

Enhanced Mammography image for Breast cancer detection using LC-CLAHE technique.

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Abstract

Breast cancer is the greatest challenging health complexities that medical science is facing. Most cases can be prevented by early detection and diagnosis which are the best way to cure breast cancer to decrease the mortality rate. The aim of this research is to obtain a method for enhancing the mammography images by using the proposed method which is incorporating the Local Contrast with Contrast Limited Adaptive Histogram Equalization (LC-CLAHE) to improve the appearance and to increase the contrast of the image and then de-noised by 2D wiener filter techniques. To extract the region of interest (tumor), we used region growing technique for the segmentation process. The standard Mammographic Image Analysis Society (MIAS) database images are considered for the evaluation. Efficiency is measured by Root Mean Square Error (RMSE) and Peak Signal to Noise Ratio (PSNR). It is observed that the proposed method with wiener filter gives higher (PSNR) and lower (RMSE), with a significant filter mask [3 3].

Keyword: Breast Cancer, Image Pre-processing, Image Enhancement, Segmentation, Wiener filter, Root Mean Square Error (RMSE) and Peak Signal to Noise Ratio (PSNR).

I. Introduction

In Yemen, breast cancer is the first of the five most common reported cancers among Yemeni women and, during the last years, it is dramatically growing, it is the most common cancer worldwide of deaths among women [4]. Early detection can survive the people lives because it is easier to treat and prevent the tumor to be expanded [10]. Yemeni breast cancer patients, like others of patients in the Arab countries, this is registered at Aden cancer center for research [4] and at Al-Amal Cancer Hospital. According to the latest WHO data, published in 2017, Breast Cancer Deaths in Yemen reached 1,133 or 0.78% of the total deaths [2].

There are two ways to check any abnormal growing cells either by self-test where every woman can do it monthly using her hand or going to a doctor of mammography [10]. Mammography is the process of using low-dose X-rays to examine the human breast for diagnostic used by the radiologist for breast cancer detection at an early stage [10 and 12], which converts the image into a digital mammogram for viewing on a computer monitor [11].

Usually, mammography images consist of many noises, artifacts in their background and pectoral muscles [1, 12, and 14], as shown in Fig.1. All these areas are unwanted portions that make the radiologist job too difficult to detect and understand the cancer at the primary stages and they are unwanted for feature extraction and classification, as well [9 and 12]. Therefore, standardization of image quality and extraction of region of interest (ROI) is essential to limit the hunt for abnormalities.

The image enhancement techniques play an important role to reduce the noise level of the image, preserving important details and enhancing the contract to improve the detection of mammographic features [6 and 11]. The proposed method consists of two main steps, including Pre-Processing and Segmentation, Mini-MIAS database [16] of mammograms that are used for evaluating this method.

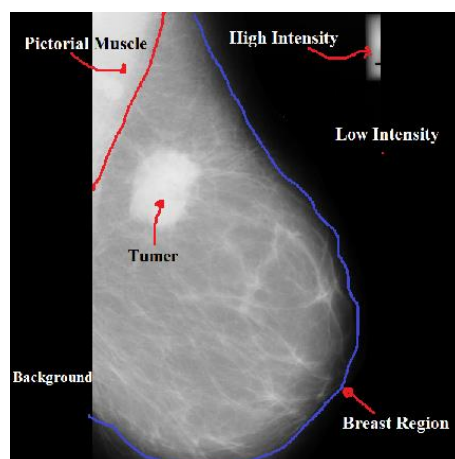


Fig.1: Types of noises observed in original image

II. RELATED WORK

In 2016, RanjitBiswas et al. [12] proposed a system for classification of mammogram images based on GLCM by applying different classifiers. The system is divided into five stages to classify mammogram images. The first step is the data set collection, the second is ROI extraction process, the third is the preprocessing steps which is again divided into two steps filtering and enhancement, the fourth is the feature extraction from GLCM, and the last stage is classification.

In June 2016, Aziz Makandar, et al. [1] proposed a method for enhancing mammography images that works in three stages. The first step is to remove the background artifacts, the second is to reduce the pectoral muscle, and the third the digital mammography enhanced by using Wiener filter and CLAHE.

In 2016, LotheSavita A, et al. [9] proposed a segmentation of mass, using seeded region growing method. The developed CAD system for segmentation of mass consists of image processing techniques as preprocessing, enhancement, and segmentation.

In January 2017, A.P.Charate, et al. [3] proposed a method to improve the mammogram image quality and made it ready for the segmentation and feature extraction. Different types of filtering techniques are available for preprocessing. Filters are used to improve image quality, to remove the noise, to preserve the edges within an image, and to enhance and smoothen the image.

III. PROPOSED METHOD

In the proposed work, the breast cancer detection is implemented by a method that accepts a mammographic image and detects any tumor (benign or malignant) regions that may appear in the image, identified as shown in Fig.2. Pre-processing is the use of Local Contrast (LC), based on Contrast Limited Adaptive Histogram Equalization (CLAHE), followed by Wiener filter. This way produces better contrast of the image, compared with [1 and 12]. The LC-CLAHE highlights the finer hidden details in mammogram images and adjusts the level of contrast enhancement. Finally, the segmentation stage is used to extract the tumor from the background tissue.

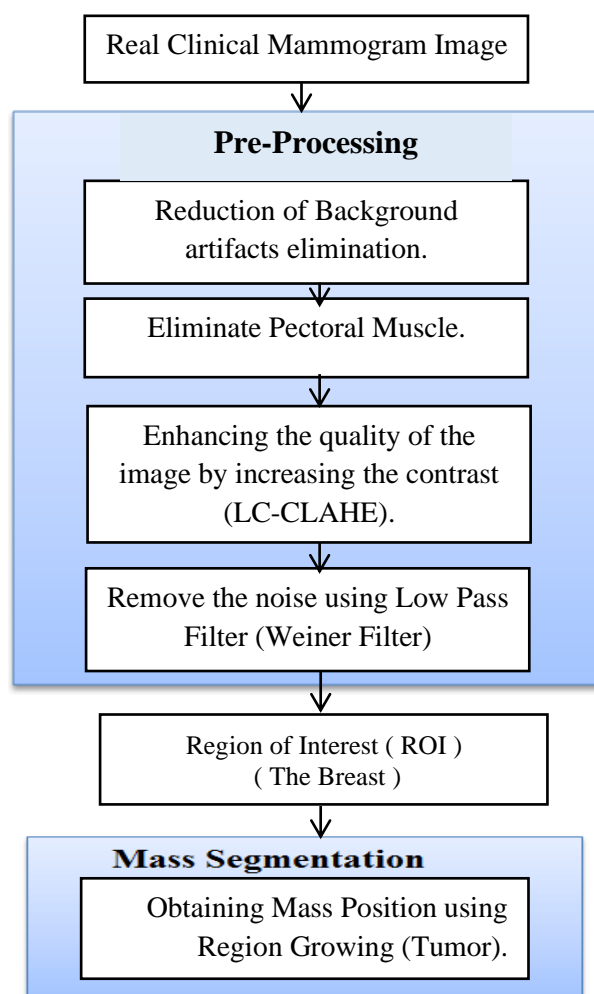


Fig.2: Block diagram of proposed method.

1. Dataset Description

The mammogram images were obtained from the Mini-MIAS data set. Mini-MIAS is an organization of the UK research groups interested in the understanding of mammograms and has generated the digital mammograms dataset for their research. It consists of 322 images of left and right breast, which contains normal and abnormal images (benign and malignant) [5 and 12]. The expert radiologists spot general details about the mammogram images, just like the location, the size of 1024×1024 pixels, the radius of the abnormalities [12], and cover all types of images such as Fatty, Fatty-Glandular and Dense-Glandular. Data set of medical images are available online for research purpose in Pilot European Image Processing Archive (PEIPA) at the University of Essex [1, 15, and 16].

2. Pre-Processing

Pre-process any image is considered to be the basic step in image processing technique [5, 12]. The aim of this step is to improve and enhance the quality or features of the image that suppress unwanted noise, poor image contrast; and unrelated parts are usual traits of clinical images with the filtering techniques [5, 10, and 12]. Pre-processing a digital mammography images increase the reliability of an optical inspection which uses the considerable redundancy of the images [5 and 13].

2.1.Reduction of background and the artifacts

The traditional method for removing the background is by using histogram method. The image is binarized by identifying the threshold value from histogram (black and white image), where the white area consists of pectoral muscle, breast and the artifacts. This binarized image will be multiplied with the original image to reduce background and the artifacts, as shown in Fig.3.

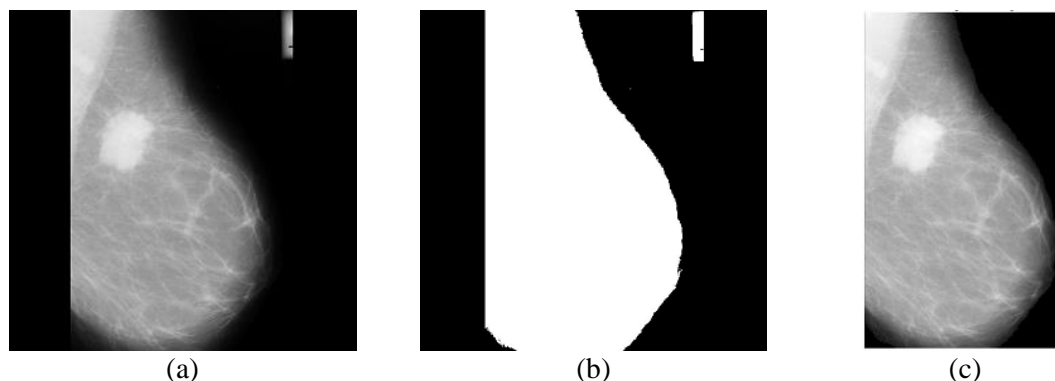


Fig.3: Suppression of background and artifacts (a) Original grayscale image with artifact and label (b) Binary Image with threshold value 0.1 (c) Reduction of background and artifacts.

2.2.Eliminating the Pectoral Muscle

To eliminate the pectoral muscle part, the region growing technique has been used [1]. Since the pectoral muscle contains the majority of the brightest pixels in the breast profile, so the contrast of the breast profile needs to be enhanced such that the grayscale pixels in the pectoral muscle become brighter. Region growing is a region-based method starting with seeds point areas of an image with homogeneous properties, and propagating seeds are growing until the specified boundary is satisfied [7 and 9]. This technique determines the neighboring pixels of the seed point if it is similar to the same region or not, to extract the region of interest (breast) which contains the abnormalities [1]. This process is iterated until the hole breast is extracted, as shown in Fig.4.

Therefore, in the proposed work, the orientation of the seed point is selected automatically by using the centroid of the object computed from the hole area of the image. After the region growing process is completed, the region of interest (breast, white pixels) is obtained [7], as shown in Fig.4. As a result of ROI, the fundamental step is used in the next step as an input for the segmentation to extract the tumor [9 and 10].

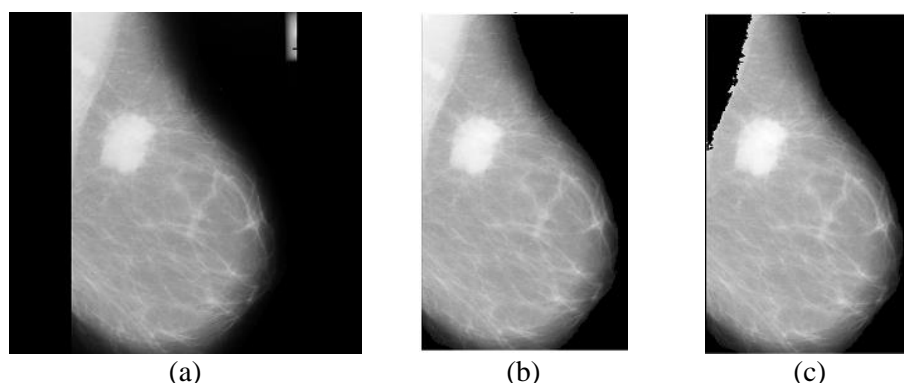


Fig.4:Eliminating the pectoral musclewith the proposedmethod (a) Original Image (b) Reduction of background and artifacts (c) Eliminate the pectoral muscle.

2.3. Image Enhancement

Image enhancement is the process of adjusting digital images to get suitable results for analysis [1 and 10]. So, this way for enhancing the fine details which are hidden in the mammogram image by using the Local Contrast (LC) enhancement, followed by the standard Contrast Limited Adaptive Histogram Equalization (CLAHE) to adjust the level of contrast because local details in mammogram images are more important than global details for the detection of mass cells. Therefore, incorporating LC with CLAHE produces an optimal contrast enhancement with all local hidden details in mammogram images which may not be obtained, using standard CLAHE.

2.4. Removing the Noise

Weiner filter technique is used to remove the noise. It is a low-pass filter with gray scale image that has been degraded by constant power additive noise that uses a pixel wise adaptive Wiener method, based on statistics estimated from a local 3-by-3 connected neighborhood of each pixel [8 and 17], as shown in Fig.5.

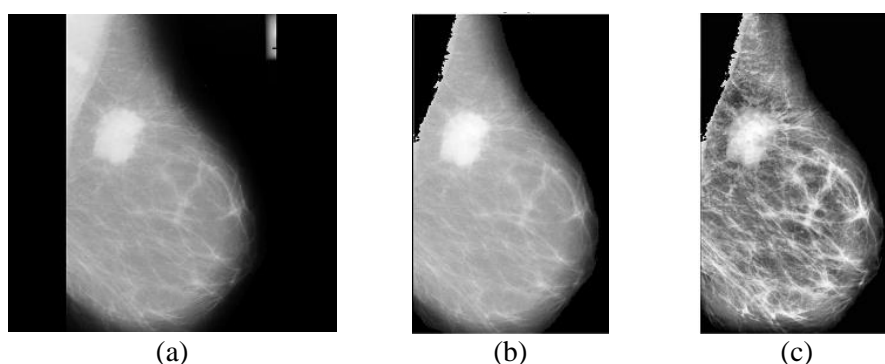


Fig.5: Noise Removal with the proposed method (a) Original Image (b) Eliminate the pectoral muscle (ROI) (c) Weiner filter with the proposed method.

To evaluate the quality of the image, it was measured by the Root Mean Square Error (RMSE), and Peak Signal to Noise Ratio (PSNR) on different mammogram images, they are reciprocal to each other. PSNR and RMSE values are calculated and compared with median filter technique. The PSNR and RMSE are presented in equation (1) and (2) respectively [3 and 12].

$$\text{RMSE} = \sqrt{\frac{1}{mn} \sum_{i=1}^m \sum_{j=1}^n (x(i,j) - y(i,j))^2} \quad (1)$$

$$\text{PSNR} = 10 * \log_{10} \left(\frac{256^2}{\text{RMSE}} \right) \quad (2)$$

Where x the matrix data of the original image and y is the noisy approximation. In the previous equations, m and n are the number of rows and columns in the input images, respectively, i and j represents the index of that rows and columns respectively. Then, the block computes the PSNR. In this paper, the mask for Wiener filter is used, and the best mask value is [3 3] due to best PSNR.

3. Segmentation

The segmentation process separates the tumor region from the breast tissue in the mammogram images [7 and 9]. In the proposed method, the region growing segmentation method is used to extract the tumor, as given in Table 2. Mass in mammography is one of the subjects to identify the abnormality. Usually, abnormality of mass is identified by its shape, margin, and intensity.

3.1. Obtaining Mass Position (Tumor)

Using pixel information to adjust the seed point is the simplest region-based image segmentation method [7 and 9]. The same operation is done when eliminating the pectoral muscle part. Fig.6 shows the example of region growing [9].

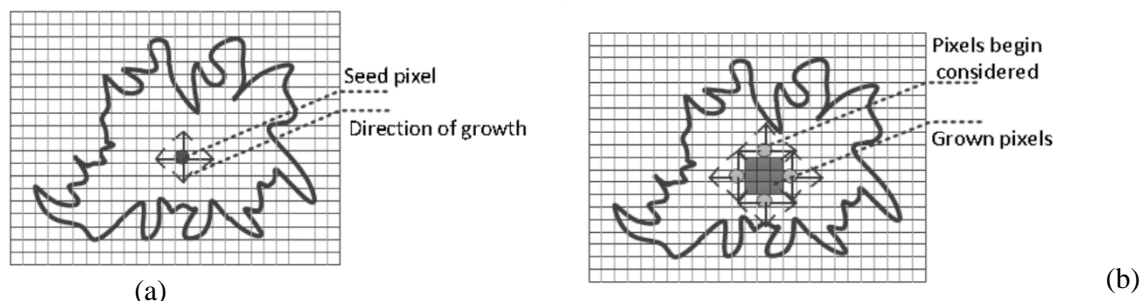


Fig.6: The region growing.

The basic formula for the region growing is denoted by R that presents all the pixels in the image, and let H be a logical predicate defined on a set of contiguous image points. Then, equation (3), presents the segmentation that can be defined as a partition of R into disjoint non-empty subsets $R_1, R_2, R_3, \dots, R_n$ which means that the growing operation will complete when every pixel in a region must be disjoint. Equation (4) implies that the regions must be connected. This requirement is very important, it affects the central structure of the region growing process, in that the sequence of pixels are processed and often proceeds according to neighbor relationships [7].

$$R = \bigcup_{i=1}^n R_i \quad (3)$$

$$R_i, i = 1, \dots, s \text{ is connected} \quad (4)$$

$$R_i \cap R_j = \emptyset \quad i \neq j \quad (5)$$

$$H(R_i) = \text{TRUE} \quad \text{for } i = 1, 2, \dots, n \quad (6)$$

$$H(R_i \cup R_j) = \text{FALSE} \quad \text{for } i \neq j, \quad \text{where } R_i \text{ adjacent to } R_j \quad (7)$$

The regions must be disjointed as indicated in equation (5). Equation (6) H states the property that the pixels must have a similar property to be in a segmented in the same region, for examples, the color distribution homogeneous. Equation (7) shows that regions R_i and R_j are different in the sense of predicate H [7].

IV. Experimental Result and Discussion

In this paper, MIAS (Mammographic Image Analysis Society) dataset is used and images, which include both cases of tumor (malignant and benign), are selected randomly. This work has been implemented by using MATLAB R2018a.

The image quality is measured by PSNR and RMSE. As a result, the use of Wiener filter gives higher PSNR and lower RMSE for all tested images, as shown in Fig.7 and Fig.8. So, it is suitable for noise removal from mammography image which is better than Median filter.

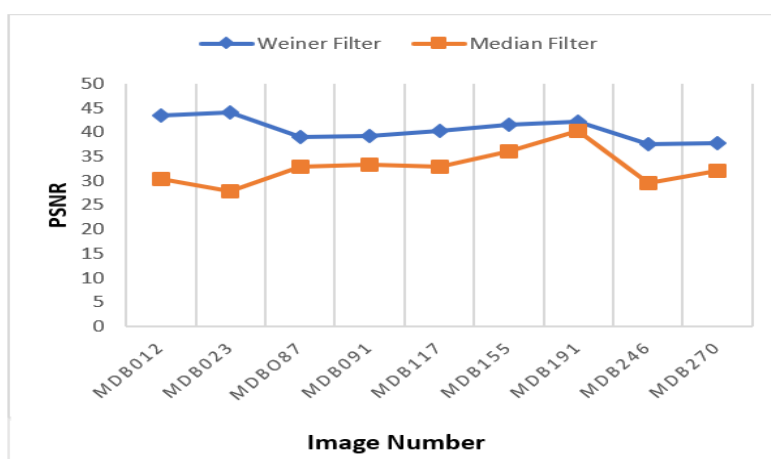


Fig.7: PSNR comparison of different filters.

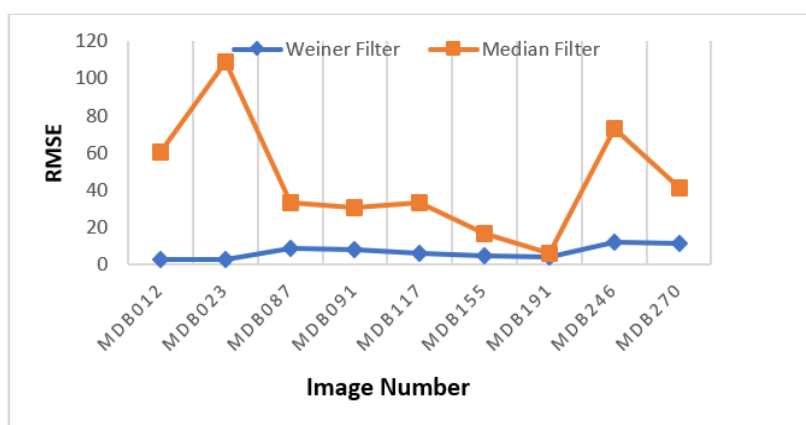


Fig.8: RMSE comparison of different filters.

From Table 1, it is clearly shown that the proposed method is affected better on the dense-glandular mammogram images for noise removal by producing higher PSNR.

Table1: PSNR VALUES OF DIFFERENT TYPES OF MAMMOGRAMS IMAGES.

Image type No.	PSNR Values		
	Fatty	Fatty-Glandular	Dense-Glandular
1	43.3808	38.687	39.1808
2	39.8989	39.6199	40.567
3	39.2113	40.5645	43.844
4	37.5239	42.1658	42.3186
5	38.8569	40.1986	40.2774
6	41.311	38.7878	41.081
7	39.4922	44.0796	41.5717
8	41.4204	39.9948	39.5362
9	39.8311	41.6779	40.4111

Fig.9 illustrates the comparison results of the contrast enhancement between the CLAHE method and the proposed work. These results suggest that the quality of the mammography images are enhanced by using LC-CLAHE technique, which provides a better contrast enhancement, compared with [1 and 12] which used CLAHE method.

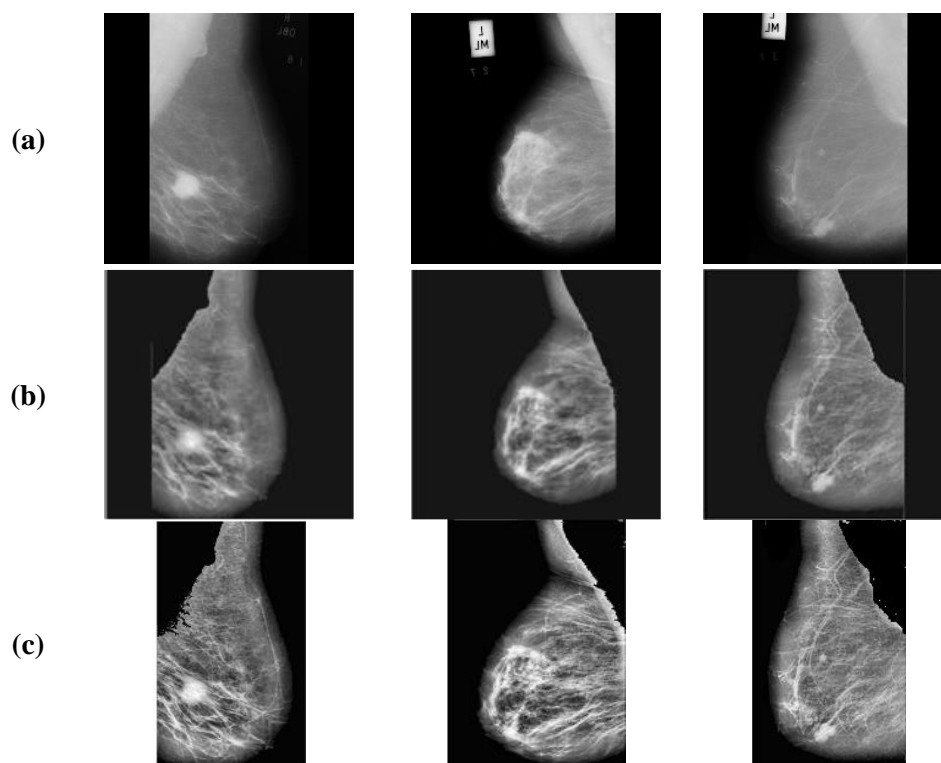


Fig.9: Comparison results of Enhanced Image (a) Original Images (b) CLAHEmethod (c) LC-CLAHE (proposed method).

Since Wiener filter with the proposed method presented better results than Median filter, it will be tested with different filtering mask from [1 1] to [8 8] to select a significant filter mask for Wiener filter.

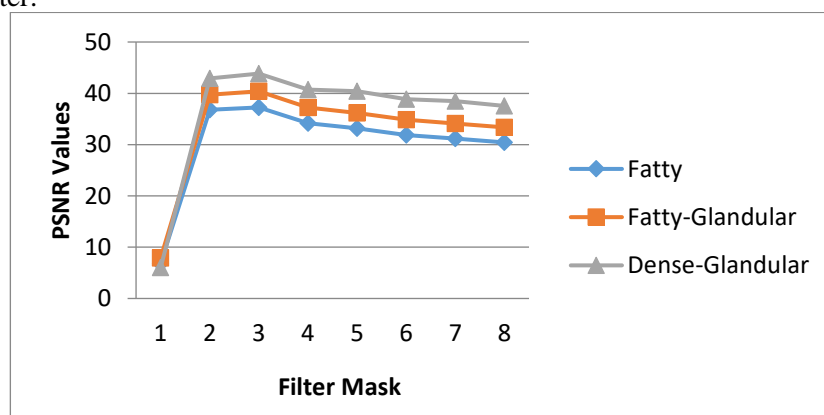


Fig.10: PSNR values of Wiener filter mask from [1 1] to [8 8].

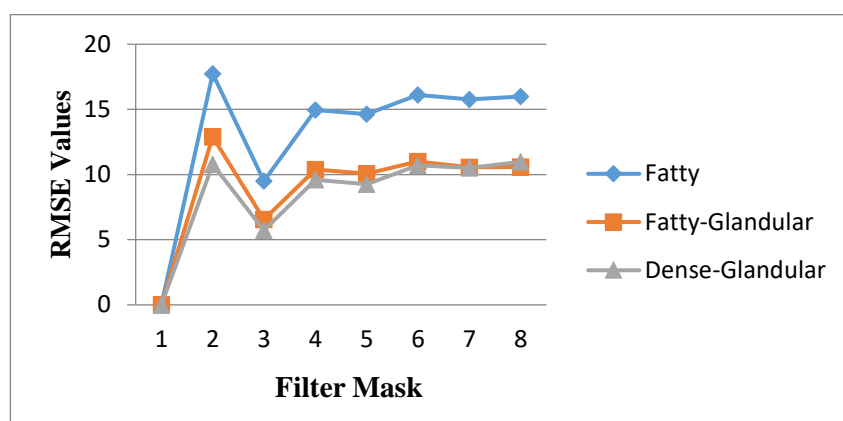


Fig.11: RMSE values of Weiner filter mask from [1 1] to [8 8].

From Fig.10, the PSNR values increased from filter mask [1 1] to [3 3] and RMES values are decreased, as shown in Fig.11. The optimal values of the mask are [3 3], after this value the PSNR values are decreased and the image becomes not clear. We select the average of contrast index in this paper which is (0.0012). It is clearly shown in Fig.12.

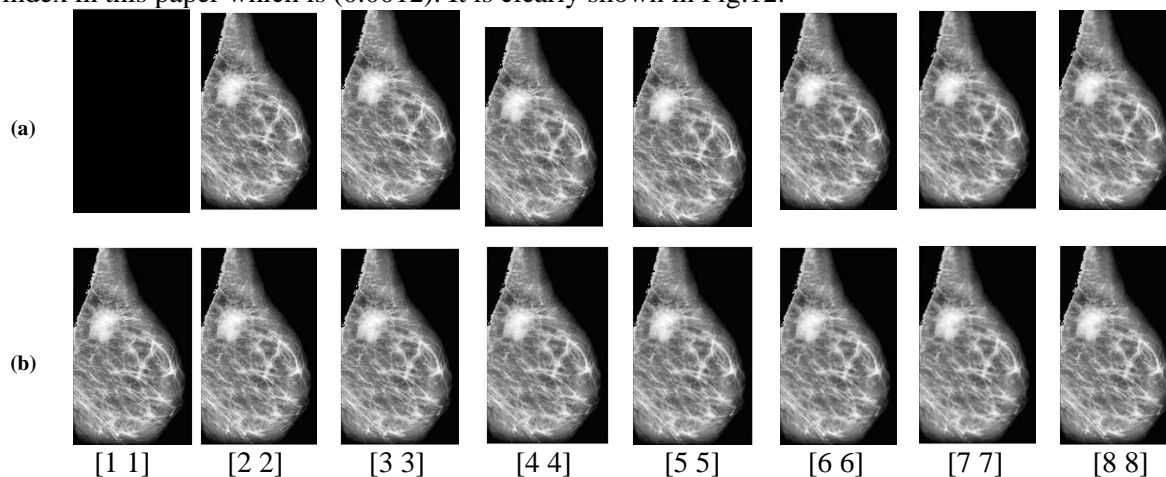
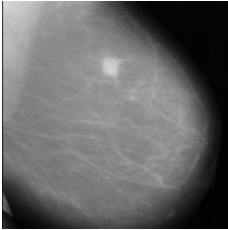
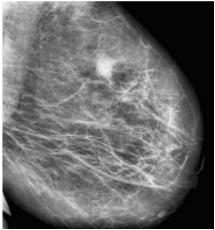
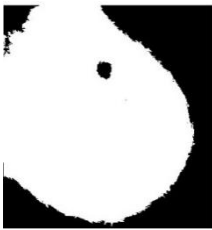
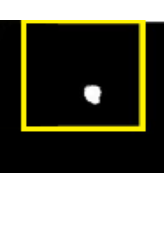
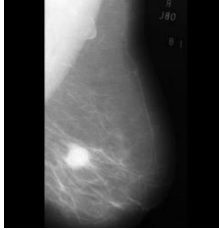
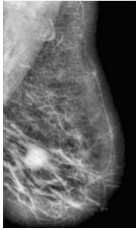


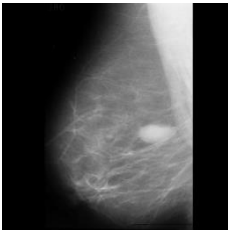
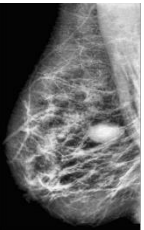




Fig.12: (a) PSNR without contrast index (b) PSNR with the contrast index.

A mass screened on a mammogram can be either benign or malignant depending on its shape. Benign tumors usually have round or oval shapes although malignant tumors have a partially rounded shape with a spiked or irregular outline. Table 2 presents the experiment result after applying region growing method on the mammogram image.

Table 2: EXPERIMENTAL RESULT FOR MASS SEGMENTATION.

Image No.	Original Image	Enhanced Image	Segmented Region	Tumor
mdb134				
mdb028				
mdb025				

CONCLUSION

In this paper, the comparison between CLAHE method and the proposed method (LC-CLAHE) has been presented. The mammogram images, such as fatty, fatty-glandular and dense-glandular of Mini-MIAS dataset, are used in the experiment.

The proposed method of pre-processing is presented with removing the background noise and pectoral muscle with image quality of the mammogram images. This method is enhanced by incorporating LC with CLAHE. The optimal contrast is enhanced with all local hidden details in mammogram images that may not be obtained using standard CLAHE and Wiener filter. Therefore, the proposed method gives higher PSNR and lower RMSE for all tested images than the CLAHE method.

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صورة محسنة للثدي للكشف عن سرطان الثدي باستخدام تقنية LC-CLAHE

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المخلص

يعد سرطان الثدي أحد أكبر التحديات التي تواجه العلوم الطبية تعقيداً. يمكن تجنب الإصابة عن طريق الكشف والتشخيص المبكر، وهي أفضل طريقة لعلاج سرطان الثدي لتقليل معدل الوفيات. الهدف من هذا البحث الحصول على طريقة لتحسين صور التصوير الشعاعي للثدي باستخدام الطريقة المقترحة التي تدمج معادلة التباين المحلي مع التباين المحدود (LC-CLAHE) لتحسين المظهر وزيادة تباين الصورة، ومن ثم إلغاء الضوضاء عن طريق تقنية الفلتر Wiener 2D. ولاستخراج المنطقة الورم استعملنا تقنية التجزئة. استعملت الصور القياسية لقاعدة البيانات للتصوير الماموجرافي (MIAS) من أجل التقييم. قيسَت الكفاءة عن طريق خطأ متوسط الجذر التربيعي (RMSE) ونسبة الإشارة إلى الضوضاء (PSNR). يلاحظ أن الطريقة المقترحة مع مرشح Wiener تعطي أعلى (PSNR) وأقل (RMSE)، مع قناع مرشح كبير [3 3].

الكلمات المفتاحية: سرطان الثدي، المعالجة المسبقة للصور، تحسين الصورة، التجزئة، الفلتر Wiener، نسبة الخطأ في تحديد نقطة الجذر التربيعي (RMSE) ونسبة الإشارة إلى الضوضاء (PSNR).