

# Al Zawiya University



Faculty of Engineering

**Electrical and Electronic Department**

**Communication Engineering Section**

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**MSc Thesis**

## Mammogram Image Enhancement For Breast Cancer Detection

**A field study**

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بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

"نَرْفَعُ دَرَجَاتِهِ مِمَّنْ نَشَاءُ ۖ وَفَوْقَ كُلِّ ذِي عِلْمٍ عَلِيمٌ"

صدق الله العظيم

سورة يوسف الآية (76)

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**ENG. FAREDA ALI**

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# **Dedication**

I dedicate my thesis to my parents, brothers, and sisters as well as my friends.

Without whom none of my success would be possible

## **Abstract**

Breast cancer is one of the most dangerous types of cancer that attack women in the world, and the best solution to curbing this dangerous disease is early detection of breast cancer, which in turn helps reduce the death rate among affected women and save the lives of many of them.

The best method used in early detection of breast cancer is a mammography technology and with the rapid development of modern technology that combines artificial intelligence and digital image processing and their effective role in the field of medical imaging.

The role of image processing and machine learning has emerged in the field of computer vision that combines engineering sciences and medical fields. Therefore, the researcher saw the importance of designing and developing effective techniques to improve mammogram images to assist radiologists in the early detection process.

Accordingly, the researcher saw the importance of designing and developing effective techniques to improve mammogram images to help the radiologist in the early detection process, and the results of this practical study were to develop an easy-to-use GUI graphic interface that included all the techniques used in the field of enhancement of digital image as it provided the radiologist with a clearer vision and second eye that helped him to diagnose more precisely, a region of interest extraction (ROI) to detect lump, masses and various cancerous lesions affecting breast tissue

## المخلص

سرطان الثدي من أخطر أنواع السرطانات التي تهاجم النساء في العالم والحل الامثل للحد من هذا المرض الخطير هو الكشف المبكر على سرطان الثدي والذي بدوره يساعد في التقليل من نسبة الوفيات بين النساء المصابات وإنقاذ حياة الكثير منهن.

أفضل وسيلة مستخدمة في الكشف المبكر عن سرطان الثدي هي استخدام تقنية التصوير بالماموغرام وذلك لسهولة استخدامه ومع التطور السريع في التكنولوجيا الحديثة التي تجمع بين الذكاء الصناعي ومعالجة الصور الرقمية ودورهما الفعال في حقل التصوير الطبي برز دور معالجة الصورة وتعلم الآلة في مجال الرؤية الحاسوبية التي تجمع بين علوم الهندسة والمجالات الطبية.

عليه رأت الباحثة أهمية تصميم وتطوير تقنيات فعالة لتحسين صور الماموغرام لمساعدة اخصائي الأشعة في عميلة الكشف المبكر، وكانت نتائج هذه الدراسة العملية تطوير واجهه رسومية GUI سهله الاستخدام تضمنت كافة التقنيات المستخدمة في مجال تحسين الصورة الرقمية حيث وفرت لإخصائي الأشعة رؤية اوضح وعين ثانية ساعدته علي تشخيص ادق، واستخلاص منطقته الاهتمام (ROI) للكشف عن الكتل الورمية والأفات السرطانية المختلفة اللي تصيب نسيج الثدي.

# Table of content

Abstract .....	i
Arabic abstract .....	ii
Table of content.....	iii
List of figures.....	vi
List of tables.....	xi
Abbreviations.....	x
<b>CHAPTER One – Introduction.....</b>	<b>1</b>
1.1 Introduction .....	2
1.2 Problem statement .....	4
1.3 Aim of the thesis.....	5
1.4 Thesis methodology .....	5
1.5 Organization of the thesis.....	6
<b>CHAPTER Two – Litutre reviews.....</b>	<b>7</b>
2.1 Introduction .....	8
2.2 Direct contrast enhancement techniques .....	8
2.3 Indirect contrast enhancement techniques .....	8
2.4 Adaptive image enhancement techniques .....	9
2.5 Wavelet Image enhancement techniques .....	9
2.6 Image thresholding techniques .....	10
2.7 Image enhancement filtering techniques .....	11
2.8 Region based techniques .....	12
2.9 K means algorithm .....	12
<b>CHAPTER Three – Breast cancer and Mammography .....</b>	<b>14</b>
3.1 Inrodcation.....	15
3.2 Cancer and breast cancer .....	15
3.3. Type of breast cancer .....	17

3.3.1 Benign .....	17
3.3.2 Malignant .....	17
3.4 Breast cancer stages .....	17
3.5 Female breast cancer statistics .....	18
3.6 Female breast cancer detection image techniques.....	18
3.7 Mammography .....	18
3.7.1 Major views of mammogram .....	19
3.7.2 Important findings mammogram.....	20
3.7.3 Mammogram evaluation parameters .....	23
3.7.4 Mammogram image processing steps .....	24
3.8 Types of mammogram.....	25
3.8.1 Screening mammogram .....	25
3.8.2 Diagnostic mammogram .....	26
3.9 Breast imaging reporting and data system (BI-RADS).....	26
<b>CHAPTER Four – Mammogram image processing .....</b>	<b>28</b>
4.1 Introduction.....	29
4.2 Spatial domain image enhancement techniques .....	30
4.2.1 Negative image transformation .....	31
4.2.2 Logarithmic transformations .....	33
4.2.3 Power law transformation .....	34
4.2.4 Contrast stretching operation .....	34
4.2.5 Mammographic image histogram-based processing .....	36
4.3. Contrast limited adaptive histogram equalization .....	46
4.4 Filtering in spatial domain (spatial filtering) .....	47
4.4.1 Smoothing linear filters .....	48
4.4.2 Smoothing non-linear filters.....	49
4.4.3 Sharpening spatial filters .....	50
4.5 Frequency domain methods of image enhancement .....	55
4.5.1 Filtering in the frequency domain .....	56



4.5.2 Smoothing frequency domain filters .....	58
4.5.3 Sharpening frequency filtering .....	59
<b>CHAPTER Five Proposed mammogram image enhancemnt and detection Methodolgy .....</b>	<b>61</b>
Introdcation.....	62
System one proposed methodology.....	63
Expermental mammogram image enhancemnt.....	64
Image enhancement evaluation.....	68
System two proosed methodology.....	70
<b>CHAPTER Six – Conclusions and future scops .....</b>	<b>84</b>
6.1 Conclusions .....	85
6.2 Future scops .....	85
References .....	86
<b>Appendixes.....</b>	<b>90</b>
A.Questionnars .....	ii
B. Approved letters .....	iii
C. Mammogramphye equipment.....	vi

## List of figures

<i>Number</i>	<i>Page</i>
Figure (3.1) Female breast anatomy	15
Figure (3.2) Mammogram images show breast mass	16
Figure (3.3) Progression from normal to invasive cancer	16
Figure (3.4) Breast cancer cases time trend (2012-2020)	18
Figure (3.5) Basis part of typical mammography device	19
Figure (3.6) Mammography views	20
Figure (3.7) Distribution of micro calcifications according to the BI-RADS	21
Figure (3.8) Example of masses by shape	21
Figure (3.9) Three mass examples with different shape and margin	22
Figure (3.10) Screening mammography showing architectural distortion	23
Figure (3.11) ACR categories exemplification (ACR, 2014)	27
Figure (4.1) Mask 3x3 neighborhood about a point (x,y) in an image	31
Figure (4.2) Negative image applied negatives transformation	35
Figure (4.3) Result of log transformation applied to mammogram image	33
Figure (4.4) The power law	34
Figure (4.5) Mammogram image with low contrast	35
Figure (4.6) Contrast stretching	36
Figure (4.7) sided mammogram image histogram	37
Figure (4.8) sided mammogram image histogram	37
Figure (4.9) sided mammogram image histogram	38

Figure (4.10) Histogram equalization	44
Figure (4.11) Contrast enhancement by using CLAHE	47
Figure (4.12) Mean filter	48
Figure (4.13) Effect of Gaussian filter	49
Figure (4.14) Effect of median filter	50
Figure (4.15) Image enhancement with unsharp masking	51
Figure (4.16) Mammography image enhancement with Sobel Operator	53
Figure (4.17) Mammogram image enhancement of applying Laplacian filter	54
Figure (4.18) Mammogram image enhancement of ideal low pass filter.	57
Figure (4.19) Image enhancement by Gaussian low pass filter	57
Figure (4.20) Image sharpening by ideal high pass filter	59
Figure (4.21) Image sharpening by homomorphic filtering	60
Figure (5.1) Steps using in image processing	62
Figure (5.2) GUI system one	64
Figure (5.3) Results of negative transform system one	65
Figure (5.4) Histogram equalization system one	65
Figure (5.5) CLAHE Filter system one	66
Figure (5.6) Multi-scale image contrast system one	67
Figure (5.7) Sobel operator system one	68
Figure (5.8) Flowchart shows proposed methods steps	72
Figure (5.9) Flowchart of the proposed method in image acquisition	73
Figure (5.10) Experimental results proposed method original image	73
Figure (5.11) Crop the Breast	74

Figure (5.12) Experimental results proposed method binary image	75
Figure (5.13) Experimental results proposed method after pectoral muscle removal	75
Figure (5.14) Flowchart of mammographic image enhancement	76
Figure (5.15) Homographic Filter	77
Figure (5.16) Morphology Operations	77
Figure (5.17) Experimental results proposed method applying adaptive histogram	78
Figure (5.18) Flowchart shows proposed method Mammogram	79
Figure (5.19) Image after the stage of converting the image to binary	80
Figure (5.20) Segmented output image K-means clustering	80
Figure (5.21) Image after edge detection	81
Figure (5.22) Experimental results proposed method applying adoptive histogram	81
Figure (5.23) Flowchart of the proposed method Mammogram Texture-based classification	82

## **List of tables**

Table (5.1) The Performance Measure	69
Table (5.2) The satisfaction percentages of image	70

## List of Abbreviations

ACR	American College of Radiology
AHE	Adaptive Histogram Equation
BBHE	Brightness-preserving bi-histogram equalization
BI – RADS	Breast Imaging Reporting and Data System
CAD	Computer Aided Diagnosis
CC	Crania Caudal
CDF	Cumulative Distribution Function
CII	Contrast Improvement Index
CLAHE	Contrast limited adaptive histogram equalization
DICOM	Digital Imaging and Communications in Medicine
DNA	Deoxyribonucleic acid
DM	Digital Mammography
DWT	Discrete Wavelet Transform
EME	Enhancement Measurement Entropy
FFDM	Full Field Digital Mammography
FN	False Negative
FP	False Positive
FFT	Fast Fourier Transform
FSM	Film Screen Mammography
GC	Gamma Correction
GUI	Graphical User Interface
HE	Histogram Equalization
IARC	International Agency for research on Cancer
KNN	K-Nearest Neighbors
MATLAB	Matrix Laboratory

MIAS	Mammography Image Analysis Society
MRI	Magnetic Resonance Imaging
MLO	Medio-Lateral Oblique
MSE	Mean Square Error
MMBEBHE	Minimum Mean Brightness Error Bi-Histogram Equalization
NCI	National Cancer Institute
NLUS	Nonlinear Unsharp Masking
PACS	Picture Archiving and Communication System
PDF	Probability Density Function
PSNR	Peak Signal-to-Noise Ratio
RMHE	Recursive Mean-Separate Histogram Equalization
RNA	Ribonucleic Acid
ROI	Region of Interest
SNR	Signal-to-Noise Ratio
UM	Unsharp Masking
WHO	World Health Origination

## **CHAPTER ONE – INTRODCATION**

### **1.1 Introduction**

### **1.2 Problem Statement**

### **1.3 Aim of the thesis**

### **1.4 Thesis methodology**

### **1.5 Organization of the Thesis**



## 1.1 Introduction

Breast cancer is becoming nightmare disturb all females around the world, it is the major public health problem among women and considered as the most common type of cancer among women in many developed and developing countries, breast cancer remains the leading cause of death among women aged 35–55 years [1].

The most common abnormalities that might indicate breast cancer are masses and calcifications, Statistics shows that a woman's chance of developing breast cancer at her lifetime is approximately 1 to 8 in America, 1 to 12 in Europe and 1 to 40 in Asia. According to the World Health Organization (WHO) every year, breast cancer kills more than (500,000) women around the world [2].

In Western countries breast cancer represents of 25% to 30% of the total incidence of cancers in women and is responsible for 15% to 18 % of mortality Worldwide (1.301.867) breast cancer new cases were registered [2].

In Libya breast cancer represents of 11.9 % of total incidence of cancers in women and is responsible for 5.3 % of mortality, the 2012 estimation of International Agency for Research on Cancer (IARC) stated that cancer incidence in Libya is 23.2 [3].

Based on the data provided by National Cancer Institute -Sabratha (NCI) from 2012 to 2020 new cases (2,196) females diagnosed with breast cancer, most of them under age 35, as we know age is the single most important risk factor for breast cancer.

It is important to recognize that the most studies proved that 1 in 10 women (10%) get breast cancer can be misinterpreted [4]. In developed countries, in spite of the increased tendency of breast cancer, the breast cancer mortality has decreased in all ages and survival rates is high comparing with developing countries which has low survival rates may be due to lack of awareness and early detection programs [4].

Possible cause for reduction in mortality rates is the introduction of screening mammography which was performed in the asymptomatic female population to detect early signs of breast cancer such as masses, calcifications, bilateral asymmetry and architectural distortion, studies indicate that screening plays an important role in detection and diagnosis of breast cancer in its early stage.

and increases the chances for successful treatment and complete recovery of the patient [5].

Although some risk factors have already been identified such as age and family history of breast cancer, there is no study has yet been able to identify with certainty why every year about one million breast cancer cases are discovered and around 500,000 women worldwide die [6].

As a consequence, undiscovered cause there is no primary prevention strategies have been identified. Thus, there is no effective way to avoid breast cancer but screening to detect it in early stages [7].

Mammography which is specialized medical imaging uses a low-dose x-ray imaging to see inside the breasts. is currently the only widely accepted imaging method used for routine breast cancer screening [8].

Screening mammography is performed in the asymptomatic population to detect early signs of breast cancer such as masses, calcifications, bilateral asymmetry and architectural distortion, the screening exam should pick up as much breast cancer cases as possible.

Diagnostic mammography is performed on patients who have already present with abnormal clinical findings [8], both screening and diagnostic mammography are traditionally performed by radiologists who visually inspect mammograms images. This is not an easy task, one of the difficulties with mammography is that images generally have low contrast [7].

Mammograms show normal structures such as fat, fibro glandular tissue, breast ducts and nipples, as well as possible abnormalities. Although fat appears as black regions on mammograms Images, other breast component like glands, connective tissue and abnormalities are appear as levels of white, which is making it hard to distinguish between normal and abnormal tissue [7].

Furthermore, due to there is a large number of mammograms to be analyzed every work day, as a consequence, during manual screening, radiologists may get exhausted, missing vital cues while studying the mammogram images. manual screening is a tiring and tedious task prone to human error, for which the lack of a “gold standard” is an additional complicating factor. Supporting these facts, studies have shown that mammography is susceptible to a high

rate of False Positives (FPs) as well as False Negatives (FNs). Radiologists classify between 10% to 30% of malignant cases as benign [6]. ,in these FN cases, the best time interval for the treatment of cancer can be missed, thus potentially endangering the patient, on the other hand, a high proportion of women without cancer (FP cases) undergo further unnecessary clinical evaluation or breast biopsy which can lead to needless anxiety

To overcome these limitations, double reading of mammograms has been advocated. In fact, this is the procedure followed in every country that adopts a screening policy. The idea is to have two radiologists read the same mammographic images; this has been shown to increase sensitivity (equivalent to decreasing the number of FNs). However, the workload and cost associated with double reading remain high, and the outcomes are still susceptible to human error.

Hence, enhancing mammogram images will significantly improve the diagnosing ability. The vague nature of mammographic image and its low differentiability from the background make it too complicated to analyze them. consequently, it is essential to reduce the noise and enhance the region of interest (ROI).

Image processing, especially, image enhancement techniques have been used widely for overcome those problems. Algorithms such as histogram equalization, median filters gamma correction, gaussian filters, logarithmic transformation and morphological filter have been applied to enhance Mammogram images. The present thesis describes an effort to apply enhancement techniques to digital mammographic images in order to improve their quality and help radiologists in both screening and diagnosis phases.

## **1.2 Problem statement**

A concerning problem with mammography is the visual detection of early signs of breast cancer might be difficult especially in dense breast tissue. X-ray mammography suffers from many problems. The main more likely problem to occur in mammogram images is quantum noise due to electrical fluctuation, quantum noise occurs in the mammogram images during acquisition due to low count X-ray photons. It affects the quality of images; it also affects the classification accuracy to classify images into benign and malignant.

Other problem of Mammography is due to high breast density, which obscures the mammographic image, the main drawback of mammography today is that it is hard to differentiate between normal, dense tissue and cancerous tissue when looking for small tumors surrounded by glandular tissues. the accurate mammography depends on the degree of image clarity and lack of noise.

### **1.3 Aim of the thesis**

The main aim of this thesis is summarized in the following points:

- To improve the image de noising base on image processing filters
- To remove the noise that increases the image blurry, and enhances its quality.
- To differentiate between Normal and malignant breast masses using image by enhancement techniques
- Design Graphic user interface GUI with collection of image enhancement techniques, which can friendly use by radiologist.
- To explore the importance of image enhancement stage by applying various techniques on Mammogram images to get better level of quality and clearness
- To work on image segmentation algorithms which are playing an effective rule in image processing stages.
- The developed techniques have been implemented in MATLAB ® and tested on real case studies.

### **1.4 Thesis methodology**

The research methodology of the thesis was filed study, researcher had visited three oncology specialized centers in Libya (National cancer institute – Sabratha, National cancer institute- Misrata, Tripoli center for oncology) and through those field visits and interviews which researcher was conducted with radiologists.

Designed questionnaire was used to collected information about enhancement techniques, the radiologists were to comment upon the accuracy of the enhanced image and segmentation

resulting in the given shape and site of a massan image was said to be enhanced if it allows the viewer to better perceive the desirable information in the image.

## **1.5 Organization of the Thesis**

This thesis is organized into six chapters in addition to the introductory chapter.

**Chapter 2 “Literature review”** This chapter provides a review of state-of-the-art at Image enhancement techniques for mammograms images of breast cancer.

**Chapter 3 “Breast cancer and Mammography”** This chapter deals with the basics of breast anatomy and breast cancer.

**Chapter 4 “Mammograms image processing”** This chapter deals with the discusses existing mammograms image processing methods and general steps involved.

**Chapter 5 “Proposed Mammogram image enhancement and detection Methodology”** presents the proposed systems for enhancement and detection of breast as well as the achieved experimental results.

**Chapter 6 “Conclusion and future scopes”** This chapter contains the concludes the results and discussions as well as recommendation and suggestions some points as a future works are also provided.

## **CHAPTER TWO – Literature Review**

### **2.1 Introduction**

### **2.2 Direct contrast enhancement techniques**

### **2.3 Indirect contrast enhancement techniques.**

### **2.4 Adaptive image enhancement techniques.**

### **2.5 Wavelet image enhancement techniques.**

### **2.6 Image thresholding techniques.**

### **2.7 Image enhancement-filtering techniques.**

### **2.8 Region based techniques.**

### **2.9 K means algorithm.**

## 2.1 Introduction

Cancer is the most dangerous disease which still killing women until today, the cure of which must be the prime target through scientific investigation. The early detection of cancer can be helpful in curing the breast cancer completely. There are several techniques available in the literature for the detection of cancer. Many works have contributed their ideas in the detection of cancer.

The literatures mainly discuss about the existing cancer enhancement techniques to improve mammogram image quality. Several domains and concepts are used in the image enhancement. Mammogram image has been in use for very long time and much work has been carried out by early works. It has used different types of algorithms to enhance mammogram image, in the following sections general reviews about the enhancement of image are described briefly

## 2.2 Direct contrast enhancement techniques.

S. Supriya and M. Subaji (2017) [9] provided a comparative survey which carried out describing various Direct and indirect Contrast Image enhancement techniques with their advantages and disadvantages. Histogram Equalization acts as a base to most of the Image enhancement techniques. Most of these methods suffer with over enhancement and high saturation effects. Based on the comparison, extracting image features plays a vital role in image enhancements. Recent studies have driven attention towards certain edge preserving filters, Intelligent based swarm methods and Fuzzy logic methods in increasing the performance of Image enhancements based on the image features. All of these algorithms are intended to enhance the image contrast but each approach is geared to handle images degraded at particular intensity level types.

## 2.3 Indirect contrast enhancement techniques

K.Akila (2015) [10] provided a methods for the indirect contrast enhancement techniques HE, CLAHE, BBHE, MMBEBHE, and RMSHE are compared by applying them to the low contrast mammographic images. The traditional HE method significantly changes the brightness of the image. Hence the details of the image cannot be viewed clearly. MMBEBHE provides better noise removal in the images. By applying some edge preservation filter to it,

the performance of enhancement can be increased. Both CLAHE and RMSHE techniques are found to offer better enhancements of masses and micro calcifications present in the images taken for study. However, based on the detailed performance evaluation studies conducted in this work, it is clearly evident that the RMSHE technique achieves the best contrast enhancement for the low contrast mammographic images taken for study and it offers the best brightness preservation as well.

## 2.4 Adaptive image enhancement techniques

Swaminathan, Anand & Gayathri, S (2015) [11] proposed an a two-stage adaptive histogram equalization for enhancement of mammogram images. Instead of using a single histogram specification, they employ two different histogram specifications for adaptive histogram equalization (AHE). Here one stage AHE follows another AHE. This proposed approach is tested on all Mammographic Image Analysis Society (MIAS) database images and the improved performances are compared with standard AHE, unsharp masking (UM) and recently proposed nonlinear unsharp masking (NLUS). The objective performances are analyzed by enhancement measure (EME) and entropy.

The method developed by Moradmand, Hajar et (2012) [12], Image processing methods have different effects on digital mammogram images and can make them clearer. The results of this study illustrated that the wavelet transformation had the highest CII about 2.61 in average. The CII averages of CLAHE, unsharp masking and morphology operation were about 2.047, 1.63 and 1.315 respectively. The results demonstrated that the wavelet transformation with Asymmetric Daubechies of order 8 method was an effective way to enhance micro calcifications especially for dense breasts and also reduced noise in high noise mammograms. It may also be able to improve the detection and classification of micro calcifications in a computer-aided diagnosis system.

## 2.5 Wavelet image enhancement techniques

The method developed by Rajput, Yashu (2012) [13] in medical image enhancement based upon non-linear enhancement technique using Histogram equalization and the Discrete wavelet transform. These techniques enhance the lower and higher contrast area of an image in both spatial and frequency domain. Here we compared these techniques based on MSE, PSNR, it got better result of PSNR and MSE in the case of preprocessed histogram technique as well as DWT results is also better than the simple histogram technique. Here Discrete



wavelet Transform enhanced the edges of the image, so we can say that the DWT is mainly using for de-noising. Result of both experiments shows that the algorithm is not only enhancing the image contrast, but can preserving the original image quality. There is another study conducted by Pelin Gorgel et.al , (2010) [14] a new method for mammographic image enhancement and restoration based on wavelet transformations and homomorphic filtering. Initially the approximation coefficients obtained by the wavelet transformations are filtered using homomorphic filter. Then the detail coefficients of the wavelet transformations associated with noise and edges are modeled using Gaussian and Laplacian variables. Finally compressing all the approximations and details coefficients and then enhancing the image using adaptive thresholding retains most of the fine details of the mammogram images.

## 2.6 Image thresholding techniques

Ashgan M. Omera, et.al , (2017) [15] proposed a method the proposed technique for preprocessing mainly based on binarization process and Otsu's thresholding, the technique has been presented to remove unwanted regions with high intensities as labels scanning artifacts and the pectoral muscle. Moreover, the proposed method enhanced the mammogram image by removed the noises and enhance the image contrast using CLAHE method which used widely in medical image applications. The results obtained on 160 images of MIAS database and have shown excellent output. The resultant mammogram can be used further for processing stage to assist on mammogram image classification and breast cancer detection.

Other study was conducted by group Al-Bayati, et.al, (2013) [16] proposed a method for detection of cancer. The purpose of this study was applied different thresholding in mammogram images and after that determine which technique was the best in thresholding (extraction) malignant and benign tumors from the rest breast tissues. The used technique is Otsu method, because it is one of the most effective methods for most real-world views with regard to uniformity and shape measures. Also, they present all the thresholding methods that used the concept of between class variance. We found from the experimental results that all the used thresholding techniques work well in detection normal breast tissues. But in abnormal tissues (breast tumors), we found that only neighborhood valley emphasis method gave best detection of malignant tumors. Also, the results demonstrate that variance and

intensity contrast technique is the best in extraction the micro calcifications which represent the first signs of breast cancer.

## 2.7 Image enhancement filtering techniques

Kshema et al (2017) [17] described an approach that used image Preprocessing is the most vital and essential stride in the mammogram analysis because of poor mammogram picture quality. It is important to redress the mammogram images for further processing and analysis. Distinctive sorts of sifting systems are accessible for pre-processing mammogram images. Filters are utilized to enhance picture quality, evacuate the clamor, saves the edges inside a picture, improve and smoothen the image and so on. Speckle clamor, salt and pepper commotion and gaussian clamor are the basic noises found in mammogram images. In this paper they looked at the performance of mean, median, wiener, adaptive median and gaussian filter based on the quality parameters such as MSE, SNR and PSNR with speckle noise, salt and pepper noise and gaussian noise defiled images. Median filter is found to be better in preserving sharp edges and is less sensitive to outliers than mean filters. From the analysis of filters, it is found that gaussian noise can be better removed by mean filter and wiener filter can also remove this noise up to an extend compared with median, adaptive and gaussian filter. Mammogram image corrupted with speckle noise can be better reconstructed with gaussian filter, wiener filter and mean filter. Mean filter, median filter and adaptive median filter works better for salt and pepper noise.

Zeng F., Liu L (2013) [18] developed a work for image enhancement techniques to aid interpretation. The study proposes a new image contrast enhancement method for digital mammograms based on guided image filtering method. Guided image filtering is a non-iterative, non-linear filter, which not only smoothest low gradient regions, but also preserve strong edges. Analogously to the bilateral filter, this filter had edge preserving properties, but can be implemented in a very fast way. Thus, they adopt guided image filtering algorithm to increase the contrast in mammograms for human easily extracting of suspicious regions. Experimental results showed that the proposed method gives superior image quality compared to other enhancement methods.

## 2.8 Region based techniques

Nirase Fathima Aboubacker el al , (2017) [19], described an approach that due to the presence of an overexposed boundary area in the majority of mammograms, a peripheral correction is required to enhance the visualization of digital mammograms in order to compensate for possible acquisition limitations. This peripheral correction that necessitates a better segmentation output was improved by using an average filter combined with the segmentation method. The paper evaluated the results by using subjective and objective methods and the performance is compared against the well-known segmentation techniques, the region growing, and the Otsu and K-means methods. Both the subjective and objective results showed that the region growing segmentation method with filter outperforms the other two segmentation methods and provide better input for the peripheral enhancement process. The peripheral enhancement using the filtered region growing segmentation method improved the image quality and provided better visualization for better assessment. Hence, the peripheral enhancement is shown to improve visualization and will play an important role in further development of CAD systems in mammography.

In other study conducted by Meenalosini, S. et al (2012) [20] described an approach to detect the mass region automatically without any human interruption. Preprocessed image is segmented using alarm region generation process in combination with region growing method. The segmented region is examined thoroughly using Gabor filter which helps to study the segmented mammogram in all possible angles and frequencies. The segmented region from the proposed work can be used for further processing such as feature extraction and classification of mass region in future.

## 2.9 K means algorithm

Gumaei, Abdu et al (2011) [21] developed a work in which, an attempt is made to implement K-means clustering algorithm with mixture of Gamma distributions for breast image segmentation for early detection of breast cancer. Mixture of Gamma distributions can model symmetric and non-symmetric data unlike mixture of Gaussian distributions which can only model symmetric data. This attempt was a new idea in image processing technique. This technique was applied on breast segmentation. their proposed segmentation algorithm was able to segment lesions (micro-calcifications and masses) efficiently and more accurately

The experimental results showed that the developed approach was able to segment breast in mammography images accurately and in a faster way.

In other study conducted by research group, Martins, Leonardo et al (2011) [23] described an approach that use of computational tools to aid detection and diagnosis of breast masses has grown and gained increasing, these tools have been contributing to increase the early detection rates for breast cancer. That work presented a methodology for detection of masses in digital screening mammograms, which can also be used in the development of a CAD tool. Such methodology used for both purposes is subdivided into preprocessing, segmentation through K-means algorithm, reduction of mass candidates, and classification of segmented structures into mass or non-mass, based on co-occurrence matrix, shape descriptors eccentricity, circularity and convexity and support vector machine classification. The results indicate that the use of these techniques in the detection of masses is promising, since it achieves accuracy rates of over 85%. This will lead to a natural development of a CAD system capable of assisting health professionals in the painstaking task of tracing mammograms in search of mass abnormalities.

## **CHAPTER Three – Breast Cancer and Mammography**

### **3.1 Introduction**

### **3.2 Cancer and Breast cancer**

### **3.3 Types of Breast Cancer**

### **3.4 Breast Cancer Stages.**

### **3.5 Female Breast Cancer Statistics.**

### **3.6 Female breast cancer detection image techniques**

### **3.7 Mammography**

### **3.8 Types of mammograms**

### **3.9 Breast imaging reporting and data system (BI-RADS)**

### 3.1 Introduction

The female breast is the organ which overlay the chest, generally the role of women's breast is to produce milk. Healthy breast is made up of fatty tissue which determines the size of the breast. It contains 12-20 sections called Lobes that are formed by smaller structures called lobules (glandular tissue) that produce milk. Each lobule is connected to the nipple by a thin tube where the milk is drained as represented in figure (3.1). [22].

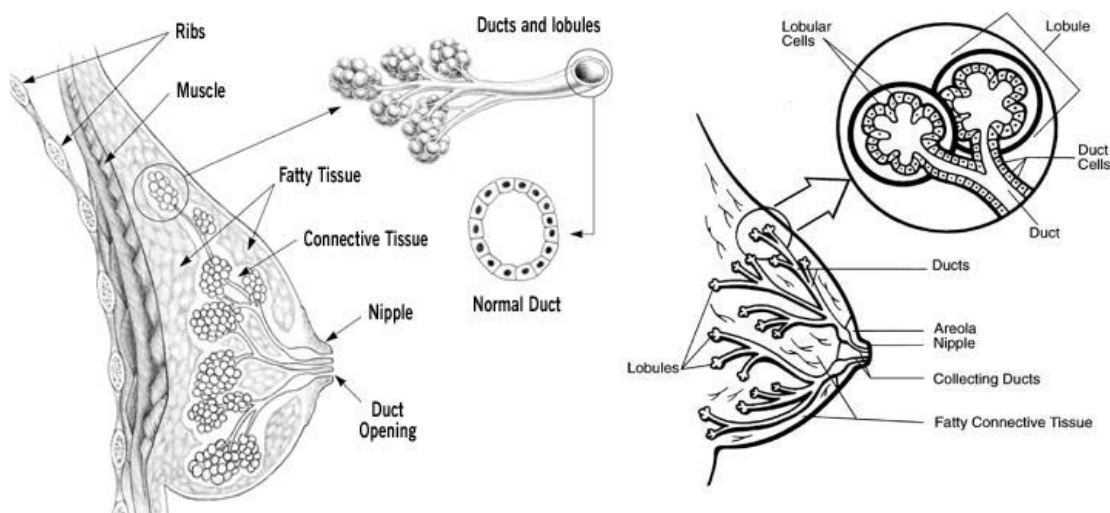
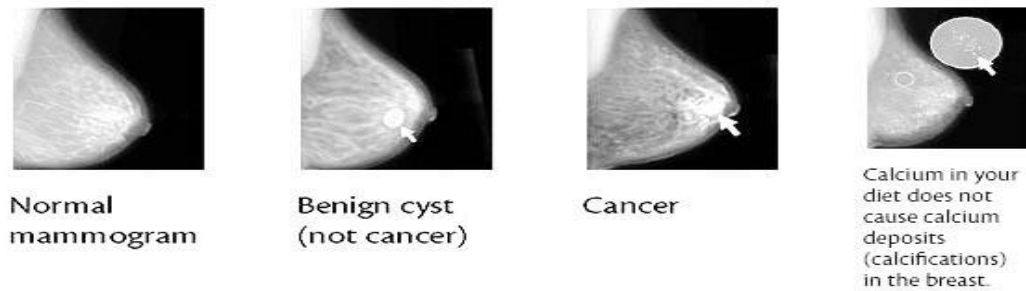


Figure (3.1). Female breast anatomy

### 3.2 Cancer and breast cancer

Breast cancer is a disease characterized by the uncontrolled growing of cells in the breast that attack the neighboring healthy cells, Breast cancer can be separated into different types based on the way the cancer cells look under the microscope. Most breast cancer is carcinomas, a type of cancer that starts in the cells that line organs and tissues like the breast. In fact, breast cancers are often a type of carcinoma called adenocarcinoma, which starts in glandular tissue. No effective way to prevent the occurrence of breast cancer exists. Therefore, early detection is the first crucial step towards treating breast cancer. It plays a key role in breast cancer diagnosis and treatment. Data from breast cancer facts and figures tells us about estimated new female cases and deaths by age the breast function and shape can be modified under certain conditions. Most women feel changes during their lifetime, this can be caused by

by changes in hormones. With menopause (advance in aging) breasts start developing some changes like reducing its size and feeling lumpy (presence of masses). This kind of changes are not cancerous and they do not make any risk to the breast called Cyst (Benign mass) as shown in figure (3.2). [22].



(3.2) Mammogram images show breast mass

Cancer is a condition of abnormal cell growth in the body. Cells form tissues and tissues form the organ. Sometimes cells growth becomes unregulated (Mutation in genes). This can be occurred under changes in some factors: physical, chemical or environmental. They start to replicate uncontrollably meaning more reproduced cells than died cells which results in masses of cells called Tumors [6]. Breast cancer is the most common cancer detected in women and rated as the second causing deaths in the world. There exist two invasive breast conditions in which cancerous cells start to invade the surrounding tissue and spread to other organs through a blood or lymphatic vessels. Non-invasive means that the cancerous cells are still contained in the duct as illustrated in figure ( 3.3) 22

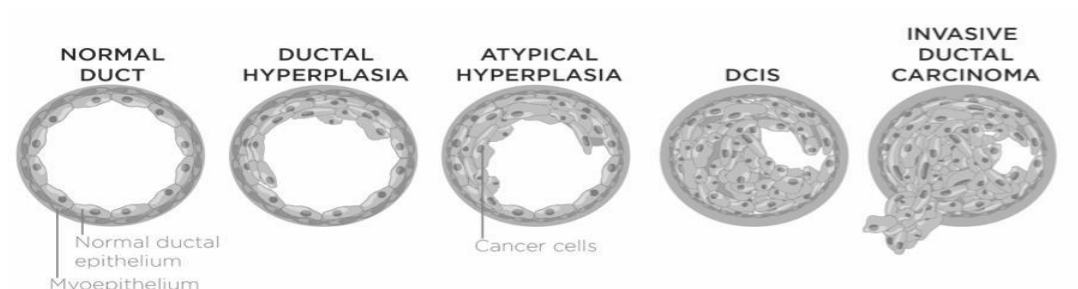


Figure (3.3). Progression from normal to invasive cancer. [22]

### 3.3 Types of Breast Cancer

There are two major types of cancer abnormality such as benign and Malignant. These schemes are described briefly in the following subsections.

#### 3.3.1 Benign

Benign tumors are not cancerous, they can usually be removed and generally do not grow back once they are gone. The cells in benign tumors do not spread and it is rare for a benign tumor to be life-threatening.

#### 3.3.2 Malignant

Malignant tumors are cancerous. The cells are abnormal and divide randomly. The cells behave aggressively and attack the tissue around them. They also can move away from malignant tumor and enter the blood stream to form new tumors in other organs of the body. Many viruses infect humans but only a few viruses are known to promote human cancer. These include DNA viruses and retroviruses, a type of RNA virus.

### 3.4 Breast Cancer Stages.

Doctors group tumors by Stage by The Stage of a tumor refers to the way the cells look under a microscope. Different Stages of cancers are there in our body system. After your health care providers know what type of cancer you have, they will determine what "stage" the cancer is in. This means how far advanced its growth is. There are many staging systems, but a common example is the TNM. The "T" refers to the size of the tumor, the "N" to the number of lymph nodes involved and the "M" to metastases (the spread of the cancer to other organs through the lymphatic and/or circulatory system). Generally, the lower the stage, the less advanced the cancer is and the better the treatment outcome is likely to be [25]:

Stage 0 = precancer.

Stage 1 = small cancer found only in the organ where it started.

Stage 2 = larger cancer that may or may not have spread to the lymph nodes.

Stage 3 = larger cancer that is also in the lymph nodes.

Stage 4 = cancer in a different organ from where it started



### 3.5 Female Breast Cancer Statistics.

According to data collected from three oncology centers (NCI-Sabratha, NCI-Musratha, Tripoli oncology center 2012-2020), breast cancer was the most common cancer registered, accounting for 44% of all female registrations. Figure 3.4 shows progress of new breast cancer cases those centers.

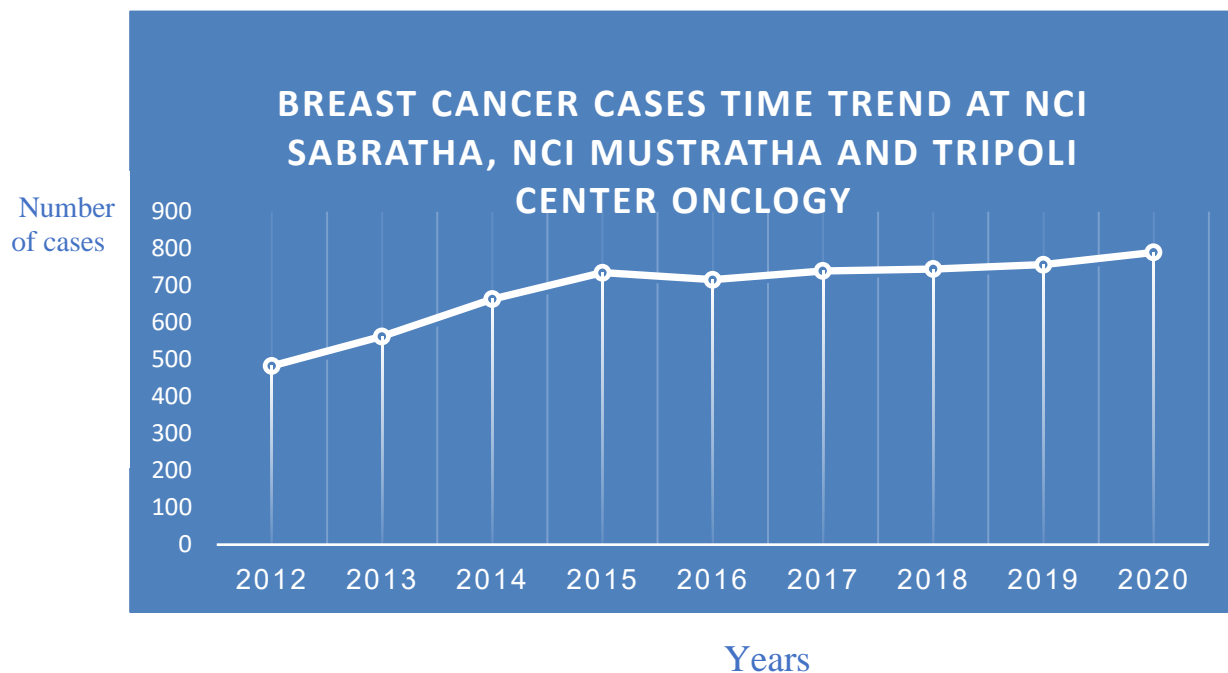


Figure (3.4). Breast cancer cases time trend (2012-2020)

### 6.3 Female breast cancer detection image techniques

Breast imaging is continuously progressing as new modalities, and advances in applications of established modalities, are developed. Although each technique has its advantages and pitfalls, mammography is still the only widely adopted screening technique. While traditionally Screen Film Mammography (SFM) was used, nowadays most medical institutions have access to Digital Mammography (DM) [23].

### 3.7 Mammography

Mammography is a specific type of imaging that uses a low-dose x-ray system to examine female breasts. A mammography exam, called a mammogram image, is used to detect and evaluate any change in the breast to aid in the early detection and diagnosis of breast diseases

in women.[25], it is an x-ray (radiograph) is a noninvasive medical test that helps physicians diagnose and treat medical conditions. Imaging with x-rays involves exposing a part of the body to a small dose of ionizing radiation to produce pictures of the inside of the body. X-rays are the oldest and most frequently used form of medical imaging, mammography history equipment, Radiation procedure, major views and important to find mammogram are described briefly in following subsections.

Today's mammography machine exposes the breast to much less radiation, X-rays do not go through tissue as easily as those used for routine chest x-ray, there are two types of Mammography machine: Digital mammography, also called full-field digital mammography (FFDM), is a mammography system in which the x-ray film is replaced by electronics that convert x-rays into mammographic pictures of the breast. These systems are similar to those found in digital cameras and their efficiency enables better pictures with a lower radiation dose. These images of the breast are transferred to a computer for review by the radiologist and for long term storage. Figure (3.5) is illustrated the illustrates basis part of typical mammography device and screening of right breast [23].

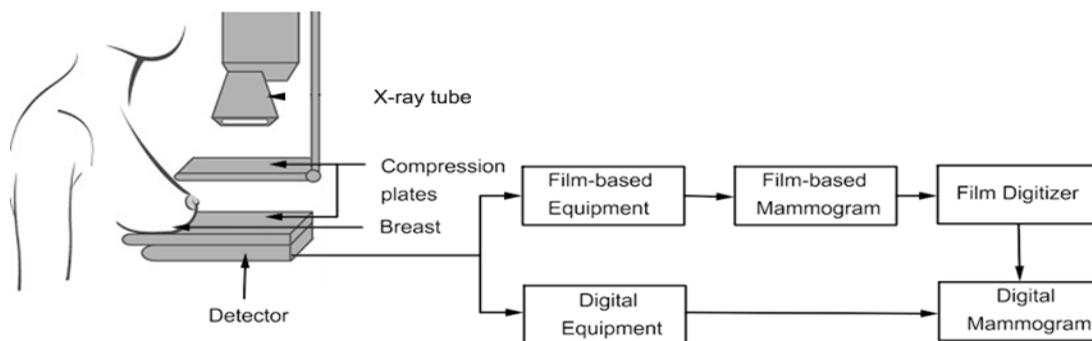


Figure (3.5) Basis part of typical mammography device and screening of right breast.

### 3.7.1 Major views of mammogram

There are two major standard views of mammogram involved in screening are the cranio-caudal (CC) view and medio lateral oblique (MLO) view. Both these two views are essential in analyzing breast images for early breast cancer detection. Radiologists usually consider these two views in different angles for analyzing the mammographic images to reach a conclusion. In both views, x-rays are used for image acquisition. Compression of breast for x-ray imaging is proportional to the spreading of tissues which in turn maximizes the quality of resultant breast image [25]., Figure (3.6) show the mammography view.

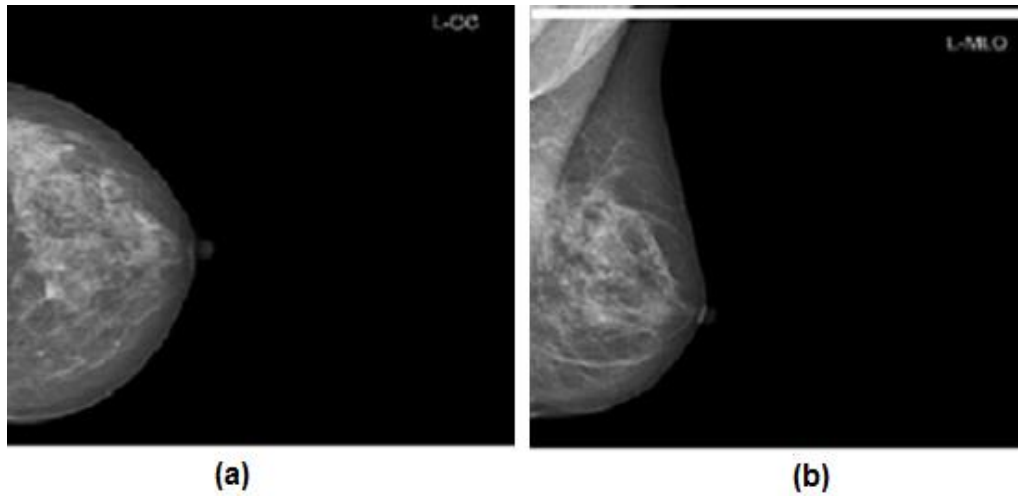


Figure (3.6) Mammography views : (a) Craniocaudal (CC), (b) Mediolateral oblique (MLO).

### 3.7.2 Important findings of mammogram

Due to Changes in breast tissue, there are several breast abnormalities that can be detected in mammography. Most commonly found abnormalities signs of breast cancer are normally associated with Presence of masses in the breast, Presence of calcifications and micro-calcifications, distortion of the normal architecture of the breast tissue and Asymmetry between images of left and right breasts, it is generally accepted that the essential characteristic of a high-quality mammogram is the ability to visualize these four features [25].

#### A. Calcification: Macrocalcification

Microcalcifications are microscopic calcifications that appear in clusters as white spots with a higher intensity level than their surrounding tissue and they are difficult to detected due to their reduced size microcalcifications are tiny specks of calcium deposits, that result from the precipitation of salts in the fluid secreted by the epithelial cells, and that can be formed in breast ducts, lobules, outside breast tissue, or within tumors, they have high attenuation after X-ray exposure, Microcalcifications found on muscle, skin or nipple are almost always benign. In addition to this, benign microcalcifications are normally found as scattering calcifications overlapping each other, and not as a cluster as in the case of malignant ones, other clues such as size, form and density can be indicators of the malign or benign nature of microcalcifications. Figure (3.7) illustrated Distribution of microcalcifications according to the BI-RADS

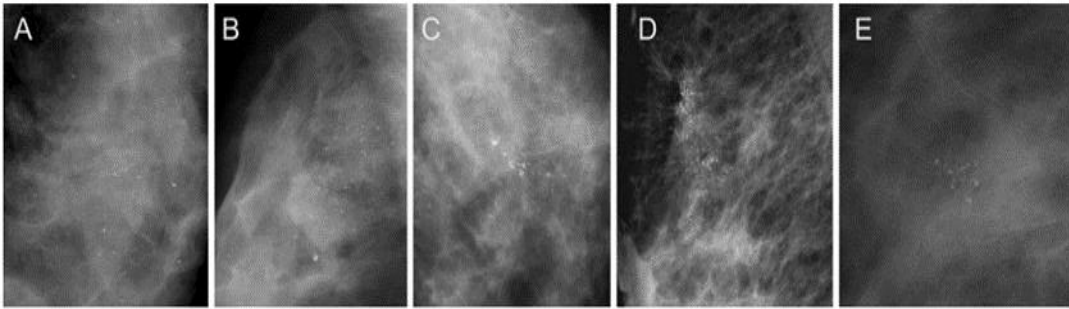


Figure (3.7) Distribution of micro calcifications according to the BI-RADS lexicon: diffuse (A), regional(B), linear (C), segmental (D), and clusters of micro calcifications (E).

## B. Mass

Breast masses are normally bigger lesions, they are considered to be one of the primary signs of breast cancer. Masses could be benign or malignant depending on the shape, density or margin (edge characteristics). Malignant masses tend to appear as more irregular in shape with ill-defined speculated margins Figure (3.8) shows an example of a benign and malignant mass in mammogram. [25], Breast masses are usually brighter than normal tissues in mammograms, and they are defined by the characteristics of their shapes and margins

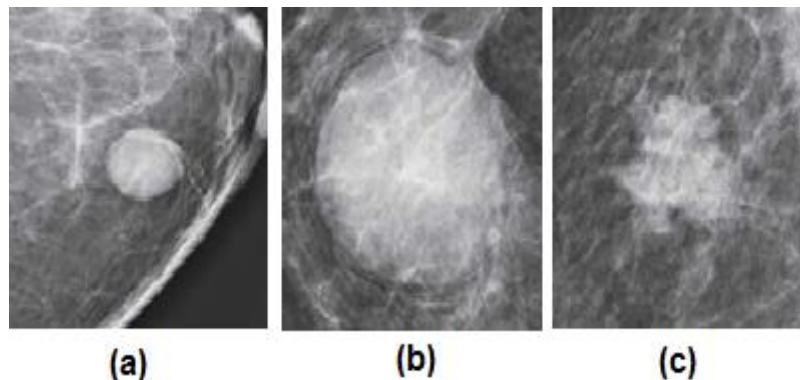
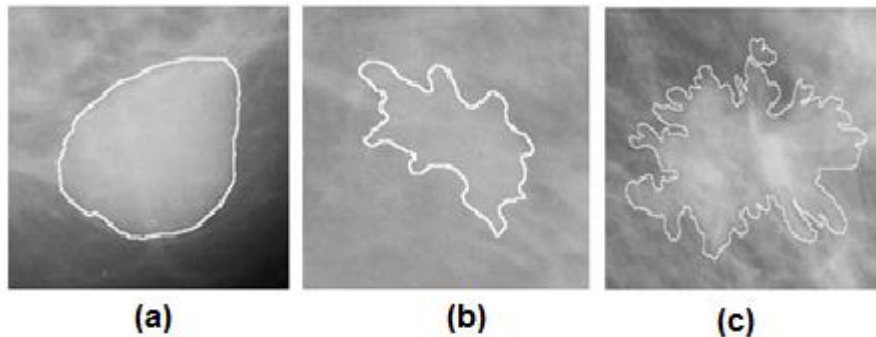


Figure (3.8) Example of masses by shape: (a) oval, (b) round, and (c) irregular

Masses by margin are classified in circumscribed, obscured, micro lobulated, indistinct or speculated as shown in figure (3.8). The margin of circumscribed masses is sharply demarcated with an abrupt transition between the lesion and the surrounding tissue. An obscured margin is one that is hidden by superimposed or adjacent fibro glandular tissue. The margin of micro lobulated masses is characterized by short cycle undulations. In indistinct masses, there is no clear demarcation of the entire margin, or of any portion of the margin,

from the surrounding tissue. Finally, speculated mass margin is characterized by lines radiating from the mass as shown in figure (3.9) [25].



Figure(3.9) Breast mass with different shape and margin:(a) Circular ShapeCircumscribed Margin, (b) Lobular ShapeWellDefinedMargin, (c) Spiculated ShapeIll Defined Margin

Figure 3.9 shows three mass examples of breast mass with different shape and margin the figure (3.9 c) has an increased probability to be malignant. be the sign of a malign process. The margin refers to the border of a mass, and it should be examined carefully because it is one of the most important criteria in determining whether the mass is the result of a benign or malign process. Radiologists classify the margin among five classes [24]:

- Circumscribed margins, which are well defined and sharply demarcated with an abrupt transition between the lesion and the surrounding tissue.
- Obscured margins, which are hidden by superimposed or adjacent normal tissue.
- Micro-lobulated margins, which have small undulating circles along the edge of the mass.
- Ill-defined margins, which are poorly defined and scattered.
- Spiculated margins, which are marked by radiating thin lines.

The probability to find a malignancy mass is normally ordered according to this classification. The more ill-defined and spiculated the margin, the higher the probability to be associated with a malignant process. It should be clear that these morphological aspects can be very subtle and difficult to diagnose, even for an expert radiologist.

### C. Arquitectural distortions

Arquitectural distortions correspond to changes of normal breast texture, like straight lines for instance. They are a normally missed signs of cancer, in addition to arquitectural distortions, other associated features such as skin and nipple retraction, may be a sign of breast cancer

Breast asymmetries can also be considered as a signal of breast cancer. When a mass or other lesion is only seen in a single-view mammography, it is called asymmetry. Asymmetries can also be referred as a difference between left and right breast. Figure (3.10) is represented the screening mammography which showing architectural distortion (arrows) [24].

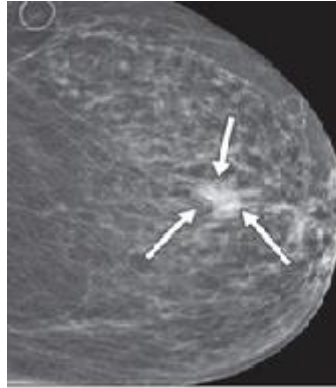


Figure (3.10) Screening mammography showing architectural distortion (arrows)

#### **D. Breast density**

Breast density refers to the prevalence and distribution of fibroglandular tissue in the breast as it appears on a mammogram. The fibrous and glandular tissues cannot be distinguished in mammography due to a combination of physiological intertwining and similar x-ray attenuation coefficients. These tissues can, however, be distinguished from fatty tissue, which attenuates x-rays to a lower degree. This causes the fibroglandular tissue to stand out as bright areas on a dark background and therefore the term density is used to describe its appearance.

#### **3.7.3 Mammogram evaluation parameters**

**True Positive (TP):** A case when the suspected abnormality is malignant i.e. the prediction is true.

**True Negative (TN):** If there is no detection of abnormality in healthy person. A case where no symptoms were found truly.

**False Positives (FP):** Indicates that detection of abnormality is found in healthy person. The prediction of presence of abnormality is not true.

**False Negatives (FN):** No detection of malignant lesion is found, proves to be false

### 3.7.4 Mammogram image processing steps

Mammogram image processing pass through steps likewise, measurement of mammogram image quality, image acquisition, image display and image storage.

#### 1. Mammogram Image Quality

The three factors that constitute the quality of mammogram images are noise, contrast and sharpness.

**A. Noise:** is the unwanted variation in brightness of an image

**B. Contrast:** is the difference in luminance or pixel value (intensity) that makes an object discernible from its background or other objects.

**C. Sharpness:** is the amount of details an image can convey

#### 2. Mammogram image acquisition

Digital detectors for mammography can be categorized as indirect or direct conversion detectors according to how the X-ray is captured. In indirect conversion methods (the earliest ones) the energy of the X-rays is captured by a scintillator which converts it to light.

Subsequently, this light is captured by an array of thin-film diodes which convert it to electronic signal which, in turn, is captured using thin-film transistors. The main problem of these systems is that the created light by the scintillator scatters to its neighborhood, and the same X-ray is captured by different transistors. On the other hand, in direct conversion systems the same photoconductor that captures the X-ray is able to directly generate an electronic signal. Thus, scattering is less severe in these systems.

#### 3. Mammogram image storage

Once the image is acquired it has to be stored. This is accomplished by the digital imaging and Communications in Medicine (DICOM) standard developed by the National Electrical Manufacturers Association. This standard handles not only the storage process but also the print and transmission of the information in medical imaging.

The DICOM format differs from all the rest in the fact that it groups together the information of the patient and of the image source (the mammograph in our case) as well as the full image or images. Thus, the images coming from a single study are never mistakenly separated neither from their information. The image data can be compressed using a variety of standards, like JPEG, JPEG Lossless, JPEG 2000, and Run-length encoding.

Moreover, the DICOM standard also handles the communication protocol enabling, therefore, the integration of the different imaging devices of the hospital. Thus displays, scanners, servers, workstations, printers, and network hardware can be integrated in a fully digital system, usually referred as the Picture Archiving and Communication System (PACS).

Typically, a PACS network consists of a central server storing the DICOM database and the set of clients which provides or uses the images.

#### **4.Mammogram image Display**

Once the digital mammograph has been acquired the image and the PACS database has received and stored it, the image can be sent to the screening workstation, where usually, one or more experts will analyze the mammogram image for and diagnose the case. However, in contrast with the typical film-screen image, the experts will have to watch the image on an electronic display (also called soft-copy display). In contrast to (static) film reading, soft-copy offers new opportunities. For instance, there is experimental evidence that alternating the current and prior mammograms on the same display allows better evaluation of temporal changes than conventional display of images next to each other, in particular if images are properly registered in the spatial and gray-scale domains . However, the main drawback is that a faulty or inadequately calibrated or improperly set up display can compromise the overall quality of a diagnostic procedure. Clinical studies show that radiologists can perform equally well with soft-copy reading of digitized screening mammograms as with reading of conventional films, where differences in sensitivity and specificity were not significant . Moreover, a lot of studies show that there was no significant difference in the speed of interpretation.

### **3.8 Types of mammograms**

There are two types of mammogram, screening mammogram and diagnostic mammogram. These types will be described briefly in the following subsections.

#### **3.8.1 Screening mammogram**

Mammogram of the breast for the women who have no sign or symptom of breast cancer, usually with two x-ray views, it is benefit in finding breast cancer early signs which are greatly improves a woman's chance for successful treatment



### 3.8.2 Diagnostic mammogram

Diagnostic mammography is used to evaluate a woman with abnormal clinical finding such as a breast lump or nipple discharge. that have been found by the woman or her doctor. Diagnostic mammography may also be done after an abnormal screening mammogram in order to evaluate the area of concern on the screening exam

### 3.9 Breast imaging reporting and data system (BI-RADS)

Overall assessment of the radiological findings often includes a classification of the mammogram using the BI-RADS system developed by the American College of Radiology (ACR).[25].Breast imaging reporting and data system (BI-RADS)

- **Category0:** additional view or ultrasound and or compare prior film
- **Category1:** negative
- **Category2:** benign(noncancerous)
- **Category3:** probably benign, repeat in 6mth
- **Category4:** suspicious abnormality consider biopsy
  - 4A: finding with low suspicion of being cancer
  - 4B finding with an intermediate suspicion of being cancer
  - 4C finding of moderate concern of being cancer but not as high as category 5
- **Category5:** highly suggestive of malignancy, biopsy is recommended
- **Category6:** known biopsy proven malignancy, appropriate action should be taken. It is only to see how well the cancer is responding to treatment
- **BI-RADS for breast density**

The breast density is very important for breast cancer detection below the types of breast density

- The breasts are almost entirely fatty (little fibrous and glandular tissue)
- There are scattered areas of fibro glandular density
- The breasts are heterogenously dense (more fibrous and glandular tissue)
- The breasts are extremely dense (It can lead to missing some cancer)

Although the figure (3.11) is shown the ACR categories exemplification



Figure (3.11) ACR categories exemplification (ACR, 2014) [25]

# **CHAPTER FOUR – MAMMOGRAM IMAGE PROCESSING**

## **4.1 Introduction**

## **4.2 Spatial Domain image enhancement techniques**

## **4.3 Contrast limited adaptive histogram equalization**

## **4.4 Filtering in spatial domain (Spatial Filtering)**

## **4.5 Frequency domain methods of image enhancement**

## 4.1 Introduction

Image enhancement processes consist of a collection of techniques that seek to improve the visual appearance of an image or to convert the image to a form better suited for analysis by a human or a machine. In an image enhancement system, there is no conscious effort to improve the precision of a reproduced image with regard to some ideal form of the image [26].

Breast lesions such as masses and calcifications may be small with low contrast when compared with the surrounding breast tissue, that is leading to unpleasant image and difficult in abnormality detection. During an image acquisition phase, it may be happened that the captured image has poor quality with very poor contrast, Low contrast images can result from poor illumination, lack of dynamic range in the image sensor, wrong setting of lens aperture during image acquisition. Therefore, the radiologist cannot clearly separate out the bright regions from the dark backgrounds, sometime the mammogram is very severely degraded with noise, which lead to a part of the image information content were unwanted , and when mammogram is affected by noise it become difficult to do any further processing until the noise is removed from image, the other problem maybe face the mammogram is that the outline or boundary of various objects presented at images are not clearly visible, due to the poor imaging conditions itself, that mean the outline of objects get blurred with respect to the background and we cannot extract the details of object boundaries.

In some other cases the mammograms are having insufficient details or a lot of extra details most of them are unwanted and we may like to eliminate or reduce some of the unwanted features form the image by applying some filtrations techniques, all the mentioned above problems are usually happened in the mammogram images, and because of that there is a strong need to improve some particular features of mammogram image so that the further processing can be carried out because the difficulty is that if the image quality or image features with which we are interested, they cannot be extracted properly from the image then further processing like analysis or interpretation with those images become very difficult unless we do some improvement on those specific features.

In this chapter we discuss and study the subject of image enhancement techniques which aiming to improve contrast or visibility Mammogram image features. basically, encompasses

a number of areas: contrast enhancement, Edge sharpening, Noise Reduction, and image filtering, there exist significant, techniques that can enhance Mammogram image without spoiling it. The enhancement techniques can broadly be divided in to the following two categories:

- Spatial Domain Methods.
- Frequency Domain Methods.

## 4.2 Spatial Domain image enhancement techniques

Spatial domain techniques work directly on the image pixels[30]; naturally we have to define a transformation function which will transform an image pixel from the original image to a pixel in the processed image, a function can be defined as:

$$g(x) = T[f(x)] \quad (4.1)$$

Because this subject is dealing with the 2-dimensional images a function defined as:

$$g(x,y) = T[f(x,y)] \quad (4.2)$$

$g(x, y)$  is equal to transformation  $T$  of the image  $f(x, y)$ , where  $f(x, y)$  is the original image,  $T$  is the transformation which is applied on this original image to produce the processed image  $g(x, y)$ .

In case of spatial domain techniques, transformation  $T$  is working directly on  $f(x,y)$ , to produce the processed image  $g(x,y)$  where  $T$  is an operator work on the original image  $f$  and the operator is defined over neighborhood of the point  $(x,y)$  in the original image  $f(x,y)$ . In such case we considering that a transformation operator  $T$  is works on single image and when we want to find out a processed image at location  $(x, y)$ ; then the operator  $T$  is works on the original image  $f$  at location  $(x, y)$  considering certain neighborhood of the point  $(x,y)$  to determine what will be the process pixel value at location  $(x,y)$  in the processed image  $g$  this neighborhood of a point  $(x, y)$  is usually a square sub image which is centered at point  $(x, y)$  as shown in figure (4.1).

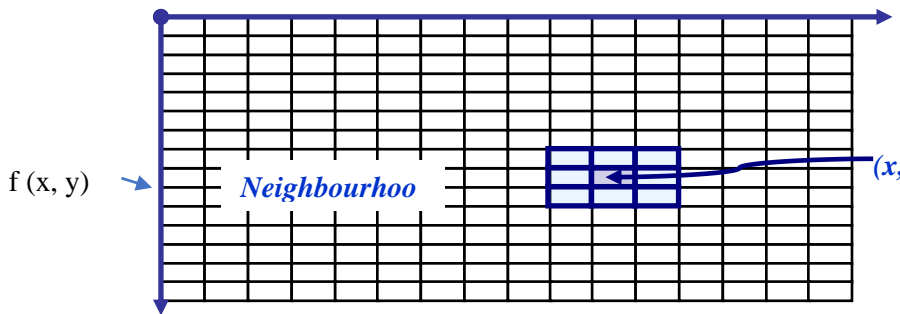


Figure (4.1) Mask 3x3 neighborhood about a point (x,y) in an image

In figure (4.1) the outer rectangular image represents the image  $f$  and within this image  $f$ , it has taken pixel at a particular location  $(x, y)$ . So, this is the pixel location  $(x, y)$  and the neighborhood of this point  $(x, y)$  it is usually a square sub image around point  $(x, y)$ . in our case it shows a 3x3 neighborhood around the pixel point  $(x, y)$  in the image  $f$ .

#### 4.2.1 Negative image transformation

The transformation of the original image into a negative image is required with conditions if the mammogram images that we obtain during the acquisition stage is contain white or grey level information embedded in black pixels, in this process the pixel gray values are inverted to compute the negative of an image [27], there is very few white or gray level information present a white background which is very much dark. in such cases, finding out the information from the mammogram images becomes very difficult, there for it will be beneficial that instead of considering the raw mammogram image we take the negative of the images. by convert all the white pixels in the image or the larger intensity values, we make them darker and the darker intensity values, we make them lighter or brighter. And in effect, we get a negative of an image and within this negative image, we will find through result that visualization or extracting information which we want will be more convenient than in the original image. The values of pixels before and after processing are denoted by  $r$  and  $s$  respectively, these values are related by an expression of the form [27].

$$s = T(r) = L - 1 - r \quad (4.3)$$

where  $L$  is Largest value in an image,  $r$  represented number of rows, whenever  $r = 0$ , then  $s$  will be  $s = L - 1$  which is the maximum intensity value within our digital image and when

$r = L-1$  that is the maximum intensity value in the original image; in that case,  $s$  will be  $s=0$ . So, the maximum intensity value in the original image will be converted to the minimum intensity value in the processed image and the minimum intensity value in the processed image will be converted to maximum intensity value in the original image will be converted to maximum intensity value in the processed image.

In effect it gets is a negative of the image, it can represent this transformation and graphically as shown in the in figure 4.2 (a), the transformation present as a straight line with a slope of (- 45) degree and passing through the points  $(0, L- 1)$  and  $(L -1, 0)$ . The result we get by applying this kind of transformation on mammogram image is shown in figure 4.2 (b) achieved using MATLAB.

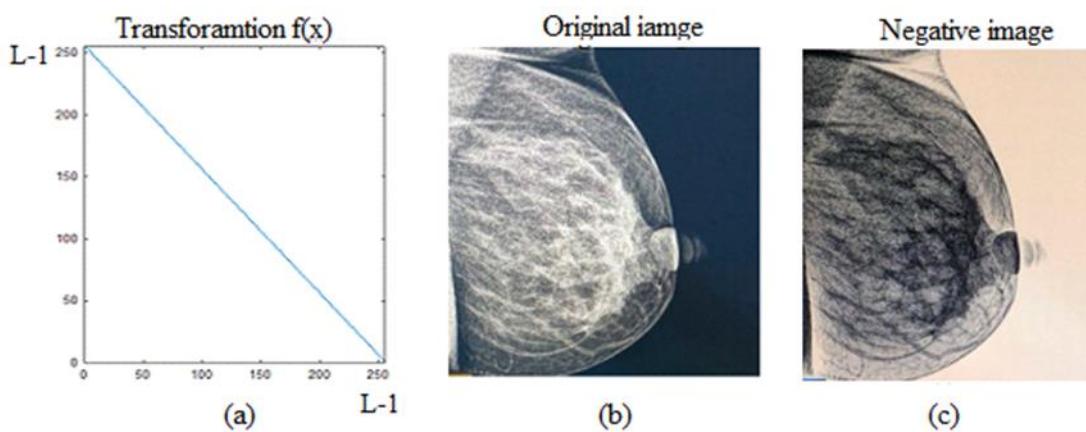


Figure (4.2): Negative image applied negatives transformation:

(a) transformation  $f(x)$ , (b) original image, (c) result of negative image

Figure 4.2 (b) is raw mammogram image, figure 4.2 (c), negative of mammogram image which is obtained by the transformation that we have discussed above. we find that in original mammogram image, there are some white grains and there is a white patch which indicates a cancerous region and this grain corresponding to the tissues, they are not very prominent. That is mean it is very difficult to make out which is what in this original image. By taken the negative of this mammogram image; we find that all the darker regions in the original image has been converted to brighter regions in this enhanced image and the brighter regions in the original image has been converted to darker regions in the enhanced image.

## 4.2.2 Logarithmic transformations

Log transformations are one of the initial image enhancement techniques of the spatial domain which is effectively used for contrast enhancements of dark images. The log transform is consisting of two type of transformation, Log transformation and inverse log transformation [28]. The conduct of inverse log transformation technique is directly opposite of the logarithmic transformation, in sometime at the mammogram image applications there is need to reduce the dynamic range, the general form of the log transformation can be mathematically represented in equation as:

$$s = c * \log (1 + r) \quad (4.4)$$

where,  $c$  is a constant, and it is assumed that  $r \geq 0$  log transformation maps a narrow range of low gray level values in the input image into a wider range of output levels.

The opposite is true of higher values of input levels. We would use a transformation of this type to expand the values of dark pixel in an image while compressing the higher-level values [27]. The opposite is true of the inverse log transformation. Figure (4.3) shows result of log transformation applied to original mammogram image; the log transformation response of original image is plotted using MATLAB.

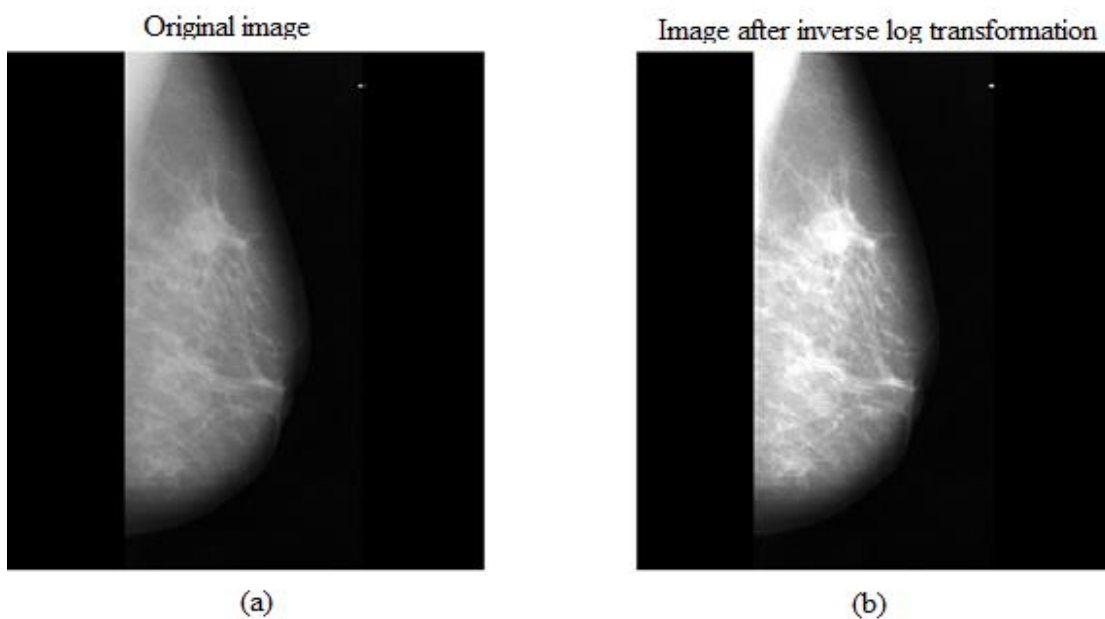


Figure (4.3) Result of log transformation applied to mammogram image:(a) Original mammogram image, (b) Image after inverse transformation



### 4.2.3 Power-law transformations

The power law transformation is used for different types of image capturing devices and image printers. The reason is all those devices mostly follow these power law characteristics. In case of power law devices, the transformation function between the original image, intensity and the processed image intensity is given by the expression [27] .

$$s = cr^\gamma \quad (4.5)$$

where  $s$  and  $r$  are the gray levels of the pixels in the output and the input images, respectively and  $c$  is a constant,  $\gamma$  is power. This transformation function is also called as Gamma Correction (GC). Figure (4.4) is shown the power law of the original image, transformed image ( $\gamma=2$ )

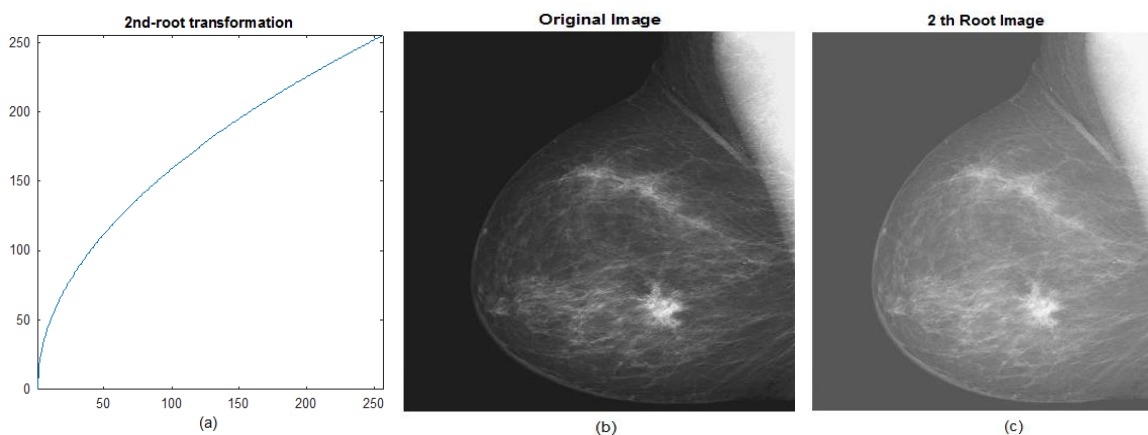


Figure (4.4) The power law :(a) 2<sup>nd</sup> power low, (b) Original image (c) 2th root image

### 4.2.4 Contrast stretching operation.

If an image is overall very dark or a very bright, the information may be lost in those areas which are excessively and uniformly dark or bright the problem is how the contrast of an image can be optimized to represent all the information in the input image.

Techniques such as histogram equalization, gamma correction, and linear contrast correction have been used to reduce these effects Contrast is the difference in visual properties that makes an object in an image distinguishable from other objects and the background. Contrast stretching is a simple image enhancement technique. Contrast enhancement is another category of image enhancement which stretches the dynamic range of the image to improve the image visibility ,low-contrast images can result from poor illumination, lack of dynamic

range in the imaging sensor [29]. The mammogram images are generally low on contrast and have noise in background such as tape markings and labels as shown in figure (4.5) , This low contrast in mammogram image may affect any further process. Therefore, contrast enhancement and background segmentation are crucial preprocessing steps in image processing.

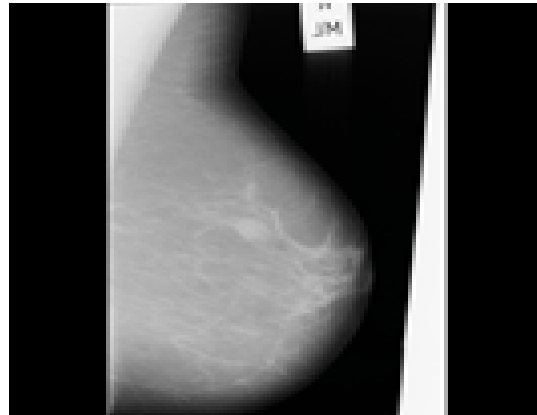


Figure (4.5) Mammogram image with low contrast.

In practice sometimes we get mammogram image from mammograph equipment with dark or poor resolution, this may happen because of various reasons, one of the reasons is illumination of the object or the illumination of the scene was poor. That means the object itself was dark. the other reason why an image may be dark is that dynamic range of the sensor on which we are imaging is small.

Dynamic range which is the capacity of the sensor to record the minimum intensity value and the maximum intensity value. So, the difference between the minimum intensity value and the maximum intensity value called the dynamic range of the sensor, contrast stretching aims to improve the image through stretching the range of intensity values. Those intensity values are rescaled, usually through the analysis of the image histogram, generally, contrast stretching is employed when the gray-level distribution is narrow due to poor illumination, lack of dynamic range in the imaging sensor or others.

This technique aims to adjust the histogram to achieve a higher separation between the foreground and the background gray-level distribution. However, it is difficult to remove noise whose gray-level are similar to the object one, such as the microcalcification. A linear rescaling transformation associated is

$$y = kx + m \quad (4.6)$$

In figure (4.6) shows mammogram image with poor contrast and overall appearance of this image is dark. Therefore, the purpose of stretching is to shows the effect of contrast enhancement on mammogram image after applying contrast improvement process

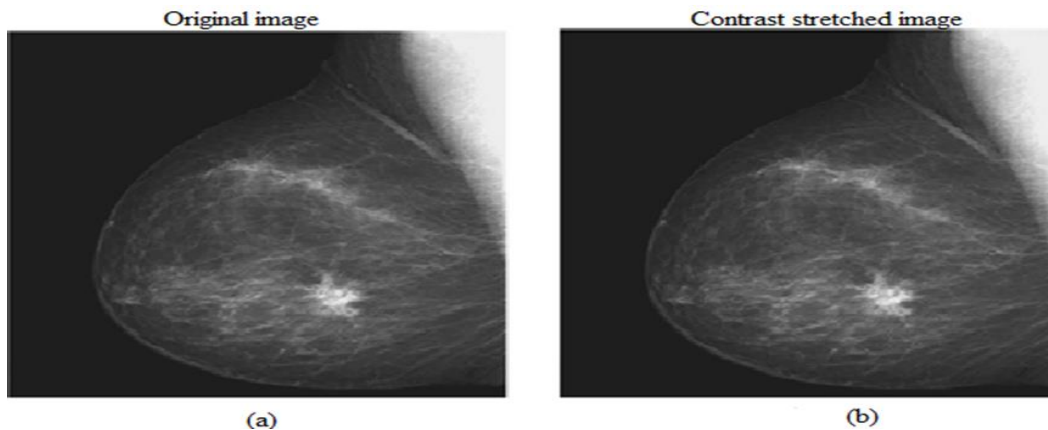


Figure (4.6) Contrast stretching:(a) Original image, (b) Contrast stretched image

The image shown in figure 4.6 (a) with low contrast and by applying the bright enhancement we have got processed image shown in figure 4.6 (b), it is clearly observed that more details are available in the processed image than in the original image. Obviously, the contrast of the processed image has become much higher than the contrast in the original image.

#### **4.2.5 Mammographic Image histogram-based processing**

Histogram is common tool for improvement contrast in medical imaging, as it has the ability to obtain a visual representation of the female breast structure as a two-dimensional digital monochromatic image is a binary representation of an array of pixels, each pixel has a numerical value that represents a grey level.

Histogram processing is an approach where the transformation techniques take care of the global appearance of the image, it plays a measurement role to provide a global description of the appearance of an image [30].

So, histogram is a graphical representation of the probability distribution of the gray values in a digital image, the visualization of the image's histogram helps in analyzing the frequency of appearance of different gray levels contained in the image.

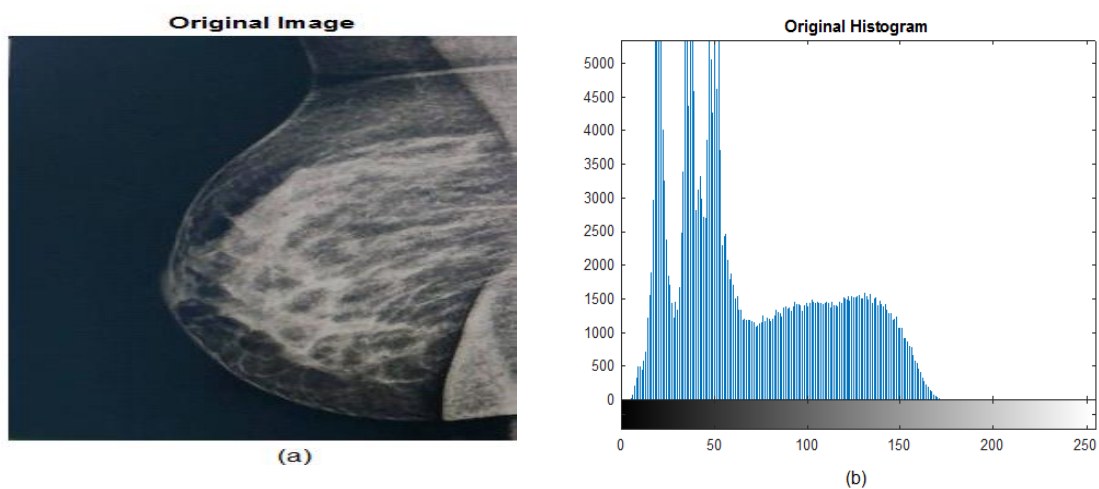


Figure (4.7) sided image Histogram:(a) Original dark left (b) Corresponding histogram

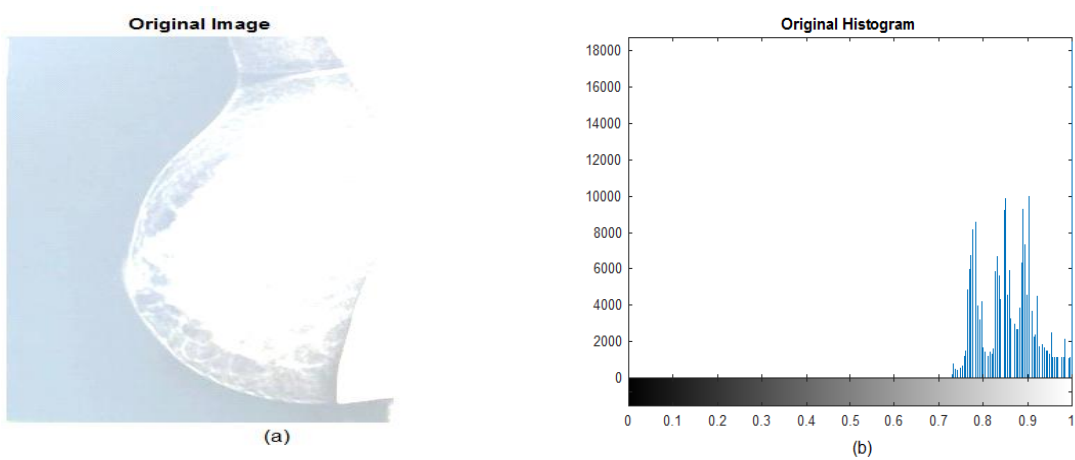


Figure (4.8) Sided image histogram:(a) Original bright right(b) Corresponding histogram

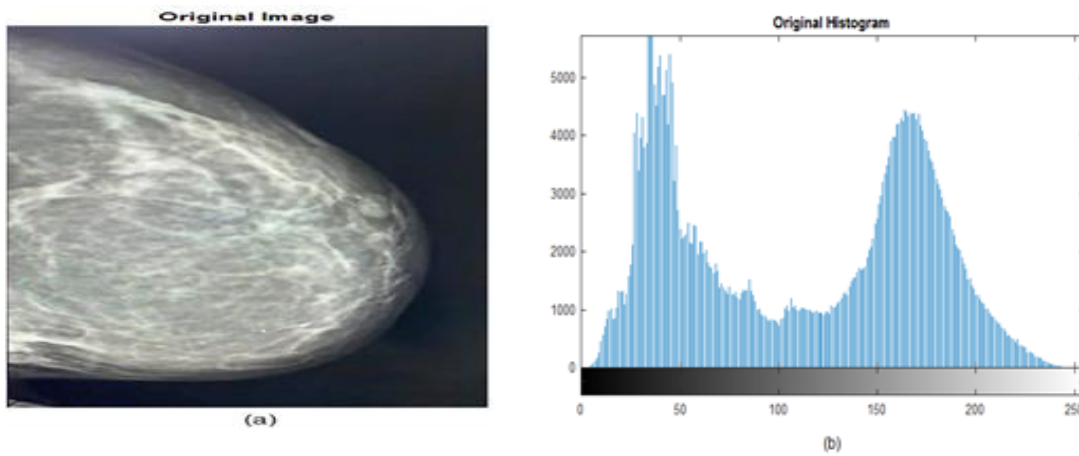


Figure (4.9) Sided image histogram (a) Original image (b) Corresponding distributed histogram

Equation (4.7) represents the relation between the histogram and the contrast of the image.[26]

$$\text{Gary – level image} = \begin{cases} \text{Bright} & \text{Right sided histogram} \\ \text{Dark} & \text{left sided histogram} \\ \text{Good appearance} & \text{well distributed histogram} \end{cases} \quad (4.7)$$

Mammograms images are commonly 8-bit grayscale images with a gray-level range from zero (black) to 255 (white). The histograms of the bright, dark, and good in appearance images, in sequence, are right-sided, left-sided, and well distributed. Thus, the histogram measures the brightness level of images and reflects either the image has a low or acceptable contrast.

In a conclusion, the histogram which covers all the possible values in the gray scale indicates that the image has good contrast and that the details in this image are clear. Figures (4.7), (4.8) and (4.9) shows the different types of mammogram images with their corresponding histograms.

Figure (4.7) shows dark mammogram image and it is very difficult to find out the content of this mammogram image and when we plot the histogram of this dark image, then the histogram is plotted on the right-hand side. therefore this plot shows most of the pixels of this mammogram image have intensity values near to zero (0). Figure (4.8) shows bright mammogram image it's corresponding histogram it is clearly observed that most of the pixels of this image have intensity values near to the maximum value (255) and that is why the

image becomes very bright. Figure (4.9) shows mammogram image with the intensity values which are higher than the intensity values of the mammogram image at figure (4.7) and it is lower than the intensity values of the mammogram image shown at figure (4.9) , it is somewhere in between and the histogram of this image shows that most of the pixels of this image have intensity values in the middle range, therefor the mammogram image shown in figure (4.8 c) appears to be a medium kind of image, it is neither very dark nor very bright, and the variation of the intensity values of this mammogram image is very poor.

As a result, the image that we have got gives a medium kind of appearance, not very bright neither very low but at the same time, the variation of intensities is not very clear. That means the contrast of the image is poor.

#### (i) Normalization of a histogram

Normalize histogram is a technique count on transforming the discrete distribution of intensities into a discrete distribution of probabilities., to do so, we need to divide each value of the histogram by the number of pixels. Because a digital image is a discrete set of values that could be seen as a matrix and it's equivalent to divide each  $n_k$  by the dimension of the array which is the product of the width by the length of the image.

To define the histogram of an image we consider that an image is having gray level intensities in the range  $[0, L-1]$ , we consider the digital mammogram image have  $L$  number of discrete intensity levels as in is in equation 4.8:

$$h(rk) = \frac{n_k}{N} \quad (4.8)$$

where variables  $r_k$  represents the  $k^{th}$  intensity level and histogram is represented by  $h(rk) = \frac{n_k}{N}$ , where  $n_k$  is the number of pixels in the image having intensity level  $h(rk)$  and if it plots these number of pixel values, the number of pixels having different intensity values against the intensity value of that of those pixels; then the plot that we get is known as a histogram , while we are dealing with the discrete images; so this function histogram  $h(rk)$  will also be discrete,  $r_k$  is a discrete intensity level,  $n_k$  is the number of pixels having intensity level  $r_k$  and  $h(rk)$  which is same as  $n_k$  also assumes discrete values.

So instead of taking a simple histogram as just defined, we sometimes take a normalized histogram, a normalized histogram is very easily derived from original histograms or the normalized histogram is represented as:

$$P(r_k) = \frac{n_k}{n} \quad (4.9)$$

where  $n_k$  is the number of pixels having intensity value  $r_k$  and  $n$  is the total number of pixels in the digital image. From the expression shown in equation 4.9, the  $p(r_k)$  actually tells us what is the probability of occurrence of a pixel having intensity value equal to  $r_k$  and such type of histograms will give information about a global description of the appearance of an image.

### (ii) Histogram equalization operation

Histogram equalization is a specific case of the more general class of histogram remapping methods, these methods seek to adjust the image to make it easier to analyze or improve visual quality.

Those techniques corresponds to the redistribution of the gray levels in order to obtain a histogram as uniform as possible, maximizing the mammogram information [31], in histogram equalization every pixel is replaced by the integral of the histogram of the image in that pixel, his histogram equalization operation, initially we assume that  $r$  to be a variable representing the gray level in an image, we assume that the pixel values in an image are continuous and they are normalized in the range  $[0,1]$ , where zero indicates a black pixel, and one indicates a white pixel, and while we are dealing with point possessing transformation, we are interested to find out a transformation as equation (4.10).

$$s = T(r) \quad (4.10)$$

It is assumed that  $T(r)$  is single-valued and monotonically increasing on  $0 \leq r \leq 1$

$$0 \leq T(r) \leq 1 \quad \text{or} \quad 0 \leq r \leq 1$$

$$r = T^{-1}(S) \quad (4.11)$$

where  $r$  is the intensity of the original image and  $s$  is the intensity of the process image,  $T$  the transformation function has to satisfy two conditions. the first condition is the  $T(r)$  should be

single valued and monotonically increasing in the range  $0 \leq r \leq 1$  and the second condition  $T(r)$  must satisfy is  $0 \leq T(r) \leq 1$  for  $0 \leq r \leq 1$ .

The first condition is maintaining the order of the gray levels in the processed image. That is a pixel which is dark in the original image should remain darker in the processed image; a pixel which is bright in the original image should remain brighter in the processed image. So, the intensity ordering does not change in the processed image and that is guaranteed by the first condition which is the  $T(r)$  should be single valued and monotonically increasing in the range  $[0,1]$  of the values of the  $r$ . The second condition  $0 \leq T(r) \leq 1$ , this condition ensures that the processed image that we get, does not lead to a pixel value which is higher than the maximum intensity value that is allowed, So, this ensures that the processed image will have pixel values which are always within the available minimum and maximum range and if these conditions are satisfied by

$T(r)$ , then the inverse that is  $r$  is equal to the inverse of  $T(s)$ ,  $r = T^{-1}(S)$  and will also satisfy these two conditions. So, we want a transfer function  $T$  which will satisfy these conditions and if these conditions are satisfied by  $T(r)$ , then the inverse transformation will also satisfy this particular condition, the transfer function shown in equation 4.12

$$Pr(r) \rightarrow PDF\ of\ r \quad (4.12)$$

$$Ps(r) \rightarrow PDF\ of\ s \quad (4.13)$$

$P(r)$  and  $T(r)$  known of  $T^{-1}(S)$  as single valued and monomodally increasing, we assume the image intensity values, normalized intensity values in the range  $[0,1]$  and  $r$  is an intensity value in the original image,  $s$  is an intensity value in the processed image. We assume  $Pr(r)$  to be the probability density function of  $r$  where  $r$  is the variable representing intensity values in the original image and we also assume  $P(s)$  to be the PDF or probability density function of  $(s)$  where  $(s)$  is a variable representing intensity values in the processed image. So, these are the two probability functions PDFs that we assume and from elementary probability theory we know that if  $pr(r)$  and the transformation function  $T(r)$  they are known and  $T$  inverse  $s = T^{-1}(S)$  is single valued and monotonically increasing,  $T$  inverse  $s$  is single valued and monotonically increasing. Then we can obtain the PDF of  $s$  that is  $Ps(s)$  is given by  $Pr(r)$  into  $dr ds$  where at  $r$  equal to  $T$  inverse  $s$ . So, this is what is obtained from elementary probability



theory that if we know  $Pr(r)$  and we also know  $T(r)$  and  $T$  inverse  $s$ , a single valued and monotonically increasing; then  $Ps(s)$  can be obtained from equation (4.14).

$$P(s) = P(r) \left| \frac{dr}{ds} \right| \quad (4.14)$$

All the histogram processing techniques, they try to modify the probability density function, PDF  $Ps(s)$  so that the mammogram image gets a particular appearance and this appearance is obtained where the transformation function  $T(r)$ . what is that type the transformation function  $T(r)$  that we can get So, let us consider a particular transformation function as

$$S = Pr(r) = \int_0^r Pr(w)dw \quad 0 \leq r \leq 1 \quad (4.15)$$

$$\frac{ds}{dr} = P(r) \quad (4.16)$$

$$Ps(s) = Pr(r) \left| \frac{dr}{ds} \right| \quad (4.17)$$

$$Ps(s) = \frac{1}{Pr(r)} \quad (4.18)$$

$$Ps(s) = 1 \quad (4.19)$$

It takes a transformation function of this forms  $s = T(r)$  is equal to integral  $Pr(w)dw$  where the range of integration varies from 0 to  $r$  and  $r$  varies in the range 0 to 1. So, we found that this integral gives the cumulative distribution function of the variable  $r$ . if we consider  $T(r)$  of this particular form, then this  $T(r)$  will satisfy both the conditions we mentioned above, and from this, we can compute  $ds$  upon  $dr$  which is  $Pr(r)$ .

If it considers, all the images are discrete image. So, we must get a discrete formulation of these derivations as shown in equations below:

$$Pr(rk) = \frac{nk}{n} \quad (4.20)$$

$$sk = T(rk) = \sum_{i=0}^k Pr(ri) \quad (4.21)$$

$$sk = \sum_{i=0}^k \frac{ni}{nk} \quad (4.22)$$

$$rk = T^{-1}(sk) \quad 0 \leq sk \leq 1 \quad (4.23)$$

So, for discrete formulation,  $Pr(rk)$  is given by  $nk$  divided by  $n$  where  $nk$  is the number of pixels having intensity value  $rk$  and  $n$  is the total number of pixels in the image. and a plot of

this  $Pr(r_k)$  for all values of  $r_k$  gives us the histogram of the image. So, the technique to obtain the histogram equalization and by that the image enhancement will be ; first we have to find out the cumulative distribution function the CDF of  $r_k$  and so we will get  $s_k$  which is given by  $T(r_k)$  and this  $T(r_k)$  now is the cumulative distribution function which is  $Pr$  of  $r_i$  where  $i$  will vary from  $[0, k]$  and this is the sum of  $n_i$  by  $n$  where  $i$  will vary from  $[0, k]$ . The inverse of this is obviously  $r_k$  is equal to  $T$  inverse of  $s_k$  for  $0 \leq s_k \leq 1$

So, if it use this as a transformation function, then the operation that we get is a histogram equalization which is basically gives us a transformed image where the intensity values have an uniform distribution and because of this, the processed image that we get appears to be a high contrast image.

The discussion of the results that we can get by histogram equalization operation form some mammogram images are figure (4.9 a) we have input mammogram image with poor contrast. Below the image we have it is histogram and from this histogram we can observe that most of the pixels have intensities very close to 0 and there are very few pixels in this image which are intensities having higher values.

By using histogram equalization, the processed image at we got is shown on figure (4.10) has a contrast which is higher than the input image because many of the details in the image are not very clear in the original image whereas those details are very clear in this processed image below this image we have shown the histogram of this processed image and if you compare these two histograms, we will find that the histogram of this processed image is more of equalization we can have such a kind of enhancement.

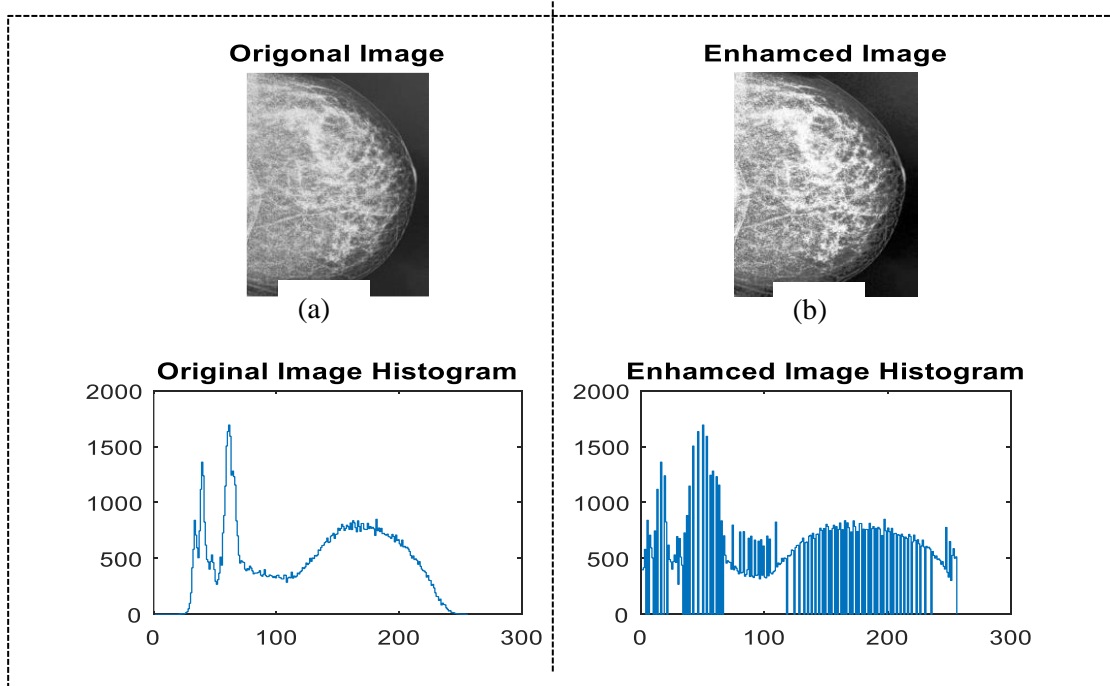


Figure. (4.10) Histogram equalization:(a) Original image (b) Enhanced image

### (iii) Histogram specification techniques

Histogram specification is other kind of histogram-based processing technique like histogram equalization which gives enhancement of the contrast obtained. though this technique gives contrast enhancement but histogram equalization has got certain limitation.

First of the limitation is using histogram equalization; whatever equalized image, we cannot have any interactive manipulation of the image, therefore, it generates only single processed image. to overcome this limitation sometimes mammogram image applications, demand to enhance only certain region of the histogram, and to have the details within certain region of the histogram; in such case this kind of technique should be used which called histogram matching or histogram specification techniques [30].

So, in case of histogram specification techniques, we have to a target histogram and the image has to be processed in such a way that the histogram of the processed image becomes same as that of the target histogram, so  $r$  and  $P(r)$  is input mammogram image while  $z$  is represented of  $z$  and  $Pz(z)$  the enhanced output image.

$$s = T(r) = \int_0^r Pr(w)dw \quad (4.24)$$

$$G(z) = \int_0^z Pz(t)dt \quad (4.25)$$

$$G(z) = T(r) = s \quad (4.26)$$

$$Z = G(z) = T^{-1}[T(r)] \quad (4.27)$$

We assume that we have two variables, variable  $r$  which is representing the continuous gray levels in the given mammogram image and we assume a variable  $z$  representing intensities in the processed image,  $r$  is the intensities in the original mammogram image and  $z$  represents the intensities in the processed image where this is specified in the form of the probability distribution function  $Pz(z)$ , this  $Pz(z)$  specifies  $r$  target histogram and from the given image  $r$ , we can obtain  $Pr(r)$  that is the histogram of the given image. In this case we can obtain from the input image whereas  $Pz(z)$  that is target histogram is specified. for histogram matching, if we equalize the input image using the transformation function  $s=T(r) = \int_0^r Pr(w)dw$  within range  $[0, r]$ ; then we get an image having intensity values with probability distribution function, probability density function which is uniform, using this  $Pz(z)$ , we compute the transformation function  $G(Z)$ . So, this  $G(Z)$  will be obtained as integration  $Pz(t)$  into  $dt$  in the range  $[0, z]$  and then from these two equations, what we can have is  $G(z) = T(r) = s$  and this gives  $Z = G^{-1}(s)$  which is equal to  $G^{-1}(T(r))$ .

We are equalizing the input image using histogram equalization techniques, finding out the transformation function  $G(z)$  from the target histogram that has been specified, then this equalized image is inverse transformed using the inverse transformation  $G^{-1}(s)$  and the resultant image by doing this operation we will get that is likely to have an histogram which is given by this target histogram  $ah Pz(z)$ . So, our procedure is; first equalize the original image obtaining the histogram from the given image, then find out the transformation function  $G(z)$  from the target histogram that has been specified, then do the inverse transformation of the equalized image using not  $T^{-1}$  but using the  $G^{-1}$  and this  $G^{-1}$  has to be obtained from the target histogram that has been specified and by doing this, the image that you get becomes an histogram modified image, a processed modified image, processed image whose histogram is likely to be same as the histogram that has been specified as the target histogram. this is a continuous domain formulation but our images are digital, so we have to go for a discrete formulation of these derivations.

$$sk = T(rk) = \sum_{i=1}^k \frac{ni}{n} \quad \rightarrow \text{from the input image } Pz(z) \quad (4.28)$$

$$un = G(zk) = \sum_{i=0}^k Pz(zi) = skk = 0,1, \dots, L - 1 \quad (4.29)$$

$$zk = G^{-1}[T(rk)] \quad (4.30)$$

We can find out  $sk = T(rk)$  which is equal to sum of  $ni$  by  $n$  where  $r$  varies from,  $i$  varies from 0 to  $k$  and this we obtained from the given image, from the input image and from the target histogram that is specified that is  $Pz(z)$ , we get a transformation function  $Vk$  equal to  $G(Zk)$  which is equal to sum of  $Pz(zi)$  where  $i$  varies from 0 to  $k$  and we set this equal to  $sk$  and this has to be for  $k = 0,1, \dots, L-1$  and then finally we obtain the processed image as the inverse of or  $G$  inverse of  $T(rk)$ [27].

### 4.3 Contrast limited adaptive histogram equalization

Contrast limited adaptive histogram equalization (CLAHE) was initially implemented in medical images, in this technique, a local histogram is calculated and a different grayscale transform is computed at each image location, based on the neighborhood.

In standard adaptive histogram equalization, there is a possibility of image over-enhancement as noise is enhancement, nearly uniform regions in the image generate high peaks in the histogram, leading to large values in the final image as a result of integration, this problem can be fixed through the limitation of the amount of contrast enhancement at every pixel, which is achieved by clipping the original histogram to a limit [32]. The CLAHE procedure consists of obtaining a local histogram with the neighbors of every pixel, clip this histogram to the specified limit, modifying the histogram by redistributing pixels, as given by equation 4.2., and integrating the histogram up to the value of the pixel to obtain the final value. Figure (4.11) show the contrast enhancement by using CLAHE, original image and result of enhancement with CLAHE [32].

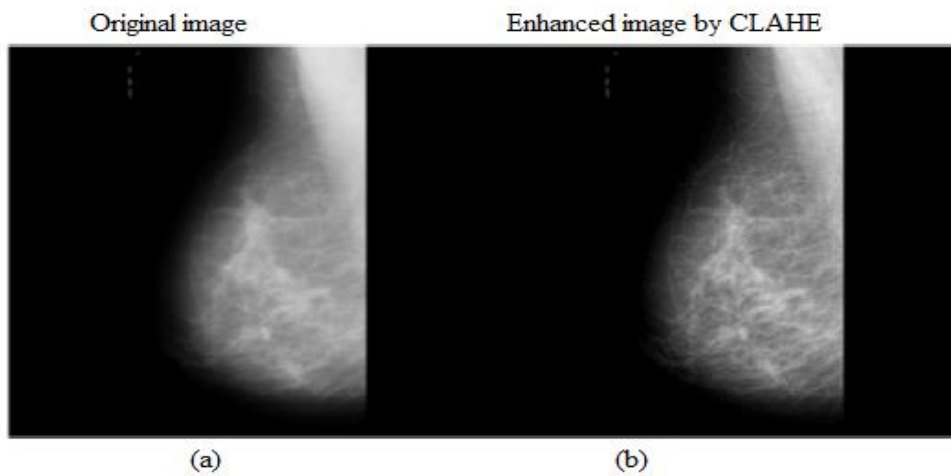


Figure (4.11) Contrast Enhancement by Using CLAHE:(a) original image, (b) Result of enhancement with CLAHE

#### 4.4 Filtering in spatial domain (Spatial Filtering)

Filtering is a fundamental signal processing operation, and often a pre-processing operation before further processing. Spatial domain filtering are techniques used for modifying or enhancing an Image the term filtering comes from the frequency domain, and it refers to image operators that change the gray value at any pixel  $(x,y)$  depending on the pixel values in a square neighborhood centered at  $(x,y)$  using a fixed integer matrix of the same size. The integer matrix is called a filter, mask, kernel or a window [29].

Spatial filters can be classified by effect into:

1. Smoothing spatial filters: also called lowpass filters. They include:

- A. Averaging linear filters
- B. Order-statistics nonlinear filters.

2. Sharpening spatial filters: also called high pass filters. for example, the Laplacian linear filter, these spatial filters types are described briefly in the following section.

### 4.4.1 Smoothing spatial linear filters

The most common, simplest and fastest kind of filtering is achieved by linear filters,[33] smoothing linear spatial filter is the average of the pixels contained in the neighborhood of the filter mask. The response of averaging filter is simply the average of the pixels contained in the neighborhood of the filter mask. The output of averaging filters is a smoothed image with reduced "sharp" transitions in gray levels. Noise and edges consist of sharp transitions in gray levels. Thus, smoothing filters are used for noise reduction; however, they have the undesirable side effect that they blur edges averaging filters or low pass filters [33].

#### (i) Mean Filter/Box Filter

The Mean Filter is a linear filter which uses a mask over each pixel in the signal. Each of the components of the pixels which fall under the mask are averaged together to form a single pixel. This filter is also called as average filter. Figure (4.12) show the mean filter input image and result of filtered image. The mean filter is poor in edge preserving and it is defined by equation [34]:

$$\text{Mean filte}(x_1, \dots, x_n) = \frac{1}{N} \sum_{l=1}^N x_l \quad (4.32)$$

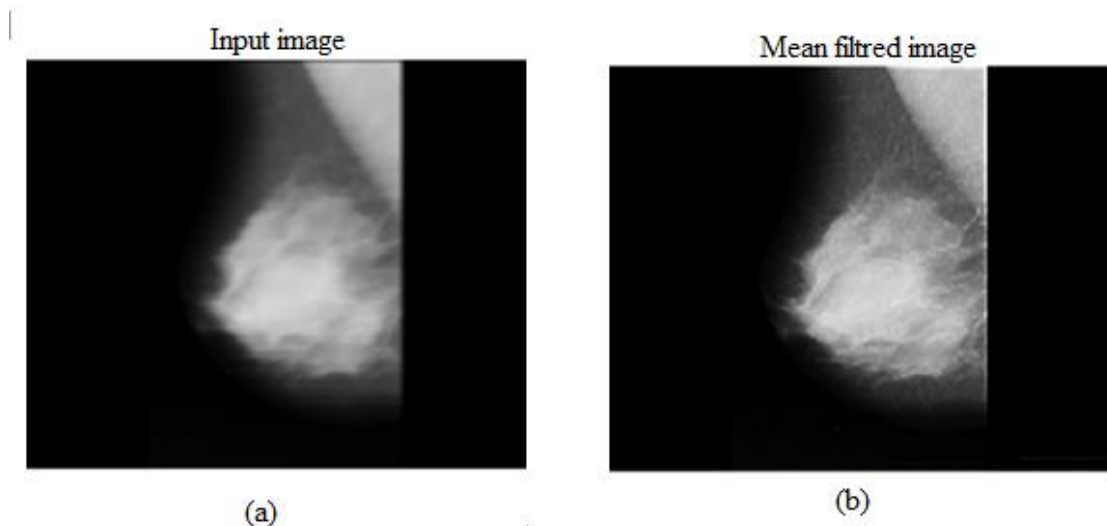


Figure (4.12) Mean Filter:(a) Input image, (b) Result of Mean filtered image.

## (ii) Gaussian Filter

Gaussian filters are a type of linear smoothing filters with the weights chosen according to the shape of a Gaussian function. The Gaussian smoothing filter is a very good filter for removing noise drawn from a normal distribution, When a Gaussian filter is used, pixel  $[x,y]$  is weighted according to [34]:

$$g(x, y) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{d^2}{2\sigma^2}} \quad (4.32)$$

Where  $d = \sqrt{(x - x_c)^2 + (y - y_c)^2}$  is the distance of the neighborhood pixel

$[x; y]$  from the center pixel  $[x_c, y_c]$  of the Enhanced image where the filter is being applied. Figure (4.13) show the effect of Gaussian filter, Image corrupted by salt & pepper noise and Result of applying  $3 \times 3$  Gaussian filter.

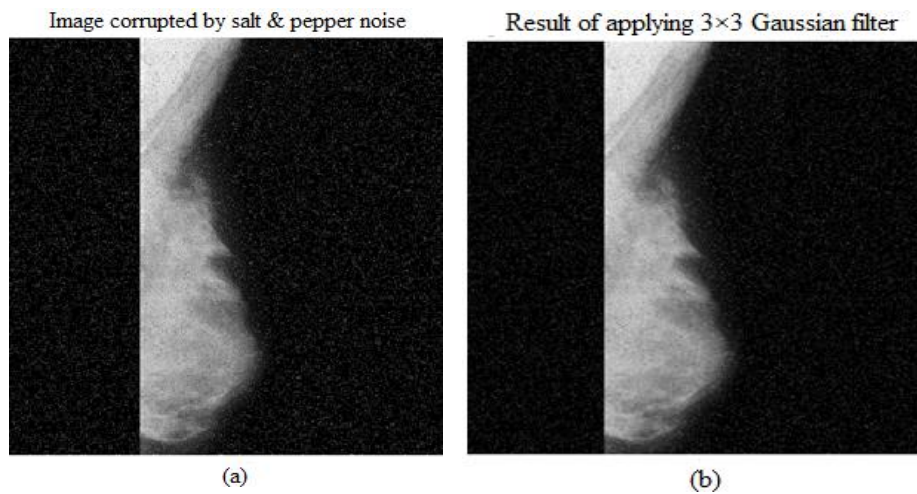


Figure (4.13) Effect of Gaussian filter:(a) Image corrupted by salt & pepper noise.  
(b) Result of applying  $3 \times 3$  Gaussian filter

### 4.4.2 Smoothing spatial Non-Linear Filters

Nonlinear spatial filters are Order-statistics filters whose response is based on ordering (ranking) the pixels contained in the image area encompassed by the filter, and then replacing the value of the center pixel with the value determined by the ranking result. Min and Max Filter, Median Filter, Midpoint Filter



### (i) Median Filter

In the processing of image de-noising, median filtering is a more common nonlinear filtering technique, because of its good edge keeping characteristics and reducing impulse noise ability, the median filter is a rank-order filter [35]. Its noise-reducing effects depend on the size and shape of the filtering mask; and its algorithm complexity mainly depends on how to get the median value. In order to improve the noise-reducing performance of the median filter The median filter is a nonlinear signal processing technology based on statistics. The noisy value of the digital image or the sequence is replaced by the median value of the neighborhood (mask). The pixels of the mask are ranked in the order of their gray levels, and the median value of the group is stored to replace the noisy value. The median filtering output is:

$$g(x, y) = \text{med}\{f(x, y, y - j), i, j \in W\} \quad (4.33)$$

where  $f(x,y)$  are the original image and the output image respectively,  $W$  is the two-dimensional mask . Figure (3.14) show the effect of median filter [34].

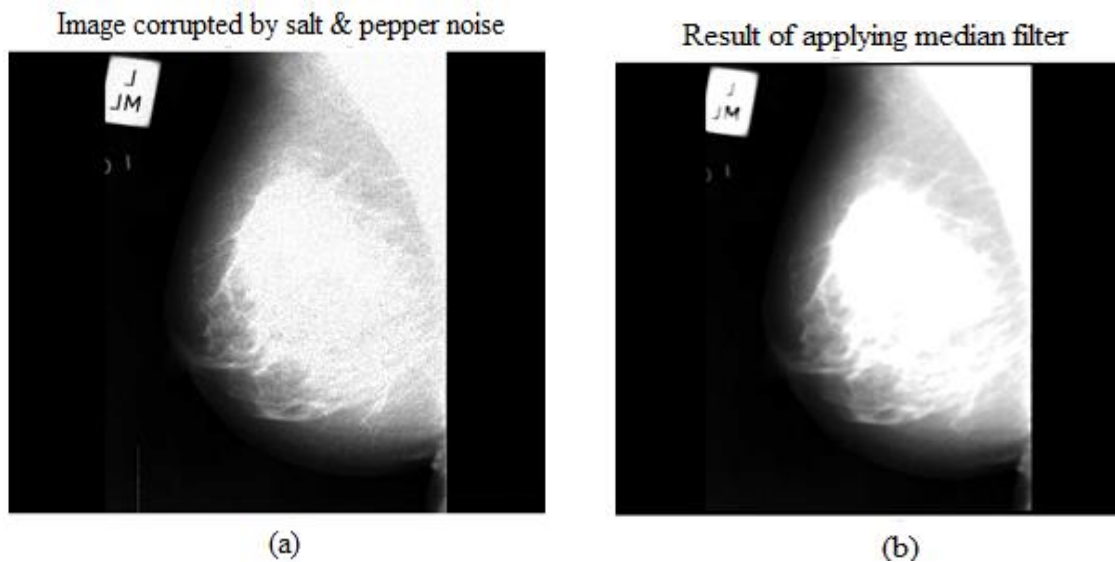


Figure (4.14) Effect of median filter (a) Image corrupted by salt & pepper noise.  
(b) Result of applying median filter

### 4.4.3 Sharpening Spatial Filters

Sharpening aims to highlight fine details (e.g. edges) in an image, or enhance detail that has been blurred through errors or imperfect capturing devices. Image blurring can be

achieved using averaging filters, and hence sharpening can be achieved by operators that invert averaging operators. In mathematics, averaging is equivalent to the concept of integration, and differentiation inverts integration. Thus, sharpening spatial filters can be represented by partial derivatives [35].

### (i) Gradient operators

Some usual gradient operators are unsharp masks and Sobel gradient

#### A. Unsharp masking

The unsharp filter is a simple well-known sharpening operator which derives its name from the fact that it enhances edges (and other high frequency components in an image) via a procedure which subtracts an unsharp, the unsharp mask. smoothed version of an image from the original image [36]. The unsharp filtering technique is commonly used in the photographic and printing industries for crispening edges. This technique uses this concept to reduce the blur and improve the image through the reduction of low frequency information and amplification of high frequency detail. The classical unsharp masking algorithm can be described by the equation:

$$v = y + \gamma(x - y) \quad (4.34)$$

where  $x$  is the input image,  $y$  is the result of a linear low-pass filter, and the gain  $\gamma$  ( $\gamma > 0$ ) is a real scaling factor. The signal factor  $d=x-y$  is usually amplified ( $\gamma > 1$ ) to increase the sharpness. Figure (4.15) show the image enhancement with unsharp masking, input image and image filtered using an unsharp filter.

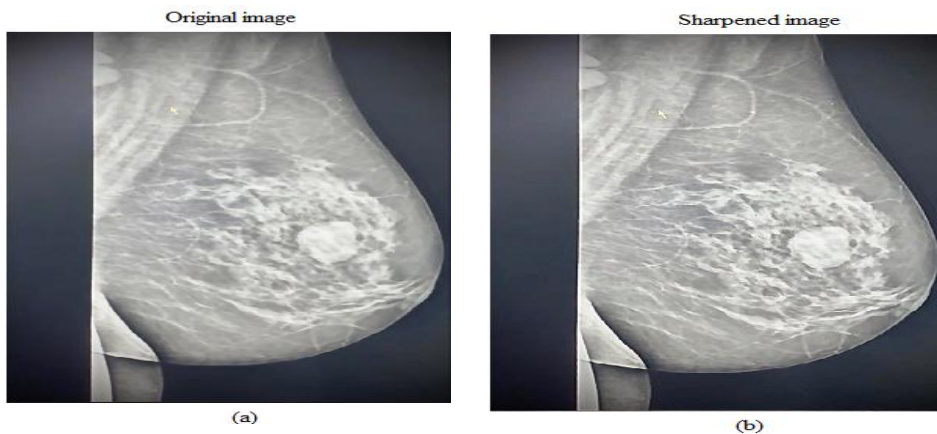


Figure (4.15) Image enhancement with unsharp masking(a) Original image, (b) Sharpened image

## B. Sobel Operator

The Sobel operator is used in image processing, particularly within edge detection algorithms, the Sobel operator is based on convolving the image with a small, separable, and integer valued filter in horizontal and vertical direction and is therefore relatively inexpensive in terms of computations [37].

Technically, it is a discrete differentiation operator, computing an approximation of the gradient of the image intensity function at each point in the image, the result of the sobel operator is either the corresponding gradient vector or the norm of this vector.

The Sobel operator is based on convolving the image with a small, separable, and integer valued filter in horizontal and vertical direction and is therefore relatively inexpensive in terms of computations, on the other hand, the gradient approximation that it produces is relatively crude, in particular for high frequency variations in the image, sobel gradient operators is used to enhance mammogram images, with using this procedure which make change to the appearance of the mammogram image, where details in the image are essential for diagnosis. the components of the Sobel operator gradient can be expressed by following approximation:

$$\frac{\partial f(x,y)}{\partial x} = \Delta x = \frac{f(x+dx,y)-f(x,y)}{dx} \quad (4.35)$$

$$\frac{\partial f(x,y)}{\partial y} = \Delta y = \frac{f(x,y+dy)-f(x,y)}{dy} \quad (4.36)$$

where dx and dy measure distance along the x and y directions respectively, in discrete images, one can consider dx and dy in terms of numbers of pixel between two points. dx = dy = 1 (pixel spacing) is the point pixel coordinates (i, j).

$$\Delta x = f(i + 1, j) - f(i, j) \quad (4.37)$$

$$\Delta y = f(i, j + 1) - f(i, j) \quad (4.38)$$

In order to detect the presence of a gradient discontinuity, one could calculate the change in the gradient at (i, j). This can be done by finding the following magnitude measure:

$$M = \sqrt{\Delta^2 x + \Delta^2 y} \quad (4.39)$$

And the gradient direction  $\theta$  is given by :

$$\theta = \tan^{-1} \left[ \frac{\Delta y}{\Delta x} \right] \quad (4.40)$$

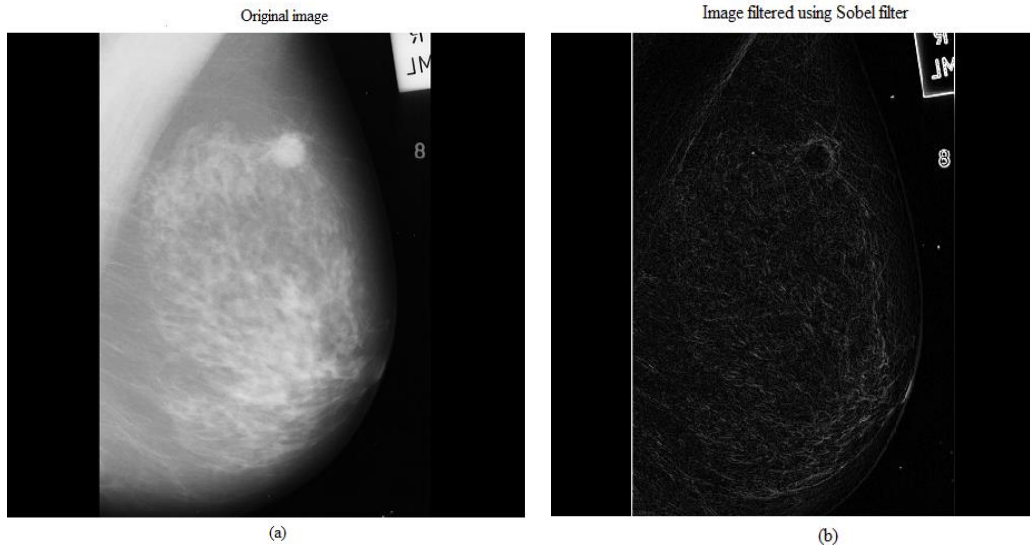


Figure (4.16) Mammography image enhancement with sobel operator: (a) Input image  
(b) Image filtered using Sobel filter

### C. The laplacian

The Laplacian operator of an image  $f(x,y)$  is:

This equation can be implemented using the  $3 \times 3$  mask:

$$\begin{array}{ccc} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{array} \quad (4.41)$$

Since the Laplacian filter is a linear spatial filter, it can apply it using the same mechanism of the convolution process. This will produce a Laplacian image that has grayish edge lines and other discontinuities, all superimposed on a dark, featureless background and background features can be recovered while still preserving the sharpening effect of the Laplacian operation simply by adding the original and Laplacian images, the Laplacian is defined as:

$$\nabla^2 f = \frac{\partial^2 f}{\partial^2 x} + \frac{\partial^2 f}{\partial^2 y} \quad (4.42)$$

Where the partial 1<sup>st</sup> order derivative in the x direction is defined as:

$$\frac{\partial^2 f}{\partial^2 x} = f(x + 1, y) + f(x - 1, y) - 2f(x, y) \quad (4.43)$$

and y direction as:

$$\frac{\partial^2 f}{\partial^2 y} = f(x, y + 1) + f(x, y - 1) - 2f(x, y) \quad (4.44)$$

So, the Laplacian can be given as:

$$\nabla^2 f = [f(x + 1, y) + f(x - 1, y) - 2f(x, y) + f(x, y + 1) + f(x, y - 1) - 2f(x, y)] - 4f(x, y) \quad (4.45)$$

The figure (4.17) shows an example of. using Laplacian filter to sharpen an image

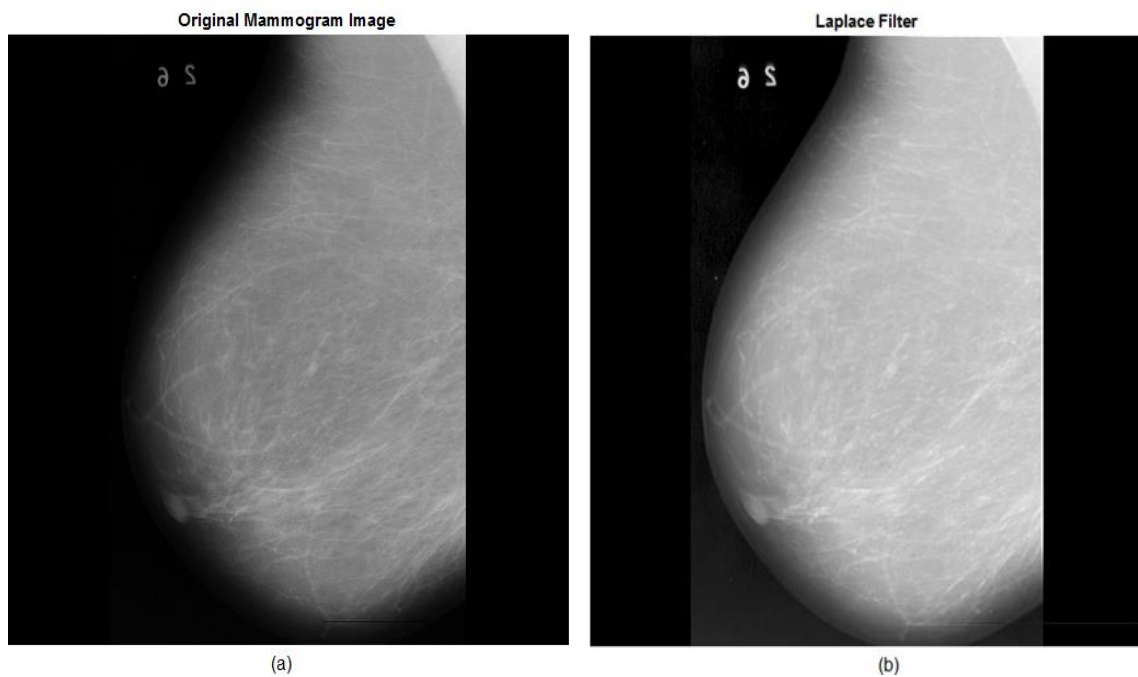


Figure (4.17) Mammogram image enhancement of applying Laplacian filter

(a)Original image (b) Laplacian filtered image.

## 4.5 Frequency domain methods of image enhancement

Based on the property that multiplying the FFT of two functions from the spatial domain produces the convolution of those functions, we can use Fourier transforms as a fast convolution on large images., it is faster to work in the spatial domain. However, you can also create filters directly in the frequency domain. There are three commonly discussed filters in the frequency domain:[38]

- Lowpass filters, known as smoothing filters
- Highpass filters, known as sharpening filters
- Bandpass filters

When an image  $f(z, y)$  is convolved with a linear operator  $h(z, y)$ , the resultant image  $g(z, y)$  is given by

$$g(x, y) = h(x, y) * f(x, y) \quad (4.46)$$

The convolution theorem states that the convolution in spatial domain is equivalent to multiplication in frequency domain. This implies that

$$G(u, v) = H(u, v)F(u, v) \quad (4.47)$$

where  $G(u,v)$ ,  $H(u,v)$ , and  $F(u,v)$  are the Fourier transforms of  $g(x,y)$ ,  $h(z, y)$ , and  $f(z, y)$  respectively. Taking the inverse Fourier transform of  $G(u,v)$ , we get

$$G(u, v) = H(u, v) \quad (4.48)$$

or

$$\mathbf{g}(x, y) = \mathfrak{F}^{-1}[H(u, v)] = h(u, v) \quad (4.49)$$

which is known as point spread function (PSF). PSF is an inverse of optical transfer function. Here a point source of light (analogous to an impulse) is blurred or spread by the imaging device which is given by the PSF, Enhancement in the frequency domain is achieved by high-pass, low-pass, and band-pass filtering of the original image. The task of enhancement in frequency domain involves computing the Fourier transform of the image  $f(z, y)$  (i.e.  $F(u, v)$ ) and the filter transfer function  $H(u, v)$  and taking the inverse Fourier transform of the product  $F(u, w)H(u, v)$  [35].

### 4.5.1 Filtering in the frequency domain

Frequency domain is basically a space defined by Fourier transform. Fourier transforms has different applications in image processing, such as image analysis, image filtering, image reconstruction and image compression [34]. In frequency domain analysis, it indicates that how signal energy is distributed over a range of frequencies. The basic principle of the frequency domain image filtering consists of computing a 2-D discrete Fourier transform of the image, for instance the 2-D DFT, manipulating the transform coefficients by an operator i.e. filter function and then performing the inverse discrete Fourier transform [34]. The basic model for filtering in the frequency domain, where  $F(u,v)$ : the Fourier transform of the image to be smoothed  $(u,v)$ : a filter transfer function smoothing is fundamentally a low pass operation in the frequency domain. It is computationally faster than spatial domain.

#### (i) Ideal low pass filter (ILPF)

This is the simplest of three filters Ideal low pass filter gives ideal response for image filtering. It passes all the frequency within a circle of radius  $D_0$  which is cutoff frequency of Ideal low pass filter, while attenuates all the frequency lies outside this circle. It is specified by the function in equation:

$$H(u, v) = \begin{cases} 0 & \text{if } D(u, v) \leq D_0 \\ 1 & \text{if } D(u, v) > D_0 \end{cases} \quad (4.50)$$

Where  $D(u,v)$  is the distance between center of the frequency rectangle and a point  $(u,v)$  in the frequency domain image calculated by equation 4.51 [33]:

$$D(u, v) = \sqrt{\left(u - \frac{p}{2}\right)^2 + \left(v - \frac{q}{2}\right)^2} \quad (4.51)$$

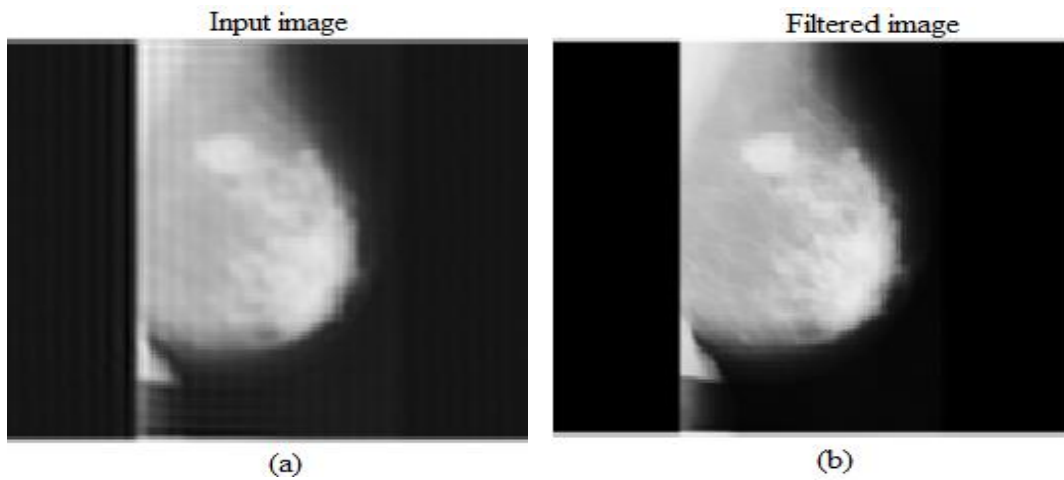


Figure (4.18) Mammogram image enhancement of ideal low pass filter. (a) Input image.  
(b) filtered image

### (ii) Gaussian low pass filter (GLPF)

Gaussian filter is the generalized filter for digital images, the disadvantages of Butterworth Low Pass Filter are removed in Gaussian filter. function for Gaussian low pass filter is denoted by equation(4.48).

$$H(u, v) = e^{-\frac{D^2}{2D_0^2}} \quad (4.48)$$

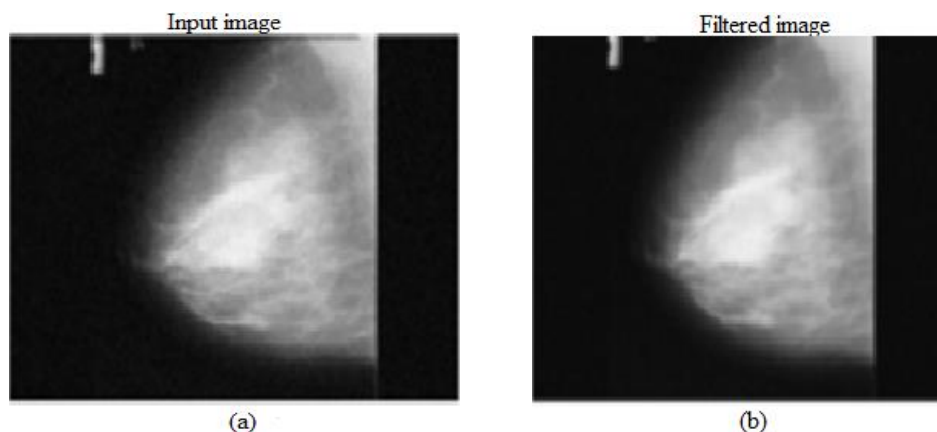


Figure (4.19) Image enhancement by gaussian low pass filter: (a) Input image.  
(b) filtered image



### 4.5.2. Smoothing frequency domain filters

Sharpening filters emphasize the edges, or the differences between adjacent light and dark sample points in an image. A highpass filter yields edge enhancement or edge detection in the spatial domain, because edges contain many high frequencies. Areas of rather constant gray level consist of mainly low frequencies and are therefore suppressed. We obtain a highpass filter function by inverting the corresponding lowpass filter, e.g. an ideal highpass filter blocks all frequencies smaller than  $r_0$  and leaves the others unchanged. The transfer function of lowpass filter and highpass filter can be related as follows [39]:

$$H_{hp}(u, v) = 1 - H_{lp}(u, v) \quad (4.53)$$

Where  $H_{hp}(u, v)$  and  $H_{lp}(u, v)$  are the transfer function of highpass and lowpass filter

#### (i) Ideal high pass filter (IHPF):

Ideal high pass filter is used for image sharpening in the frequency domain, image Sharpening is a technique to enhance the fine details and highlight the edges in a digital image.

It removes low-frequency components from an image and preserves high-frequency components. The Ideal high pass filter cuts off all low frequencies of the DFT but maintain the high ones that are within a certain distance from the center of the DFT [39]

$$H(u, v) = \begin{cases} 0 & \text{if } D(u, v) \leq D_0 \\ 1 & \text{if } D(u, v) > D_0 \end{cases} \quad (4.54)$$

where  $D_0$  is the cutoff frequency, and  $D(u, v) = \sqrt{\left(u - \frac{M}{2}\right)^2 + \left(v - \frac{QN}{2}\right)^2}$

The IHPF sets to zero all frequencies inside a circle of radius  $D_0$  while passing, without attenuation, all frequencies outside the circle. The figure below shows the results of applying IHPF with cutoff frequencies 15, 30, and 80., This is demonstrated clearly in the figure (4.20).

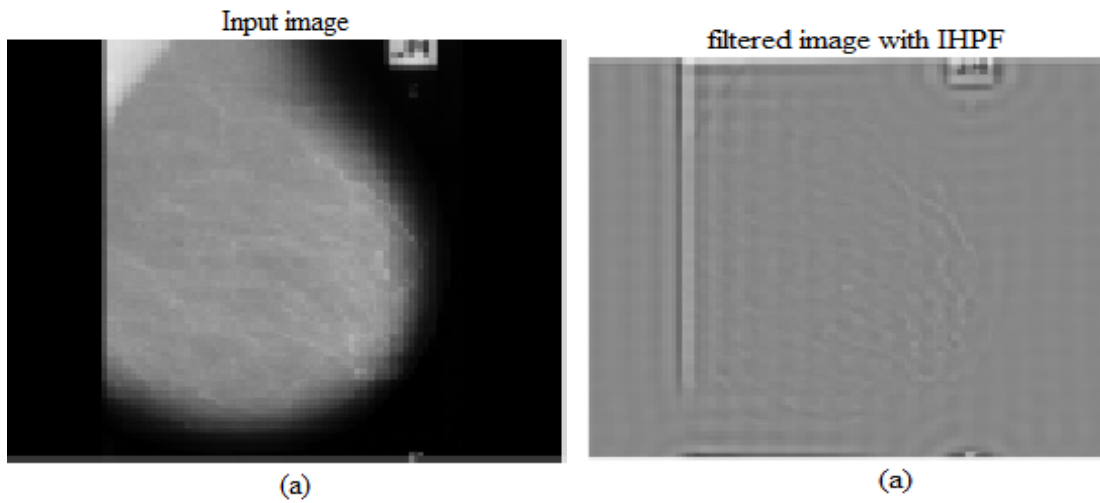


Figure (4.20) Image sharpening by ideal high pass filter:(a) original image. (b) filtered image with IHPF

### 4.5.3 Sharpening frequency filtering

As previously mentioned, high frequency components are related to edges, noise and small objects. Image sharpening can be implemented in the frequency domain with a high-pass filter, which attenuates the low frequency components, as the opposite of the low-pass filtering. Thus, it attenuates the objects and the background which does not have sharp characteristics while enhances the edges and small objects. It also enhances the random noise associated to the image. The intended function of filters is the reverse operation of the low-pass filtering; thus, the transfer function of the high-pass filters is:

$$H_{hp} = 1 - H_{lp}(u, v) \quad (4.55)$$

#### (i) Homomorphic Filtering Approach

An image can be expressed as a product of the amount of source illumination incident on the scene being viewed, which is called illumination,  $i(x,y)$ , and the amount of illumination reflected by the objects in the scene, which is called reflectance [39]. Homomorphic filtering technique can enhance the contrast by adjusting the brightness across the image and simultaneously normalize the images. This technique can be applied easily and produce a satisfying result, especially when the original image appears in the poor illumination problem.

The Homomorphic filtering algorithm involves Logarithmic transform, Discrete Fourier Transform (DFT), Inverse Discrete Fourier Transform (IDFT), Exponential transform and  $H(u,v)$  represents the filtering type. the Homomorphic filtering can be expressed as the product of illumination and reflectance components as follows:

$$F(x,y) = I(x,y) * R(x,y) \quad (4.56)$$

Equation (4.56) cannot be used directly to operate separately on the frequency components of illumination and reflectance because the Fourier transform of the product of two functions is not separable. Instead the function can be represented as a logarithmic function wherein the product of the Fourier transform can be represented as the sum of the illumination and reflectance components as shown in figure (4.21):

$$\ln(x,y) = \ln(I(x,y)) + \ln(R(x,y)) \quad (4.57)$$

The Fourier transform of equation (4.51) is

$$Z(u,v) = Fi(u,v) + Fr(u,v) \quad (4.58)$$

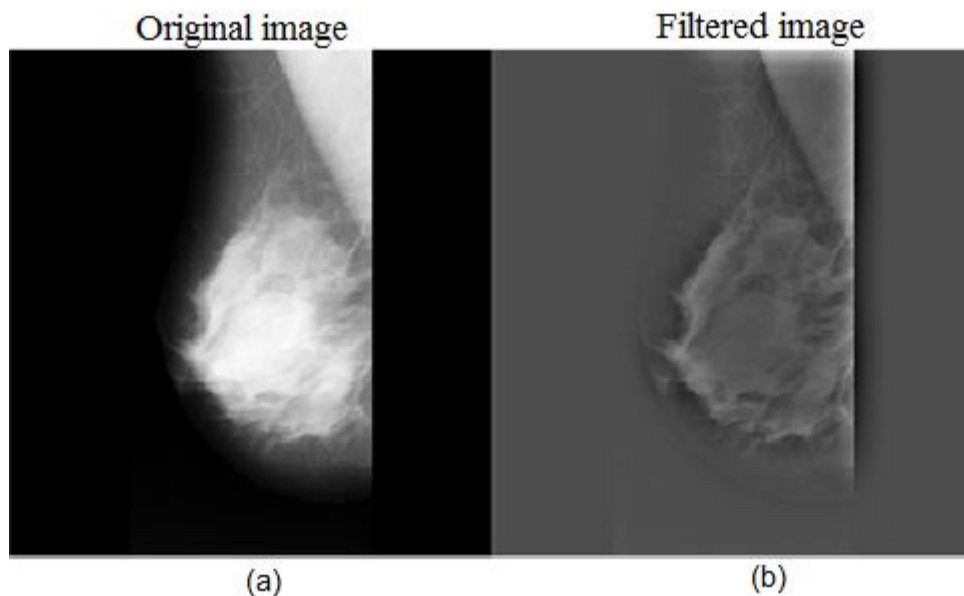


Figure (4.21) Image sharpening by homomorphic filtering: (a) Original image.

(b) Filtered image

## **CHAPTER Five –Proposed mammogram image enhancement and detection methodology**

### **5.1 Introduction**

### **5.2 System one proposed methodology**

### **5.3 System two proposed methodology**

## 5.1 Introduction

This chapter presents a detailing about the methodologies implemented, as well as exemplifications of their results and their evaluation. The techniques have been implemented in MATLAB® (version 7.11.0.584 – R2017b). This chapter introduced systems proposed methodology and described workflow of the proposed methodology-preprocessing, region of interest selection, feature extraction, and analysis of extracted features values.

The visual quality of medical images is very useful in medical diagnosis and thus providing a quality medical service to the community, the image enhancement techniques discussed in chapter four are very useful for processing the mammogram images, as they clearly contributed to reducing the blurring of image.

This chapter focused on analyzing and designing a service system for the purpose to enhance the mammogram image, where the system was divided into two parts, the first part is a graphic user interface GUI design that the radiologist uses to enter the mammogram images and manipulate the image to reach a satisfactory form of the image, this will help the radiologist to make his medical decision.

Use the image processing steps there are several stages for Mammogram image processing. The first stage, Mammogram image acquisition through mammography. The next stages are preprocessing image, segmentation, feature extraction, feature selection and object classification, characteristics calcification, circumscribed, speculated and other ill-defined masses can be diagnosed, figure (5.1) shows the steps using in image processing.

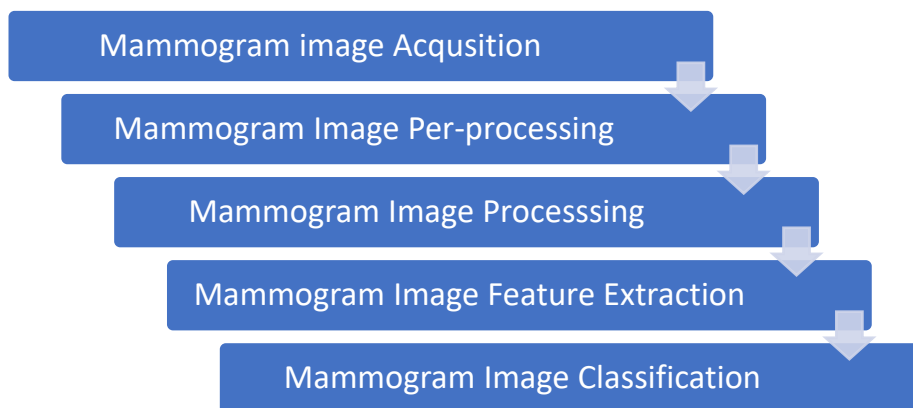


Figure (5.1) Steps using in image processing

Image acquisition phase using the connection between mammogram and the computer. Computer will receive the image in digital format. Image preprocessing steps are to enhance the image for further processing, which in analyzing the image to obtain desired object 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 phase to make decision based on test and analysis done on the image [26]. The above methods are used to develop the following system;

## **5.2 System one proposed methodology**

Mammographic images of breast cancer detection by using image enhancement techniques to recognize the importance of image enhancement in the proposed systems which they used diverse enhancement techniques algorithms in both domains frequency domain and spatial domain.

Various of image enhancement techniques have been applied to improve the quality and readability of mammograms, image enhancement refers to accentuation, or sharpening of image features such as edges, boundaries, or contrast to make a graphic display more useful for visual and analysis, mammogram image enhancement can be carried out by using a variety of techniques.

This system has designed to help radiologists to detect breast cancer mammogram, the detailed proposed image enhancement system used method is based on image enhancement for mammographic images will be presented including the illustrations. The design system that helps to improve the mammogram image that has defects by noise or poor contrast by using a set of image enhancement techniques have been developed to support radiologists in detecting mammographic abnormality that may indicate the appearance of breast abnormality. these techniques act only as a second reader and the final decision is made by the radiologist; one is the way to recognize tumors as suspicious regions may be very weak contrast to the background.

The proposed system is implemented by MATLAB program where the front user interface GUI is designed in a user-friendly manner to help who use the system without any hassles as shown in figure (5.2).

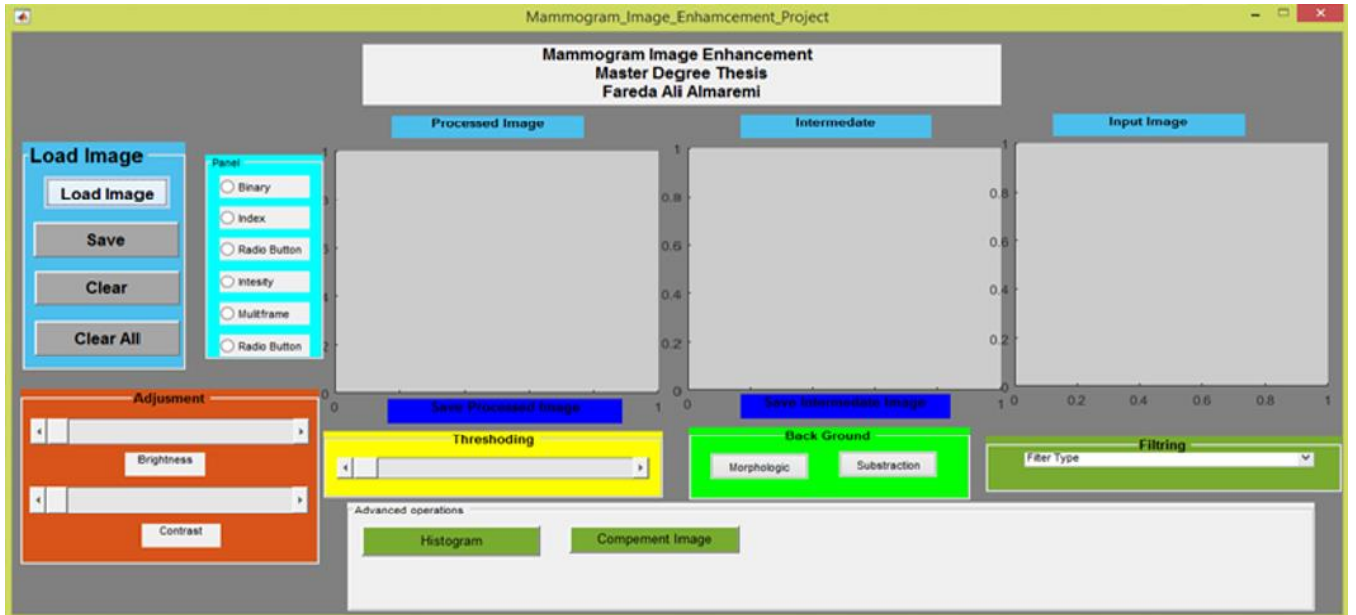


Figure (5.2) GUI system one

### 5.2.1 Experimental mammogram image enhancement

The proposed system covered histogram equalization, CLAHE Filter, Multi-scale image contrast amplification and sobel operator algorithms and tested them on breast mammogram images.

In addition, it evaluated each of them using PSNR, and MSE. to show the results of the proposed system one thesis used mammogram as input to the system, the output image was image enhanced by image enhancement techniques which was discussed in chapter four, then the Radiologist as a user of the system chose the suitable method.

For testing and analysis of the proposed algorithm which applied on mammographic images taken from standard dataset such as Mammographic Image Analysis Society (mini-MIAS)[32] and real databases taken from their oncology centers from Libya (National Cancer Institute – Sabreatha / National Cancer Institute- Musratha / Tripoli Oncology center - Tripoli).

#### •Negative version

Figure 5.3 shows the original and the inverted image, the image on the left shows the conventional appearance of an x-ray mammogram, the density in the center of the breast is ill-defined, the right-hand image indicates an inverted version of the original image in which the density is better defined

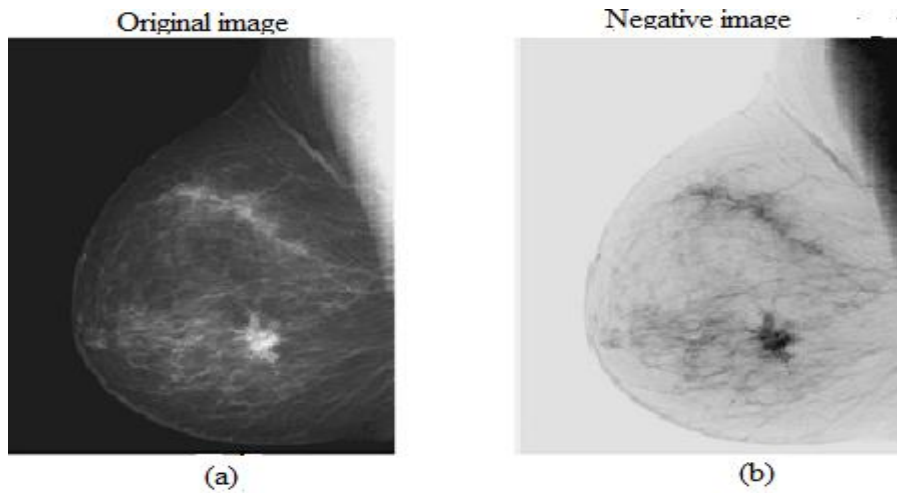


Figure (5.3) Negative transform: (a) Original Image (b) Negative version

This operation was the production of an inverse image this was obtained by simply swapping pixel intensities about the central intensity within an image, ten radiologists were shown a number of images with the original image alongside a negative inverted image, all were asked to state which image they preferred without exception; all radiologists shown the inverted mammograms beside the originals expressed a preference for the inverted image, all stated it to be easier to read, with significant features such as microcalcification being much more distinguishing.

### • Histogram equalization

Histogram equalization is generally used as a pre-processing step for enhancing the contrast of an image so that the quality of the image gets improved for further processing. Figure (5.4) shows the histogram processing.

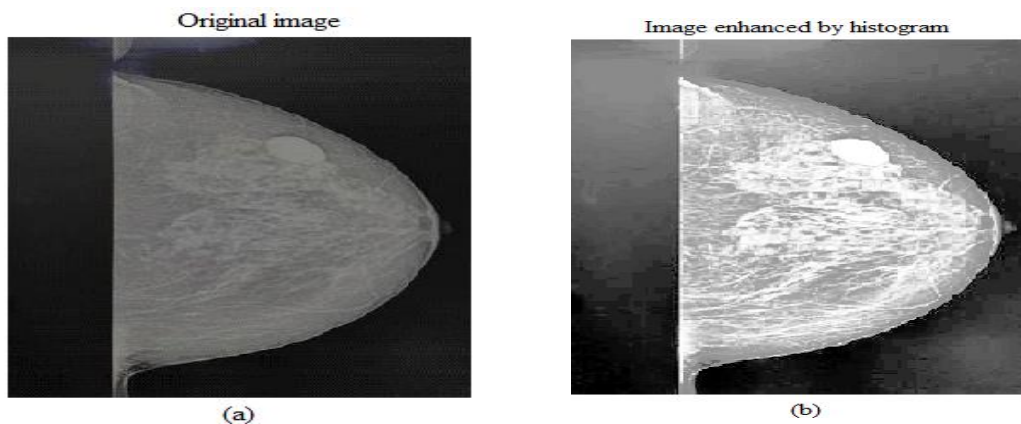


Figure (5.4) Histogram equalization:(a) Original image (b) Image enhanced by histogram



- **CLAHE Filter**

Figure 5.5 show the CLAHE which produces good results on Mammogram image images and its procedures was discussed in details in chapter four, techniques efficiently aids for enhancing the quality of the image, thereby it also removes the unwanted background and the pectoral muscle by using thresholding and modified region growing technique respectively.

The CLAHE filter originally developed for medical imaging to reduce the noise and edge shadowing effect produced in homogeneous area

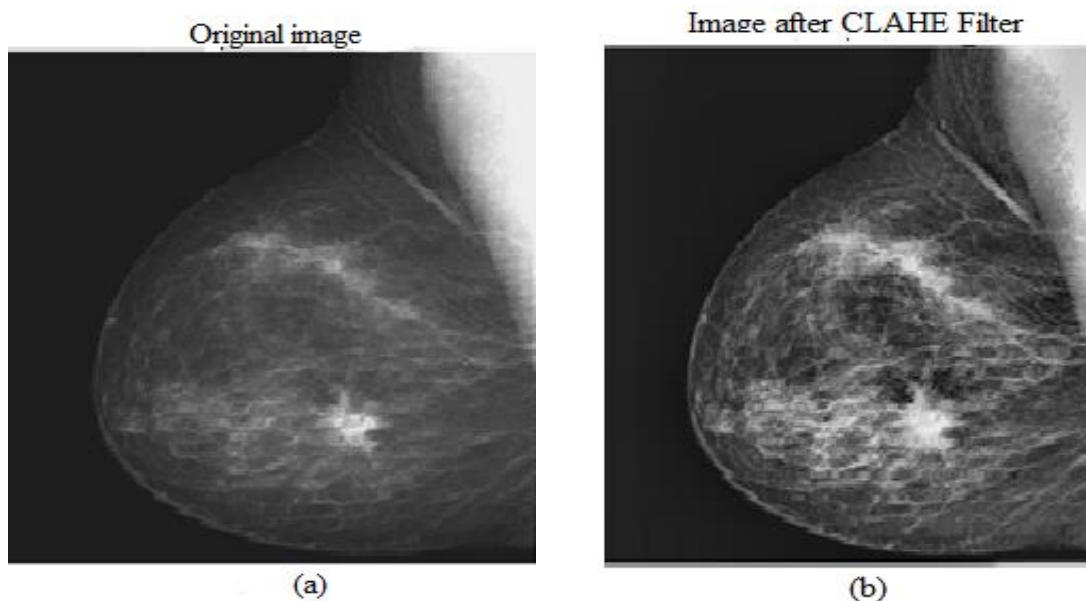


Figure (5.5) CLAHE Filter:(a) Image before applying CLAHE filter

(b) Image after CLAHE filter

- **Multi-scale image contrast amplification**

For tuning contrast enhancement to certain frequency bands, it is possible to use multi-scale image processing, enhance of contrast can be done at different scales, it is possible to enhance micro-calcifications and masses in a range of scales, while suppressing other structures.

Two well-known multiscale processing are: wavelet transform and laplacian pyramid. contrast enhancement of digital mammography based on multiscale analysis; the proposed image Enhancement techniques was improved contrast of mammogram by enhancing image feature based on multi-scale decomposition.

Figure (5.6 )shows resulting image which has a greater separation between foreground and background gray-level distributions.

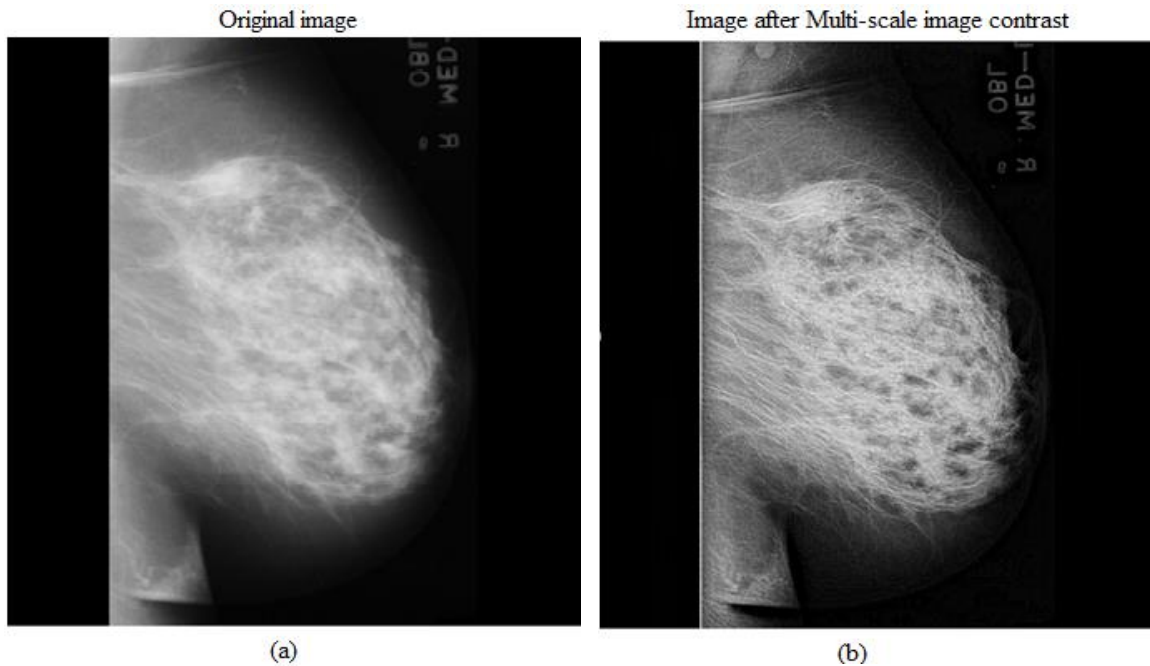


Figure (5.6) Multi-scale image contrast (a) Original image  
(b) image after multi-scale image contrast

### • Sobel Operator

With the purpose of enhancing the contrast of microcalcifications it will focus on the enhancement of breast calcifications using sobel operator, which are the deposits of calcium that can be seen on a mammogram of the breast, the presence of microcalcification clusters has been considered as a very important indicator of malignant types of breast cancer, and its detection is important to prevent and treat the disease.

Microcalcifications are tiny deposits of calcium in breast tissue, which appear in a mammogram as small clusters of a few pixels, with relatively high intensity and closed contours compared with neighboring pixels. Microcalcifications clusters are primary signs of breast cancer. Figure 5.7 shows the processing of Sobel gradient.

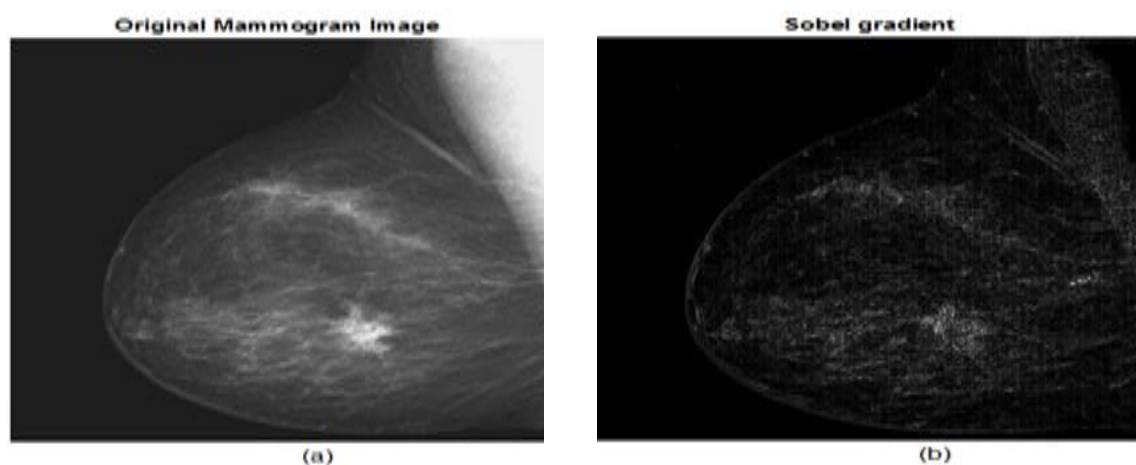


Figure (5.7) Sobel operator (a) Original image (b) Image after Sobeloperator

### 5.2.2 Image enhancement evaluation

The quality of an image is examined by objective evaluation as well as subjective evaluation, for judge the importance of medical image enhancement techniques image enhancement requires a suitable image enhancement measure which should provide a quantitative evidence whether the image is enhanced and also an indicator on how much it is enhanced, the quality of enhanced images must be evaluated to see the resulting of processed images using proposed image enhancement techniques.

In this thesis the quality of an image is examined by objective evaluation as well as subjective evaluation, we used two famous methods, the first method was objective measurement by using the mathematical equations to measure quality of enhanced images in which the mathematical averages are used in determining the difference between the original image and the improved image and determining the percentage of difference.

The second method was human visual inspection, which is an evaluation made by the radiologist who has an experience in reading and analysis of mammogram, the resulting shapes of masses were presented to several radiologists alongside the original image. The radiologists were asked using designed questionnaire by searcher to comment upon the accuracy of the enhanced image and segmentation resulting in the given shape and site of a massan image is said to be enhanced if it allows the viewer to better perceive the desirable information in the image.

### •Objective evaluation performance measurement

The quality of an enhanced image is measured by peak signal to noise ratio (PSNR). This parameter is a close estimation to human impression of reproduction quality. Higher the PSNR better is the picture quality. PSNR is the assessment standard of the recreated picture quality PSNR (Peak Signal Noise Ratio) is a common parameter used as an indicator in comparing the similarity of the two images (raw image and processing image). Detail results of PSNR value show in Table 5.1. This table defined that only some of mammographic have better visualization, the PSNR values was calculated by using following equation (5.1) [34].

$$PSNR = 10 \text{ Log } \frac{(2^n - 1)^2}{MSN} \quad (5.1)$$

Table (5.1) Performance Measurement

Grade	Contrast Enhancement	Contrast Stretching	Logarithmic	Sobel Operator	CLAHE Filter	Negative image	Power Law	Multi Scale
PSNR	44.23158	43.2544	33.7371	44.999	43.897	43.2333	18.236	44.3353

### •Subjective evaluation performance measurement

The radiologists were asked to evaluate the original images and the resultant images and a questionnaire was designed to reflect their judgments, this questionnaire was designed to measure the degree of satisfaction that each radiologist has with the processed images. ten specialists were involved in evaluating the cases and filling the questionnaire for each case of the ten algorithms. 11 cases were displayed, one of them is the original and the other one is the processed one. The Radiologists were asked to make a comparison between the original and the processed images. The comparison is based on the characteristics image quality

The results of the questionnaire were converted to the following table (5.2) that shows the percentage of satisfaction for ten specialists.

Table (5.2) Satisfaction percentages of image

Grade	Enhancement Contrast	Stretching Contrast	Log	Operator Sobel	CLAHE Filter	Negative image	Power Law	Multi Scale	Segmentation
Poor	0	0	0	0	0	0	7	0	0
Good	10	1	7	0	0	0	3	0	0
Excellent	0	9	3	10	10	10	0	10	10
Percentage	100%	99%	70%	100%	100%	100%	80%	100%	100%
	good	Excellent	Good	Excellent	Excellent	Excellent	Poor	Excellent	Excellent

Almost similar satisfaction percentages were obtained for both image Segmentation and negative conversion algorithms. A higher satisfaction percentage was obtained for the image enhancement stage.

This result is expected since most specialists found that brightness and contrast were low for the first two algorithms, while the image enhancement provides an image with increased focus on the suspicious area. The radiologists reported that they were able to notice some features of interest in the enhanced images that they were not able to notice in the original images. This was agreed upon by all the specialists.

### 5.3 System two proposed methodology

Mammograms are difficult images to interpret, and a preprocessing phase is necessary to improve the quality of the images and make the feature extraction phase more reliable.

The proposed technique follows step by step procedures such as:

- (a) Image Enhancement
- (b) Mass Segmentation.
- (c) The extraction of properties from the segmented Mass region.
- (d) The utilization of KNN classifier.

This thesis proposed an algorithm based on hybrid approach combination of both frequency domain morphology and adaptive histogram technique to output of hybrid approach filtering

was applied to the input image in order to improve the contrast of mammogram images and morphological operations are applied for noise removal in order to smooth the edges of the resulting image was then processed with a C means clustering algorithm to group all marked pixels.

Any pixels which did not form clusters were removed as noise the refined technique involved a five steps process commencing with segmentation of the breast from the background area using c-means and a morphological erosion operator to remove remaining artefacts, the next step involved spatial filtering of the image to enhance the calcification whilst suppressing the normal background tissue a combination of thresholding and morphological techniques were then used to extract possible calcifications

The next stage involved examination of the possible calcification sites in the original image in order to examine such features as contrast and texture and hence remove any particles which were unlikely to be calcification. The final step involved knn to identify any marked particles which were unlikely to be calcification. Figure (5.8) shows the block diagram of the overall system design for the cancer detection system

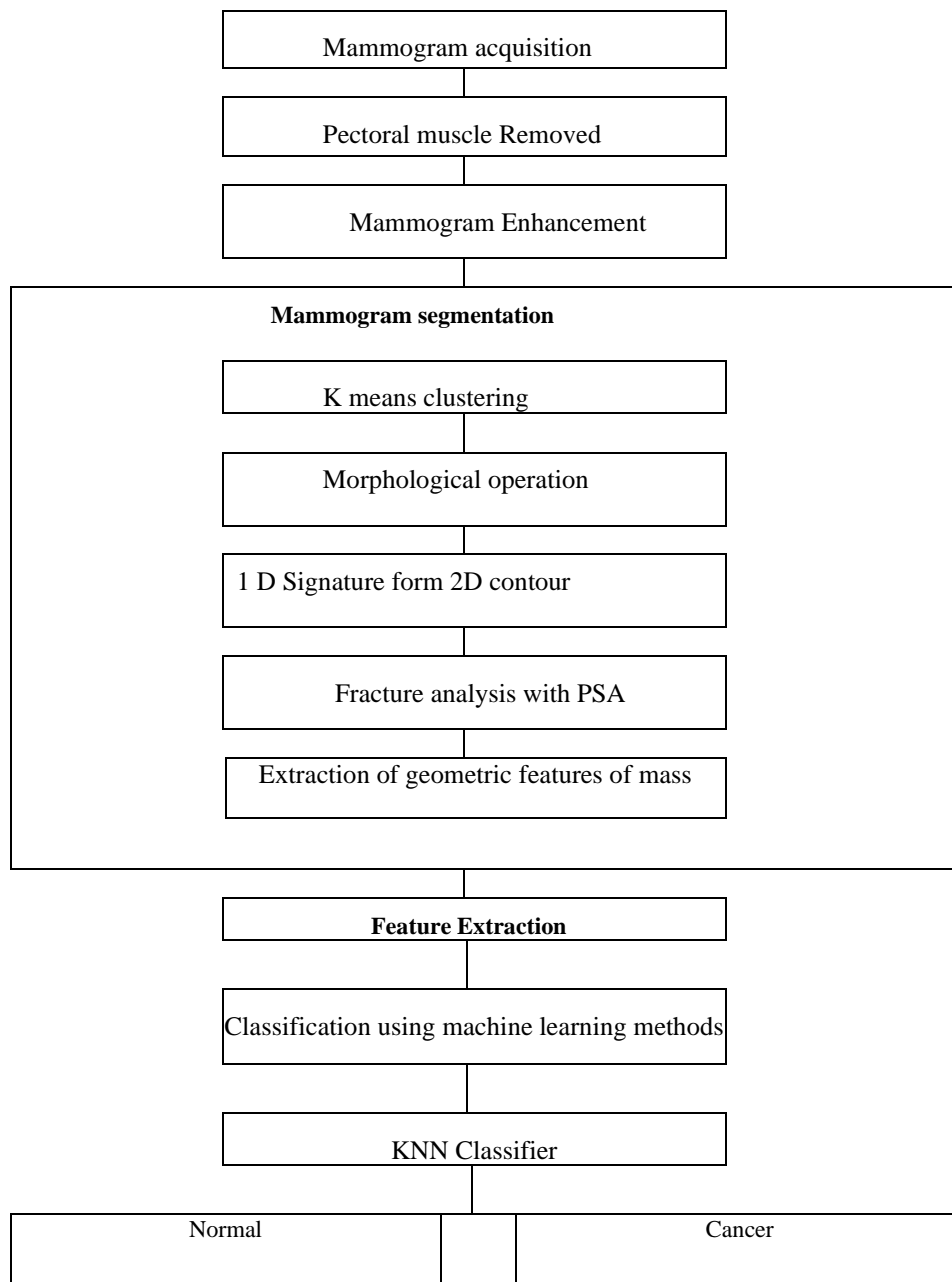


Figure (5.8) Flowchart shows steps and classified mammogram images

### (i) Preprocessing Methodology

Preprocessing includes steps like background removal, image type conversion, unwanted pectoral muscle skin and tissue portion is removed from the mammogram, morphological operations, histogram processing and frequency filtering of mammogram image.

**Stage One:** Mammogram image Acquisition, the system use. pgm (portable gray map), a raw mammogram from the MIAS database. The mammogram images are generally low on contrast and have noise in background such as tape markings and labels as shown in figure (5.9) completely pre-processing steps were used to remove the background noise and enhance the image quality of mammogram images. The pre-processing steps illustrated in Figure (5.9).

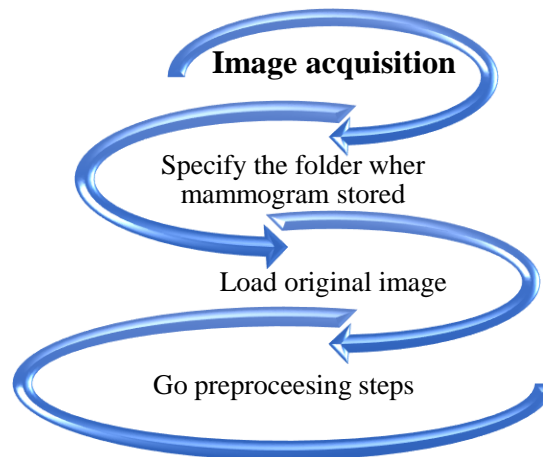


Figure (5.9) Flowchart of the proposed method in image acquisition

#### Step 1: Load original mammogram image from image folder.

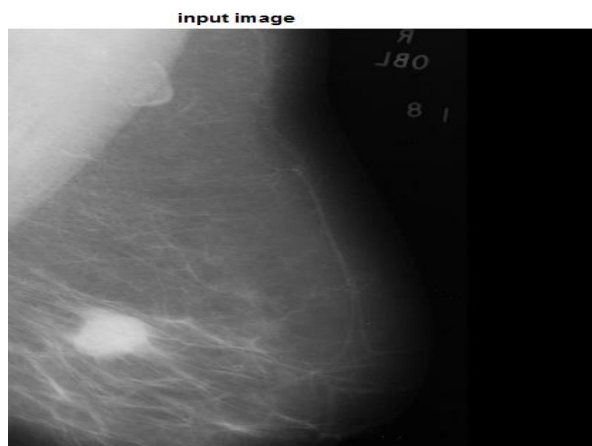


Figure (5.10) Experimental results proposed method Original image



**Stage two:** Removing of artifacts and pectoral muscles from mammogram images.

The anatomy of breast is a complex structure due to the presence of pectoral muscles as well as the varied density of breast parenchyma, pectoral muscles are the regions in mammograms that contain brightest pixels. For an expert, it is easy to analyze breast tissues without getting confused with pectoral muscles. However, for image processing algorithm, it is difficult to differentiate between pectoral muscles and mass. Therefore, generally, pectoral muscle segmentation is an important step as the presence of pectoral muscles may increase false alarms generated by segmentation, therefore pectoral muscle must be removed before detection of the mass can be done efficiently. Figure (5.9). Block diagram removed pectoral, first, a raw mammogram from the MIAS database is cropped to remove dark areas that are not related to the breast region [35].

In the MIAS database, each image is clipped or padded so that it is  $1024 \times 1024$  pixels, which is the size of all MIAS raw images.

**Step 1:** Breast cropped

The original mammograms are  $1024 \times 1024$  pixels, and almost 50% of the image comprised of the background with a lot of noise such as label and pectoral muscle. Therefore, a cropping operation is applied to the images to cut off the unwanted portions of the images. Image cropping is the process of cutting or deleting a part of an image and extracting another part of the image. This process is very important in our work since it can delete the margin of images in our dataset shown in Figure (5.11).

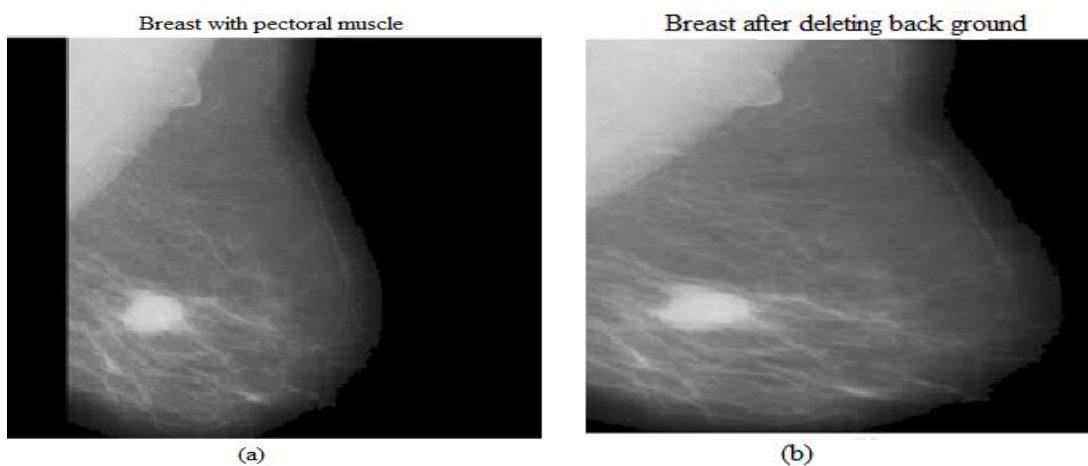


Figure (5.11) Crop the Breast: (a) Breast with pectoral muscle

(b) Breast after deleting back ground

**Step2:** Take the binary image of mammogram

In this step the image is converted to binary format, the conversion process of a gray scale image into a binary (black/white), as shown in figure(5.12)

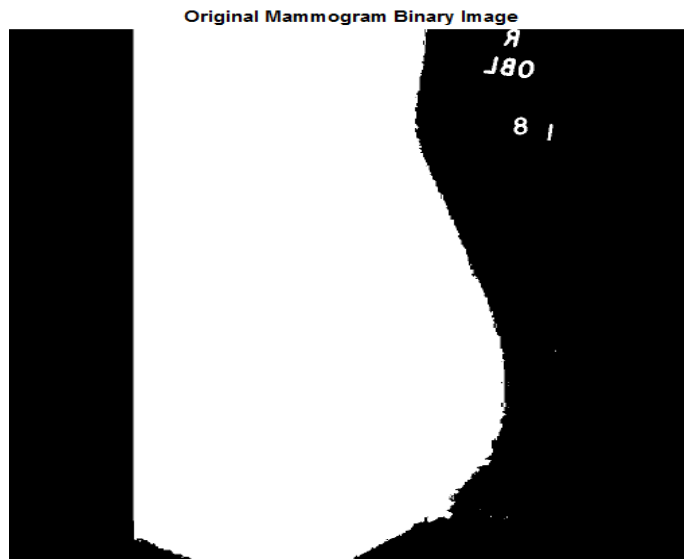


Figure (5.12) Experimental results proposed method binary image

**Step 3:** Removed breast pectoral muscle

This preprocessing step to eliminated the pectoral muscle which was redundant information in the mammograms, as shown in figure (5.13).



Figure (5.13) Experimental results proposed method after pectoral muscle removal

**Stage three: Mammogram image enhancement**

After pectoral muscle was removed, the next step was image enhancement technique which was based on hybrid method combination of frequency domain homomorphic filtering and spatial domain morphology, the obtained output image went through adaptive histogram techniques. Figure (5.14) shows flowchart of mammogram enhancement the Block diagram of this process

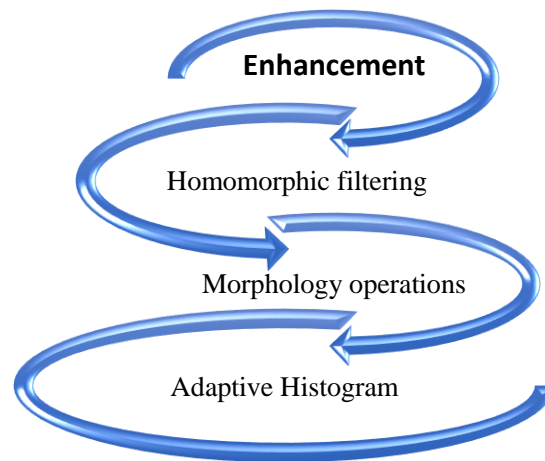


Figure (5.14) Flowchart of Mammographic Image Enhancement

**Step 1: Applying Homomorphic filtering**

Homomorphic filtering is a logarithm-based image enhancement procedure used to highlight details in a mammogram image, Homomorphic filtering processes to compress brightness range and enhance contrast of mammogram image, shown in figure 5.15. Experimental results proposed method applying Homographic Filter

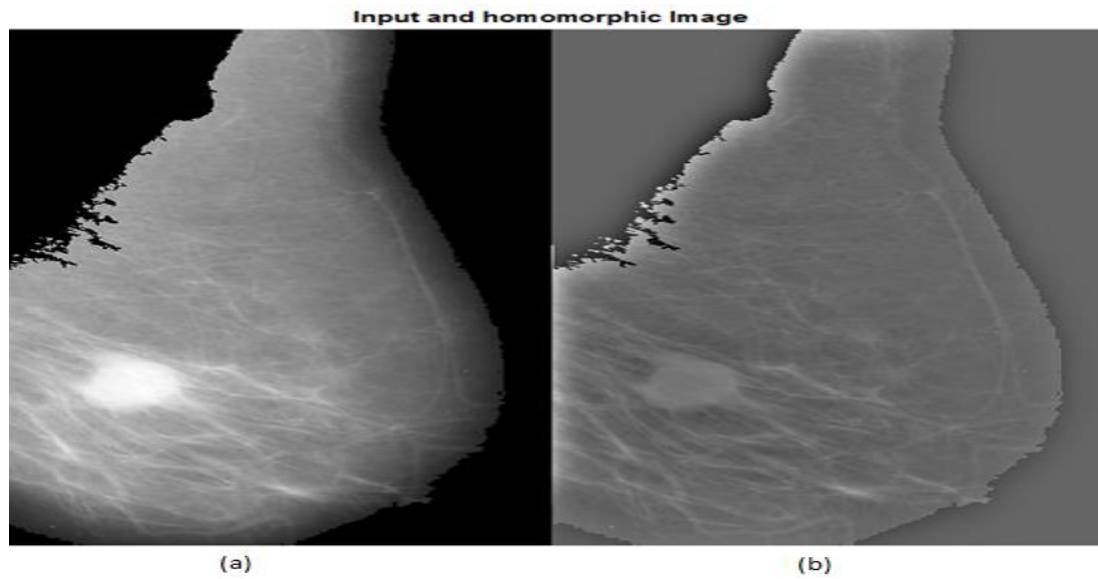


Figure (5.13) Homomorphic Filter(a) Input image (b) Homomorphic image

### Step 2: Mammogram image morphology operations

Morphology enhancement, which is resulted from combining top-hat operation and bottom-hat operation, was used as a proposed enhancement algorithm, the proposed morphology enhancement techniques depends on top-hat operation and bottom-hat operation to enhance mammographic image in terms of accentuating high-intensity and low-intensity morphological structures. And closing operations are built from erosion and dilation as follows. Tophat transforms with the disk radius 15 as structing was used to separate the objects, it was applied to the output image obtained from the previous step. Figure (5.16) shows the experimental results proposed method applying top and bottom hot transform

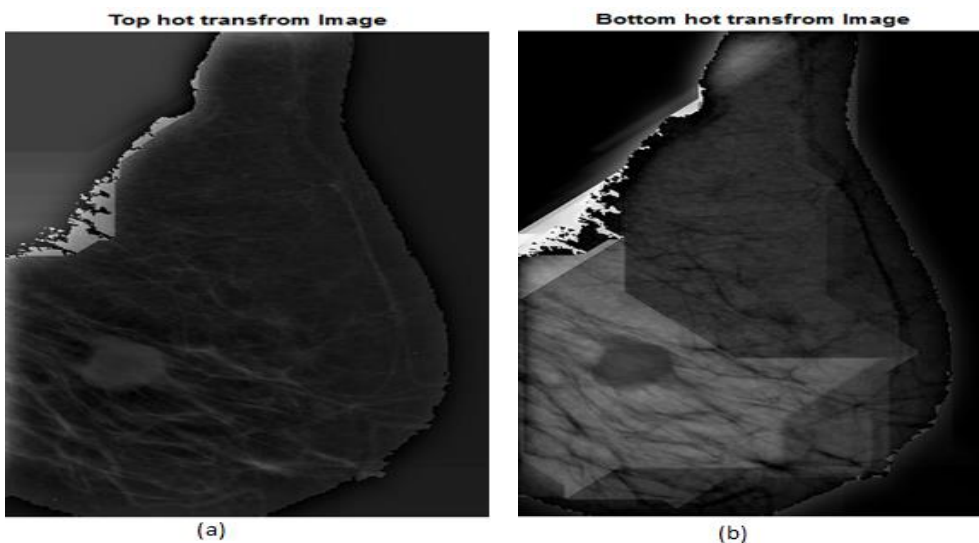


Figure (5.16) Morphology Operations(a) Tophot image (b) Bottom hot image

**Step 3:** Enhance the output image

In literature, several contrast enhancement techniques have been proposed for the enhancement of mammograms in this research, adaptive histogram equalization is applied to enhance the contrast of masked mammogram image. Figure (5.17) shows the contrast enhanced image obtained.

The objective to use adaptive histogram equalization is to efficiently enhance the output results image from the which is the combination form the previous steps.

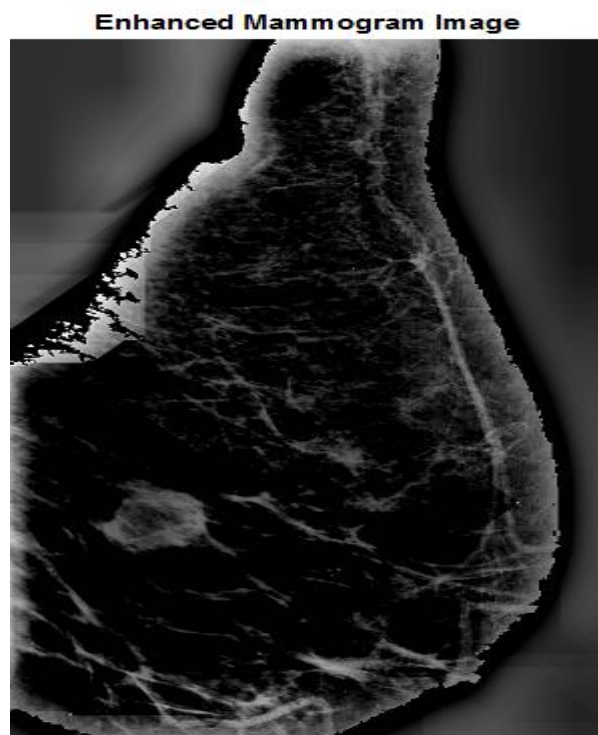


Figure (5.17) Shows the contrast enhanced image obtained

**Stage four:** Mammogram image segmentation

After preprocessing, the region of interest (region where mass is expected) is to be segmented the purpose of image segmentation stage is to divide the mammogram image into regions and separate an area or Region of interest (ROI) that is estimated to show abnormalities.

The estimated area is the one that has a brighter spot in the mammogram image than its surrounding tissue, segmentation proposed used k-means clustering techniques and operators to segment mass and extract border, clustering analysis based on partitioning a collection of

data points into a number of subgroups, where the objects inside a cluster known as a subgroup which is show a certain degree of closeness or similarity. In abnormality detection, the image pixels are partitioned and the pixels corresponding to abnormality are clustered on similarity basis, the K-means procedure to group into k number of clustering features, where k is a positive integer and we segmented mass region using k means , we consider the input pixels and their features are their gray level values, k means aims to minimizing sum of any pixel point to clustering centroid distance , we have chosen euclidean distance as distance measure [36], after that procedure the following step use clustering techniques to and morphological operation to segment and extract the border of mammogram image mass, opening is used to remove small bright objects details and border pixel while leaving the overall pixel intensity values and large bright objects, for edge detection we use Signature is used as a 1D function representation of the boundary in order to plot the distance from centroid to boundary as a function of angel, figure (5.18) shows step by step image segmentation.

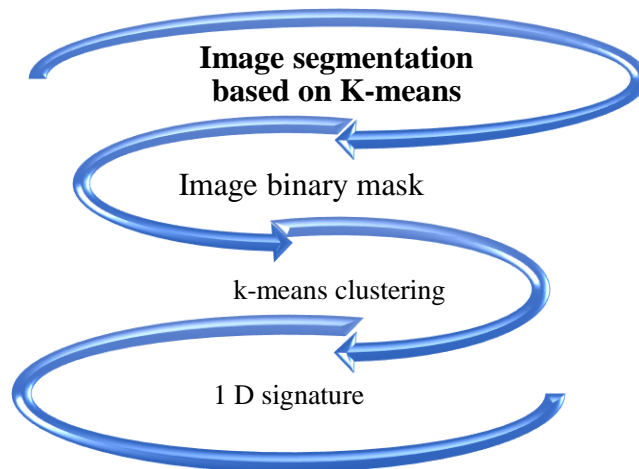


Figure (5.18) Flowchart of image Segmentation

### Step 1: Image binary

Taken an area that has estimated abnormalities by whitening the area which is regarded as abnormal and suspected to be Mass. Black areas are considered as areas that are normal. This step is called converting the image to binary. Figure (5.19) illustrated the experimental results proposed method of converting the image to binary stage



Figure (5.19) Image after the stage of converting the image to binary

**Step 2:** K-means clustering segmentation techniques

Now to take the enhancement image for segmentation techniques and find out boundary and edge detection, figure 5.20 illustrates the result of segmenting a mammogram image based on K-means technique.

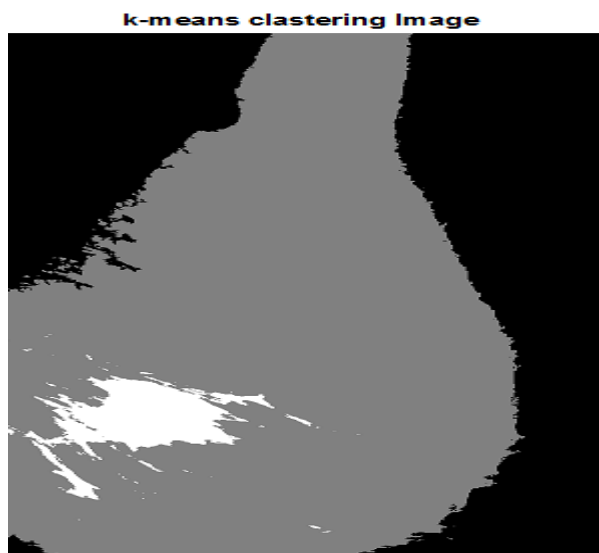


Figure (5.20) Segmented output image K-means clustering

**Step 3: Boundary image edge detection**

Detection of edges in an image is important step towards understanding image features. Since edges often occur at image locations representing object boundaries, edge detection is extensively used in image segmentation when images are divided into areas corresponding to different objects, this can be used specifically for enhancing the abnormal area in mammographic images.

Edge detecting method performed in this proposed system was the Sobel method, and the result is shown in figure (5.21.). Experimental results proposed method imageafter edge detection this method was chosen because it is able to produce a boundary edge more detailed because of capacity of smoothing effect on the random noises of an image



Figure (5.21) Imageafter edge detection

**Step 3: Detection of boundary**

Figure 5.22 shows the boundary detection

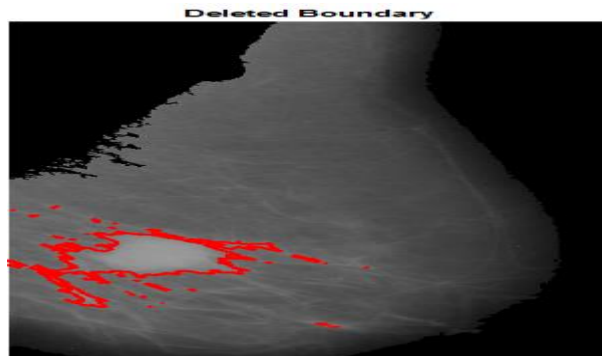


Figure (5.22) Experimental results proposed method applying adoptive histogram



**Stage five: Classification**

There are many different approaches available classification [37]. The proposed system calculates the fractal dimension and fractal signature values for the individual image. The extracted features are then input to the knn for training and classification purposes. final procedure for calculating the signature value, as shown in figure 5.23.

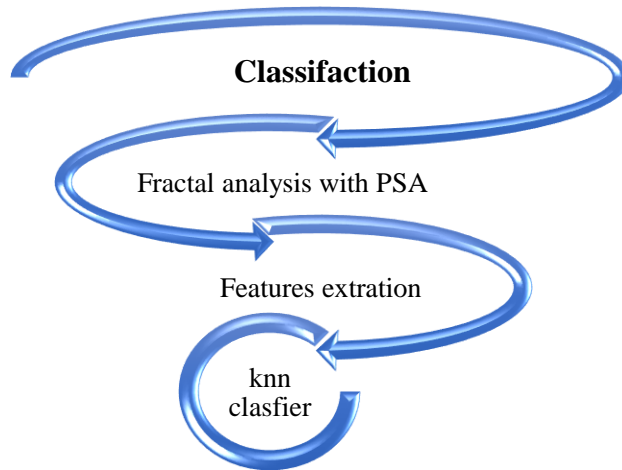


Fig (5.23) Flowchart of the proposed method mammogram texture-based classification

**Step1: Fractal dimension**

Fractal analysis is useful in mammogram image processing for characterizing shape and gray-scale complexity. Breast masses present shape and gray-scale characteristics that vary between benign masses and malignant tumors in mammograms, classifying breast masses based on shape. The fractal dimension of mass may be computed either directly from the 2-dimensional (2D) contour or from a 1-dimensional (1D) signature [38]

**Step 2: Feature extraction**

It is considered as one of the main parts of the breast abnormality detection. It is applied to extract unique features from the input image to use it in the classification stage. It aims to reduce the amount of data that can be used to represent a large set of accurate data by computing the properties or features that can be used to recognize different samples. There are many methods available for feature extraction. The proposed system describes the process of finding image attributes. it extracts features like, geometrical features, and texture features.

The features which is used in proposed system were: Radius, perimeter, and area are considered as geometrical features. Geometrical features are simplest features in breast cancer analysis, but we consider these features to show the impact it on breast cancer research. Generally, Radiologists identify this feature by looking at mammograms.

- **Geometrical Features Extraction**

The result showed related geometrical features and evaluate the importance of these features in breast cancer research. Radius: it enlists radius of normal mass and radius of cancer separately to show comparative results. This also gives a sense of boundary or range of normal and malignant tumors.

Radius, area, perimeter comes under geometrical features and it can be used to extraction of lesion boundary at breast mass in order to characterize malignant or Normal lesion seven morphologic features were extracted from each lesion to describe feature six as shape, contour and size as in circularity is defined as perimeter divided by circumference a circle with the same area, the closer the shape of lesion is to a disk, the closer the circularity index to , area which is the number of pixels contained in the circumference of lesion and lastly P.A the length ratio of the major (long) axis to the minor (short) axis of equivalent ellipse of lesion.

### **Stage 3: Classification by Knn**

The k-Nearest Neighbour algorithm is a non-parametric method used for classification and regression. In both cases, the input consists of the k closest training examples in the feature space. The KNN algorithm is among the simplest of all machine learning algorithms. Both for classification and regression, it can be useful to weight the contributions of the neighbors, so that the nearer neighbors contribute more to the average than the more distant ones. We used Knn method to classify the dataset of features. Both classifiers calculate a weight for each feature, and then we multiply the weight to respective feature. Finally, we add all feature values in order to get a single number. This single number now can be used to make the final decision.

# **CHAPTER Six – CONCLUSIONS AND FUTURE COPES**

## **6.1 Conclusions**

## **6.2 Future Scopes**

## 6.1 Conclusions

Breast cancer is a deadly disease to the human race. A large number of women all around the world is affected by breast cancer. However, current treatment methods are not adequate. We propose two system to enhance and analysis mammograms. Proposed methodology finds doubtful areas; extract hidden attributes of doubtful areas, and finally classify them as normal or malignant. Input mammogram is converted into a matrix of their pixel values; afterward, this matrix is used to find a different statistical function like mean, entropy, etc.; typically known as feature. Finally, the decision is made by classifying extracted features either as benign or malignant. We use open source mammogram images from DDSM and MIAS to evaluate the proposed methodology. A prototype of the proposed methodology is developed based on MATLAB platform. The experimental results from both systems shows that feature extraction is a promising way to dig into breast cancer field. Although, Therefore, the proposed system can detect breast cancer and by feature extraction, it can classify tumor efficiently.

## 6.2 Future Scopes

Analyzing breast cancer images is very complicated. Our proposed mammogram image analysis technique has potential to treat breast cancer. This work can be extended to the following directions:

- An automated intelligent system to predict image detection system
- To implemented the tumors detection techniques by using Auto CAD and find out the tumors size and patterns.

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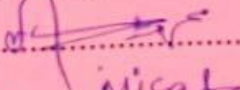

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# APPENDICES

# A. Questionnaires

Ministry Of Higher Education And Scientific Research University of Zawiya Faculty of Engineering Communication Engineering Section		وزارة التعليم العالي والبحث العلمي جامعة الزاوية كلية الهندسة قسم هندسة الاتصالات
	<b>Mammogram Image Enhancement Evaluation</b>	
<h3>Questionnaire</h3>		
<b>Contrast enhancement</b> Poor <input type="checkbox"/> Good <input checked="" type="checkbox"/> Excellent <input type="checkbox"/>		<b>Segmentation results</b> Poor <input type="checkbox"/> Good <input checked="" type="checkbox"/> Excellent <input type="checkbox"/>
<b>Logarithmic Transformations</b> Poor <input type="checkbox"/> Good <input type="checkbox"/> Excellent <input checked="" type="checkbox"/>		<b>Negative image transformation</b> Poor <input type="checkbox"/> Good <input type="checkbox"/> Excellent <input checked="" type="checkbox"/>
<b>Contrast Stretching</b> Poor <input type="checkbox"/> Good <input checked="" type="checkbox"/> Excellent <input type="checkbox"/>		<b>Power-Law Transformations</b> Poor <input checked="" type="checkbox"/> Good <input type="checkbox"/> Excellent <input type="checkbox"/>
<b>Sobel Operator</b> Poor <input type="checkbox"/> Good <input type="checkbox"/> Excellent <input checked="" type="checkbox"/>		<b>Gaussian Filter</b> Poor <input checked="" type="checkbox"/> Good <input type="checkbox"/> Excellent <input checked="" type="checkbox"/>
<b>CLAHE Filter</b> Poor <input type="checkbox"/> Good <input checked="" type="checkbox"/> Excellent <input type="checkbox"/>		<b>Multi-scale</b> Poor <input type="checkbox"/> Good <input type="checkbox"/> Excellent <input checked="" type="checkbox"/>
<b>Detection of boundary</b> Poor <input type="checkbox"/> Good <input checked="" type="checkbox"/> Excellent <input type="checkbox"/>		Notes
Radiologist Name: <u>Dr. M. Bashagha, ABOR, FBBR</u> Signature:  Oncology Center: <u>Misata</u> Years of Experience: <u>7 yr</u>		
		

Ministry Of Higher Education And  
Scientific Research  
University of Zawiya  
Faculty of Engineering  
Communication Engineering Section



وزارة التعليم العالي والبحث العلمي  
جامعة الزاوية  
كلية الهندسة  
قسم هندسة الاتصالات



Mammogram Image  
Enhancement  
Evaluation



Questionnaire

<b>Contrast enhancement</b>			<b>Segmentation results</b>		
Poor <input type="checkbox"/>	Good <input checked="" type="checkbox"/>	Excellent <input type="checkbox"/>	Poor <input type="checkbox"/>	Good <input type="checkbox"/>	Excellent <input checked="" type="checkbox"/>
<b>Logarithmic Transformations</b>			<b>Negative image transformation</b>		
Poor <input type="checkbox"/>	Good <input checked="" type="checkbox"/>	Excellent <input type="checkbox"/>	Poor <input type="checkbox"/>	Good <input checked="" type="checkbox"/>	Excellent <input type="checkbox"/>
<b>Contrast Stretching</b>			<b>Power-Law Transformations</b>		
Poor <input type="checkbox"/>	Good <input checked="" type="checkbox"/>	Excellent <input type="checkbox"/>	Poor <input checked="" type="checkbox"/>	Good <input type="checkbox"/>	Excellent <input type="checkbox"/>
<b>Sobel Operator</b>			<b>Gaussian Filter</b>		
Poor <input type="checkbox"/>	Good <input type="checkbox"/>	Excellent <input checked="" type="checkbox"/>	Poor <input type="checkbox"/>	Good <input checked="" type="checkbox"/>	Excellent <input type="checkbox"/>
<b>CLAHE Filter</b>			<b>Multi-scale</b>		
Poor <input type="checkbox"/>	Good <input type="checkbox"/>	Excellent <input checked="" type="checkbox"/>	Poor <input type="checkbox"/>	Good <input type="checkbox"/>	Excellent <input checked="" type="checkbox"/>
<b>Detection of boundary</b>			Notes		
Poor <input type="checkbox"/>	Good <input type="checkbox"/>	Excellent <input checked="" type="checkbox"/>			

Radiologist Name.....*Fareha Jamer*

Signature:.....*[Signature]*

Oncology Center:.....*Tripoli oncology*

Years of Experience:.....*13*

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جامعة الزاوية  
كلية الهندسة  
قسم هندسة الاتصالات



Mammogram Image  
Enhancement  
Evaluation



Questionnaire

<b>Contrast enhancement</b>			<b>Segmentation results</b>		
Poor <input type="checkbox"/>	Good <input checked="" type="checkbox"/>	Excellent <input type="checkbox"/>	Poor <input type="checkbox"/>	Good <input type="checkbox"/>	Excellent <input checked="" type="checkbox"/>
<b>Logarithmic Transformations</b>			<b>Negative image transformation</b>		
Poor <input type="checkbox"/>	Good <input checked="" type="checkbox"/>	Excellent <input type="checkbox"/>	Poor <input type="checkbox"/>	Good <input type="checkbox"/>	Excellent <input checked="" type="checkbox"/>
<b>Contrast Stretching</b>			<b>Power-Law Transformations</b>		
Poor <input type="checkbox"/>	Good <input type="checkbox"/>	Excellent <input checked="" type="checkbox"/>	Poor <input type="checkbox"/>	Good <input checked="" type="checkbox"/>	Excellent <input type="checkbox"/>
<b>Sobel Operator</b>			<b>Gaussian Filter</b>		
Poor <input type="checkbox"/>	Good <input type="checkbox"/>	Excellent <input checked="" type="checkbox"/>	Poor <input type="checkbox"/>	Good <input checked="" type="checkbox"/>	Excellent <input type="checkbox"/>
<b>CLAHE Filter</b>			<b>Multi-scale</b>		
Poor <input type="checkbox"/>	Good <input checked="" type="checkbox"/>	Excellent <input type="checkbox"/>	Poor <input type="checkbox"/>	Good <input checked="" type="checkbox"/>	Excellent <input type="checkbox"/>
<b>Detection of boundary</b>			Notes		
Poor <input type="checkbox"/>	Good <input checked="" type="checkbox"/>	Excellent <input type="checkbox"/>			

Radiologist Name... S.A.S.A.B.T.I... Al.Gou 1

Signature:.....

Oncology Center:.....

Years of Experience:.....8.....

CS Scanned with CamScanner

B- Approval Letters



السيد المحترم / المدير التنفيذي بمركز طرابلس لتشخيص وعلاج الأورام (طرابلس)

بعد التحية؛؛؛

في الوقت الذي نحي فيه جهودكم ودوركم الفعال في الدعم والدفع في كل ما من شأنه الرقي والرفعة بالصالح العام، وفي اطار التعاون بين مؤسسات الدولة الليبية لخدمة المؤسسات العامة .

نفيدكم بان الطالبة فريدة علي المريمي تحت رقم قيد 017301570 أحدى طلبة الدراسات العليا بالكلية لنيل درجة الاجازة العليا (الماجستير) بقسم الهندسة الكهربائية والالكترونية (شعبة الاتصالات) وهي الان بمرحلة إتمام رسالتها تحت عنوان:

( تحسين صورة جهاز الماموغرام لكشف عن سرطان الثدي )

نأمل منكم السماح لطالبة بإجراء دراسة بحثية مفصلة والمساعدة في الإجراءات التالية :

1. الحصول على البيانات والاحصائيات المتعلقة بسرطان الثدي .
2. الحصول على صور الماموغرام وتجريب النظم المقترح لتحسين الصورة والكشف عن سرطان الثدي (تجربة عملية).
3. تقسيم النظام المقترح من خلال نتائج استبيان يوزع على اطار الأشعة.

شاكرين على حسن تعاونكم والسلام عليكم ورحمة الله وبركاته

د. نجيب علي يحيى  
وكيل الكلية للشؤون العلمية



مكتب الدراسات العليا  
الصادر + الدوري العام ..

د. رمضان ..



السيد المحترم / مدير المعهد القومي لعلاج الأورام (مصراته)

بعد التحية!!!

من الوقت الذي نحى فيه جهودكم ودوركم الفعال في الدعم والدفع في كل ما من شأنه الترفي  
والترقية بالمصالح العام، وفي إطار التعاون بين مؤسسات الدولة الليبية لخدمة المؤسسات العتمة  
نفيدكم بأن الطالبة فريدة علي المريني تحت رقم قيد 017301570 إحدى طلبة الدراسات العليا  
بالمعهد لتبذل درجة الاحتراف العليا (الماستر) بسم الهندسة الكهربائية والإلكترونية (شعبة الاتصالات)  
وهي الآن بمرحلة اتمام رسالتها تحت عنوان:

( تحسين صورة جهاز الماموغرام لكشف عن سرطان الثدي )

تأمل منكم السماح لمطالبة بإجراء دراسة بحثية مفصلة والمساعدة في الإجراءات التالية:

1. الحصول على البيانات والاحصائيات المتعلقة بسرطان الثدي.
2. الحصول على صور الماموغرام ولحزيب النظم المقترح لتحسين الصورة والكشف عن سرطان الثدي (تجربة عملية).
3. تكسيب النظم المقترح من خلال نتائج اسئيلان يوزج على اطار الاشعة.

شاكرين على حسن تعاونكم والسلام عليكم ورحمة الله وبركاته

د. نجيب علي يحيى  
وكيل الكلية للشؤون العلمية



التدريس  
الاستاذ الدكتور محمد حنيفة الكمامة  
د. علي القوي

مكتب الدراسات العليا

مصراتة - ليبيا

د. رطل



السيد المحترم / مدير المعهد القومي لعلاج الأورام (صبراتة)

بعد التحية!!!

في الوقت الذي نحي فيه جهودكم ودوركم الفعال في الدعم والدفع في كل ما من شأنه الرقي والرفعة بالصالح العام، وفي اطار التعاون بين مؤسسات الدولة الليبية لخدمة المؤسسات العامة .  
نفيدكم بان الطالبة فريدة علي المريمي تحت رقم قيد 017301570 أحدى طلبة الدراسات العليا بالكلية لنيل درجة الاجازة العليا (الماجستير) بقسم الهندسة الكهربائية والالكترونية (شعبة الاتصالات) وهي الان بمرحلة إتمام رسالتها تحت عنوان:

( تحسين صورة جهاز الماموغرام لكشف عن سرطان الثدي )

نأمل منكم السماح لطالبة باجراء دراسة بحثية مفصلة والمساعدة في الإجراءات التالية :

1. الحصول على البيانات والاحصائيات المتعلقة بسرطان الثدي .
2. الحصول على صور الماموغرام وتجريب النظم المقترح لتحسين الصورة والكشف عن سرطان الثدي (تجربة عملية).
3. تقسيم النظام المقترح من خلال نتائج استبيان يوزع على اطار الاشعة.

شاكرين على حسن تعاونكم والسلام عليكم ورحمة الله وبركاته

د. نجيب علي يحيى  
وكيل الكلية للشؤون العلمية



لتقديم مشروع بحثي  
سيد الموراح المرفوق

مكتب الدراسات العليا  
الصالر + الثوري الم

د. رمضان

## C- Mammogram Equipments

