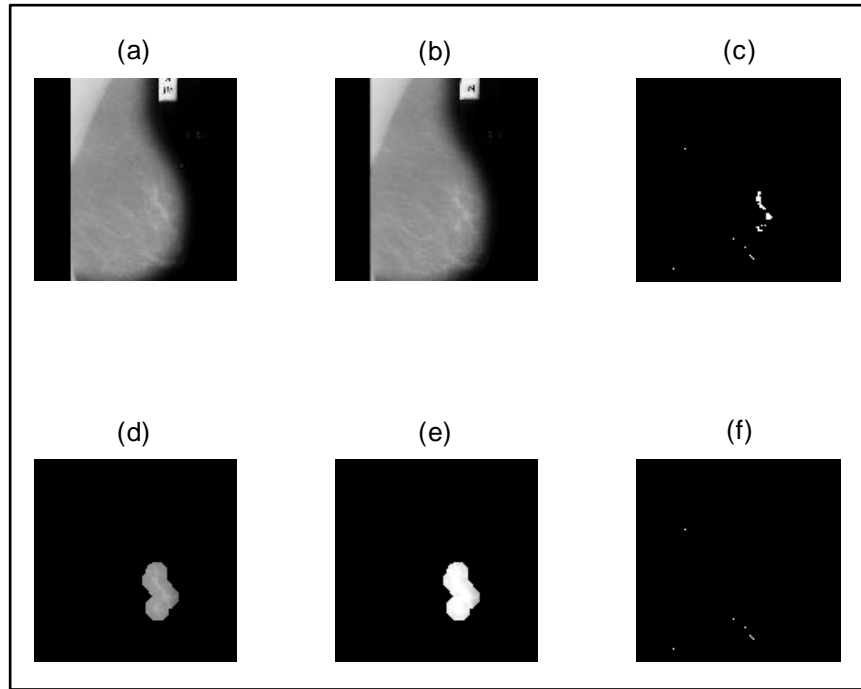


Figure 4.1 Overall results. (a) original image, (b) cropped image of (a), (c) output image after BW conversion and noise removal apply to image (b), (d) possible area of cancerous cell, (e) sharpened image of (d), (f) output image after noise removal.

Figure 4.1 show the image processing on a sample of mammogram image before the output image obtain and classified. Figure 4.1(a) show the original image before cropped into Figure 4.1(b). The image is cropped to reduce the resolution of the image which will increase processing time and increase accuracy rate as some of the noise has been crop. After converting to BW and applying *imclearborder* function to remove noise, image shown in Figure 4.1(c) obtained. Image shown in Figure 4.1(d) then obtained after morphological opening and multiplication process apply to image Figure 4.1(c). This image shows the possible area of the cancerous cell. The image then sharpened using top-hat filtering and *imadjust* function for further analysis on the normalities of the cell in the image as shown in Figure 4.1(e). The image then process again to remove noise which finally produce image as shown in Figure 4.1(f). The pitch black image shows no possible cancerous cell image exists and the summation pixel value will be low.

4.1.2 Result for ‘Abnormal Fatty breast’ images.

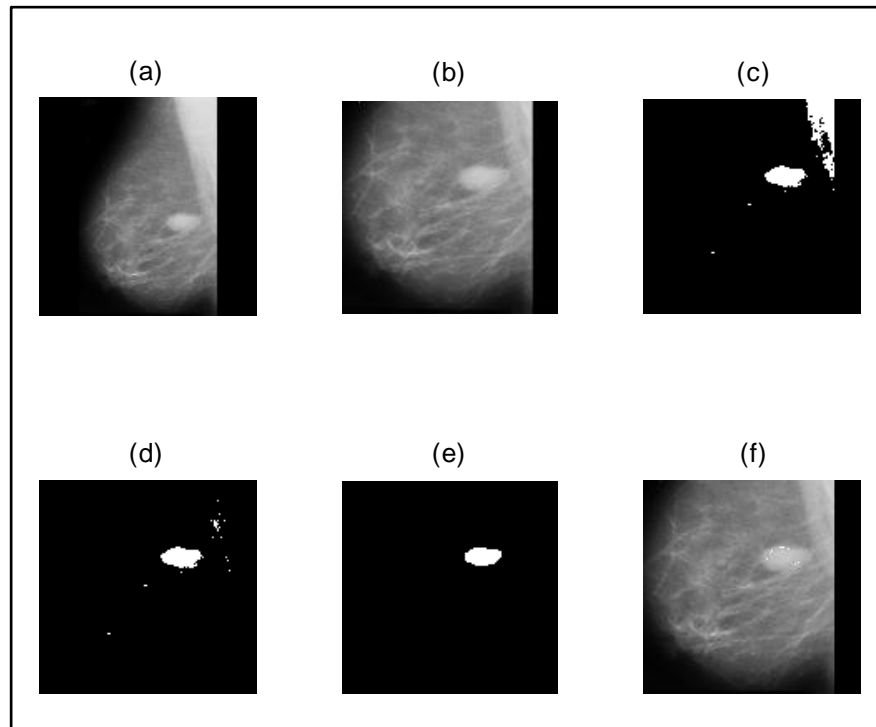


Figure 4.2 Overall result. (a) original image, (b) cropped image, (c) BW image, (d) and (e) noise removed image, (f) image (b) with outlined area.

Figure 4.2 show the overall process on a sample image before the image classify as “abnormal fatty breast’ image and the possible breast cancer cell outlined. Figure 4.2(a) show the original image before processed and cropped to form image in Figure 4.2(b). The image then convert to BW as shown in Figure 4.2(c) to allow noise removing process take place and produce an image which will only show the possible cancer cell image as shown in Figure 4.2(e). The summation value will depend on this image and the value will be higher than the summation value obtained for ‘Normal fatty breast’ type image but lower compare to summation value for ‘Glandular breast’ type. The possible cancer cell image lastly will be outline in the crop image based on image shown in Figure 4.2(e) and finally produce output image as shown in Figure 4.2(f).

4.1.3 Result for ‘Glandular breast’ images.

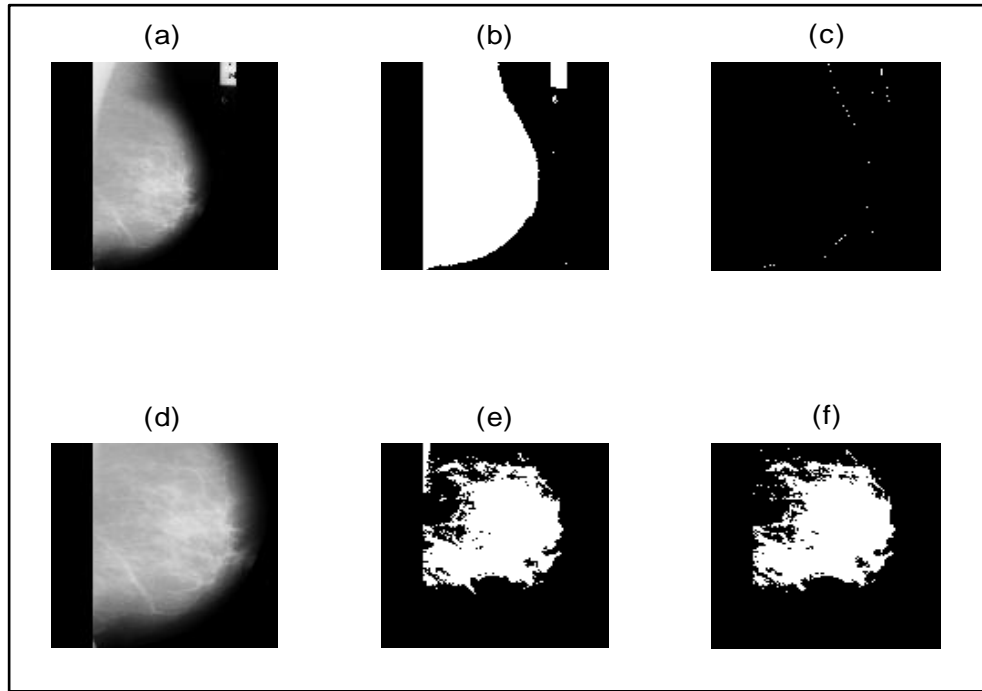


Figure 4.3 Overall result. (a) original image, (b) BW image of (a), (c) edge line of image (b), (d) cropped image, (e) sharpened image using *Laplacian* filter and BW conversion on image (d), (f) output image after noise removal.

The overall process before ‘Glandular breast’ type classify to its class is shown in Figure 4.3. Figure 4.3(a) show one sample of the original ‘Glandular breast’ type image. The image then converts to BW using *im2bw* function to produce Figure 4.3(b). After that, the edge line of previous image obtained as shown in Figure 4.3(c). This line will be used as guideline to crop the ROI of the image as shown in Figure 4.3(d). Figure 4.3(e) will be obtained after the previous image sharpened using *Laplacian* filter and convert to BW using specific level. Figure 4.3(f) show the output image after noise removal. This image show that for ‘Glandular breast’ type image, even after being sharpened and undergoes noise removal, the tissues are still visible. This will cause high summation value.

4.1.4 Threshold value for classification between ‘Fatty breast’ and ‘Glandular breast’.

In object classification step to differentiate between ‘Fatty breast’ type and ‘Glandular breast’ type, linear classification tool is use. All 150 mammogram image summation values are plotted on the graph shown in Figure 4.4. The feature value or decision boundary are generate from this graph to differentiate and separate both types. The separation function chosen are $y=18000$. The types of breast than classified based on value in Table 4.1. If the number of pixel value (summation value) is more than 18000, it is classified as ‘Glandular breast’ type image as the image consist lot of noise by surrounding tissues. If the summation value less than 18000, therefore the image consists less noise which allow the image to be analyse further.

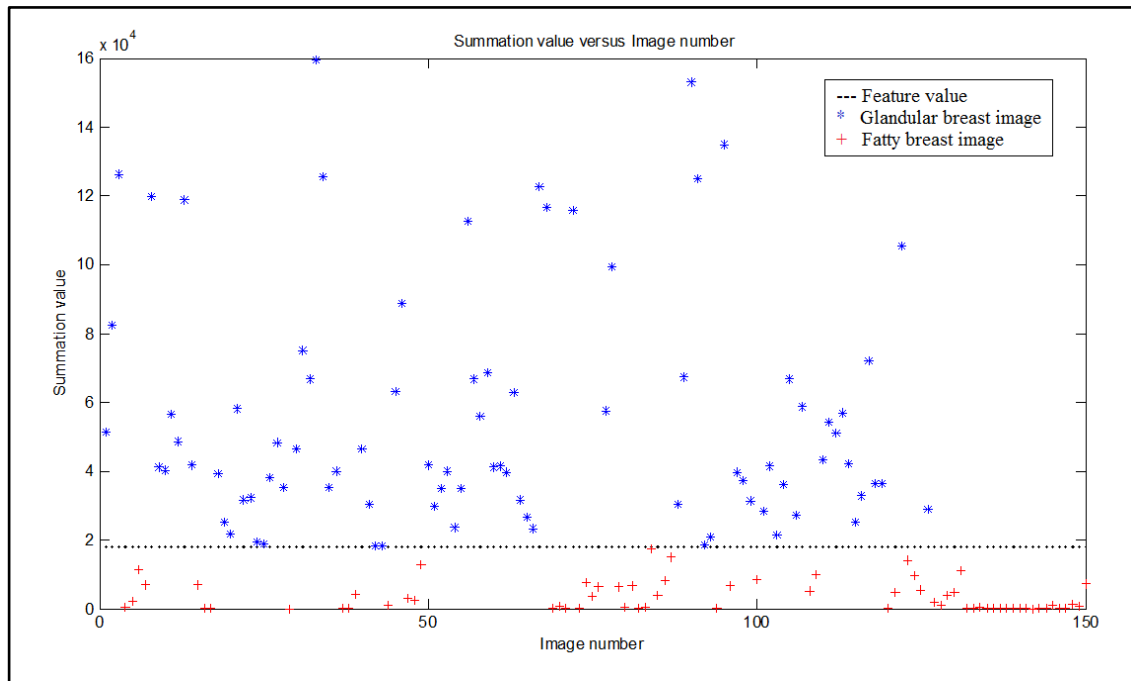


Figure 4.4 Classification graph for breast type.

Type of breast	Total pixel
Fatty breast	<18000
Glandular breast	>18000

Table 4.1: Threshold value for classification

4.1.5 Threshold value for abnormalities detection for ‘Fatty Breast’ images.

Second classification was done to classify the ‘Fatty breast’ image whether it is ‘Normal’ image or ‘Abnormal’ image. Linear classification tool was also done for this classification. The feature value chosen to classify the ‘Fatty breast’ type images into 2 classes is $y=0.491$. The value for ‘Glandular breast’ type in this classification is set to 12 thus it will not disrupt the result. The plotted summation values are shown in Figure 4.5. The classifications are shown in Table 4.2 where ‘Normal’ image summation value will be less than feature value and ‘Abnormal’ image summation value will be higher than feature value. This is due to the existing of addition tissue visible in mammogram which is cancer tissue in ‘Abnormal’ image.

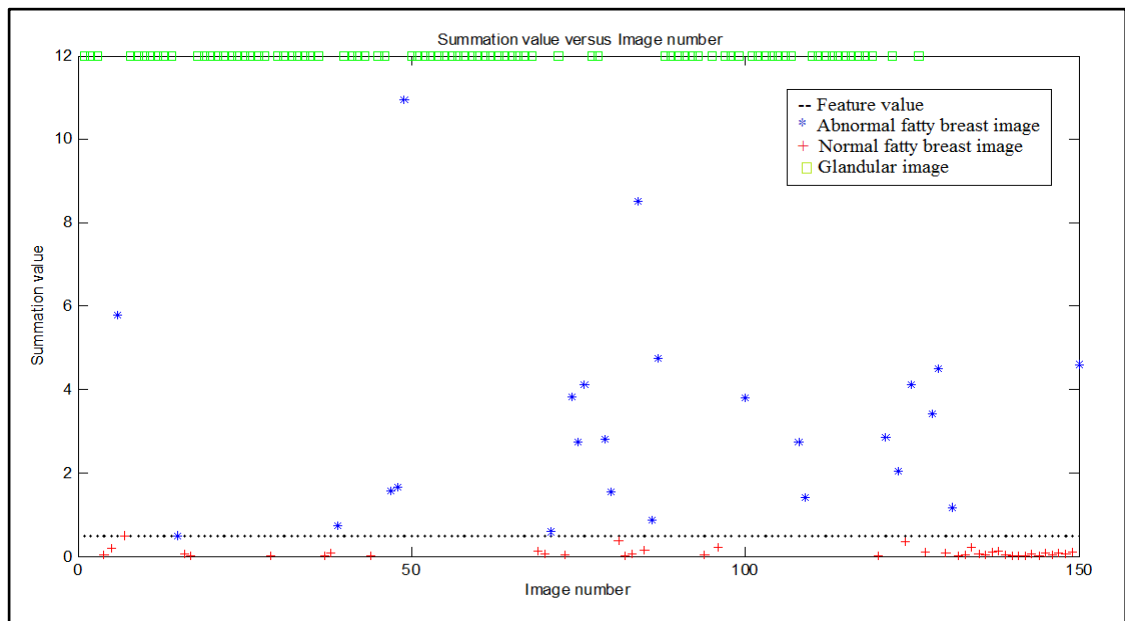


Figure 4.5 Classification graph for normalities type fatty breast.

Condition of Fatty Breast	Total pixel (sum/ 10^4)
Normal breast	<0.491
Abnormal breast	>0.491

Table 4.2: Threshold value for classification

4.1.6 Correlation between MIAS database result and analysis result.

The results for all the analysis done on 150 mammogram image are also written on text file using *fprintf* function as shown in Appendix B to be compare with result given by MIAS database as shown in Appendix A. Based on both appendices, the result obtain after all the analysis done on Matlab give 100% correct result when compare with MIAS database result.

4.1.7 Result for DDSM database image

After the system design using 150 mammogram images from MIAS database and proven 100% correct, the system tested again using another 150 images from Digital Database for Screening Mammography (DDSM) database [22]. 10 “Glandular breast” type images, 28 “ Normal Fatty breast” type images and 112 “Abnormal Fatty breast” type images taken from the database to be tested using the system designed. Figure 4.6 shows the result printed in file txt after the entire image analyse by the system. The error of the system calculated is based on “Fatty breast” type and “Glandular breast” type. The calculation is shown in Equation (1).

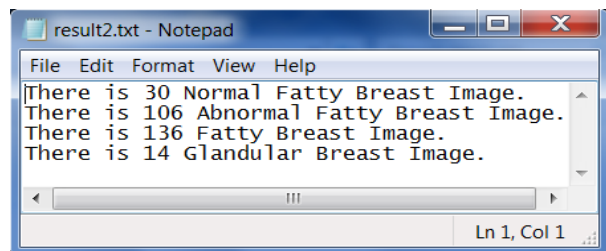


Figure 4.6 DDSM database images result.

$$error = \frac{136 - 130}{150} \times 100\% = 4\% \dots \dots \dots (1)$$

According to the answer in Equation (1), 6 images provide wrong answer, therefore the total error for 150 images from DDSM database is 4%. Based on this value, the reliability of this system can be concluded as 96% reliable.

4.2 Results for Thermogram Analysis

For thermal image analysis, the detection of the high temperature area is important. This is because if cancer cell exist in the breast, the surface temperature located near to the cancer cell will not drop following to the surrounding. Therefore even the patient put inside a quarantine area with low temperature and the thermal image of her breast taken after several minute, the high temperature cause by the cancer cell won't drop. As a result, the high temperature area indicates the possible area of the cancer cell as shown in Figure 4.6.

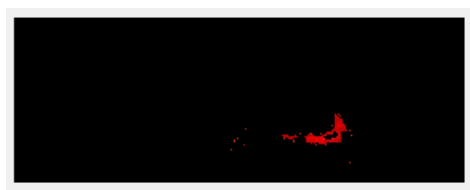


Figure 4.7 High Temperature detected after analysing thermal image.

4.3 GUI

GUI (Graphical User Interface) then developed to create a user friendly CAD system. Figure 4.7 show the GUI for the CAD system discuss in this paper. The GUI consists of two different panels that allow user to choose whether they want to analyse mammogram image or thermal image.

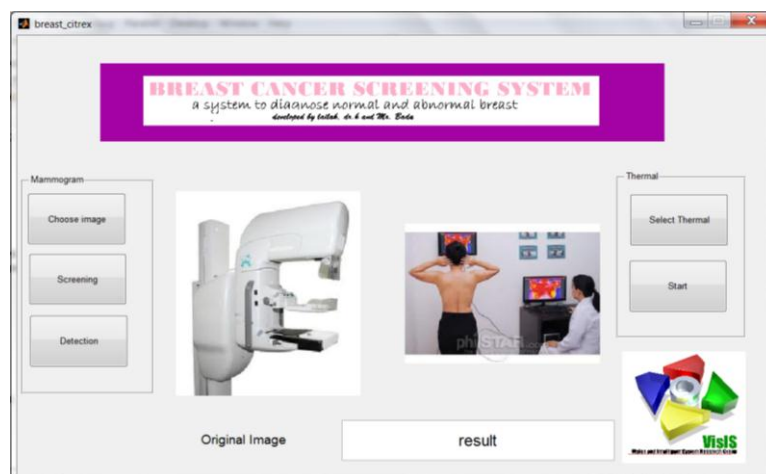


Figure 4.8 GUI for CAD system.

Figure 4.9 until Figure 4.11 show one example on how to use the GUI shown in Figure 4.8. Figure 4.9 shows that to start using the GUI, press ‘Choose image’ button pointed by arrow. A new window will appear to allow user to browse for the image. After clicking button ‘OK’ in the other window, the image will appear in the right display area as shown by the red box. Figure 4.10 show the result (red box) after pressing ‘Screening’ button (pointed by arrow). Based on the result, if “Glandular breast” is written the process will be ended. However, if the result written as “Fatty breast”, the next step will be selecting button ‘Detection’ to show image of the possible area of the cancer cell as shown in the red box of Figure 4.11. Green box in Figure 4.11 show the type of the breast.

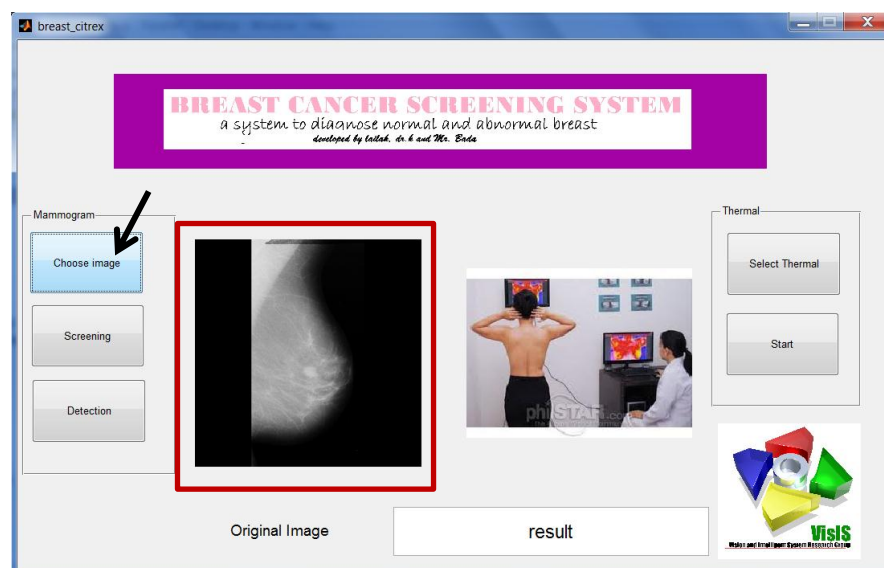


Figure 4.9 ‘Choose image’ button selected and its result.

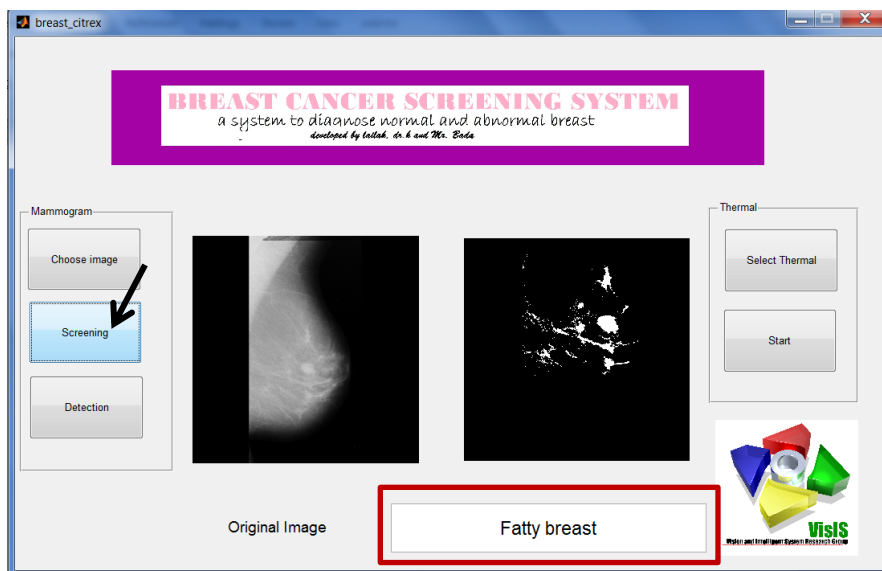


Figure 4.10 'Screening' button selected and the result.

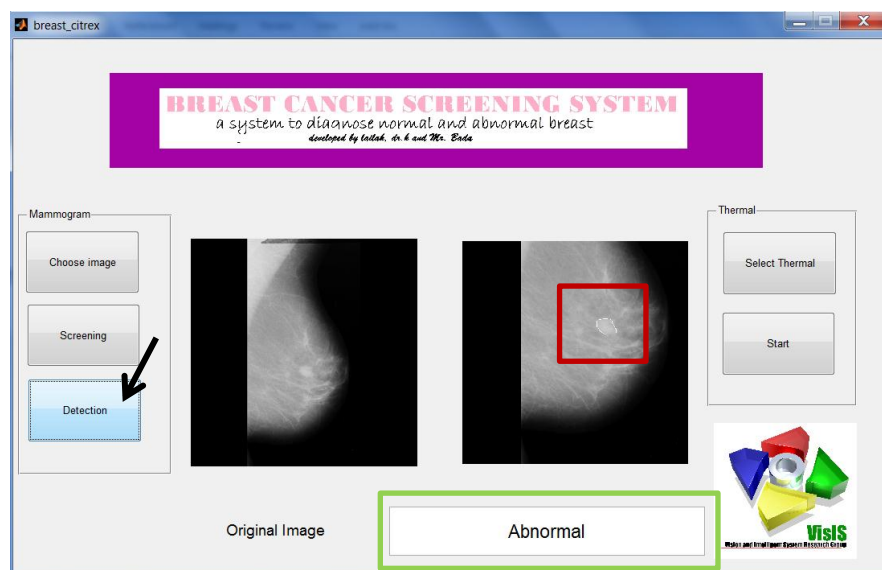


Figure 4.11 'Detection' button selected and the result.

CHAPTER 5

CONCLUSION

As a conclusion, the system successfully fulfils its objective. The system is fully design based on image processing technique elements (image acquisition, image pre-processing, image processing, feature extraction, object classification and classification decision). The system also can be used for both mammogram and thermal image. As discuss in Chapter 4, this system able to classify 'Fatty breast' type image or 'Glandular breast' type image for 300 images from 2 different databases with minor error. Besides that, the system also is able to classify 'Fatty breast' type image into more detail classification which is 'Normal' and 'Abnormal'. Chapter 4 also show that thermal image processing is feasible to detect breast cancer.

5.1 Future Recommendation

For future recommendation, this system can be improved by testing it with more mammogram and thermal image. Besides that, the improvement on GUI also can be taken into account to allow the system to be more user-friendly. Interface the system with mammography machine and thermal camera also recommended.

REFERENCES

- [1] Gulzar A. Khuwaja, "Breast cancer detection using mammography," *Proceedings of the 5th WSEAS International Conference on Signal Processing*, pp. 20-23, May 2006.
- [2] http://www.who.int/gho/women_and_health/en/index.html [Accessed: November 2011]
- [3] Jelena Bozek, Kresimir Delac, Mislav Grgic, "Computer-Aided Detection and Diagnosis of Breast Abnormalities in Digital Mammography," *50th International Symposium ELMAR-2008*, September 2008.
- [4] <http://www.breastthermography.com> [Accessed: November 2011]
- [5] Haifeng Zhang, Liqun He, Liang Zhu, "Critical Conditions for the Thermal Diagnosis of the Breast Cancer," *IEEE 2009*.
- [6] Ranjeet Singh Tomar, Tripty Singh, Dr. Sulochana Wadhwani, Dr. Sarita Singh Bhadoria, "Analysis of Breast Cancer Using Image Processing Techniques," *2009 Third UKSim European Symposium on Computer Modelling and Simulation*, IEEE 2009.
- [7] Hala Al-Shamlan, Ali El-Zaart, "Feature Extraction Values for Breast Cancer Mammography Images," *International Conference on Bioinformatics and Biomedical Technology*, IEEE 2010.
- [8] Monique Frize, Christophe Herry, Rober Roberge, "Processing of Thermal Images to Detect Breast Cancer: Comparison with Previous Work," *Proceedings of the Second Joint EMBS/BMES Conference*, IEEE 2002.
- [9] V. Umadevi, S. V. Raghavan and Dr. Sandeep Jaipurkar, "Interpreter for Breast Thermogram Characterization," *IEEE EMBS Conference on Biomedical Engineering and Sciences*, IEEE 2010.
- [10] Pragati Kapoor, Dr. S. V. A. V. Prasad, "Image Processing for Early Diagnosis of Breast Cancer Using Infrared Images," *2nd International Conference on Computer and Automation Engineering*, IEEE 2010.

- [11] <http://peipa.essex.ac.uk/ipa/pix/mias/> [Accessed: November 2011].
- [12] Kamarul Hawari, Nurul Wahidah, Faradila, Rosyati, Nazriyah, Rohana, Farizan, Falfazli, Lailatul, “The Computer Vision System Module”, 2011.
- [13] <http://www.alibaba.com/> [Accessed: May 2012]
- [14] <http://www.flir.com/thermography> [Accessed: May 2012]
- [15] Julien Cauchie, Valerie Fiolet, Didier Villers, (2007), “*Optimization of an Hough transform algorithm for the search of a centre*”, Pattern Recognition 41 (2008) 567-574.
- [16] R.M.Rangayyam, F.J. Ayres, J.E.L. Desautels, “A Review of Computer-Aided Diagnosis of Breast Cancer: Toward the Detection Subtle Signs”, *Journal of the Franklin Institute*, Vol. 344, Issues 3-4, 2007, pp.312-348.
- [17] Alasdair McAndrew, “An Introduction to Digital Image Processing with MATLAB: Notes for SCM2511 Image Processing 1”, 2004.
- [18] Marius Leordeanu, Rahul Sukthankar, Cristian Sminchisescu, “Generalized Boundaries from Multiple Image Interpretations”, *Technical Report*, INS, University of Bonn, November 2011.
- [19] Hao Yuen Kueh, Eugenio Marco, Mike Springer, Sivaraj Sivaramakrishnan, “Image analysis for biology”, MBI, Physiology Course, 2008.
- [20] Tomoko Matsubara, Hiroshi Fujita, Satoshi Kasai, Miki Goto, Yoshinobu Tani, Takeshi Hara, Tokiko Endo, “Development of New Schemes for Detection and Analysis of Mammographic Masses”, IEEE, 1997.
- [21] JF Head, CA Lipari, F Wang, RL Elliot, “Image Analysis of Digitized Infrared Images of the Breasts from a First Generation Infrared Imaging System”, Proc. 19th IEEE/EMBS, pp. 681-684, Chicago, 1997.
- [22] <http://marathon.csee.usf.edu/Mammography/Database.html> [Accessed: May 2012]

APPENDIX A

Image Type and Normalities Based on MIAS database

NO	Type	N/A	NO	Type	N/A	NO	Type	N/A	NO	Type	N/A
1	G		39	F	A	77	G		115	G	
2	G		40	G		78	G		116	G	
3	G		41	G		79	F	A	117	G	
4	F	N	42	G		80	F	A	118	G	
5	F	N	43	G		81	F	N	119	G	
6	F	A	44	F	N	82	F	N	120	F	N
7	F	N	45	G		83	F	N	121	F	A
8	G		46	G		84	F	A	122	G	
9	G		47	F	A	85	F	N	123	F	A
10	G		48	F	A	86	F	A	124	F	N
11	G		49	F	A	87	F	A	125	F	A
12	G		50	G		88	G		126	G	
13	G		51	G		89	G		127	F	N
14	G		52	G		90	G		128	F	A
15	F	A	53	G		91	G		129	F	A
16	F	N	54	G		92	G		130	F	N
17	F	N	55	G		93	G		131	F	A
18	G		56	G		94	F	N	132	F	N
19	G		57	G		95	G		133	F	N
20	G		58	G		96	F	N	134	F	N
21	G		59	G		97	G		135	F	N
22	G		60	G		98	G		136	F	N
23	G		61	G		99	G		137	F	N
24	G		62	G		100	F	A	138	F	N
25	G		63	G		101	G		139	F	N
26	G		64	G		102	G		140	F	N
27	G		65	G		103	G		141	F	N
28	G		66	G		104	G		142	F	N
29	F	N	67	G		105	G		143	F	N
30	G		68	G		106	G		144	F	N
31	G		69	F	N	107	G		145	F	N
32	G		70	F	N	108	F	A	146	F	N
33	G		71	F	A	109	F	A	147	F	N
34	G		72	G		110	G		148	F	N
35	G		73	F	N	111	G		149	F	N
36	G		74	F	A	112	G		150	F	A
37	F	N	75	F	A	113	G				
38	F	N	76	F	A	114	G				

Guide:

NO = Image number

F = Fatty breast image

G = Glandular breast image

N = Normal fatty breast image

A = Abnormal fatty breast image

APPENDIX B

Result for image type and normalities written in text file.

Image 1 is a Glandular Breast Image.
Image 2 is a Glandular Breast Image.
Image 3 is a Glandular Breast Image.
Image 4 is a Fatty Breast Image. Image is a Normal Fatty Breast Image.
Image 5 is a Fatty Breast Image. Image is a Normal Fatty Breast Image.
Image 6 is a Fatty Breast Image. Image is an Abnormal Fatty Breast Image.
Image 7 is a Fatty Breast Image. Image is a Normal Fatty Breast Image.
Image 8 is a Glandular Breast Image.
Image 9 is a Glandular Breast Image.
Image 10 is a Glandular Breast Image.
Image 11 is a Glandular Breast Image.
Image 12 is a Glandular Breast Image.
Image 13 is a Glandular Breast Image.
Image 14 is a Glandular Breast Image.
Image 15 is a Fatty Breast Image. Image is an Abnormal Fatty Breast Image.
Image 16 is a Fatty Breast Image. Image is a Normal Fatty Breast Image.
Image 17 is a Fatty Breast Image. Image is a Normal Fatty Breast Image.
Image 18 is a Glandular Breast Image.
Image 19 is a Glandular Breast Image.
Image 20 is a Glandular Breast Image.
Image 21 is a Glandular Breast Image.
Image 22 is a Glandular Breast Image.
Image 23 is a Glandular Breast Image.
Image 24 is a Glandular Breast Image.
Image 25 is a Glandular Breast Image.
Image 26 is a Glandular Breast Image.
Image 27 is a Glandular Breast Image.
Image 28 is a Glandular Breast Image.
Image 29 is a Fatty Breast Image. Image is a Normal Fatty Breast Image.
Image 30 is a Glandular Breast Image.
Image 31 is a Glandular Breast Image.
Image 32 is a Glandular Breast Image.
Image 33 is a Glandular Breast Image.
Image 34 is a Glandular Breast Image.
Image 35 is a Glandular Breast Image.
Image 36 is a Glandular Breast Image.
Image 37 is a Fatty Breast Image. Image is a Normal Fatty Breast Image.
Image 38 is a Fatty Breast Image. Image is a Normal Fatty Breast Image.
Image 39 is a Fatty Breast Image. Image is an Abnormal Fatty Breast Image.
Image 40 is a Glandular Breast Image.
Image 41 is a Glandular Breast Image.
Image 42 is a Glandular Breast Image.
Image 43 is a Glandular Breast Image.
Image 44 is a Fatty Breast Image. Image is a Normal Fatty Breast Image.
Image 45 is a Glandular Breast Image.
Image 46 is a Glandular Breast Image.

Image 47 is a Fatty Breast Image. Image is an Abnormal Fatty Breast Image.
Image 48 is a Fatty Breast Image. Image is an Abnormal Fatty Breast Image.
Image 49 is a Fatty Breast Image. Image is an Abnormal Fatty Breast Image.
Image 50 is a Glandular Breast Image.
Image 51 is a Glandular Breast Image.
Image 52 is a Glandular Breast Image.
Image 53 is a Glandular Breast Image.
Image 54 is a Glandular Breast Image.
Image 55 is a Glandular Breast Image.
Image 56 is a Glandular Breast Image.
Image 57 is a Glandular Breast Image.
Image 58 is a Glandular Breast Image.
Image 59 is a Glandular Breast Image.
Image 60 is a Glandular Breast Image.
Image 61 is a Glandular Breast Image.
Image 62 is a Glandular Breast Image.
Image 63 is a Glandular Breast Image.
Image 64 is a Glandular Breast Image.
Image 65 is a Glandular Breast Image.
Image 66 is a Glandular Breast Image.
Image 67 is a Glandular Breast Image.
Image 68 is a Glandular Breast Image.
Image 69 is a Fatty Breast Image. Image is a Normal Fatty Breast Image.
Image 70 is a Fatty Breast Image. Image is a Normal Fatty Breast Image.
Image 71 is a Fatty Breast Image. Image is an Abnormal Fatty Breast Image.
Image 72 is a Glandular Breast Image.
Image 73 is a Fatty Breast Image. Image is a Normal Fatty Breast Image.
Image 74 is a Fatty Breast Image. Image is an Abnormal Fatty Breast Image.
Image 75 is a Fatty Breast Image. Image is an Abnormal Fatty Breast Image.
Image 76 is a Fatty Breast Image. Image is an Abnormal Fatty Breast Image.
Image 77 is a Glandular Breast Image.
Image 78 is a Glandular Breast Image.
Image 79 is a Fatty Breast Image. Image is an Abnormal Fatty Breast Image.
Image 80 is a Fatty Breast Image. Image is an Abnormal Fatty Breast Image.
Image 81 is a Fatty Breast Image. Image is a Normal Fatty Breast Image.
Image 82 is a Fatty Breast Image. Image is a Normal Fatty Breast Image.
Image 83 is a Fatty Breast Image. Image is a Normal Fatty Breast Image.
Image 84 is a Fatty Breast Image. Image is an Abnormal Fatty Breast Image.
Image 85 is a Fatty Breast Image. Image is a Normal Fatty Breast Image.
Image 86 is a Fatty Breast Image. Image is an Abnormal Fatty Breast Image.
Image 87 is a Fatty Breast Image. Image is an Abnormal Fatty Breast Image.
Image 88 is a Glandular Breast Image.
Image 89 is a Glandular Breast Image.
Image 90 is a Glandular Breast Image.
Image 91 is a Glandular Breast Image.
Image 92 is a Glandular Breast Image.
Image 93 is a Glandular Breast Image.
Image 94 is a Fatty Breast Image. Image is a Normal Fatty Breast Image.
Image 95 is a Glandular Breast Image.
Image 96 is a Fatty Breast Image. Image is a Normal Fatty Breast Image.

[illegible]

Image 147 is a Fatty Breast Image. Image is a Normal Fatty Breast Image.
Image 148 is a Fatty Breast Image. Image is a Normal Fatty Breast Image.
Image 149 is a Fatty Breast Image. Image is a Normal Fatty Breast Image.
Image 150 is a Fatty Breast Image. Image is an Abnormal Fatty Breast Image.

There is 40 Normal Fatty Breast Image.
There is 25 Abnormal Fatty Breast Image.
There is 65 Fatty Breast Image.
There is 85 Glandular Breast Image.

APPENDIX C

MATLAB source code for Classification between ‘Fatty breast’ image and ‘Glandular breast’ image.

```
%read image
aa=imread('001.pgm');
%image pre-processing (crop image)
bb=im2bw(aa,0.05);
cc=edge(bb,'sobel');
h=hough(cc);
e=houghpeaks(h);
x=e(1)/4; y=e(2)*7.5;w = 700;
f=imcrop(aa,[x-w/2 y-w/2 w w]);
%image processing
k=fspecial('laplacian');
r=imfilter(f,k);
m=imadd(f,r);
g=im2bw(m,0.7);
j=imclearborder(g);
%feature extraction
h1=sum(sum(j));
```