Comparative Analysis of Mammogram Enhancement using Weiner filter for Early Detection of Breast Cancer

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Abstract - This paper presents an analysis and identification of image enhancement techniques suitable for mammogram images. Enhancement techniques are used for mammogram image enhancement to aid an early detection of breast cancer which can identify the micro calcification as benign and malignant. Mammograms are denoised by linear and nonlinear filtering techniques. This paper comprises the different denoising techniques to recognize the suitable enhancement techniques for mammography. These techniques are implemented using MATLAB. The results obtained are compared on the basis of Peak Signal to Noise Ratio (PSNR) for a set of mammogram images. Mammogram Enhancement techniques used here are Median filter, Max and Min filters, Weiner filter. The PSNR values of all pre-processing techniques will be analysing here. A high value of PSNR indicates better suitability of the enhancement technique for further image processing. These identified pre-processing techniques, chosen carefully may give better results for further identification of micro classification and aid in early detection of breast cancer.

Keywords - Mammogram Enhancement, CLAHE, MSE, PSNR.

I. INTRODUCTION

Breast cancer is a major health problem for women. Mammography is basic screening method for early detection of cancer. In conventional mammography tumours are not properly visible. A tumour can be of two types benign or malignant. In benign tumors the cells are normal in appearance but it is not cancerous, the cells will grow slowly but it does not spread to other parts of the body [2], [3], [4]. But malignant tumors can spread to other parts of the body and it is cancerous. The most challenging area in medical imaging is mammography. In mammography the low energy X-rays is used to create images and to examine the human breast and thus it helps to detect the breast cancer at the early stage by detecting the small calcium deposits. In this sense, an image enhancement plays an important role to reduce the noise level of the image, preserving important details and enhancing the con-tract to improve the detection of mammographic features. Several denoising methods based on linear and nonlinear filters have been introduced to reduce the noise level. In this paper filters considered are: average, median, min-max, wiener filters based on the independent component analysis of the image [5], [6]. The proposed system consists of two main steps including denoising image and contrast enhancement. To evaluate this method, images of mini-MIAS database of Mammograms are used.

In this paper seven image pre-processing techniques are explored for better results suitability in case of mammogram images. The rest of the paper is organized as follows: section II presents review of related literature. Image pre-processing techniques considered are presented in Section III. Results are presented in Section IV. Finally, conclusions and future work are given in Section V.

II. RELATED WORK

The common anomalies indicative of cancer in breast are masses, micro-calcifications (MCs) and architectural distortion. A breast mass could be defined as space occupying lesion seen in at least two different projections or as a localized lump in the breast. A mass is parameterized according to its shape, size, location margins and density etc. Circular or oval shaped mass are generally considered as benign whereas masses with spackles tend to be malignant. Micro-calcifications represent one of the earliest signs of breast cancer. These are small deposits of calcium (and related) salts representing either warnings of malignancy or just benign formations. They are encountered in approximately 25% of mammograms and appear as bright spots or clusters of such spots, due to the high X-ray attenuation factor of calcium.

Numerous approaches for image enhancements using Histogram processing are available. It includes histogram equalization, adaptive histogram equalization and local histogram processing. Adaptive histogram equalization is explored in this paper because of improvement in the appearance of images. For a dark image histogram would be oriented towards the lower gray scale values. It means the entire image detail lie in the dark end of the histogram. To obtain uniform distribution of gray levels, stretching of gray levels at the dark end is required. Direct application of this method often results in the enhancement of noise present in the image. Contrast-limited adaptive histogram equalization (CLAHE) could be used to solve this over enhancement problem. Histogram Modified Contrast Limited Adaptive Histogram Equalization (HM-It adjusts the level of enhancement giving a strong contrast image and also highlights the local information present in the original image for better interpretation. In an

image enhancement algorithm based on edge detection is used to preprocess mammograms. The proposed algorithm was applied on preprocessed mammograms. It helped to get more details from images and lesions were clearly differentiable from background.

Many image processing operations involving enhancement makes use of oriented filters. In this same filter is applied over again by rotating it at different orientations under adaptive control. One can remove noise and enhance oriented structures by angularly adaptive filtering.

Lot of work has been done in the past for the enhancement of mammograms. The contrast enhancement of mammograms for rapid detection of microcalcification clusters method consisted image scaling, breast region segmentation, noise cancellation using a filter, which is sensitive to microcalcifications and contrast enhancement of mammograms using Contrast-Limited Adaptive Histogram Equalization (CLAHE) and wavelet transform [3]. The literatures review on some of the image enhancement techniques for enhancing digital mammograms. Various spatial and frequency domain techniques were discussed [4]. In [2] a comparative study in digital mammography image enhancement algorithms such as wave-let-based enhancement, CLAHE, morphological operators and unsharp masking were presented. An optimal adaptive neighborhood processing algorithm with a set of contrast enhancement functions to enhance the mammographic features were discussed. The method can enhance the desired, but unseen or barely seen features of an image with little enhancement of the noise and other background variations [6]. Algorithms for both local contrast enhancement and background texture suppression in digital mammography images [7]. The dual-tree complex wavelet transform overcomes the limitations of linear filtering techniques- it is nearly shift-invariant and is oriented in 2D.

III. METHODOLOGY

The mammography image enhancement technique is done in two ways. First denoising image by using average, median and wiener filter. Second contrast enhancement using histogram based techniques. The enhancement can be measured by the Peak Signal to Noise Ratio which is given by

$$\text{PSNR} = 10\log_{10}\frac{[(\text{peak to peak value of original data})^2]}{MSE} \ldots\ldots\ldots (1)$$

3.1 Removing the Noise

The basic enhancement needed in mammography is denoising, especially for dense breasts. Normally mammography image can be filtered by using linear filtering and nonlinear filtering techniques and also spatial and frequency domain filtering techniques.

3.1.1 Median Filter

A median filter is nonlinear type of filter and efficient to remove of salt and pepper noise and Gaussian noise. It helps to keep the sharpness of the image at the time of removing the noise. Potency of median filter depends on the scale of the windowing. For mammography 3X3 window provides smart result. In median filter, the value of an output component is determined by the median of the neighborhood pixels. The median is good to evaluate extreme values and so better able to take away this outlier without reducing the sharpness of the image.

3.1.2 Max and Min Filter

The median filter is order statistics filter most used in image processing. The minimum and maximum intensity values of all the elements inside a windowed region. If the intensity of the central element lies inside the intensity vary unfold of its neighbors, it is passed on to the output image without changing the intensity. However, if the central element intensity is larger than the utmost worth, it is s set up to the utmost maximum value; if the central element intensity is a smaller amount than the minimum value, it is set up to the minimum value. Max filter, is given by the equation

$$f(x, y) = max\{g(s, t)\}\ (s, t) \in Sxy \ldots\ldots (2)$$

The *0th* percentile filter is the min filter.

$$f(x,y) = min\{g(s,t)\}\ (s, t) \in Sxy \ldots\ldots (3)$$

This filter is useful for finding the darkest and brightest points in an image.

3.1.3 Weiner Filter

The wiener filter is a type of linear filter which is applied to an image adaptively, designing itself to local image variance. If the variance is large then it performs little smoothing. If the variance is small, it performs smoothing is better with preserving edges and other details [1]. The wiener is frequency domain filter. It works better for Gaussian noise. It can be achieved with the following equations.

$$X'(k,l) = G(k,l)Y(k,l) \ldots\ldots\ldots\ldots (4)$$

Where G(k,l) is minimum value

$$E[|X(k,l) - G(k,l)Y(k,l)|^2] \ldots\ldots\ldots (5)$$

Both noise and signal are random process and independent to one another. Hence the minimized expression is

$$G(k,l) = H(k,l)/\{|H(k,l)|^2 + Su(k,l)/Sx(k,l)\} \ldots. (6)$$

Where Sx is signal power spectrum and Su is noise power spectrum.

3.2 Contrast Enhancement:

3.2.1 Histogram Equalization:

This method is most useful for medical image applications because it helps to increase the contrast globally especially when the interested area and background are represented by close contrast values. By this method the intensities can better distributed on the histogram which allows getting better contrast of the image. In this particular application it leads to better views of breast part from the background.

3.2.2 Contrast Limited Adaptive Histogram Equalization (CLAHE):

Adaptive histogram equalization is a computer image processing technique used to improve contrast in images. It differs from ordinary histogram equalization in the respect that the adaptive method computes several histograms, each corresponding to a distinct section of the image, and uses them to redistribute the lightness values of the image. Ordinary histogram equalization simply uses a single histogram for an entire image.

Consequently, adaptive histogram equalization is considered an image enhancement technique capable of improving an image's local contrast, bringing out more detail in the image. However, it also can produce significant noise. A generalization of adaptive histogram equalization called contrast limited adaptive histogram equalization, also known as CLAHE, was developed to address the problem of noise amplification. CLAHE operates on small regions in the image, called tiles, rather than the entire image. Each tile's contrast is enhanced, so that the histogram of the output region approximately matches the histogram specified by the 'Distribution' parameter.

IV. SIMULATION RESULTS

Among all the techniques discussed above the wiener filter gives low RMSE and high PSNR. To measure the analysis of the filtering techniques, the image quality measures such as RMSE and PSNR is used. The Table1 values are RMSE values, the wiener filter gives minimum RMSE values and Maximum PSNR as shown in the Table 2. The same PSNR and RMSE are represented. The CLAHE is efficient technique for contrast enhancement.

Database	Average	Median	Weiner
mdb001	18.14	15.09	4.01
mdb002	29.43	24.62	6.21
mdb003	41.51	33.61	4.73
mdb004	42.84	33.46	5.21
mdb005	29.12	24.49	4.87
mdb006	37.04	30.52	5.02
mdb007	29.08	26.44	5.62
mdb008	42.56	38.44	6.27
mdb009	26.60	20.12	5.17
mdb010	23.05	18.59	4.09

Table 1. Mean Square Error values for Ten Images of mini-MIAS Database.

Database	Average	Median	Weiner
mdb001	35.56	36.34	42.10
mdb002	33.44	34.21	40.20
mdb003	31.94	32.86	41.38
mdb004	31.81	32.88	40.96
mdb005	33.48	34.24	41.25
mdb006	32.44	33.28	41.13
mdb007	33.49	33.90	40.63
mdb008	31.84	32.28	40.15
mdb009	33.88	35.09	40.99
mdb010	34.50	35.43	42.02

Table 2. PSNR values for Ten Images of mini-MIAS Database.

V. CONCLUSION AND FUTURE WORK

Presently the breast cancer is leading for death of middle age women. Most of the doctors suggest mammography as basic test for diagnosis of breast cancer. In this paper the low contrast, noisy and blur images are enhanced by using different filtering techniques and contrast enhancement techniques. Wiener filter is suitable for denoising the image and CLAHE is good for increase the contrast of the image. These methods help to doctors and radiologist for correct diagnosis of the diseases at an earliest. The future research will be carried out to improve the early identification of masses, calcification, architectural distortion and bilateral asymmetry for detection of breast cancer by using these identified pre-processing techniques.

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