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Enhancement of Mammogram Image by using Image Processing Technique

تحسين الصور الأشعاعية للثدي بإستخدام تقنية معالجة الصور

A thesis submitted for partial fulfillment for the requirements of M.Sc. degree in Medical Physics

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بسم الله الرحمن الرحيم

قال تعالـي:

(ويسالونك عن الروح فل الروح من امر ربي وماااتيتم من العلم الا قليلا)

صدق الله العظيم

Dedication

This study is dedicated to

My best man my father

And

My dear mother

ACKNOWLEDGEMENT

My great and special thanks to my supervisor:

DR. MOHAMED ALFADIL MOHAMED GARELNABI, for his contact supervision and unlimited help. My Thanks extend to all colleagues whom were beside me and help me to complete this study.

Abstract

This study was carried out in order to enhance the quality of mammography image using image processing technique. The technique of processing image performed using IDL software as platform. The images were collected from a different Centers from 40 females patients. The intensity improvement was measure in low and high intensity areas before and after the enhancement. The result showed that there is an increased in the amount intensity after enhancement for low intensity area was 39.7±21.6 and after enhancement was 63.8±28.2 and for high intensity area before enhancement was 161.6±27.5 and after enhancement was 200.6±23.8. The noise which is represented by standard deviation it shows slight increases after enhancement which record 2.3±1.0 and 4.1±2.1 respectively in the low intensity region. Similar results achived in the high intesity region after enhancement 4.0±2.7 and 7.0±7.6 respectively. The signal of the image also increased after enhancement in the low intensity regions in average from 1429.5±776.7 to 2297.3±1016.2 and for the high intensity regions in average from 5816.1±989.5 to 7222.8±855.1. the signal to nosie also arbitrary increased after enhacement in low and high intensity regions from 736.6±536.5 to 697.7±455.7 and from 1978.1±997.5 to 2964.1±3108.7 respetively.

الملخص:

تهدف هذه الدراسة من أجل تحسين جودة الصورة الأشعاعية للثدي بإستخدام تقنية معالجة الصورة. تقنية معالجة الصورة تمت بإستخدام ال اي دي إل كصيغة نمطية. الصور جمعت من مراكز مختلفة من 40 حالة. تطور الإشارة قيس في مناطق الإشارة العالية والمنخفضة قبل وبعد التحسين. النتيجة أظهرت ذلك أنه يوجد زيادة في كمية الإشارة بعد التحسين , لمنطقة الإشارة المنخفضة كان39.7±21.6 وبعد التحسين كان 63.8±28.2 و لمنطقة الإشارة العالية قبل التحسين كان 161.6±27.5 وبعد التحسين كان 200.6±23.8 . التشوه عبر عنه بالإنحراف المعياري و أظهر زيادة طردية بعد التحسين قد سجلت 2.3±1.5 و 4.1±2.1 علي التوالي في منطقة الإشارة المنخفضة. نتائج مشابهة انجزت في مناطق الشدة العالية بعد التحسين 4.0±2.7 و 7.0±7.6 علي التوالي وإشارة الصورة أيضا إرتفعت بعد التحسين في مناطق الإشارة المنخفضة بمعدل من 1429.5±776.7 إلي 2297.3±1016.2 و لمناطق الإشارة العالية بمعدل من 5816.1±989.5 إلي 7222.8±855.1 . الإشارة إلي التشوه أيضا إعتباطيا إرتفع بعد التحسين في مناطق الإشارة المنخفضة والعالية من 736.6±536.5 إلي 697.7±455.7 و من 1978.1±997.5 إلي 2964.1±3108.7 علي التوالي.

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List of abbreviation

PEM positron emission mammography.

MRI magnetic resonance imaging.

MTF	modulation transfer function.
NPS	noise power spectrum
Mo	molybdenum
Rh	rhodium
KVp	kilo voltage peak
mA	milli ampere
W	tungsten
Ag	silver
SNR	signal to noise ratio
DQE	detective quantum efficient
AEC	automatic exposure control
SD	standard deviation
N	the number of the photons absorbed
3D	three dimensions
2D	two dimensions
m	number of the columns of the image matrix
n	number of the rows of the image matrix
FOV	field of view
IDL	interactive date language

Chapter One

Chapter One
Introduction

Mammography is an x-ray examination of the breast. Its principal purpose is to facilitate the detection of the breast cancer at point earlier in its natural history than is possible by clinical examination. It has been demonstrated that routine screening with high quality mammography is effective in reducing mortality from breast cancer in women aged 40-69. In countries with mammography screening programs, these have been a marked decrease in breast cancer mortality over the past two decades. Mammography is also useful in refining the diagnosis of breast cancer after suspicious area in the breast has been detected and for localizing a lesion for therapy. The radiological signs of breast cancer include mass densities that are typically slightly more attenuating of x-ray than surrounding normal tissue, small micro calcifications, asymmetry between the two breasts and architectural distortion of tissue patterns. To detect breast cancer accurately and at the earliest possible stage, the image must have excellent contrast to reveal mass densities and speculated fibrous structures radiating from them which are characteristic of cancer. In addition, the spatial resolution must be excellent to reveal the calcification their number and their shape.

1.1 Image processing technique

These techniques give medical images where they are analysis and enhancement by image processing (Image processing is the study of any algorithm that takes an image as input and returns an image as output) image processing give Image enhancement, noise removal, restoration, feature detection, compression and image analysis give Segmentation, image registration, matching. Image processing has a major impact on image quality and diagnostic performance of image radiographs. Goals of processing are to optimize spatial resolution, to enhance structural contrast, and to suppress image noise. The most simple and still widely applied spatial filtering algorithms are based on unsharp masking. Various modifications were introduced for dynamic range reduction. More elaborate and more effective are multi-scale frequency processing algorithms. They are based on the subdivision of an image in multiple frequency bands according to its structural composition. This allows for a wide range of image manipulations including a size-independent enhancement of low-contrast structures. (Williams, 2003)

1.2 Problem of the study

Mammogram images depicted 3D image in 2D image format which make all the structures in the breast superimposed. Also Medical images are often deteriorated by noise due to various interferences and other factor associated with imaging process and data acquisition system. All these factors and others will make the visibility of the image details very low and hence a subtle tumours or presence of microcalcification might be hidden from the observer. Using image processing technique to enhance the image will improve the visibility of image textures in a way that it can gives optimum diagnostics workup.

1.3 Objectives of the study

The main objective of this study was to enhance mammographic images using image processing techniques to increase the visual perception characteristics.

Specific objectives

- To enhance the mammographic images using histogram equalization function before and after applying median filte.r
- To find the contrast, noise and signal in the mammogram images before and after enhancement and filtering.

- To find the relationship between the contrast, noise and signal before and after enhancement and filtering.

1.4 Important of the study

This study will provide measures for the improvement of the mammogram images after enhancement and filtering by revealing the effect of enhancement and reduction of noise and hence increasing signal to noise ratio and therefore contrast of the image

1.5 Over view of the study

This study falls into five chapters, Chapter one, which is an introduction, It presents the statement of the study problems, objectives of the study and significant, chapter two deals with radiological physics, back ground and previous study. Chapter three deals with material and method, Chapter fours present results and finally chapter five gives discussions, conclusion and recommendations.

Chapter two
Literature Review

2.1 Anatomy of the Breast:

Vary in shape and size, cone shaped with the post surface, three types of tissue: glandular, fibrous or connective tissues and adipose (fat).

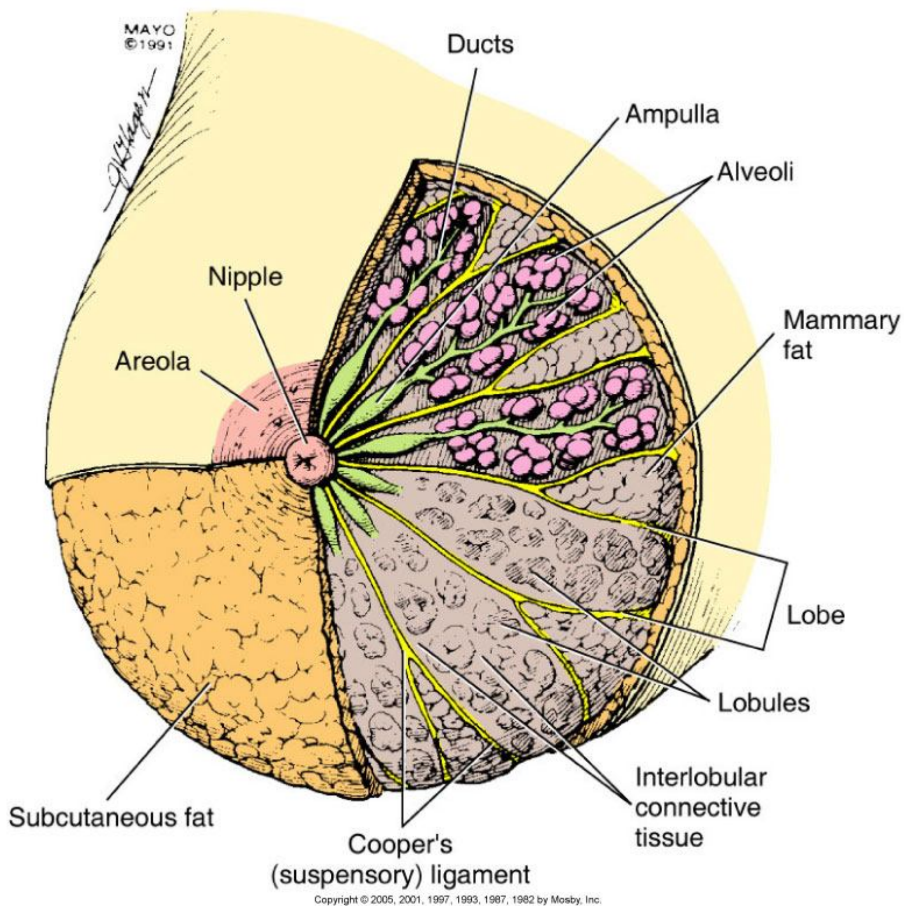


Figure (2.1) Anatomy of the breast

There are two general categories of breast cancer: Non –invasive: cancer confined to lobules or ducts. Invasive: cancer spread to fatty connective tissue (D. Charman, M. Ed. ,R.T.(R,M)2010).

2.2 X-Ray Mammography

A mammogram is an x-ray examination of the breasts, that uses low dose x-ray system, used to detect and diagnose breast diseases, Screening mammography is used as a preventive measure for women who have no symptoms of breast disease, Diagnostic mammography involves additional x-rays of the breast to provide different views of the suspicious area, if an abnormality is detected during screening mammography, or in women with breast complaints. The x-rays can be taken at different angles tailored to the specific area of abnormality. In addition, magnification views or spot compression can be used to make the area easier to evaluate (Annuniata L, Michael F. ,2007).

2.3 Mammography technique:

Mammography is the process of using low-energy X-rays (usually around 30kVp) to examine the human breast, which is used as a diagnostic and screening tool. The goal of mammography is the early detection of breast cancer, typically through detection of characteristic masses and/or micro calcifications like all X-rays, mammograms use doses of ionizing radiation to create images. Radiologists then analyze the images for any abnormal findings. It is normal to use lower-energy X-rays than those used for radiography of bones. Ultrasound, positron emission mammography (PEM), and magnetic resonance imaging (MRI) are adjuncts to mammography. Diagnostic mammography involves additional x-rays of the breast to provide different views of the suspicious area, if an abnormality is detected during screening mammography, or in women with breast complaints. The x-rays can be taken at different angles tailored to the specific area of abnormality. In addition, magnification views or spot compression can be used to make the area easier to evaluate (Dendy ,p.p; B; Heaton,CRC press , USA, 1990).

2.4 Digital mammography:

The theory behind the digital mammography is that it is to increase the incidence of detecting more breast cancers that would not normally be detected as easily in film- screen systems. It allows for faster image production with less radiation to the patient, this is new system is more costly but in the long run will save the facility money in storage and film processing costs. Direct digital systems use amorphous selenium photo detector screens; these screens have high x-ray absorption efficiency, high intrinsic resolution, low noise and well-established manufacturing process. Indirect digital systems use cesium iodide doped with thallium to absorb x-rays, thes systems generate light scintillation that then is detected by an array of photodiodes. They have resolution degradation caused by light spread in scintillator and poor quantum efficiency with then scintillator. In producing the image spatial resolution plays a big part, spatial resolution is determined by the pixel size with fever microns per pixel, the amount of contrast information available in the image is defined by the bit depth per pixel. Radiation dose in digital mammography systems may be the same or less than that used in film - screen mammography. With digital systems image enhancement is much greater than that with film - screen system, digital mammography expellant contrast resolution, especially in dense breast tissue, will eventually make way for more accurate breast cancer detection. In film –screen systems there are blind areas where the film is very dark or very light because there is a linear response of digital detectors to incident radiation, there is more contrast between areas of similar x- ray absorption. In addition image contrast can be manipulated on the computer monitor for improved conspicuity. In digital image systems the amount of time it takes to produce an image approximately four seconds to image the breast in one projection, the technologist to look at her position right away (Fabrizio Russo, IEEE, August 2002).

2.5 Computer-Aided Diagnosis

Computer-aided diagnosis aided diagnosis a diagnosis made by a radiologist who takes into consideration the results of an automated computer analysis of radiographic images. A much more specific definition A more sophisticated and technologically challenging form in which the image is directly analyzed by computer with a view to detecting, localizing, and quantitating abnormalities in the radiograph.

The purposes of computer-aided diagnosis are: to improve the reproducibility of image interpretation and to improve diagnostic accuracy (Fabrizio Russo, IEEE, August 2002).

2.6 Image quality analysis in mammography

The quality of the breast images depends critically on the design and performance of the radiographic unit, the image receptor, and on how that equipment is used to acquire and process the mammogram. The type of display and the conditions under which the image is viewed have an important effect on the ability of the radiologist to extract the information recorded in the mammogram. The diagnostic information is integrally related to the quality of the image and higher image quality will result in more accurate diagnosis. Image quality can be quantified with basic physical characteristics: contrast, spatial resolution (Modulation Transfer

Function, MTF) and noise (Wiener spectrum or Noise Power Spectrum, NPS), each representing a specific characteristic of the imaging system. The systematic monitoring of both image quality and radiation dose is needed to guarantee a constant high quality of the mammography examination (ICRU, 2009; Ng,2005,Jerrold T. Bushberg , J. Anthony seibert , Edwin M. leidt, JR. ,John M.).

2.6.1 Image contrast

Capability of the system to make visible small differences in soft tissue density., *Image contrast***:** is the difference in intensity corresponding to different concentration of activity in the patient. For high diagnostic accuracy, mammography images must be of high contrast. The image contrast is principally affected by the radiopharmaceutical that is used for imaging and the scattered radiation. In general, it is desirable to use a radiopharmaceutical which has a high uptake within the target organ. The contrast must be made as high as possible by imaging with a low photon energy (hence increasing breast dose). In practice, to avoid a high breast dose, a compromise must be made between the requirements of low dose and high contrast. The concurrent need to detect and characterize minute micro calcifications governed more by spatial resolution, and the structural characteristics of the margins of masses governed more by contrast resolution. Subject contrast is the relative difference between the

X-ray transmissions at the entrance plane of the image receptor through different parts of the breast. Attenuation, and therefore subject contrast, depend strongly on the X-ray energy spectrum**,** which is determined by the target material, kVp, and on filtration (either inherent in the tube or added). - Molybdenum (Mo) target X-ray units generate characteristic radiation at 17.9 and 19.5 keV. A Mo filter 0.025 to 0.03 mm thick strongly suppresses photon energies less than 15 keV and those greater than 20 keV, yielding high subject contrast and avoiding excess radiation dose for 2 to 5 cm breasts imaged at typical voltages of 25 to 28 kVp.

- Incident X-ray beams with higher effective energy are used for thicker and/or denser breasts (5 cm to 7 cm). These beams are achieved with higher voltage (>28 kVp) on a Mo target with either a Mo filter (0.030 mm) or a rhodium (Rh) filter (0.025 mm). For denser breasts, an Rh filter preferentially transmits energies from 15 to 23 keV, including Mo characteristic radiation.

- A more penetrating beam is obtained with an Rh target emitting 20 and 23 keV characteristic X-rays combined with a Rh filter (0.025 mm), operated at 28 kVp or higher. For very dense, difficult-to-penetrate breasts, the resulting spectrum preserves subject contrast and reduces dose to a practical level.

- Tungsten (W) target materials permit longer exposures than molybdenum (Mo/Mo) exposures, allow for higher effective energy, better tube heat loads, and, in some cases, lower dose. Without useful characteristic radiation, the energy spectrum of W targets is optimized for mammography with Mo, Rh, and silver (Ag) filters, typically of 0.05 mm thickness or greater. Greater filter thickness is necessary to attenuate useless L X-rays emanating from the W target. Careful choice of kVp and filter material can yield excellent results in terms of contrast and breast dose.

The properties of digital detectors and image processing adjustment of display contrast allow the use of higher energy X-ray**s** (25 to 35 kVp and above) for digital systems compared to screen-film systems (where 22 to 32 kVp is more typical). Dose is reduced for the same image SNR by using higher energy X-rays, especially for large or dense breasts. Any technique adjustments should be performed in consultation with and verified by the radiologist in charge of the digital mammography program and the Qualified Medical Physicist (Tinku Achary , Ajoy K. Ray, USA, 2005 , Fabrizio Russo, August 2002).

In digital mammography, it is important to discuss noise as well as contrast. Radiographic image noise is the unwanted random (uncorrelated), nonrandom (correlated), or static (e.g., detector defect) variation in signal in a radiograph that has been given a uniform X-ray exposure. Using fewer quanta increases random noise or quantum mottle (for a fixed signal) or decreases SNR and reduces the ability to discern subtle differences in contrast. Fine calcifications or subtle masses that can be the first signs of cancer may not be visible in a noisy (underexposed) image. The exposure required to achieve a desired output SNR is inversely related to the DQE (detective quantum efficiency), and systems with high DQE are usually more dose efficient. “Appropriate” X-ray exposure depends on the system’s DQE, and requisite SNR can be achieved with a calibrated automatic exposure control (AEC) system ((Tinku Achary , Ajoy K. Ray, USA, 2005 , Fabrizio Russo, August 2002).

2.6.2 Noise

The main component of noise in radiographic images is the quantum noise, which is associated with the statistical fluctuations in the photons, fluence on the detector and with the random variations in the absorption. The simplest way to define the noise is through a measurement of the standard deviation (sd) of the number of photons absorbed (N) in a region of the detector. Noise refers to any unwanted information that prevents the accurate imaging of an object. Noise is the major factor in the degradation of image quality. Image noise may be divided into random and structured noise. Random noise (also referred as statistical noise) is the result of statistical variations in the counts being detected. The image noise is proportional to N1/2 where N is the number of detected photons per pixel. Therefore, as the number of counts increases the noise level reduces. Image noise is usually analysed in terms of signal-to-noise-ratio (SNR). SNR is equal to N/ N1/2. If the SNR is high, the diagnostic information of an image is appreciated regardless of the noise level. Structured noise is derived from non-uniformities in the overlying structures in patient body (Tinku Achary , Ajoy K. Ray, USA, 2005 , Fabrizio Russo, August 2002).

2.6.3 Uniformity:

The initial operation which usually occurs is a "flat-field", a correction of the uniformity of gain. The non-uniformity of the sensitivity of the detector is corrected through a gain map and is also used to correct all the images acquired. Moreover, if an element of a single (pixel) detector is defective its signal can be replaced with a reasonable combination of adjacent detector signals. This is acceptable if the defective detectors are isolated and only few of them are faulty.

2.6.4 Artifacts

Artifacts are undesirable characteristics which are not related to the mammary anatomic structures of a radiographic image. They can hinder the image by hiding or simulate a lesion on detection. Artefacts can be caused by the source of X-rays, the beam filter, the compression device, breast support, grid, and flaws in processing, amongst others. In digital mammography, besides the sources just cited, the non-uniformity in the response of the elemental detectors may also generate artefacts, owing to the results of an inadequate flat-fielding. Another drawback in the digital system is the presence of reminiscent images (ghost images), resulting from previous exposures (ICRU, 2009).

2.7 Image analysis and processing in mammography:

In the last several decades, medical imaging systems have advanced in a dynamic progress. There have been substantial improvements in characteristics such as sensitivity, resolution, and acquisition speed. New techniques have been introduced and, more specifically, analogue images have been substituted by digital ones. As a result, issues related to the digital images' quality have emerged (Nailon, 2010).

2.7.1 Digital images:

The digitization of images generally consists of two concurrent processes Image Sampling: This process is used to digitize the spatial information in an image. It is typically achieved by dividing an image into a square or rectangular array of sampling points. Each of the sampling points is referred to as a picture element - or pixel to use computer jargon**.** Naturally, the larger the number of pixels, the closer the spatial resolution of the digitized image approximates that of the original analogue image. Image Quantization: This process refers to the digitization of the brightness information in an image. It is typically achieved by representing the brightness of a pixel by an integer whose value is proportional to the brightness. This integer is referred to as a 'pixel value' and the range of possible pixel values which a system can handle is referred to as the gray scale. Naturally, the greater the gray scale, the closer the brightness information in the digitized image approximates that of the original, analogue image (Gonzalez, R et al, 2009).

In all modern mammography imaging systems, the images are displayed as an array of discrete picture elements (pixels) in two dimensions (2D) and are referred as digital images. Each pixel in a digital image has an intensity value and a location address, In a mammography image the pixel value shows the number of counts recorded in it. The benefit of a digital image compared to the analogue one is that data from a digital image are available for further computer processing (Lyra, et al, 2011).

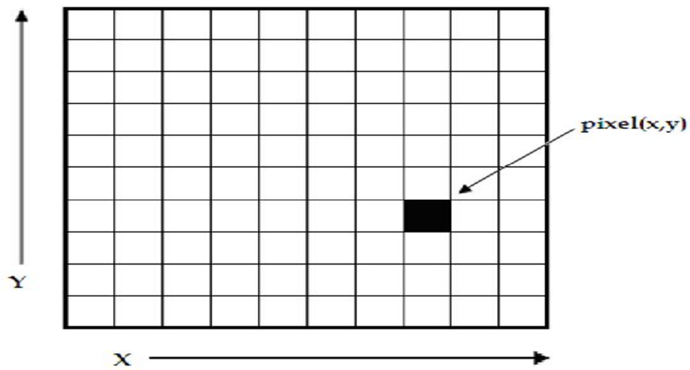


Figure (2.2) A digital image is a 2D array of pixels each pixel is characterized by its (x, y) coordinates and its value (Lyra, et al, 2011)

Digital images are characterized by matrix size, pixel depth and resolution. The matrix size is determined from the number of the columns (m) and the number of rows (n) of the image matrix (m×n). The size of a matrix is selected by the operator. Pixel or bit depth refers to the number of bits per pixel that represent the colour levels of each pixel in an image. Each pixel can take 2k different values, where k is the bit depth of the image. This means that for an 8-bit image, each pixel can have from 1 to 28 (=256) different color levels (grey-scale levels). The term resolution of the image refers to the number of pixels per unit length of the image. In digital images the spatial resolution depends on pixel size. The pixel size is calculated by the Field of View (FoV) divided by the number of pixels across the matrix. For a standard FoV, an increase of the matrix size decreases the pixel size and the ability to see details is improved. (Lyra, et al, 2011).

2.7.2 Image Processing Considerations:

Image processing has great potential to improve image quality and secondarily diagnostic accuracy and even to reduce the radiation dose necessary to achieve an image of acceptable quality. Digital mammograms typically have a wide dynamic range, and the ability to process the image data provides an opportunity to display the data more effectively. Storage of “for processing” image data provides greater flexibility for subsequent postprocessing using different algorithms. Systematic variations in intensity can be equalized, local contrast can be enhanced, and the sharpness of calcifications can be restored. Enhanced visualization of subtle structures is suggested as a possible contributor to the improved performance of digital mammography in patients with dense breast tissue.

- *Segmentation* of the breast from the region of the direct beam is the first step for defining the areas to be processed, using edge detection algorithms and grayscale adjustment to equalize apparent tissue thickness. Artifacts near the skin line can occur in the equalized image, and the potential for this improper segmentation requires the ability to turn off the algorithm.

- *Image processing steps* (spatial frequency restoration and deblurring) are then carried out to render microcalcifications with greater detail and higher conspicuity.

- *Selective (adaptive) noise reduction* attempts to reduce noise only in regions where tissue contrast does not have noticeable fine detail. Difficulty arises in reducing noise and preserving high spatial resolution with the same process. In some cases, noise reduction might not improve detection performance if the reduced noise texture is similar to that of target objects.

- *Unsharp masking* and global latitude reduction increase the relative signal in underpenetrated areas and reduce the signal in highly transmissive regions. Fourier filters or spatial convolution kernels of large spatial extent create a low frequency blurred image that is then subtracted from the nonblurred image.

- *Adaptive local contrast enhancement and multiscale processing* are other methods that have been used. When applying global latitude equalization or adaptive contrast enhancement, there is always some risk that subtle tissue characteristics of potential diagnostic significance may be diminished in relation to the detail that is enhanced.

- *Differently processed* versions of the same digital mammogram are preferred, depending on the task and lesion type, suggesting that workstations might implement multiple processing options for use during interpretation .

- *Desired processing parameters* may vary with radiographic factors such as tube target, kVp, and tube filter type and thickness. One must be careful to ensure that the processing being used is appropriately matched to the techniques used to obtain the mammogram.

- *Comparison of images* from prior mammography examinations is essential in the interpretation of a new study. However, variations in the processing of prior and current images may make such comparisons difficult. See the discussion below under “Archive” for further information on this subject.

  - *Application of image processing* at the reading station (or by a separate processing box located separately from the primary interpretation workstation) requires image processing software that is applicable to the images from any digital mammography system. This requires an understanding of the characteristics of the image data from the digital mammography system or other input devices (e.g., film digitizers) as well as storage of image data in the DICOM format intended “for processing.”

2.8 Digital image processing:

Digital image processing is the use of computer algorithms to perform image processing on digital images. As a subcategory or field of digital signal processing, digital image processing has many advantages over analog image processing. It allows a much wider range of algorithms to be applied to the input data and can avoid problems such as the build-up of noise and signal distortion during processing. Since images are defined over two dimensions (perhaps more) digital image processing may be modeled in the form of multidimensional systems.(Azriel Rosenfeld,1969).

2.9 Previous studies:

In reviewing of literature in locally and internationally there are many published studies regarding the enhancement of mammography image by many researchers, enhancement of mammographic features by optimal adaptive neighborhood image processing was published by Dhawan et al 1986) they stated that mammographic detection of early breast cancer requires optimal radiological or image processing techniques. They presented an image processing approach based on adaptive neighborhood processing with a new set of contrast enhancement functions to enhance mammographic features. This procedure brought out the features in the image with little or no enhancement of the noise. They also found that adaptive neighborhoods with surrounds whose width was a constant difference from the center yield improved enhancement over adaptive neighborhoods with a constant ratio of surround to center neighborhood width.

Feature enhancement of film mammograms using fixed and adaptive neighborhoods described by Richard and Rangaraj (1984) where digital techniques were presented for xerography like enhancement of features in film mammograms. The mammographic image was the first digitized using a procedure for gray scale dynamic range expansion. A pixel operator was then applied to the image, which performed contrast enhancement according to the specified function. The final transformation lead to either a positive or negative mode display as desired. They also presented an adaptive neighborhood feature enhancement technique that enhanced visibility of objects and details in an image. The availability of the enhanced images should aid diagnosis of breast cancer without requiring additional x-ray dose such as for xeromammography.

Morrow et al. (2002) used Region-based contrast enhancement, they said that diagnostic features in mammograms vary widely in size and shape. Classical image enhancement techniques cannot adapt to the varying characteristics of such features. An adaptive method for enhancing the contrast of mammographic features of varying size and shape is presented. The method uses each pixel in the image as a seed to grow a region. The extent and shape of the region adapt to local image gray level variations, corresponding to an image feature. The contrast of each region is calculated with respect to its individual background. Contrast is then enhanced by applying an empirical transformation based on each region's seed pixel value, its contrast, and its background. A quantitative measure of image contrast improvement was also defined based on a histogram of region contrast and used for comparison of results. Using mammogram images digitized at high resolution, it was shown that the validity of micro calcification clusters and anatomic details is considerably improved in the processed images.

Chapter three

Materials and Methods

3.1 Materials:

The mammography machine used here was a digital mammography machine manufactured by Toshiba company.

The table (3.1) show the feature of the mammography machine:

Company	Toshiba
Kv Range	22-49 Kvp in 1Kvp increments
mAs Range	4-500 mAs
m A Range	30-100
Time Range , sec	0.04-65
Parameters controlled	Track, filter, Kv, mAs
Imaging area	24×31
Hard Disk capacity	250 GB
Rotation Degrees	165-185
SID	66

3.2 Population of the study

The data of this study collected from mammograms of women with age above 40 where the density of the breast were moderate or mostly fatty because dense breast got coarse features therefore texture details were minimum.

3.3 Study design

This is an analytical study where the data collected from the images before enhancement were compared to the data collected after enhancement

3.4 Study area and duration:

The data of this study were collected form department in modern medical center in the period from 2014 to 2015.

3.5 Study Sample size and type:

The data of this study were collected from a mammogram for 40 patients using convenient sample type.

3.6 Methods of data collection:

The mammogram images were read by IDL program where a region of 3×3 pixels were chosen in a low intensity area by clicking on that region then repeat the same process in a high intensity area located nearby the first region. Then noise, signal, signal to noise ratio and contrast were calculated in both region. After that the image enhanced using histogram equalization function and the same quantity were collected again and after applying filtering using median filter the same process repeated.

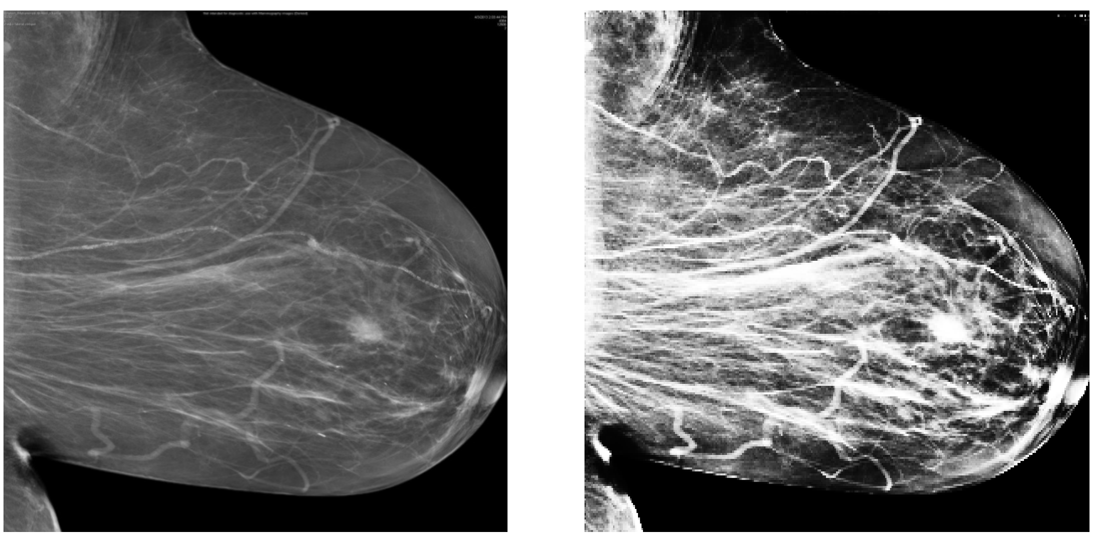
3.7 Methods of data analysis:

The mean and standard deviation of the noise, signal, signal to noise ratio and contrast calculated data from the low and high intensity areas , and scatter plot shows the linear relationship between these quantities before and after enhancement were displayed to fined the coefficient of improvement after enhancement.

Chapter four

The results

The results of this study presented using the: mean intensity, standard deviation, signal, signal to noise ratio in low and high intensity region before and after the enhancement. As well the result presented using scatter plot for the above mention quantities using the data before the enhancement as independent variable and after enhancement as dependant variable with the rate of change as coefficient.

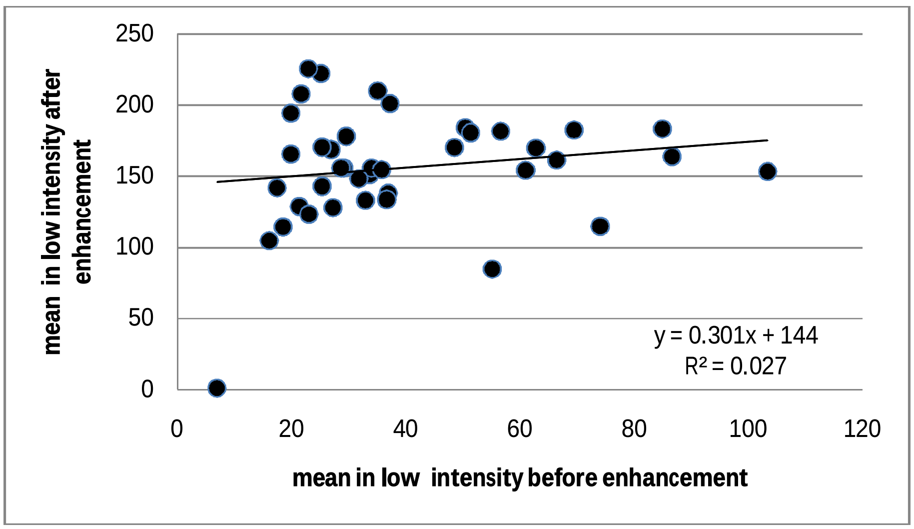


(A) (B)

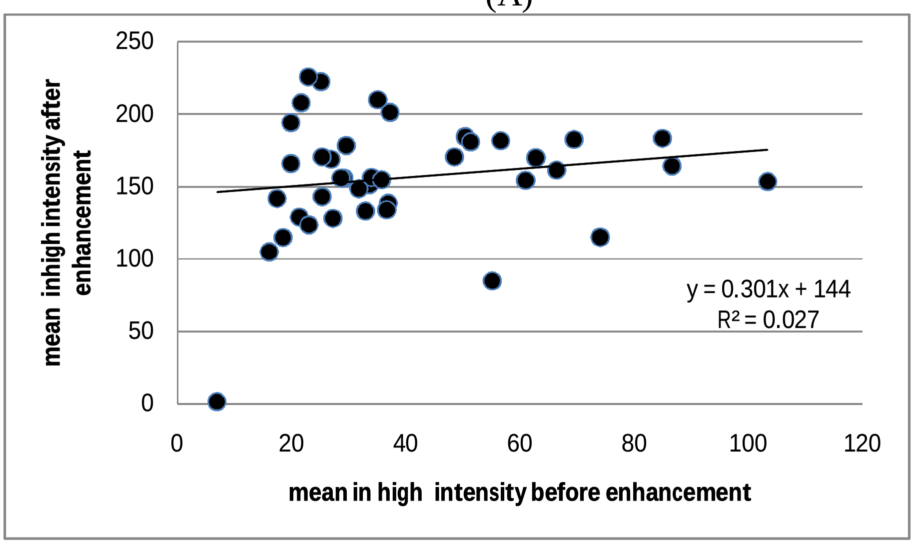
Figure (4.1) Mammography image (A) before enhancement (B) after enhancement

The Table (4.1) show mean signal in low and high intensity region before and after enhancement:

Region of intensity	Mean ± SD
Low area before enhancement	39.7±21.6
Low area after enhancement	63.8±28.2
High area before enhancement	161.6±27.5
High area after enhancement	200.6±23.8



(A)

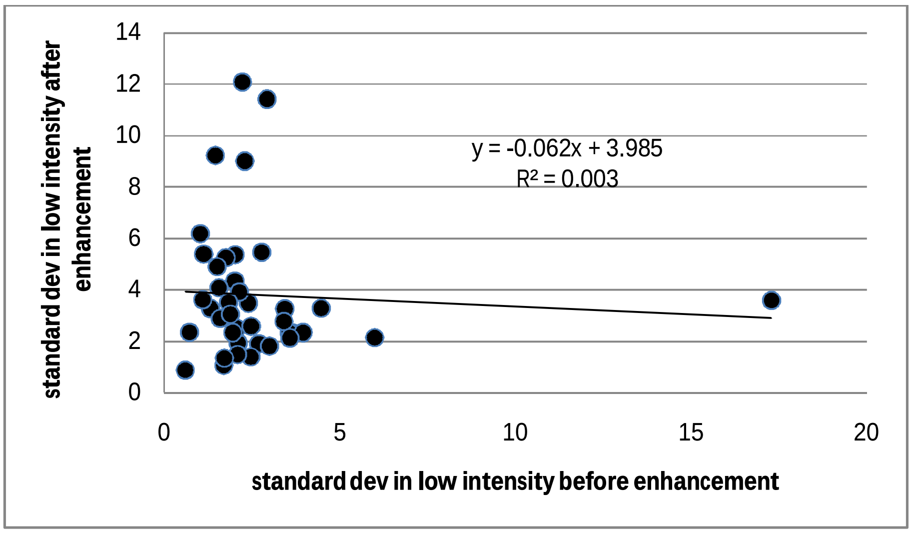


(B)

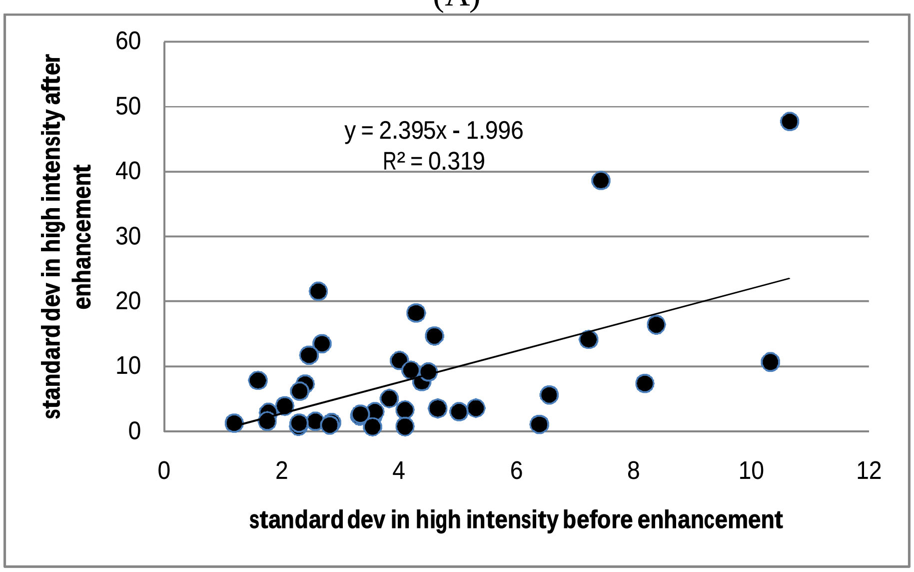
Figure (4.2) scatter plot of the noise in mammography image before and after enhancement, (A) in low intensity area, (B) in high intensity area

The Table (4.2) shows Standard deviation signal in low and high intensity region before and after enhancement:

Region of intensity	**Mean ± SD**
Low area before enhancement	2.3±1.0
Low area after enhancement	4.1±2.1
High area before enhancement	4.0±2.7
High area after enhancement	7.0±7.6



(A)

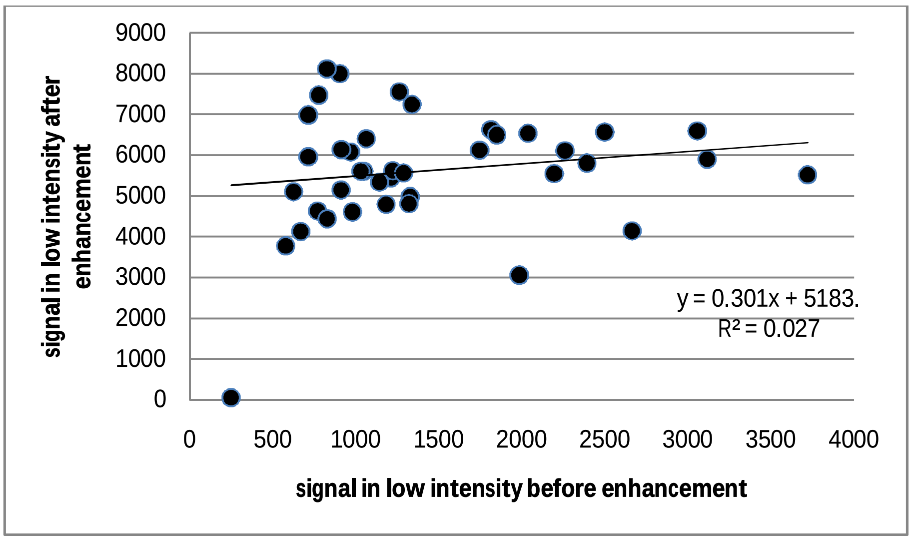


(B)

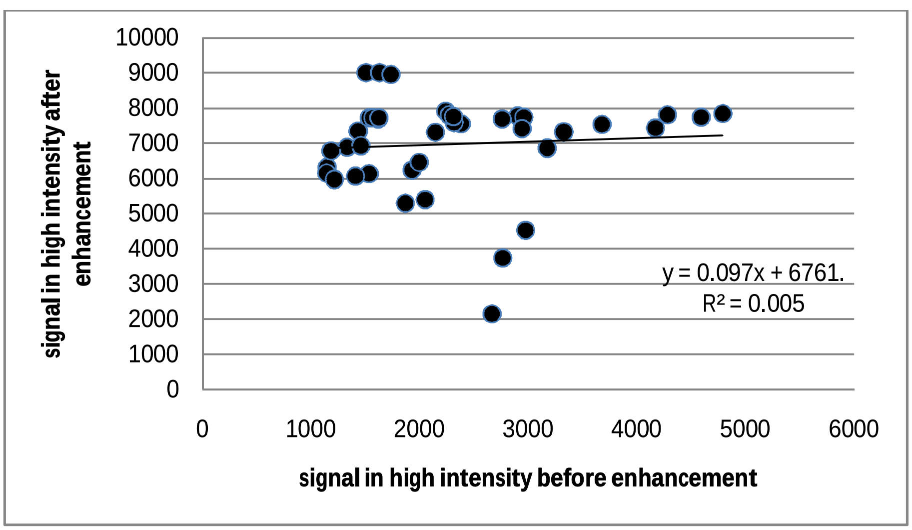
Figure (4.3) scatter plot of the SD in mammography image before and after enhancement in (A) low intensity area and (B) in high intensity area

Table (4.3) shows Signal data in low and high intensity region before and after enhancement:

Region of intensity	**Mean ± SD**
Low area before enhancement	1429.5±776.7
Low area after enhancement	2297.3±1016.2
High area before enhancement	5816.1±989.5
High area after enhancement	7222.8±855.1



(A)

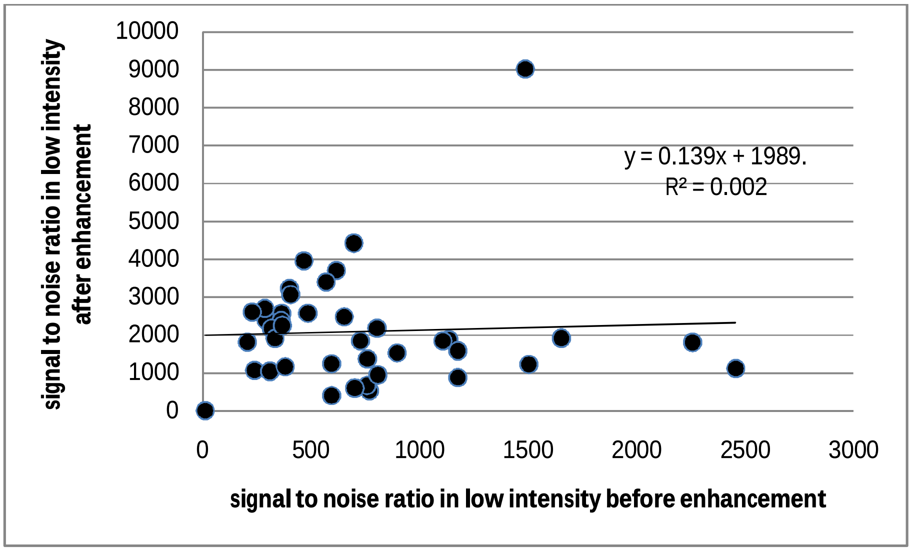


(B)

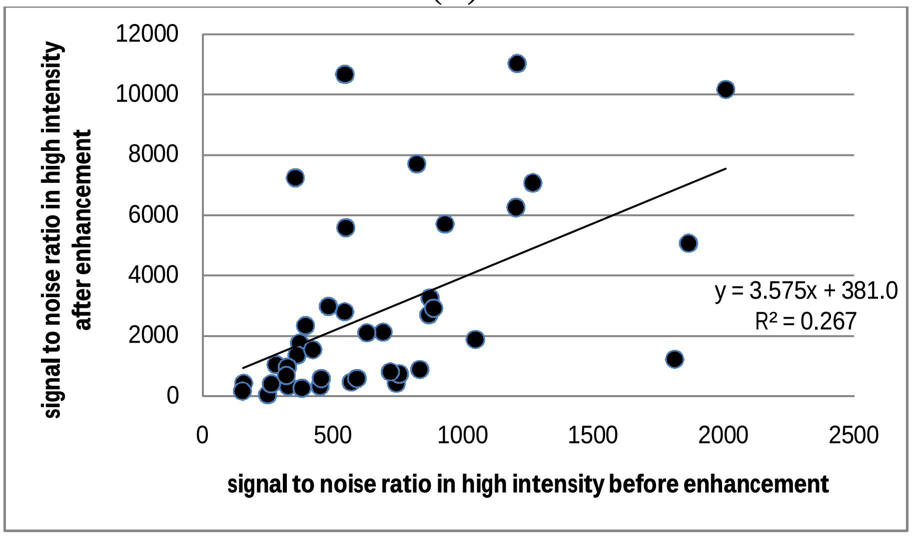
Figure (4.4) scatter plot of the signal in mammogram before and after enhancement (A) in low intensity area (B) in high intensity area.

The table (4.4) show signal to noise ratio in low and high intensity before and after enhancement:

Region of intensity	**Mean ± SD**
Low area before intensity	736.6±536.5
Low area after intensity	697.7±455.7
High area before intensity	1978.1±997.5
High area after intensity	2964.1±3108.7



(A)



(B)

Figure (4.5) scatter plot of the signal to noise ratio in mammogram image before and after enhancement (A) in low intensity area and (B) in high intensity area

Chapter five
Discussion, Conclusion and Recommendations

This study was aimed to enhance mammogram images using image processing technique, the study was done in Modern Medical center, and 40 mammography images were processed using IDL software to enhance the contrast within the breast, reduce the noise, filter the images and find signal to noise ratio and the standard deviation.

5.1 Discussion

The results of this study as shown In Table (4-1) and Figure (4-1 and 4-2) the amount of the mean intensity before and after enhancement respectively for low intensity area was 39.7±21.6 and 63.8±28.2 respectively and for high intensity area was 161.6±27.5 and 200.6±23.8. This result implise that enhancement of the the image increases the intensity in both the low intensity regions and the high intensity linearly, so the imges look more better than before the enhancement from vesual perception point of view and quatitatively, where objects in low intensity areas shows better visibility.

The noise which is represented by standard deviation it shows slight increases after enhancement which record 2.3±1.0 and 4.1±2.1 respectively in the low intensity region. Similar result achived in the high intesity region after enhancement 4.0±2.7 and 7.0±7.6 respectively. The increases in noise were minimum copared to the signal. This is why the image look more plesent to the eye after enhancement (Table 4.2 and Figure 4-3).

The signal of the image also increased after enhancement in the low intensity regions in average from 1429.5±776.7 to 2297.3±1016.2 and for the high intensity regions in average from 5816.1±989.5 to 7222.8±855.1 this result dictate similar essence, that the signal increases linearly after enhacement in the low and high intensity regions since the intensity was increased (Table 4.3 and Figure 4.4). Also this result opivously means the signal to nosie was increased after enhacement in low and high intensity regions from 736.6±536.5 to 697.7±455.7 and from 1978.1±997.5 to 2964.1±3108.7 respetively.

5.2 Conclusion

The main objective of this study was to enhanced mammography images using image processing technique where 40 mammography images were used, in conclusion the results of this study proved that the mammogram imges quality improved as a result of enhancement where the signal to noise was better after enhancement althought noises was encreased as a result of enhancement but the increses were very limited , as well as the used image were digital one where noises were low and enhancment will strach the intensity over low intensity area and hence increase the dynamic range of the grey scale for better perception.

5.3 Recommendations

- The technologist should be trained to handle the image electronically i.e. be able to highlight the region of interest.
- Image enhancement is basically improving the interpretability or perception of information in images and it is important to develop image enhancement program after obtained images.
- Similar study can be done for different organs such as chest, bone and so on.

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