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Mammography Image Enhancement using Linear, Nonlinear and Wavelet Filters with Histogram Equalization

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Abstract

In the worldwide, breast cancer is one of the major diseases among the women. In the modern medical science, there are plenty of newly devised methodologies and techniques for the timely detection of breast cancer. However, there are difficulties still exist for detecting breast cancer at an early stage for its diagnoses because of poor visualization and artifacts present in the mammography. Thus the Digital mammographic image preprocessing often requires, enhancement of the image to improve the quality while preserving important details. The proposed method works in three stages. First it removes all the artifacts present in the image. Second it denoise the image by using Linear, nonlinear and wavelet filters. Third, contrast of the image increased by histogram equalization. This method definitely helps to computer aided diagnosis system to increase the accuracy. The experimental results are tested on two standard datasets MIAS and DDSM.

Keywords: Breast Cancer; Mammography; Medical Image Processing; Wavelet filters; Contrast Enhancement.

1. Introduction

In the worldwide, breast cancer is one of the major diseases among the women. In the modern medical science, there are plenty of newly devised methodologies and techniques for the timely detection of breast cancer. Thus, early detection of breast cancer prognosis is an important step towards treating a patient since the causes of the disease are still unknown to us [1].

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Breast cancer has become a significant health problem with the women. Currently, mammography is the most frequently adopted methods for early detection. Today early cancer diagnosis cannot be achieved exactly [2]. Many researchers working on breast cancer imaging to get desired result but still it remains challenging. Sequence approaches, such as image de-noising and enhancement, edge detection for microcalcification detection; texture analysis and cancerous and non-cancerous cell classification have been employed in order to solve the underlying problem [3-6]. All the medical images consist of many errors like noise, low contrast, weak boundaries etc. The pre-processing is fundamental steps in the medical image processing to produce better image quality for segmentation and feature extractions. The preprocessing steps deal with image enhancement, noise and special mark removal. To highlight the features of the lesion region and improve the visual effect of the mammogram, the most commonly used technique is quality improvement of the mammography image in preprocessing [7-9]. Thus the proposed preprocessing techniques for mammographic images definitely improve the accuracy of detection of early signs of breast cancer.

2. Literature Review

Table 1: Existing de-noising techniques for mammography

Author's	Noise Models	Filtering Techniques	Result
R. Ramani, Dr. N.Suthanthira, S. Valarmathy [10]	Gaussian noise, Speckle noise, Salt and Pepper noise	Adaptive median filter, mean filter, wiener filter	Prominent result from Adaptive median filter
Xinsheng Zhang, Hua Xie [11]	Noises from labelling and weak edges	Non subband conterlet, transform filter and spatial filter	Non sub and conterlet is robust filtering techniques
P. Mayo, F. Rodenas, G. Verdu [12]	Gaussian noise	Adaptive wiener filter, donoha wavelet shrinkage, inter dependent component analysis filter	All techniques are good to reduce Gaussian noise
Tajinder Kaur , Manjit Sandhu , Preeti Goel, Harpreet Singh [13]	Spackle noise, salt and pepper noise	wavelet, forst, SRAD(Speckle reducing anisotropic Diffusion), multiscale Ridglet	Multiscale Ridglet
Vishnukumar K. Patel, Prof. Syed Uvaid, Prof. A. C. Suthar [14]	Impulse noise, random noise	Wiener filter, multiwavelet based, neigh shrink and visual shrink	Multiwavelet based
Kother Mohideen, Arumuga Perumal, Krishnan and Mohamed Sathik [15]	Gaussian noise	Multiwavelet denoising techniques	Three level multiwavelet decomposition and fourth level multiwavelet decomposition gave optimum results.

We reviewed and compared some of the de-noising methods of the mammography image. R. Ramani and his colleagues [10], Xinsheng Zhang and Hua Xie [11], P. Mayo and his colleagues [12], Vishnukumar K and his colleagues [13], Kother Mohideen and his colleagues [14] and Tajinder Kaur and his colleagues [15] and so on listed in the table 1.

By the review we found that the noise models observed in mammography are salt and pepper noise, Gaussian noise and speckle noise. Currently, contrast stretching, histogram equalization spatial domain filtering, frequency domain filtering, mathematical morphology etc. are the major commonly used image preprocessing techniques. Although those techniques have achieved good enhancement results to some extent, however, it is still far from being satisfactory because difficulties still exist for detecting breast cancer at an early stage for its diagnoses because of poor visualization and artifacts present in the mammography. Thus the Digital mammographic image preprocessing often requires.

3. Material and Methods

3.1. Dataset Used

For testing and analysis of the proposed algorithm, we have used two standard dataset such as Mammographic Image Analysis Society (mini-MIAS) database and DDSM

MIAS Database

MIAS dataset, organized by J Suckling and his colleagues in 1994 [16]. It consists of 322 images of normal, benign and malignant type with fatty, glandular and dense tissue. All the images were taken in the UK National Breast Screening Programme (NBSP) digitized to 50 micron pixel and reduced to a 200 micron pixel and padded, all the images are in 1024×1024 size.

DDSM Dataset

Digital Database for Screening Mammography [17] is the mammographic dataset designed under the project of breast cancer research program, US Army medical research and material command collaborative with co-p.i.s at the Massachusetts General Hospital, University of South Florida and Sandia National Laboratories. Images are collected by 2500 studies with the details of ground truth information of location and region of abnormality.

3.2. Methodology

The proposed method works in three steps, first removal of background and pectoral muscle, second denoising the image and contrast enhancement of the image using histogram equalization as shown in figure 1.

Removing Background and Pectoral Muscle

Initially image is binirized with threshold values 0.1 then the breast profile is extracted by rearranging the connected components in descending order. The pectoral muscle removed by selecting the seed point based on orientation of the image, if the image is left oriented then the seed point is left top corner otherwise seed point is right top corner. Based on seed point single seed region growing technique is applied to suppress the pectoral muscle from the breast profile.

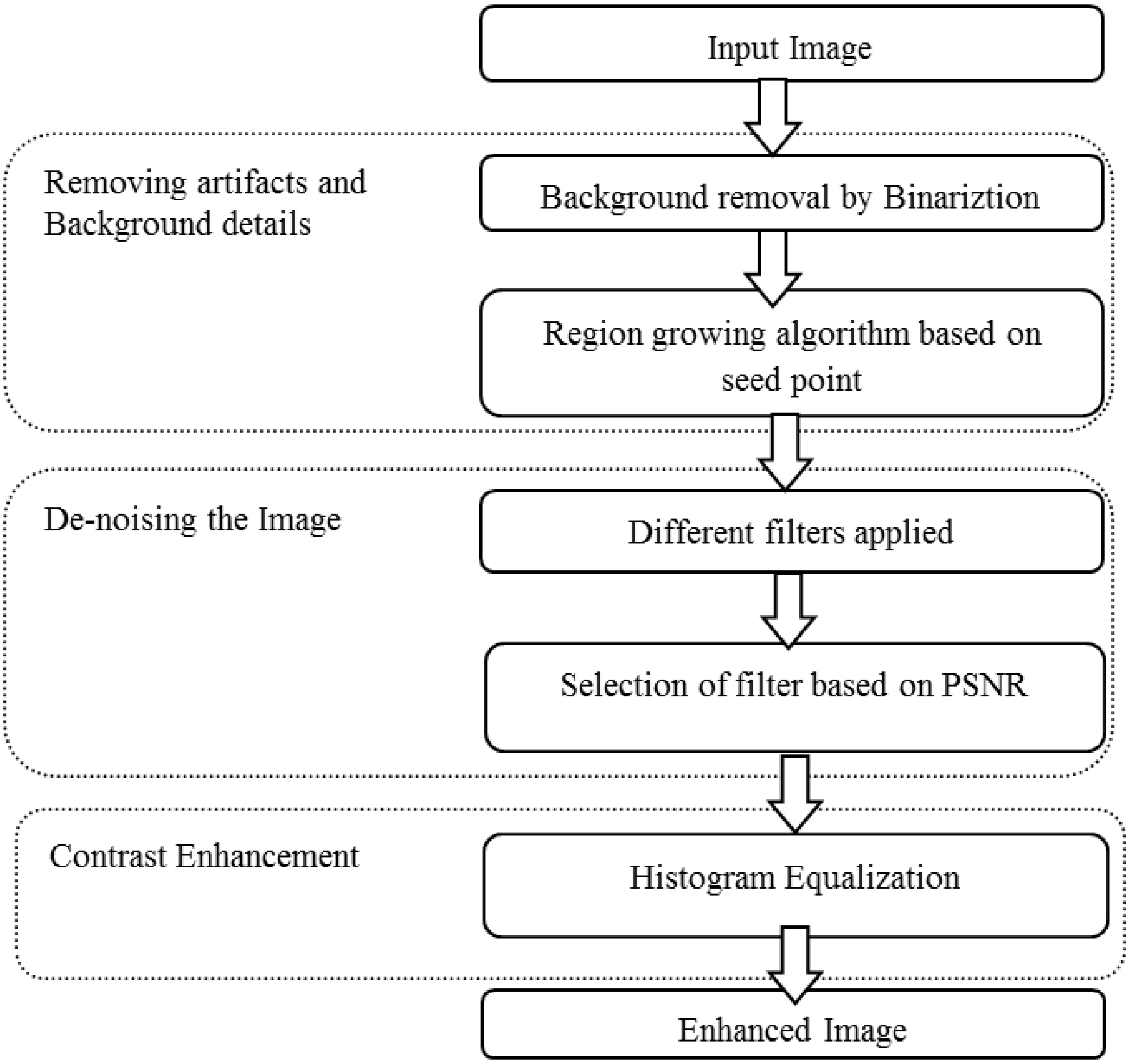

Figure 1: Flow of proposed method.

Denoising using Linear and Nonlinear filtering techniques

All the medical images required filters because they are affected with noise and unwanted data. Filtering helps to smoothen and sharpen the image along with removing the noise which helps to discriminate the boundry between required object and background [18-20]. It also helps to interpret the visual information from the image that further helps to computer aided processing. Filtering is evaluation of each pixel value also reevaluating the pixels after transformation carried out on the image using linear or non-linear types. The limitation of linear filter is blurring the image whereas non-linear filter helps to smoothen the image without blurring and also helps to detect edges clearly. The proposed method uses filters such as Gaussian, Average, Disk, Motion, Median, Order and Wiener filters as shown in figure 2; among these entire filters wiener filter is suitable to de-noise the mammography image.

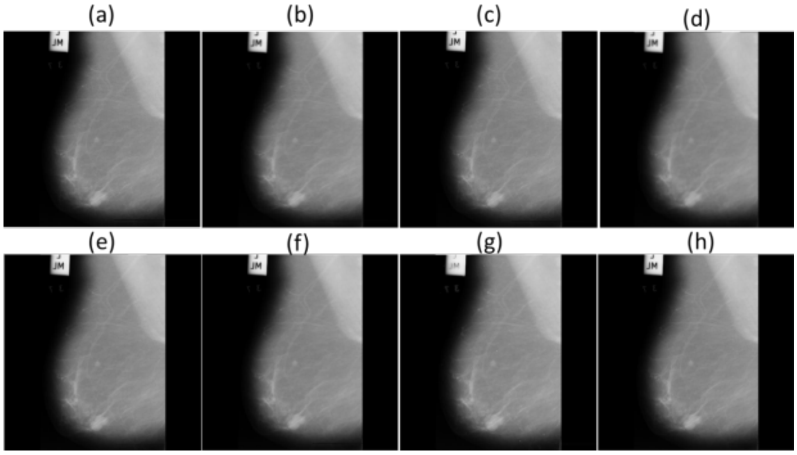

Figure 2: (a) Original Image (b) Average filter © Motion filter (d) Gaussian Filter (e) Disk filter (f) Wiener filter (g) Order Filter (h)Median filter

Denoising the image using Wavelet filters

The wavelet is the application in different fields of medical imaging such as denoising, segmentation, enhancement, compression, image matching and other medical image technologies [21]. It allows complex patterns of the image and signal processing and these patterns to be decomposed in different levels and reconstructed with high precision. Initially wavelet introduced by Morlet[22]. Then Mallat [23] introduced the fast wavelet transform. The DWT is wavelet transform using discrete set of scales and translations followed by some rules. To use a wavelet it is necessary to discretize with respective to scale parameters i.e sampling [24]. The scale and translation parameters are given by, S=n1-m and T=n2-m where m ,n are the subset of all integers. Thus, the family of wavelet is defined in equation 1.

$$\psi_{m,n}(t) = 2^{m/2}\psi(2^m t - n) \quad (1)$$

The wavelet transform decomposes a signal x(t) into a family of waveletsas given in equation 2 and

$$x(t) = \sum_m \sum_n c_{m,n} \psi_{m,n}(t) \quad (2)$$

Where

$$c_{m,n} = \langle x(t), \psi_{m,n}(t) \rangle \quad (3)$$

For a discrete time signal x[n], the decomposition is given by:

$$x[n] = \sum_{i=1 to I} \sum_{k \in Z} c_{i,k}\, g[n - 2^i k] + \sum_{k \in Z} d_{I,k}\, h_I[n - 2^I k] \quad (4)$$

In case of images, the DWT is applied to each dimensionality separately. The resulting image X is decomposed in first level is xA, xH,xV and xD as approximation, horizontal, Vertical and diagonal respectively as shown in figure 3. The xA component contains low frequency components and remaining contains high frequency components [25].

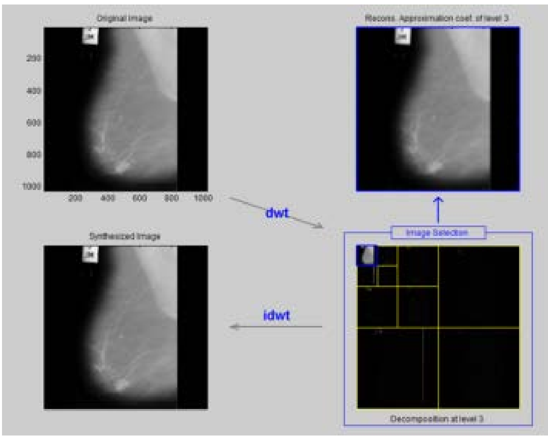

Figure 3: Wavelet Decomposition of level 3

The proposed denoising method uses the three level decomposition is used for different filters as shown in the figure 4 Haar, Daubechies, Symlets, Coiflets and Biorthogonal. Comparing all the filtering techniques with Signal to Noise Ratio (SNR) the debauchee is giving the highest SNR hence for denoising the image debauchee wavelet filter is selected with three level decomposition and soft thresholding.

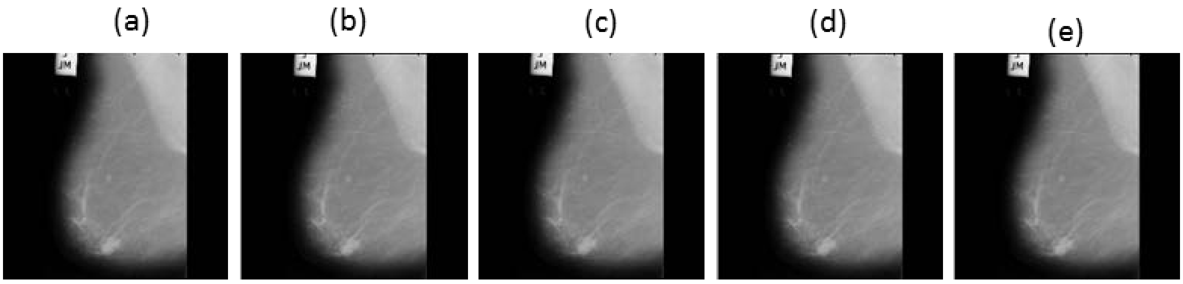

Figure 4: (a) Haar (b) Daubechies (c) Symlets (d) Coiflets and (e) Biorthogonal

Contrast Enhancement

Enhancement of the image increased by contrast limited adaptive histogram equalization (CLAHE) [26]. It is one of the well-known technique in which range of the contrast is modified in such way that histogram should give required shape based on cumulative distribution function. Peak of the histogram stretched through the intensity level is basically called adaptive histogram equalization (AHE) [27] it helps increase the local contrast of the image. Hence the improved version of histogram equalization is CLAHE in which image is divided into number of tiles and contrast of the each tile is increased. The histogram of the enhanced image matches to the uniform distribution which helps to eliminate artificially induced boundaries.

4. Results and Discussion

The evaluation of image quality is crucial for medical imaging systems such as compression, transmission and enhancement. Quality of the image measured by traditional methods [28] Root Mean Square Error (RMSE), Peak Signal to Noise Ratio (PSNR) and Image Quality Index (IQI) on different images with different levels of Contrast Index (CI). The RMSE values and PSNR values are reciprocal to each other and calculated by using following equation 1 and 2 respectively.

$$RMSE = \sqrt{\frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}\big(x(i,j) - y(i,j)\big)^2} \qquad (1)$$

$$PSNR = 10\log\frac{(2^n-1)^2}{RMSE} \qquad (2)$$

The experimental results shows that the comparing different linear and non-linear filters with PSNR and RMSE values. The values are tabulated in Table 2 and Figure 5. Comparing these values of linear and nonlinear filter, wiener filter gives lower RMSE and High PSNR values.

Table 2: RMSE and PSNR values of linear and non-linear filters

Filters	RMSE	PSNR
Gaussian	0.0003	83.4979
Average	0.0015	76.3295
Disk	0.0018	75.4981
Motion	0.0016	76.0383
Median	0.0016	76.0903
Order	0.007	69.6572
Wiener	0.0002	85.1324

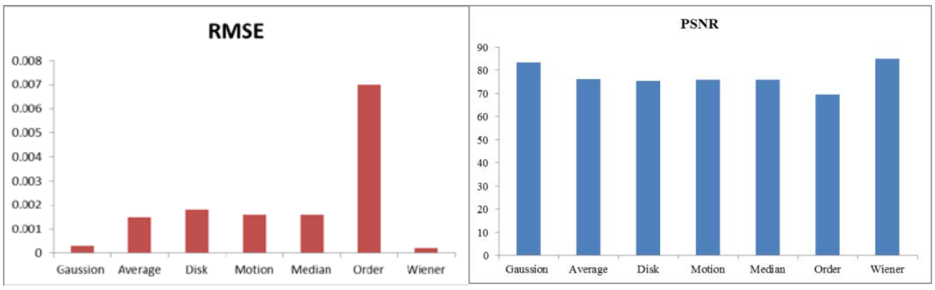

Figure 5: PMSE and PSNR values linear and non-linear filter

In the proposed method different wavelet filters also applied to find the suitable wavelet filter to denoise the mammography. The values are tabulated in table 3 and figure 6 represents the PSNR and RMSE values respectively. These figures suggest that Daubechies (db2) wavelet filter is suitable to denoise the mammography images.

Table 3: RMSE and PSNR values of wavelet filters

Wavelet Filters	RMSE	PSNR
Haar	1.8876	45.4057
Daubechies	1.0076	48.13192
Symlets	1.8076	45.59378
Coiflets	1.8806	45.42183
Biorthogonal	1.0976	47.76036

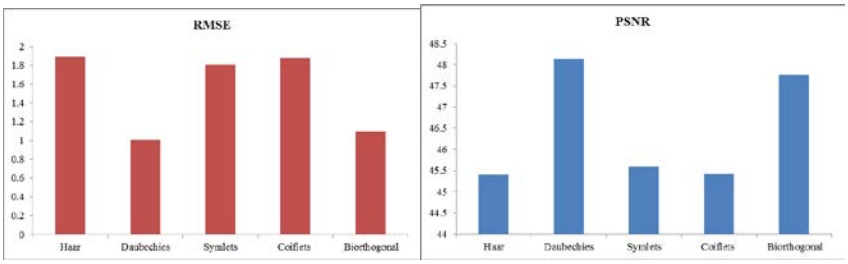

Figure 6: RMSE and PSNR Values wavelet filters

After the selection of proper filter to denoise the results for preprocessing are organized as shown in the figure 7. First background of the image is removed, then pectoral muscle suppressed by regiongrowing technique with orientation of the image, then denoised by either wiener filter or wavelet filter(db2) at last contrast of the image is increased by CLAHE.

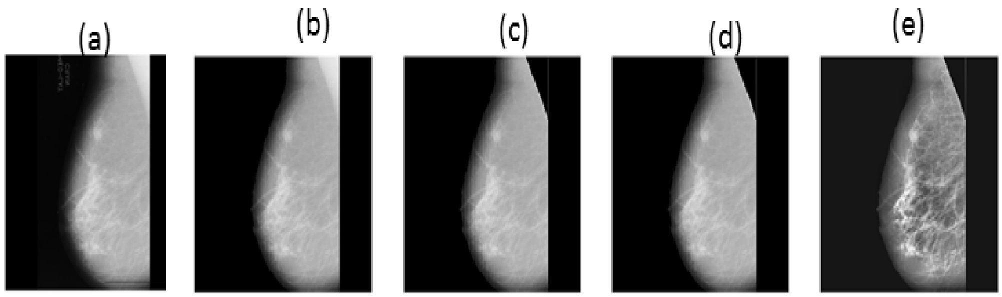

Figure 7: (a) Original Image (b) Background Removal (c) Removal of pectoral muscle (d) Denoised Image (e) Contrast Enhancement.

5. Conclusions

This paper highlights the various filtering techniques which can be used particularly for medical image enhancement which enable medical professional. The paper briefly concise the facts that, there still much improvements are required in existing techniques to get better results. In order to overcome the limitations of the earlier techniques. The experimented results were compared and replicated the image quality measuring parameters such as RMSE and PSNR. All the filters tested for mammogram images of MIAS and DDSM datasets, among the all the linear and nonlinear techniques such as Gaussian, Log, Average, Disk, Laplacian, Motion, Prewitt, Sobel, Median, Order and Wiener filters, the lower RMSE we got for wiener filter and among wavelet filters such as Haar, Daubechies, Symlets, Coiflets and Biorthogonal, the lower RMSE achieved by db2 filter. This preprocessing technique will definitely increase the efficiency of CAD system for Breast cancer detection.

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