A CAD System for the Detection of Clustered Microcalcification in Digitized Mammogram Film

by

Noor Aniwati Hilmi

Dissertation Submitted in Partial Fulfilment of
The Requirement for the
Bachelor of Technology (Hons)
(Business Information Systems)

July 2007

Universiti Teknologi Petronas
Bandar Seri Iskandar
31750 Tronoh
Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

A CAD System for the Detection of Clustered Microcalcification in Digitized Mammogram Film

by

Noor Aniwati Hilmi

A project dissertation submitted to the
Business Information Systems Programme
Universiti Teknologi PETRONAS
in partial fulfilment of the requirement for the
BACHELOR OF TECHNOLOGY (Hons)
(BUSINESS INFORMATION SYSTEMS)

Approved by,

Dr. Baharum Baharudin

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK
July 2007

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

NOOR ANIWATI HILMI

ABSTRACT

Cluster of microcalcification in mammograms are an important early sign of breast cancer. This report presents a computer aided diagnosis (CAD) system for the automatic detection of cluster microcalcifications in digitized mammograms. The main objective of this study is to present the approach for microcalcifications detection in mammography image. In literature review author illustrate the techniques used in image processing, segmentation, feature extraction and neural network in detecting microcalcification. The proposed system consists of two main steps. First step is image preprocessing and segmentation in order to improve and enhance the quality of image. Then second step is feature extraction to analyze the image and conclude whether the case is malignant or benign. The programming of the project using MATLAB still need to be improved since it produce the output that did not meet the author expectation especially in feature extraction.

ACKNOWLEDGEMENT

In the name of Allah S.W.T the Most Gracious, the Most Merciful.

First and foremost, thanks to the Allah the Almighty for given me strength, wisdom and patience to be able to fulfill the entire requirement of the project. Heartiest thankful firstly go to the most dedicated person Dr. Baharum Baharudin, Final Year Project Supervisor for his kindness and guidance in completing this project. Thank you again for your endless encouragement and patience.

The author also would like to express her deepest appreciation and sincere gratitude to friends for their encouragement and greatest cooperation to share their experience and knowledge to thin and thick. Greatest thank again to all for the continual support.

Author's big gratitude also goes to Universiti Teknologi PETRONAS for providing convenience place and superb facilities for learning.

Last but not least, the author would like to express a special thank to the family for their understanding, priceless support and constant love throughout the accomplishment of the project. Lastly, thank you again to all people who involved directly starting from the first day until the end of project completion. Your endless contribution is highly appreciated.

TABLE OF CONTENTS

LIST OF ILUSTRATION

LIST OF FIGURE

LIST OF TABLE

CHAPTER 1

BACKGROUND OF STUDY

1.1 BACKGROUND OF STUDY

Current statistic indicates that 1 in 9 women will develop breast cancer in their lifetime. Breast cancer as known, is one of the leading causes of women mortality in the world. Breast cancer is cancer that forms in tissues of the breast, usually the ducts (tubes that carry milk to the nipple) and lobules (glands that make milk). It occurs in both men and women, although male breast cancer is rare.Primary prevention seems impossible since the causes of this disease are still unknown. Early detection is the key to improve breast cancer prognosis.

Over the past two decades, computer-aided detection and diagnosis (CAD) has been developed to help radiologists detect suspicious areas on mammograms. This is done most commonly with screen-film mammograms and less often with digital mammograms.

Mammogram is a low voltage X-ray photograph of the breast. A mammography is a specialized x-ray procedure used to create detailed images of the breast. It is used to detect changes in the breast tissue, such as thickened tissue lumps or calcification that may indicate the presence of breast cancer, and finding them early can significantly increase a patient's odds of survival. Mammography is excellent for differentiating fat from soft tissue but cannot differentiate between glandular, connective, and malignant tissues if this not separated by fat.

Mammograms don't prevent breast cancer, but they can save lives by finding breast cancer as early as possible. For example, mammograms have been shown to lower the risk of dying from breast cancer by 35% in women over the age of 50; studies suggest for women between 40 and 50 they may lower the risk of dying from breast cancer by 25–35%. [1]

The main mammographic sign of breast cancer are clustered of calcification and masses. There are two types of calcification which are microcalcification and macrocalcification. Microcalcification is tiny speck of calcium in the breast that may appear alone or in cluster and related to malignant. Malignant is cancerous; a growth that tends to spread into nearby normal tissue and travel to other parts of the body. Macrocalcification is coarse (large) calcium that is related to benign (non cancerous) condition and do not require biopsy.

One of the important early symptoms of breast in the mammograms is the appearance of microcalcification cluster which have a higher X-ray attenuation than the normal breast tissue and appear as a group of small localized granular bright spot in mammogram like Figure 1 below.

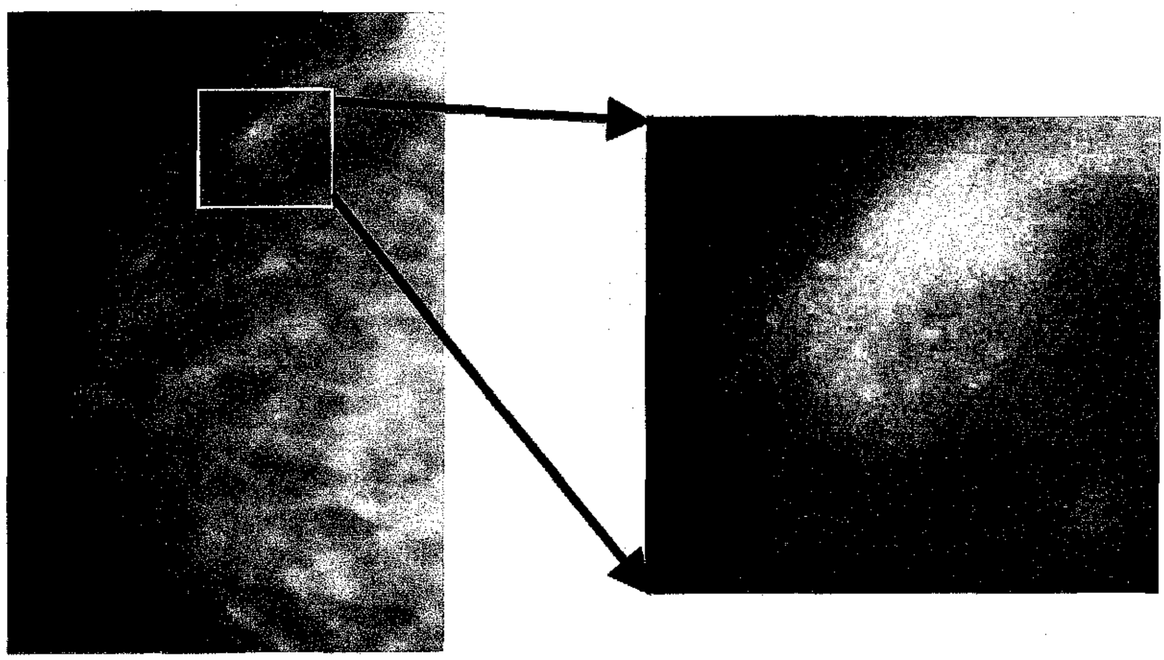

Figure 1: Expanded View Showing Calcification.

A mass, which may occur with or without calcifications, is another important change seen on mammograms. Masses can be caused by many things, including cysts (non-cancerous, fluid-filled sacs) and non-cancerous solid tumors (such as fibroadenomas), but they could be cancer and usually should be biopsy if they are not cysts.

Computers can help doctors identify abnormal areas on a mammogram by acting as a second set of "eyes." For standard mammograms, the film is fed into a machine, which converts the image into a digital signal that is then analyzed by the computer. Alternatively, the technology can be applied to an image captured with digital mammography. The computer then displays the image on a video screen, with markers pointing to areas it "thinks" the radiologist should check especially closely [2].

Early tests have found that CAD can help find some cancers that doctors might have otherwise missed. But doctors still disagree about how many cancers the device will pick up. Some doctors feel that the device is not as effective as simply having a second radiologist review the films. Others are concerned that the device may lead to unnecessary biopsies by falsely identifying benign abnormalities as being suspicious for cancer. Most breast specialists are encouraged by recent progress in CAD, and look forward to more technical refinements and studies that help to clarify its role in breast cancer detection.

1.2 PROBLEM STATEMENT

Although computer aided mammography has been studied for two decades, automated interpretation of microcalcifications is still very difficult. Microcalcification cluster is an early sign of breast cancer that appear as isolated bright sport in mammograms image. The major reasons are: First, the object of interest can be extremely very small. They lead to potential of misidentification. Second, different size, various shapes and variable distribution of microcalcifications appear in mammograms: hence temple matching seems to be impossible. Third, the region of contrast maybe low. The intensity difference between suspicious areas and surrounding tissues can be quite slim. Fourth, dense tissue or skin thickening especially in younger woman can cause suspicious areas to be almost invisible. Finally dense tissue may be easily misinterpreted as calcification, causing high false positive (FP) rate.

1.3 OBJECTIVES

- To present the approach for microcalcifications detection in mammogram image.
- To develop a feature matching algorithms that can take an example shape of particular mammograms image and systematically match it to a database of images.
- To provide pattern recognition system using neural network.

1.4 SCOPE OF STUDY

The scope of study of the project is based on the pattern recognition system which includes image processing, feature extraction and classification. Understanding the term and technique in medical imaging is desirable.

The project basically focused on mammogram's image, the enhancement of the image, technique used in processing the image, and other related topics. Preprocessing stage will covered image enhancement such as filtering which is the essential process in order to extract the features. MATLAB is used as development tool.

CHAPTER 2

LITERATURE REVIEW

2.1 MICROCALCIFICATION DETECTION TECHNIQUES

Computer-aided methods for detecting clustered microcalcifications have been developed by a number of investigators and using different techniques [3]. The purpose of which is to assist radiologist in detecting and diagnosing breast cancer. Karssemeijer *et al.* [4] developed a statistical method for detection of microcalcifications in digital mammograms. The method is based on the use of statistical models and the general framework of Bayesian image analysis.

Woods *et al.* [5] used a neural network whose input was the mammogram image or an enhanced version of the image to recognize patterns that that might include microcalcifications in digital mammograms.

Recently, many researches based on the wavelet transform have been proposed for the detection of microcalcifications. Wang and Karayianis *et al.* [6] presented an approach for detecting microcalcifications in digital mammograms employing wavelet-based sub band image decomposition. Given that the microcalcifications correspond to high frequency components of the image spectrum, microcalcifications can be extracted form the original mammograms by suppressing the sub band of the wavelet-decomposed image that carries the lowest frequencies, before the reconstruction of the image.

Cheng and Wang *et al.* [7] used fuzzy logic and scale space approach in detecting microcalcification. The advantage of this approach is the ability to detect microcalcification in very dense breast mammograms.

2.2 IMAGE PROCESSING

The literature review of this project is based on Chan *et al.* [8]. He investigated a computer-based method for the detection of microcalcifications in digital mammograms. The method is based on a difference image processing technique in which a signal suppressed image is subtracted from a signal enhanced image to remove structured background in the mammogram. Global and local threshold techniques are then used to extract potential microcalcifications signals. Subsequently, signal extraction criteria are imposed on the potential microcalcifications to distinguish true positives from noise and artifacts.

An image processing operation is defined simply as an operation that somehow manipulates image data to generate another image. The size of the image will not be altered, but the size of storage unit (pixel) might.

Image is a two-dimensional function, $f(x, y)$ where x and y are spatial coordinates. The amplitude of f at any pair coordinates (x, y) is called the intensity of grey level of the image at that point. In digital image, the x, y, and amplitude value of f are all finite and discrete quantities. Processing digital images by means of digital computer is called digital image processing

In processing the image there are many steps that can be applied. Level of image processing is divided into three categories which are:

- Low Level Processing- restoration, image preprocessing to reduce noise, contrast enhancement image, image sharpening. In low level processing that both the inputs and outputs will be images.
- Mid or intermediate level processing- segmentation, portioning an image into regions or object. In mid level processing its input will be generally images but outputs will be attributes, such as edges, contours and the identity of the objects, extracted from the input image.
- High level processing- the analysis of image like feature extraction and recognition.

2.2.1 Digital Image Formation

Digital image formation is a process of capturing the image. The system basically consists of image acquisition and digitizer. Image acquisition is done to generate digital image from sensed data, which includes optical system and sensor. An analog signal is transformed to digital by a digitizer.

In order to convert analog signal to digital form, we need to sample the function in both coordinates and amplitude. Digitizing amplitude values is called quantizing. Each digital image formation subsystem introduces deformation or degradation to the digital image, such as geometrical distortion, noise, and nonlinear transformation. The aims of the image transformation being discussed are as follow:

- To remove or correct for degradation introduced by the image capture process
- To improve the appearance of the image for human perception or for further processing
- To identify and quantity structures in the image that may be indicative of the objects in the scene being viewed
- To transform the image into an alternative representation in which some operations may be performed more efficiently

2.2.2 Digital Image Enhancement

Accurate diagnosis depends on the quality of mammograms; in particular, on the visibility of small, low contrast objects within the breast image. Unfortunately, contrast between malignant tissue and normal tissue is often low that detection of malignant tissue becomes more difficult.

Image enhancement techniques are used to improve an image, where 'improve' is sometimes defined objectively like increase the signal-to-noise ratio and sometimes subjectively as make certain features easier to see by modifying the color or intensities.

Image enhancement technique can be classified into two methods: spatial domain which operate directly to pixel and frequency domain which operate on Fourier Transform of an image. Image enhancement includes grey level and contrast manipulation, noise reduction, edge crispening and sharpening, filtering, interpolation and magnification, pseudocoloring and so on.

Chan et al. [9] investigated unsharp masking filter for digital mammography: according to their receiver operating characteristic (ROC) studies, the simple unsharp masking filter could improve the detect ability of calcification in digital mammogram. However this method also increased image noise and enhancement of artifacts.

2.2.3 Image Analysis

Image analysis is related to make quantitative measurement from an image to produce a description of it. It requires extraction of certain features that aid in the identification of the object. Image analysis consist of edge and line detection, texture analysis, segmentation, region of interest (ROI) processing, feature measurement and so on.

Segmentation also known as region detection is the process of dividing an image into a set of non overlapping regions that completely cover the image. The region might be an object, part of an object and the background. Objective of segmentation is to partition an image into meaningful regions with respect to objects within the scene. Grey-level thresholding is the simplest segmentation process and it is computationally inexpensive and fast. The main approaches of segmentations are:

- Pixel Based or Local Method -Detect and enhance edge or edge elements within an image
- Region Based or Global Approach – Create region directly by grouping together pixels which share common features into regions of uniformity

Edge is defined as an abrupt change in color intensity. Edge detection drastically removes the amount information in the image as it removes all non-structural data, leaving all information about the edges. Edge information in an image is found by looking at the relationship that a pixel has with its neighbor. If a pixel has a neighbor with widely varying grey level, it may represent an edge point. If a pixel grey level value is similar to those of its surrounding neighbor, probably there is no edge at the point.

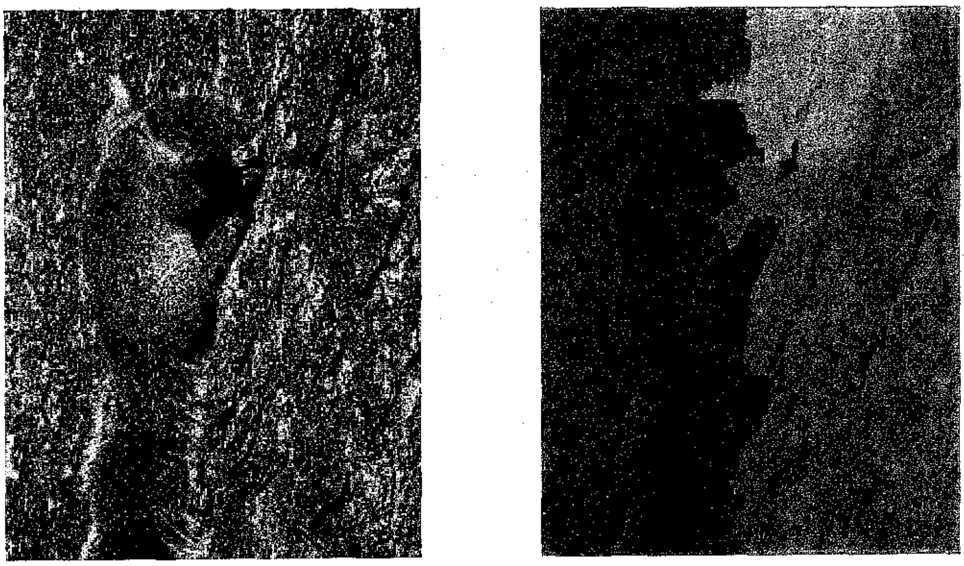

Figure 2: Edge Detection

Another aspect in analyzing the image is pattern recognition. Statistical pattern recognition assumes that the image may contain one or more objects and that the image may contain one or more objects that each object belongs to one of several predetermined types, categories, or pattern classes. There are three major phases in pattern recognition: image segmentation, feature extraction and classification. Pattern recognition systems usually consider a feature space onto which the observation vector is first mapped. The feature vector is then used to decide the class to which the observation vector belongs to based on measured objects.

2.3 FEATURE EXTRACTION

To reduce the number of false detections, features are extracted and are used to differentiate true calcifications from false detections. A large number of different features are being used by different investigators [3].

Most features are extracted either the original image or a processed image that has sought to preserve the shape and contrast of calcification in the original image. Sheshadri et al [10] on her paper authors have made an attempt to classify the breast tissue based on the intensity level of histogram of a mammogram. Statistical features of a mammogram are extracted using simple image processing techniques. The proposed scheme uses texture models to capture the mammographic appearance within the breast. Parenchymal density patterns are modeled as a statistical distribution of clustered filter responses in a low dimensional space.

The statistical features extracted are the mean, standard deviation, smoothness, third moment, uniformity and entropy which signify the important texture features of breast tissue. Based on the values of these features of a digital mammogram, the authors have made an attempt to classify the breast tissue in to four basic categories like fatty, uncompressed fatty, dense and high density.

According to "Interactive Mammography Analysis Web Tutorial" [11] masses are three dimensional lesions that may represent a localizing sign of breast cancer. They are described by their location, size, shape, margin characteristic, x-ray attenuation (radio density), effect on surrounding tissue, and any other associated finding (i.e. architectural distortion, associated calcifications, skin changes). Depending on morphologic criteria of the mass, the like hood of malignancy can be established.

Aside from masses, a suspicious single geographic abnormality can also be classified by calcification. Calcifications are analyzed according to their size, shape, number and distribution. The general rule is that the larger, round or oval shaped calcifications uniform in size has a higher probability of being associated with benign process. For smaller, irregular, polymorphic, branching, calcifications heterogeneous in size morphology are more often associated with a malignant process.

Feature	Benign Characteristics	Malignant Characteristic
Shape	Regular	Irregular, Lobulated
Border	Sharp	Fuzzy Spiculated
Matrix		
Calcification	Dense	Fine
Texture	Smooth	Variegated

Table 1: Common Features of Benign and Malignant Tumors Seen on Images

Shen *et al.* [12] discussed different shape factors including compactness, moments, and Fourier descriptors in calcification analysis. These quantitative measures represent the roughness of shapes and are used to classify calcifications in mammograms. They conclude that the combination of these three measures is better than just using only one or two.

However, according to Woods [5] because of the small size of microcalcification, the characterisation of benign and malignant lesion represents a very complex problem even for an experienced radiologist. Moreover there are many cases in which structure that malignant microcalcifications is not very different from that benign ones. These perceptual problems resulting in screening errors that leads.

Number of calcification that made up a cluster has been used as an indicator of benign and malignancy. While the actual number of itself is arbitary, radiologist tend to agree that the minimum number of calcification be four, five, or six to be of significance. Any number of calcification less than four will rarely lead to the detection of breast cancer in and of itself. Again, as with all criteria in mammography analysis, no number is absolute and two or three calcifications may merit greater suspicion if they exhibit worrisome morphologies.

Area is computed as the number of pixels in the grown region. It is measured by counting number of pixels inside and including boundaries. It is relates to the size of calcification. Most radiologists place calcifications 0.5 mm or less to have high probability of association with cancer; and calcification of 2.0 mm or larger are typical of benign process. The smallest visible calcification is approximately 0.2- 0.3 mm.

Perimeter measurement to measure an object's perimeter to establish that the boundary of an object is polygon having a vertex at the center of each boundary pixel. Perimeter can be also measures by summing center to center distance between adjacent pixels on boundary. The perimeter is measured after the *bwperim* process, which is after perimeter determination by applying [13] *sum ([data2.Area])* to the *bwperim* image. Thus to calculate the total perimeter, total area of *bwperim* is divided with the number of calcification.

Eccentricity and orientation is a scalar vector. The eccentricity is the ratio of the distance between the foci of the ellipse and its major axis length. The values is between 0 and 1, which is approaching o represent a circle and approaching 1 represent line segment. Orientation is the angle (in degree) between the x- axis and the major of axis of the ellipse that has the same second moments as region. Solidity is also scalar vector.

It is proportion of the pixels in the convex hull that are also in the region. Solidity is computed as $Area \;/\; ConvexArea$

Mathematically, area of a circle is calculated as $pi * r^2$ while the perimeter is calculated as $2 * pi * r^2$. By computing the equivDiameter, the diameter of an object can be obtained. Thus circularity can be calculated as follow $Circularity = (4 * pi * area) perimeter^2$

CHAPTER 3

METHODOLOGY

3.1 PROJECT DEVELOPMENT

The procedure of the project is to research, design, develop, test and troubleshoot the image processing program using MATLAB. In this project, author divided the stage into two steps which are preprocessing and segmentation and feature extraction.

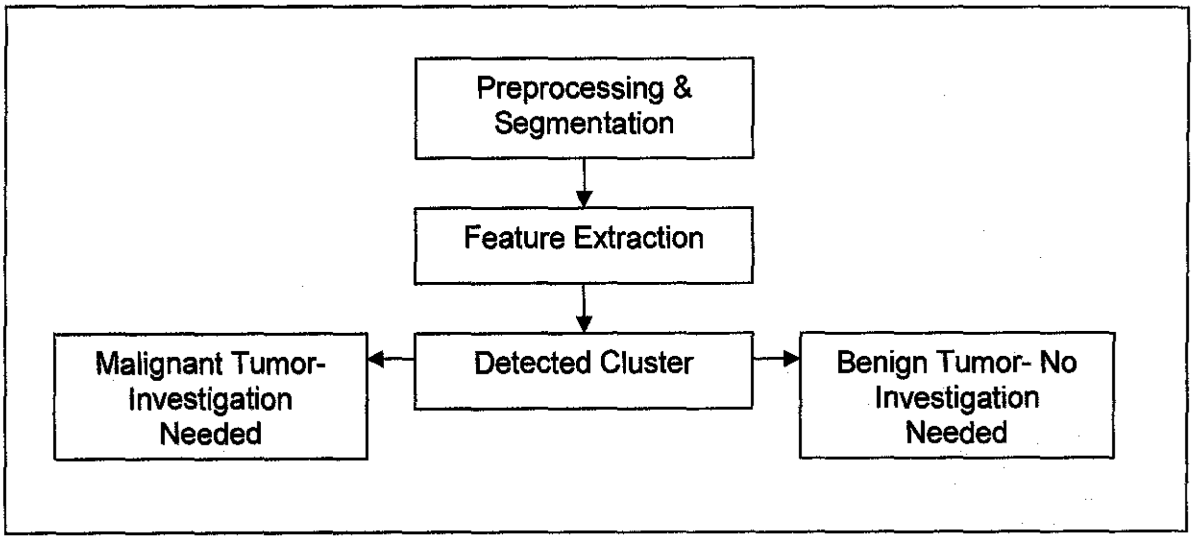

Figure 3: Flowchart of Project Development

3.1.1 First Part- Image Preprocessing & Segmentation

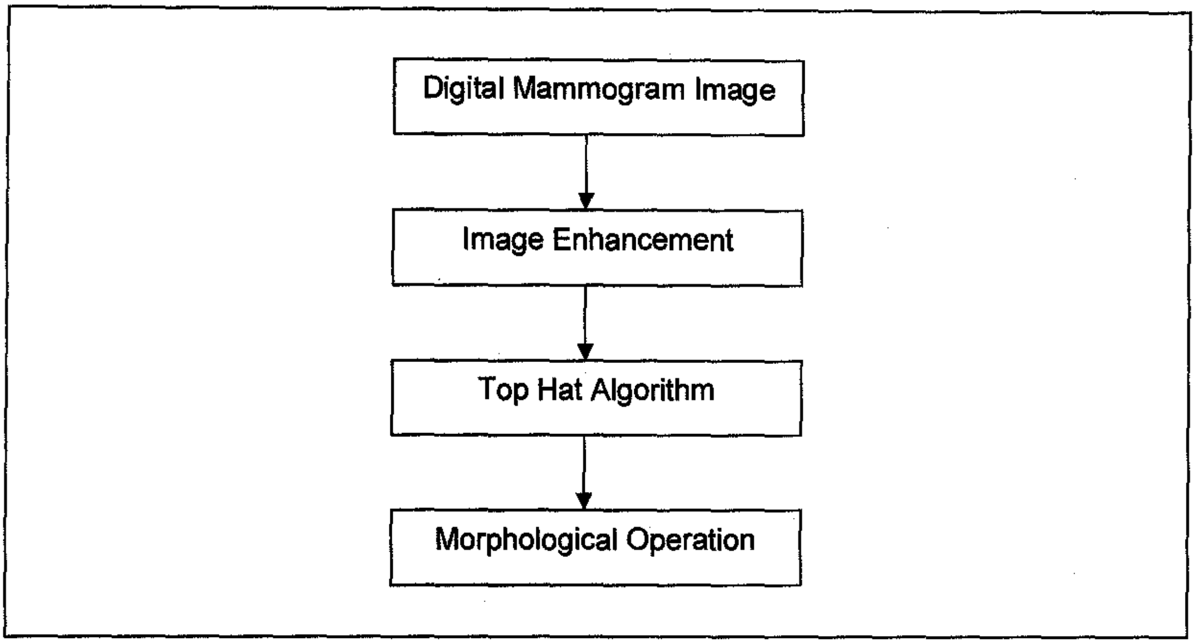

Figure 4: Image Preprocessing & Segmentation Process

3.1.1.1 Image Enhancement

The image enhancement technique is performed to obtain a clearer and better image. The image enhancement techniques used are contrast and brightness adjustment and filtering. The first step is to enhance image is by remove noises. Gaussian low-pass filter operates as a smoothing mechanism to reduce noise. This filtering process results in an image with reduced sharp transition in grey level. Median filter in other hand replaces the value of a pixel by the median of the grey level in the neighborhood of the pixel, and it is better in reducing random noise without reducing the sharpness of the image.

However the sharp transition in grey level also consist of edges which are the advantageous features in an image, but averaging filters have the undesirable side effects that can blur edges. So to overcome the problem, unsharp masking filter is performed with intensity adjustment.

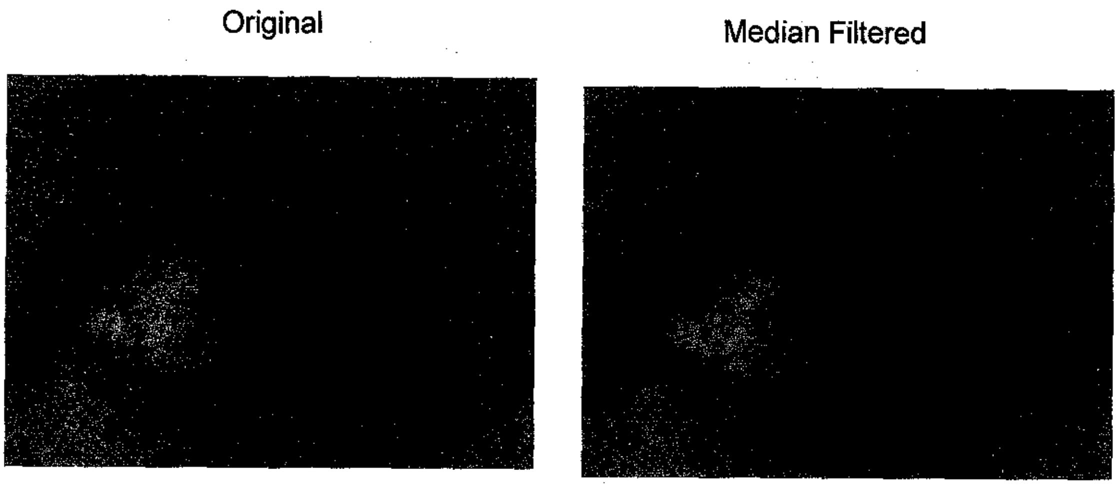

Figure 5: Median Filter

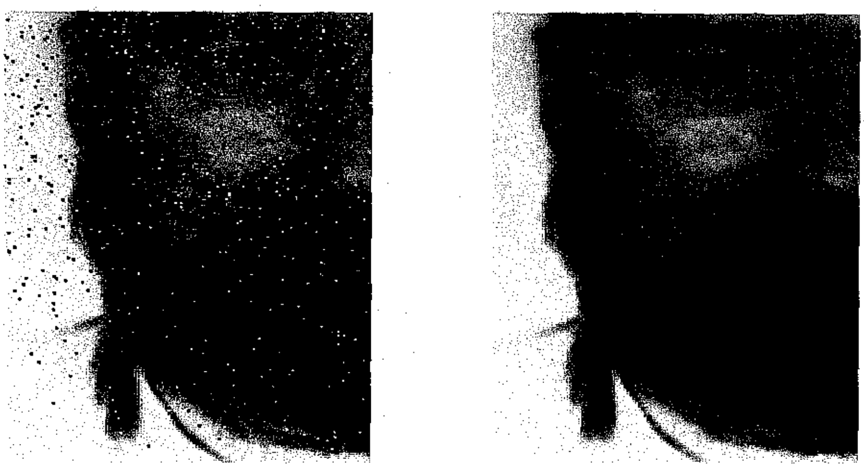

Figure 6: Median Filter Remove Pepper and Salt

3.1.1.2 Top Hat Algorithm

The Top Hat transformation is defined by the difference between an image and its opened version. Its strength lies in ability to enhance detail in an image that would otherwise be secured by shading. Top Hat masking filter with a disk-shape structuring element have been apply to the image to remove the uneven background illumination, and as the output of the operation is dark, author apply *stretchlim* which calculates the histogram of the image and determine adjustment limits automatically.

3.1.1.3 Morphological Operation

Morphology is defined as the "study of the form of thing"; that is the structure of the segmentation of objects. Morphological technique frequently used to improve the appearance of a threshold image and used to understand the structure or form of an image, identifying the objects or boundaries within an image.In this step dilation and erosion operations are performed. Dilation increases the size of objects in relation to their background. Erosion reduces the size of objects in relation to their background. These two operations are used to eliminate small object features like noise spikes and ragged edges.

Original Eroded

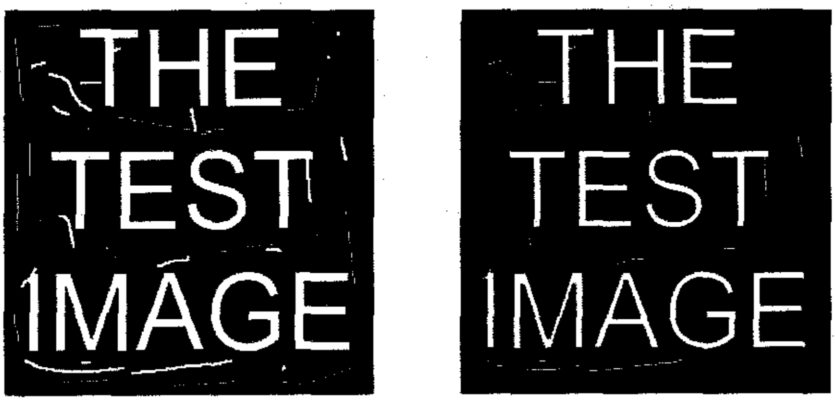

Figure 7: Erosion Process

Original Dilated

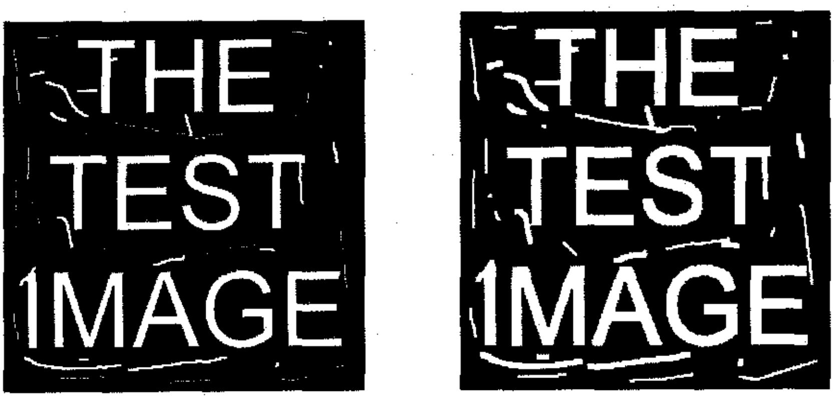

Figure 8: Dilation Process

3.1.2 Second Part- Feature Extraction

An analysis of the image can be performed to conclude that the case is malignant or benign. One of the analysis techniques of image is feature extraction. The selected features are circularity, eccentricity, orientation, and area.

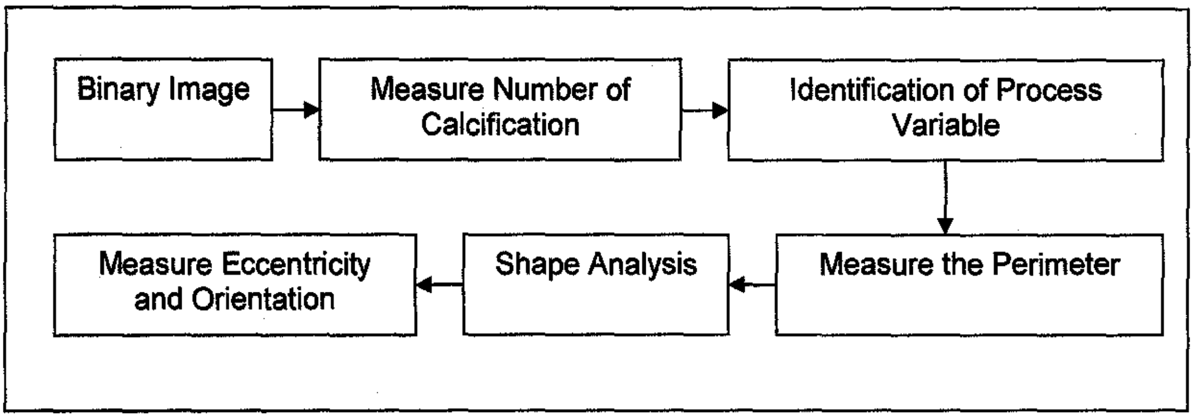

Figure 9: Process of Feature Extraction

The binary image is produced after applied morphological operation. It is important to measure the number of microcalcification because it will determine whether the tumor is benign or malignant. Any number of calcification less than four will rarely lead to the detection of breast cancer in and of itself. For measurement of the perimeter, most radiologists place calcifications 0.5 mm or less to have high probability of association with cancer; and calcification of 2.0 mm or larger are typical of benign tumor. As stated on in Table 1, the shape of malignant and benign is different. The shape analysis of the microcalcification is important in determining the tumor type.

3.2 DETECTED CLUSTER

A decision made during a detection task falls into one of four possible categories, shown on Table 2. An image region can be called cancerous (positive) or normal (negative), and the decision can be either be correct (true) or incorrect (false). There are two types of errors that can be made: false negative and false positive errors. A false negative (FN) implies that true abnormality was not detected. A false positive (FP) errors when a detection of corresponds to a normal region, and thus falsely identifies the region as abnormal.

Two types of correct decision also can be made: true positive (TP) and true negative decision (TN). A detection that corresponds to an actual abnormality is called true positive a true negative decision simply means a normal region was correctly labeled a being normal.

True State	IS	IS NOT
Computer Decision	a cancer	a cancer
Called a cancer	True Positive (TP)	False Positive (FP)
Not Called a cancer	False Negative (FN)	True Negative (TN)

Table 2: A Decision Made During a Detection Falls into of Four Possible Categories

CHAPTER 4

RESULT AND DISCUSSION

4.1 MAMMOGRAM DATABASE

The mammograms used here are extracted from the MIAS database [14]. The images from this database have detailed information, including the characteristic of background tissue (fatty, fatty- glandular or dense glandular), class of abnormality (calcification, masses and speculated masses). Each mammogram shows one or more cluster of microcalcification marked by expert radiologist.

4.2 RESULT AND DISCUSSION

The preprocessing processes, which are filtering, contrast enhancement, and image segmentation have been done. Some of the result did not meet author expectation which mean the object did not show the real output. For the neural network, author unable to do deliver it. The result and discussion will base on image generated from MATLAB program.

Figure 10 to 18 show the results of MATLAB programming. Image (a) for benign tumor and image (b) for malignant tumor. For information the output image of threshold, segmented, dilate gradient and outlined image show the black image, which is mean did not work as expected. The perimeter determination also did not show the right calculation to detect the total area, mean area, mean eccentricity, mean orientation, mean solidity, mean perimeter and mean circularity.

Figure 10: Input Image

The input mammograms image from database will be displayed as whole using *imread* function in MATLAB.

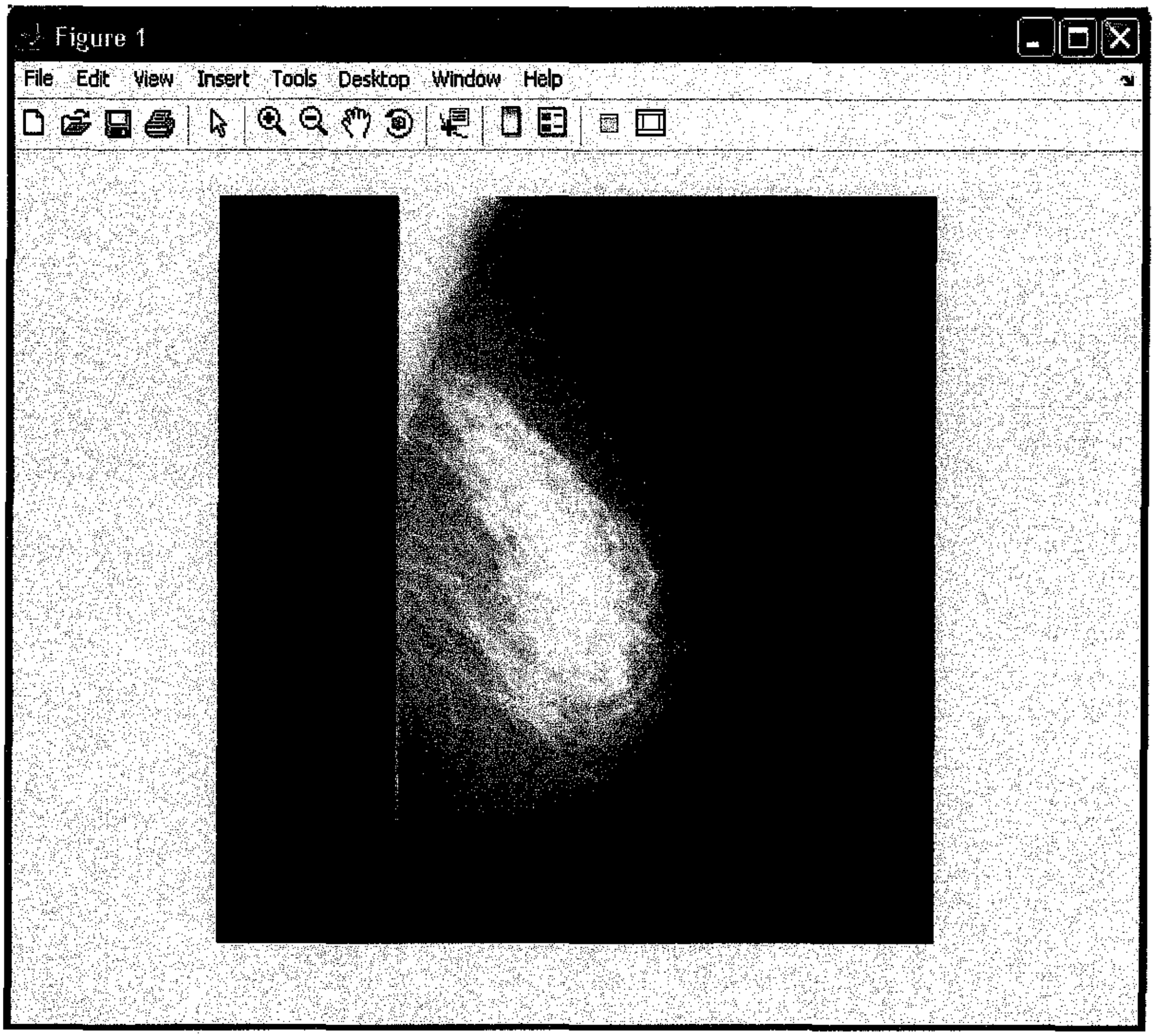

Figure 10 (a): The Input of Benign Image

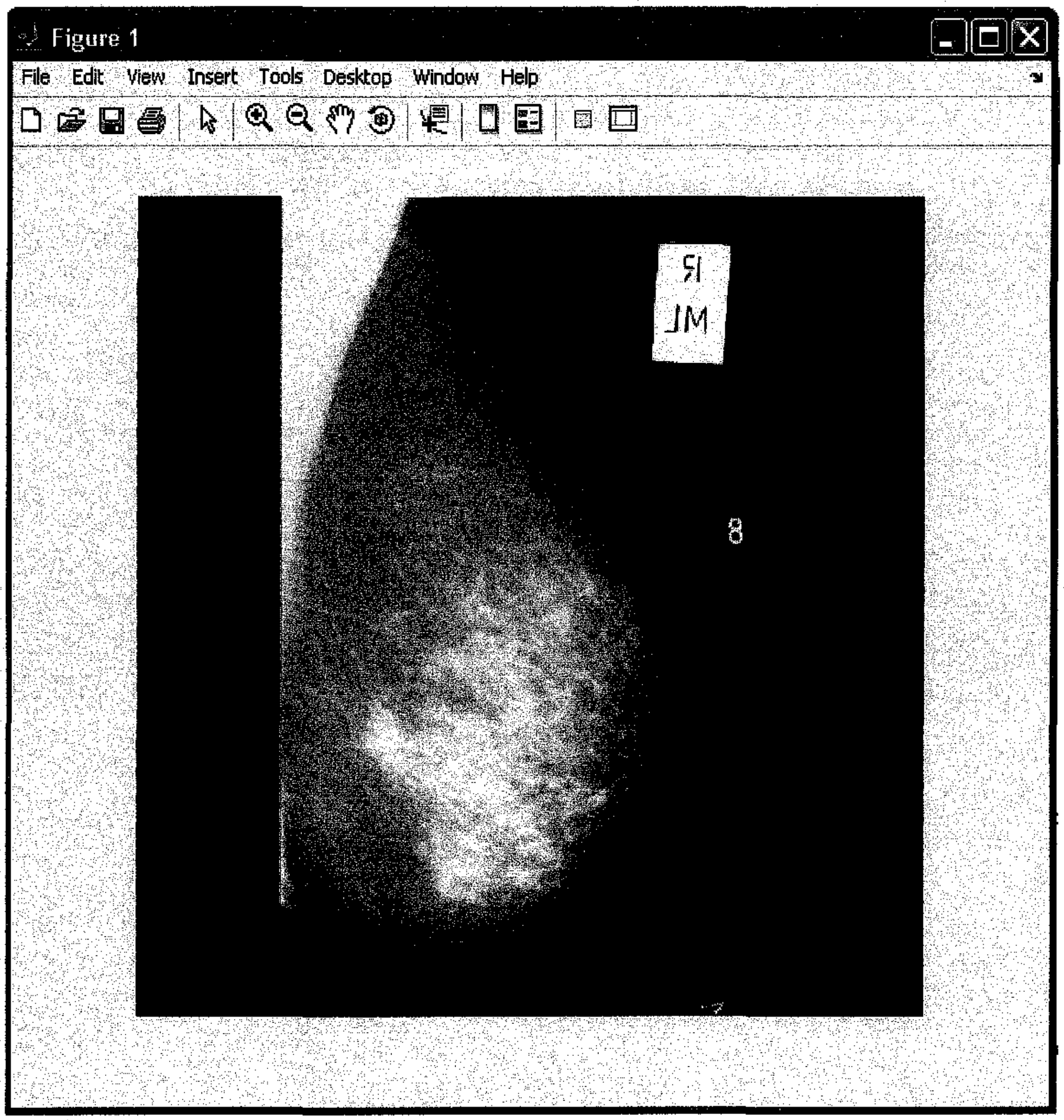

Figure 10 (b): The Input of Malignant Image

Figure 11: Cropped Image

The user might select a specific area of the breast to further process. Microcalcification is usually clustered or distributed on certain area of the breast and it is an advantage for user to crop the image on certain area suspected contain microcalcification. Size of the cropped image is depending to the selection by the user. The function used in the MATLAB is *imcrop* that crop image to a specified rectangle.

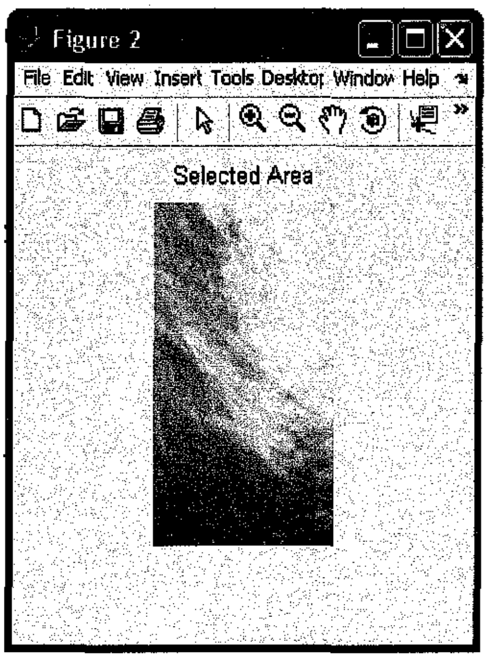

Figure 11(a): The Cropped of Benign Image

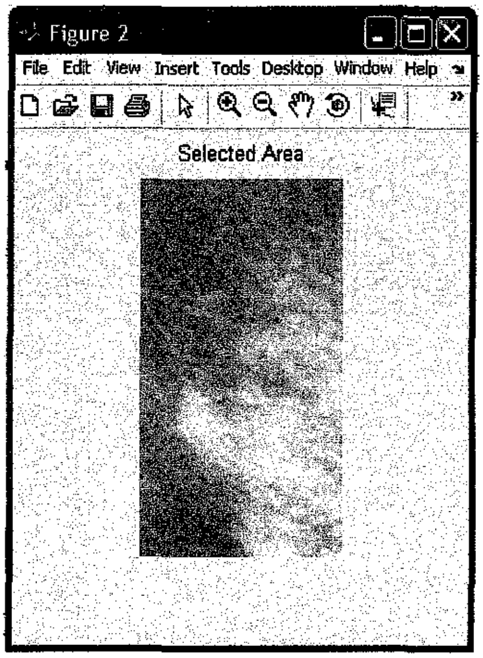

Figure 11(b): The Cropped of Malignant Image

Figure 12: Histogram

Histogram image show the distribution of the pixel in the image. The important of the histogram is that it shows the distribution of data and indicates the overall brightness or darkness of the selected are. The horizontal axis is the value that a pixel can have range from 0-255 and the vertical axis in other hand indicates the frequency at each value of image. As we can see from two histogram image below the frequency distribution of figure 12(b) is high compare to figure 12(a). The frequency is related to the brightness of image. Since that the cancerous tissue is very white so histogram can help in determine the suspicious area.

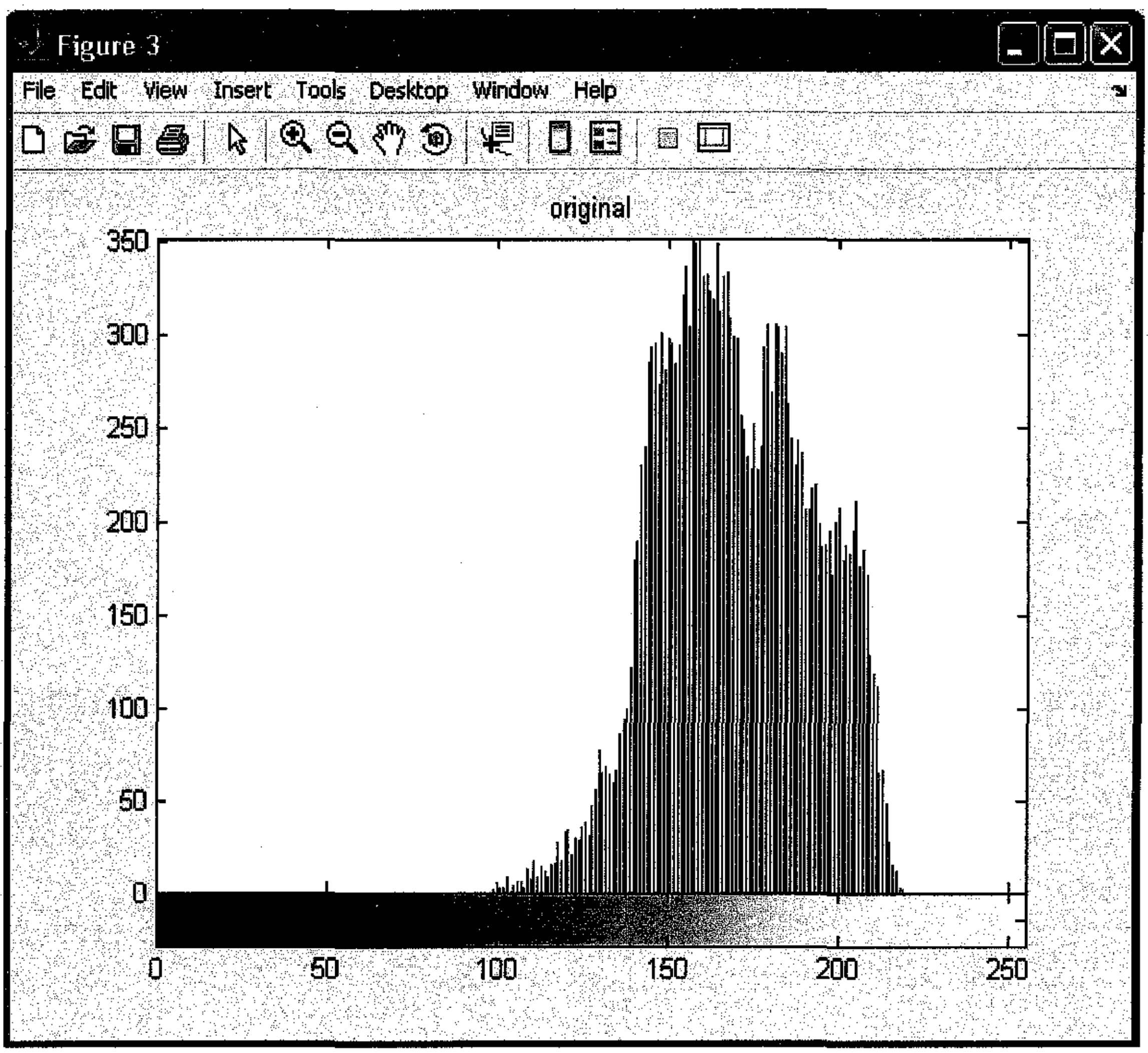

Figure 12 (a): The Histogram of Benign Image

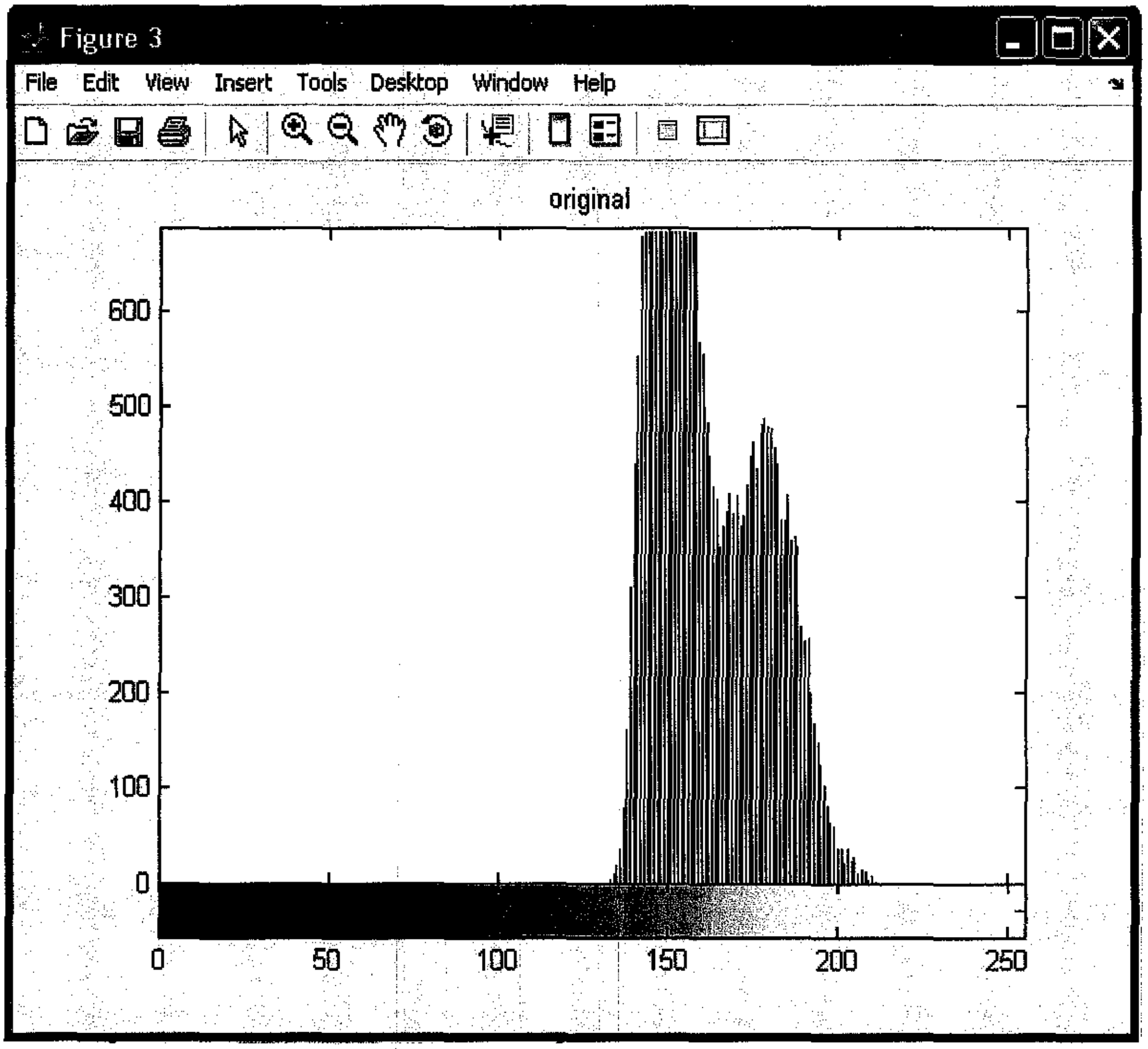

Figure 12 (b): The Histogram of Malignant Image

Figure 13: Gaussian Lowpass Filter Image

Operates as smoothing mechanism to remove the noise of the image.

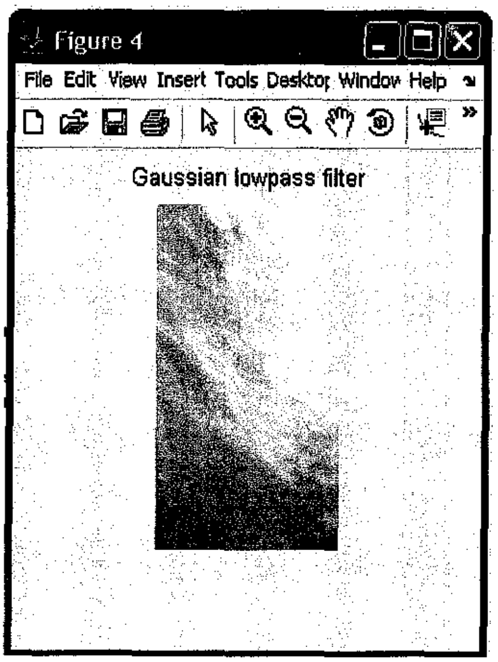

Figure 13 (a): Benign Image

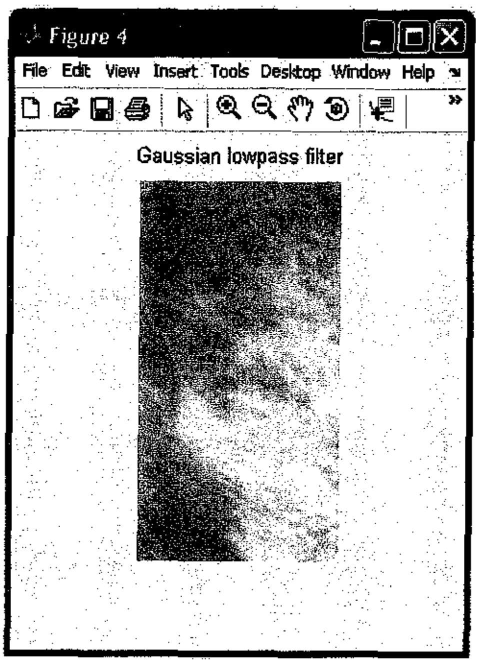

Figure 13 (b): Malignant Image

Figure 14: Median Filter Image

Median Filter is effective for removing the impulse noise which usually happened during digitization of the image. The median filter is performed to all images and had shown a good output image.

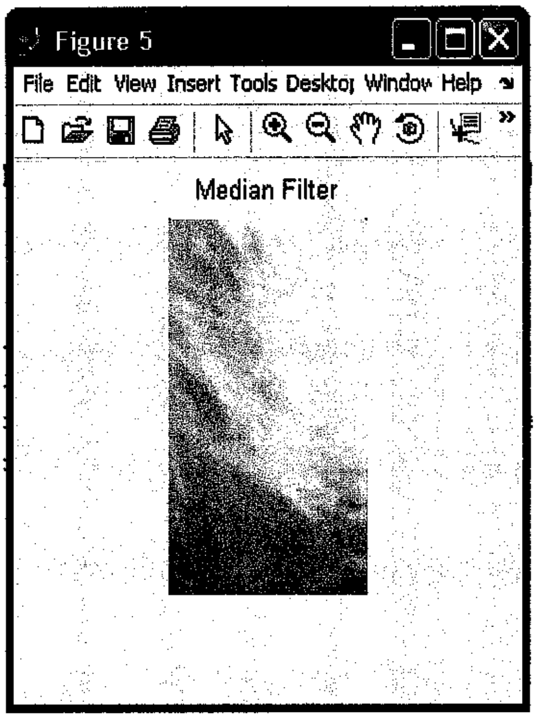

Figure 14(a): Benign Image

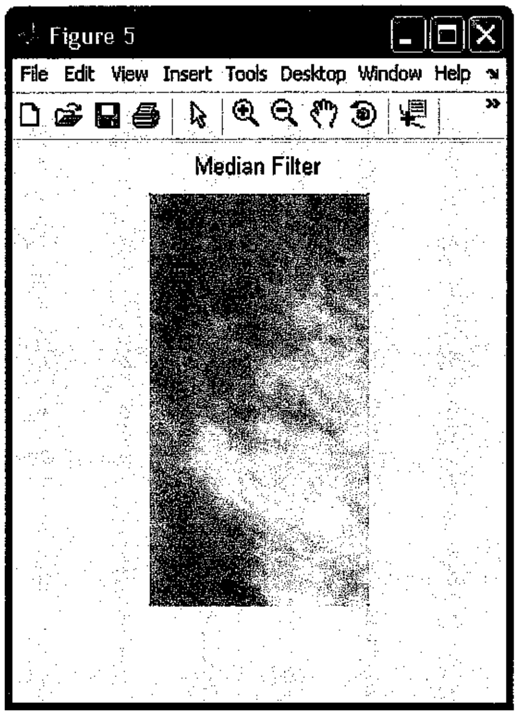

Figure 14(b): Malignant Image

Figure 15: Unsharp Masking Filter Image

The resultant image is sharpen where the features in the image is increased in contrast. This filter has the effect of making edges and fine detail in the image crispier and this approach is called high- boost filtering.

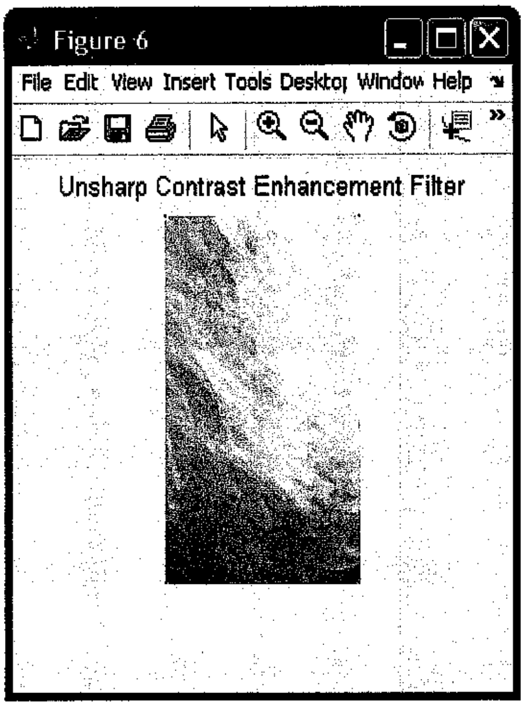

Figure 15(a): Benign Image

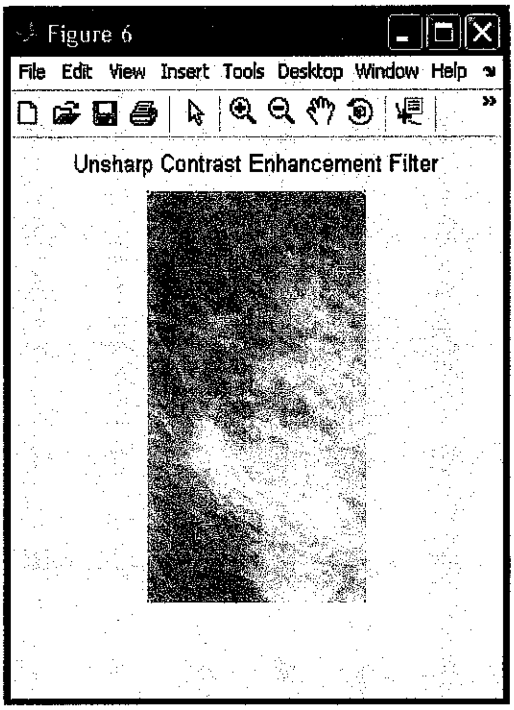

Figure 15(b): Malignant Image

Figure 16: Intensity Adjustment Image

The intensity adjustment is performed to enhance the contrast of image.

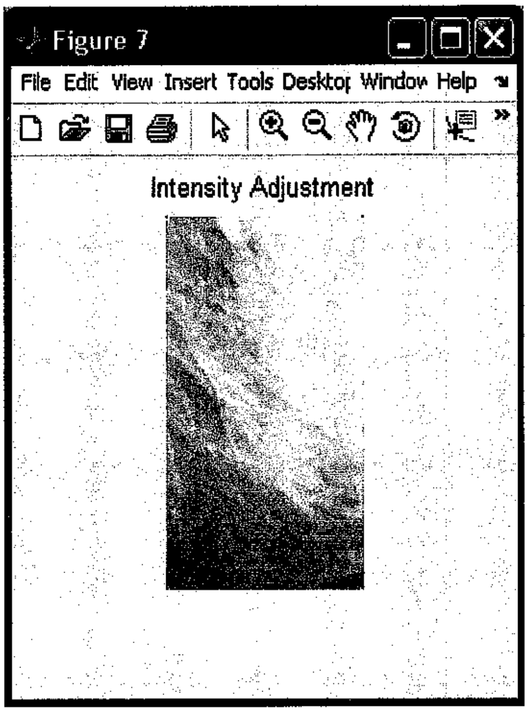

Figure 16 (a): Benign Image

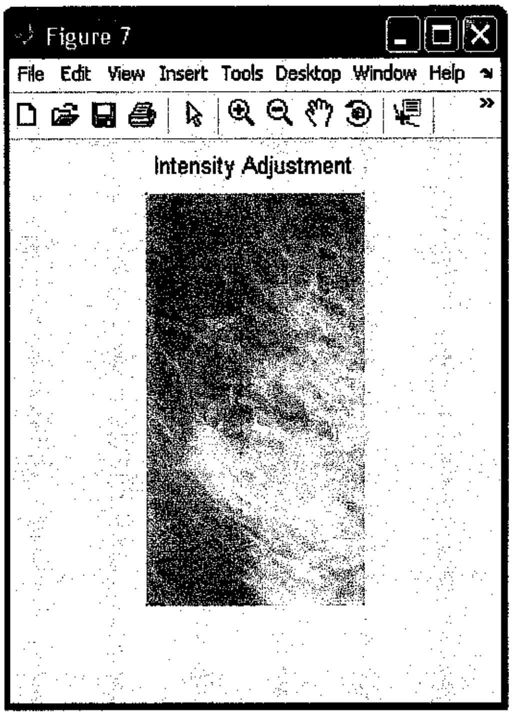

Figure 16 (b): Malignant Image

Figure 17: Top-Hat Filtering Image

Before the top hat algorithm is applied, the morphological structuring element is created by using the command *sterl.* Various type of structuring element can be used with different neighborhood. After various type and value of the neighborhood applied to images, the disk types with 12 neighborhoods are found to be must suitable.

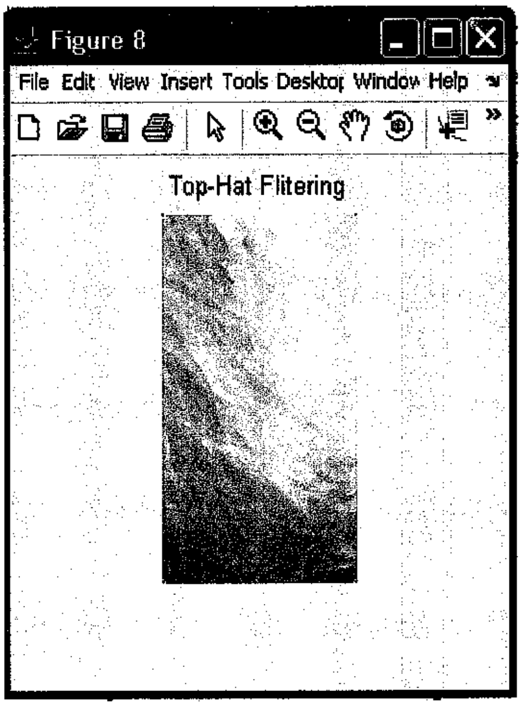

Figure 17(a): Benign Image

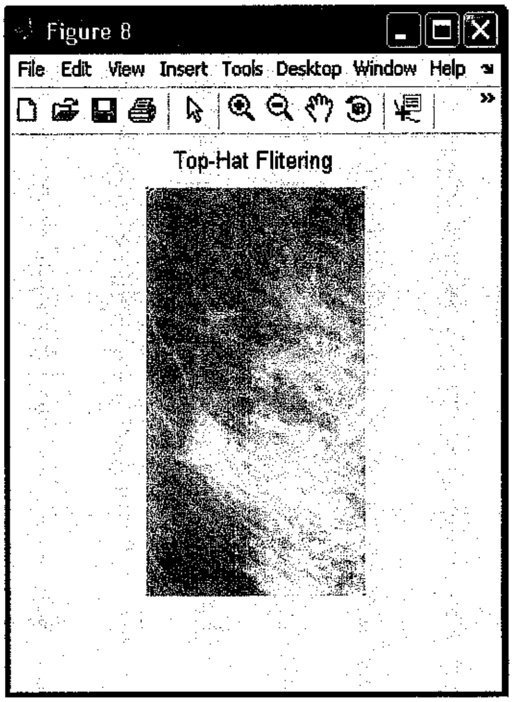

Figure 17(b): Malignant Image

Figure 18: Improved Visibility with Contrast Stretch Image

The image is enhancing by contrast stretching that adjusting the image histogram so that there is greater separation between foreground and background grey level distribution. The contrast and brightness is very important to enhance the mammograms image since it is binary images thus, the more contrast the white particle from the black particle the more clearer the white particle can been seen.

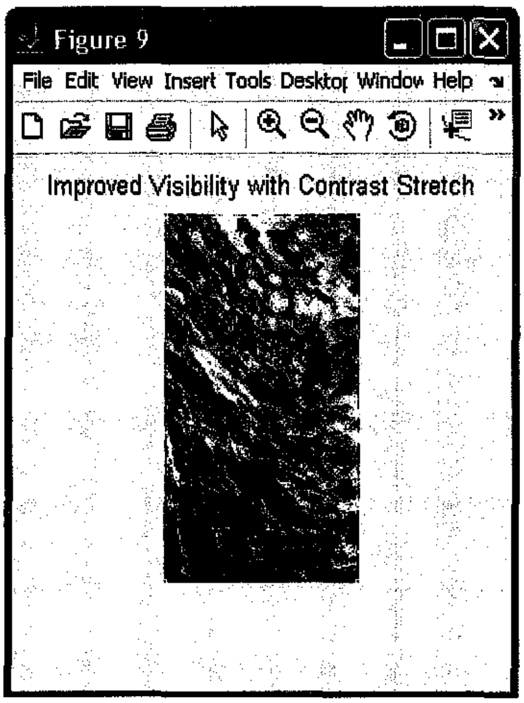

Figure 18(a): Benign Image

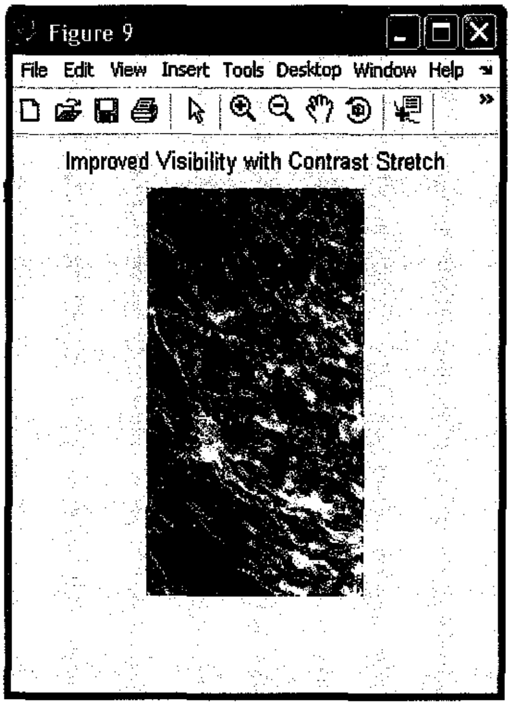

Figure 18(b): Malignant Image

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

Breast cancer is one of the leading causes of death for women. Primary functions seem impossible since the causes of this disease still remain unknown. Mammograms have been shown to be one of the most reliable methods for early detection of breast carcinomas.

Mammograms aren't perfect. Normal breast tissue can hide a breast cancer, so that it doesn't show up on the mammogram. This is called a false negative. And mammography can identify an abnormality that looks like a cancer, but turns out to be normal. This "false alarm" is called a false positive. To make up for these limitations, more than mammography is needed.

Computers can help doctors identify abnormal areas on a mammogram by acting as a second set of "eyes." For standard mammograms, the film is fed into a machine, which converts the image into a digital signal that is then analyzed by the computer.

Most breast specialists are encouraged by recent progress in computer-aided detection, and look forward to more technical refinements and studies that help to clarify its role in breast cancer detection.

5.2 RECOMMENDATION

For this project the report consists of two main steps which are research, preprocessing and segmentation and feature extraction Because of author only have one semester to complete the research and come out with the product, so some of the part did not meet the objective. Below are recommendations to improve the project in future:

- Somebody can continue this project to achieve the third objective by applying neural network part.
- To improve feature extraction of the image other than using shape and area measurement somebody can use different technique like wavelet transform or fuzzy-logic to have more accurate value.
- Try to digitize the image instead of download from Internet. With this implementation we can have the image that required and it easy when it comes to programming part.

REFERENCES

1. Breastcancer.org is non profit organization dedicated to providing the most reliable, complete and up to date information; available online at http://www.breastcancer.org

2. American Cancer Society; available online at http://www.cancer.org

3. Jan J. Medical Image Processing, Reconstruction and Restoration, CRC Pres, USA, 2006.

4. N. Karssemeijer, "A stochastic model for automated detection of calcifications in digital mammograms," in Proc. 12th Int. Conf. Information Processing Medical Imaging, Wye, U.K., pp. 227–238, July 1991

5. Kevin S. Woods, Chris C. Doss, Kevin W. Bowyer, Laurance P. Clarke and Robert A. Clark, "A Neural Network Approcah to Microcalcification Detection", IEEE Tran. on Medical Imaging, pp. 1273-1274, 1993.

6. Ted C. Wang and Nicolaos B. Karayiannis, "Detection of Microcalcifications in Digital Mammograms Using Wavelets", IEEE Tran. on Medical Imaging, vol. 17 pp. 498-509, Aug. 1998.

7. H.D. Cheng and Jingli Wang, "Fuzzy Logic and Scale Space Approach To Microcalcification Detection", IEEE Tran. on Medical Imaging, pp. 345-348, 2003.

8. H. P. Chan, K. Doi, S. Galhotra, C. J. Vyborny, H. MacMahon, and P. M. Jokich, "Image feature analysis and computer-aided diagnosis in digital radiography, 1. Automatic detection of microcalcifications in mammography," Med. Phys., vol. 14, no. 4, pp. 538–548, July/Aug. 1987.

9. H. P. Chan, CJ Vborny, H MacMahon, CE Metz, K Doi, EA Sickles, " ROC Studies of the effect pixles size and unsharp masking filter on detection of subtle microcalcification", Invest Radiol 22:581-589, 1987

10. H. S. Sheshadri and A. Kandaswamy, " Breast Tissue Classification Using Statistical Feature Extraction of Mammograms", vol. 23, no. 3, pp. 105-107, 2004

11. Interactive Mammography Analysis Web Tutorial; available online at http://sprojects.mmi.mcgill.ca/mammography/

12. L. Shen, R. M. Rangayyan, and J. E. L. Desautels, "Application of shape analysis to mammographic calcification" , IEEE Trans. Medical Imaging, vol. 13, pp. 263–274, June 1994

13. Siti Aishah Fadilullah " Breast Cancer Detection Using Computational Detection" , 2004

14. Mammographic Image Analysis Society (MIAS), MiniMammography Database; available online at http://peipa.essex.ac.uk/info/mias.html

APPENDICES

APPENDIX 1: MIAS LICENSE AGREEMENT

APPENDIX 1

MAMMOGRAPHIC IMAGE ANALYSIS SOCIETY
MiniMammographic Database

LICENCE AGREEMENT

This is a legal agreement between you, the end user and the Mammographic Image Analysis Society ("MIAS"). Upon installing the MiniMammographic database (the "DATABASE") on your system you are agreeing to be bound by the terms of this Agreement.

1. GRANT OF LICENCE
MIAS grants you the right to use the DATABASE, for research purposes ONLY. For this purpose, you may edit, format, or otherwise modify the DATABASE provided that the unmodified portions of the DATABASE included in a modified work shall remain subject to the terms of this Agreement.

2. COPYRIGHT
The DATABASE is owned by MIAS and is protected by United Kingdom copyright laws, international treaty provisions and all other applicable national laws. Therefore you must treat the DATABASE like any other copyrighted material. If the DATABASE is used in any publications then reference must be made to the DATABASE within that publication.

3. OTHER RESTRICTIONS
You may not rent, lease or sell the DATABASE.

4. LIABILITY
To the maximum extent permitted by applicable law, MIAS shall not be liable for damages, other than death or personal injury, whatsoever (including without limitation, damages for negligence, loss of business, profits, business interruption, loss of business information, or other pecuniary loss) arising out of the use of or inability to use this DATABASE, even if MIAS has been advised of the possibility of such damages. In any case, MIAS's entire liability under this Agreement shall be limited to the amount actually paid by you or your assignor, as the case may be, for the DATABASE.