A Novel Ratio Based Approach on Weighted Frost Filter to Reduce Quantum Noise for Efficient Restoration of Digital Breast Mammograms

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ABSTRACT

Early detection of breast calcification or mass area plays a vital role in saving women from breast cancer. There are many technologies existing to detect breast cancer but with the mammographic images, earlier detection is much easier. Since mammogram is an X-ray image, the capturing conditions impose a quantum noise of almost 1 percentage, which is Gaussian type in nature. So the Gaussian noise is to be removed to perceive the calcification or mass area by naked eye. This paper adapts the Weighted Frost Filter and proposes a new filter which is much effective in removing quantum noise. The proposed methodology enhances the digital mammograms with relatively high Peak Signal-to-Noise Ratio (PSNR) and less Mean Square Error (MSE) by enhancing the correlation between neighbor pixels. The performance of the new methodology is measured by using the mammographic images of size 1024 X 1024 which are taken from Mini-MIAS database.

Keywords: Breast Cancer, Denoise, Enhancement, Frost Filter, Mammogram & PSNR.

I INTRODUCTION

Cancer is the uncontrolled growth of body cells. Obviously the uncontrolled growth in breast cells leads to breast cancer. The factors such as Genetics, Aging, Obesity, and Asymmetry in breasts, Ethnicity, History of breast feeding, Menses life cycle, etc. cause breast cancer [1]. In India, the breast cancer accounts for 25% to 31% of all cancers found in women [2]. A mammogram is a breast X-ray that is suggested by a physician when there is something suspected [3]. Basically the cancer cells are dark and the mammographic images have low contrast, it is essential to enhance the mammographic images to detect the calcifications or the masses.

1.1 Image Enhancement

Image Enhancement is not concerned with the overall image improvement but concerned with enhancing some required features of the image. Images which need enhancement are basically,

1. *Images with poor contrast.*
2. *Images are severely degraded with unwanted information (Noise)*

3. *Images captured at poor imaging conditions. (Example: Mammographic images, which have quantum noise when capturing them.)*

Images with poor contrast can be enhanced by a variety of contrast stretching techniques [4] such as

i. *Local Contrast Stretching*

$$I_P(x,y) = 255.[\, I_o(x,y) - \min \,] / (\max - \min) \quad ..... \quad (1)$$

Where,

$I_P(x,y)$ is the gray / intensity level of output pixel.

$I_o(x,y)$ is the gray / intensity level of input pixel.

max is the maximum gray level of the input image.

min is the minimum gray level of the input image.

ii. *Global Contrast Stretching*

iii. *Partial contrast stretching*

iv. *Bright contrast stretching*

v. *Dark contrast stretching*

Contrast Stretching can also be done by Image Histograms, Homomorphic Filter[5], etc. Images with unwanted information can be denoised with various filters. Filtering can be done in either spatial domain or Frequency domain. In spatial domain, the filtering technique is:

$$g(x,y) = T[f(x,y)] \quad ..... \ (2)$$

Where,

g(x,y) is the Denoised or Filtered or Transformed or Restored Image.

f(x,y) is the input image with Noise.

T is the Transformation function or Filtering methodology which changes the gray level of current pixel (x,y) according to the correlated neighbor pixels of current pixel(x,y).

1.2 Correlation among the Neighbor Pixels

If the current pixel is taken as P(x,y), it is correlated with its 4 Neighbors, that is the gray value of current pixel P(x,y) is probably very close with its 4 neighbors shown in Fig. 1(a). The four neighbors can be expressed as

$$N_4(P(x,y))=\{P(x-1,y),P(x+1,y),P(x,y-1),P(x,y+1)\} \quad ..... (3)$$

Where,

P(x,y) is the current pixel.

P(x-1,y) is the correlated left pixel with lag distance of 1.

P(x+1,y) is the correlated right pixel with lag distance of 1.

P(x,y-1) is the correlated top pixel with lag distance of 1.

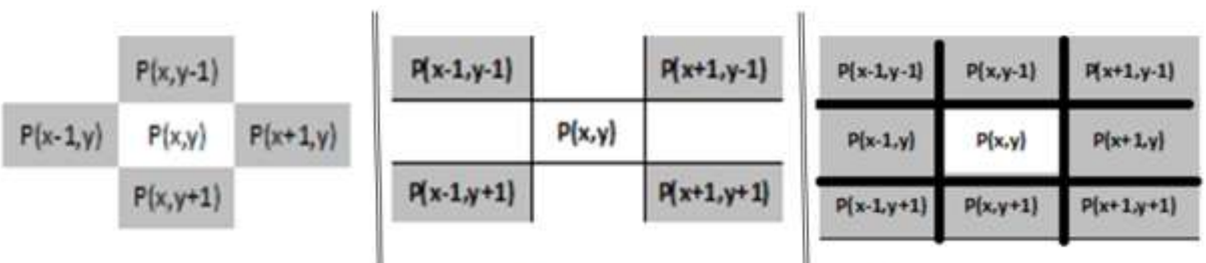
P(x,y+1) is the correlated bottom pixel with lag distance of 1.

The 4 diagonal neighbors of P(x,y), shown in Fig. 1(b), can be expressed as

$$N_D(P(x,y))=\{P(x-1,y-1),P(x+1,y+1),P(x+1,y-1),P(x+1,y+1)\} \quad ..... (4)$$

The Eight neighbors of P(x,y) is the combination of N_4P & N_DP, shown in Fig. 1(c), can be expressed as

$$N_8(P(x,y)) = \{N_4(P(x,y)) + N_D(P(x,y))\} \quad ..... (5)$$



a.) $N_4P(x,y)$ b.) $N_DP(x,y)$ c.) $N_8P(x,y)$

FIGURE 1: *Neighbor Pixels of Current Pixels P(x,y)*

II COMPARISON OF VARIOUS EXISTING FILTERS

Author’s	Noise Models	Filtering Techniques	Result
R. Ramani, Dr. N.Suthanthira, S. Valarmathy [6]	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 [7]	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.	Gaussian noise	Adaptive wiener filter,	All techniques are

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Verdu [8]		donoha wavelet shrinkage, inter dependent component analysis filter	good to reduce Gaussian noise
Tajinder Kaur , Manjit Sandhu , Preeti Goel, Harpreet Singh [9]	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 [10]	Impulse noise, random noise	Wiener filter, multiwavelet based, neigh shrink and visual shrink	Multiwavelet based
Kother Mohideen, Arumuga Perumal, Krishnan and Mohamed Sathik [11]	Gaussian noise	Multiwavelet denoising techniques	Three level multiwavelet decomposition and fourth level multiwavelet decomposition gave optimum results.

TABLE 1: *Existing Filters for mammography and their Significance*

III PROPOSED METHODOLOGY

3.1 Ratio Based Modified Adaptive 8-Neighbor and Second Lag Distanced 4-Neighbor Weighted Frost Filter

If the adjacent pixels are nearly connected then there is a very less probability of the central pixel to be corrupted. Frost filter, proposed by Frost et al. in 1982, is a famous filter for removing quantum noise [12]. The Frost filter uses simple local averaging even though the correlation between neighbor pixels is very important. The main drawback of Frost Filter is that it does not form the correlation between the neighbor pixels of the image. Therefore the filtered mammographic image will not produce good results [13]. In order to handle this issue in Frost filter, a small modification is made to achieve correlation between the neighbor pixels and the new ratio based Modified Adaptive 8-Neighbor and Second Lag Distanced 4-Neighbor Weighted Frost Filter for Quantum Noise Removal technique is proposed.

The proposed ratio based new Ratio Based Filter gives more weight to $N_8(P)$ neighbor pixels and Second lag $N_4(P)$ neighbor pixels in terms of doubling corresponding gray values and performs weighted mean to replace the current pixel (P).The new filter is of 5 X 5 window size. The Weighted Sum is computed and obtained by the Equation (6). The proposed 5 X 5 window is shown in Fig. 2, which is used to calculate the gray value of current pixel.

$$\text{Weighted\_Sum}^K = \sum_{i=-2,i=0}^{2}\left(W^i * \frac{|P^i_{(x,y)}|}{5}\right), -2 \le i \le 2 \quad \text{..... (6)}$$

Where,

P(x,y) is the current Pixel.

$$W^i = \begin{cases} 2, i = -1, +1, 2^{nd} \text{ Lag } (N_4[i]) \\ i = 0, \text{ otherwise} \end{cases}$$

Figure 2: *5 X 5 Window for Weighted Local Mean*

0	0	**2**	0	0
0	**2**	**2**	**2**	0
2	**2**	1	**2**	**2**
0	**2**	**2**	**2**	0
0	0	**2**	0	0

The gray / intensity values are closer when the lag distance of two pixels is less. So that, as in Fig. 2, more weight is assigned to the $N_8(P)$ and second lag distanced $N_4(P)$. When comparing to any other filtering methodologies, especially for mammographic images, this proposed filter achieves high correlation among neighbor pixels and hence the overall mammographic image quality is enhanced.

3.2 Performance Evaluation

In general, a good reconstructed image is one with low MSE and High PSNR. That means that the image has low error and high image Fidelity [17]. The Peak Signal-to-Noise Ratio is often used as a quality measurement between Original and transformed image [17].

$$\text{PSNR}[T, O] = 10 \log_{10}\left(\frac{R^2}{MSE\,(T,O)}\right) \quad \text{..... (7)}$$

Where,

T is the Transformed / Restored / Enhanced Mammogram.

O is the Original Image.

R is the maximum gray level in the input image.

$$\text{MSE}[T, O] = \frac{\sum_{M,N}[\,O(m,n) - T(m,n)]^2}{M\ X\ N} \quad \text{..... (8)}$$

Where,

M and N are number of Rows & Columns in the input Image.

MSE is the Mean Square Error between Transformed image and Original image.

IV RESULTS AND DISCUSSION

The above proposed methodology is implemented and the PSNR & MSE values are obtained by using MATLAB R2013a.

After imposing the Gaussian Noise, the performance measurements of various filters including the proposed method are obtained by using various breast cancer mammographic images. The quantitative results are shown in Table 2 and depicted through Fig. 6A to Fig. 6B. The breast cancer mammographic images are taken from the Mammographic Image Analysis Society Mini-MIAS database – dataset 21. The proposed filter performs well in removing the noise from every mammographic image and the transformed images are well enhanced and denoised.

The PSNR values of the proposed filter for all the input images are relatively good and the enhanced images are very close to original images, which are shown in Fig. 3 through Fig. 5. For example, the PSNR value produced by the New Ratio Based Filter for mdb110 is 35.84, the adaptive weighted frost filter is 18.96, Naveed et al. is 30.7[15], Frost filter is 27.8[12] and wiener filter is 29.1[16]. Same inclination is shown by all mammographic images which clearly state the dominance of the new Ratio Based Filter. Therefore the enhanced / restored images can be used for further processing such as morphological processing, Object Recognition, Feature selection and Classification.

Figure 3: Image Restoration for the Mini-MIAS breast cancer Mammographic Image mdb075 of size 1024 X 1024.

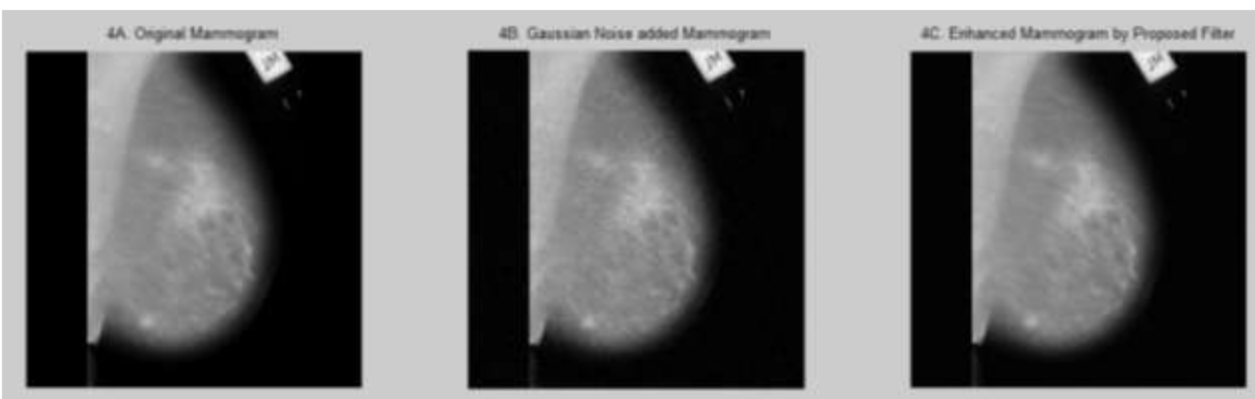

Figure 4: Image Restoration for the Mini-MIAS breast cancer Mammographic Image mdb206 of size 1024 X 1024

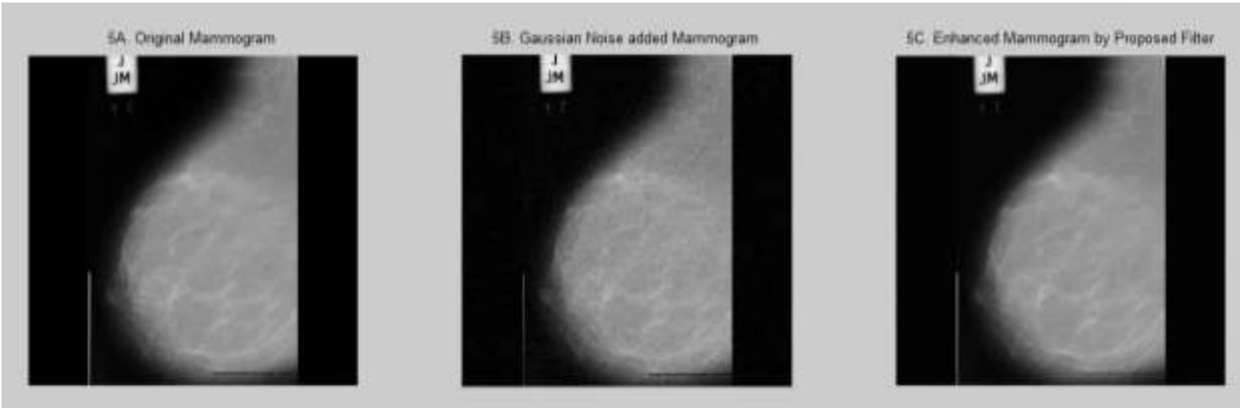

Figure 5: Image Restoration for the Mini-MIAS breast cancer Mammographic Image mdb322 of size 1024 X 1024.

Image	Proposed Method	Naveed et.al[15]	Frost Filter[12]	Wiener Filter[16]	Weighted Frost
mdb001	36.7	28.4	27.9	26.9	20.6
mdb005	35.6	33.2	32.1	28.7	18.4
mdb007	34.7	33.5	30.9	31.1	19.2
mdb010	36.4	31.4	31.3	26.9	19.6
mdb025	35.3	28.7	28.5	27.6	18.8
mdb041	35.3	31.2	27.3	29.1	19.7
mdb064	35.4	30.6	25.1	31	18.9
mdb081	35	29.1	27.4	24.9	18.4
mdb099	35.2	31.8	31.5	25.2	19
mdb101	34	29.7	28.5	23.8	19.3
mdb110	35.8	30.7	27.8	29.1	18.9
mdb118	35.7	31.5	29	23.7	19.4
mdb130	36.5	28.4	26.7	25.7	17.5
mdb143	33.8	32.7	29.3	28.9	17
mdb162	36.3	29.9	24	27.5	19
mdb178	35.9	32.3	31.7	25.6	20
mdb119	35	30.6	26.5	27.1	19

mdb206	36	31.5	29.4	31.1	18.9
mdb219	34.5	33.5	27.3	23.2	17.7
mdb244	36.2	31.4	28.1	27.4	17.2
mdb275	34	30.6	26.9	25.8	18.5
mdb313	34.9	29.8	31.5	21.9	20.6
mdb320	35.5	28.9	27.5	26.4	16.4
mdb322	36.2	31.6	28.4	28.7	18

TABLE 2. PSNR Comparison of Proposed Methodology with the existing methodologies.

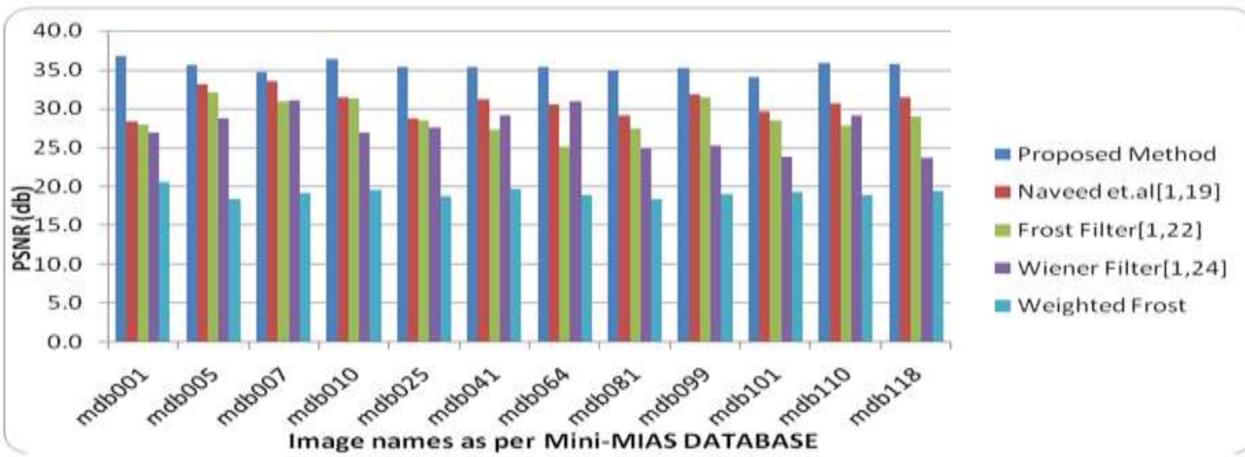

FIGURE 6A. PSNR Comparison of proposed Method with Existing Methods

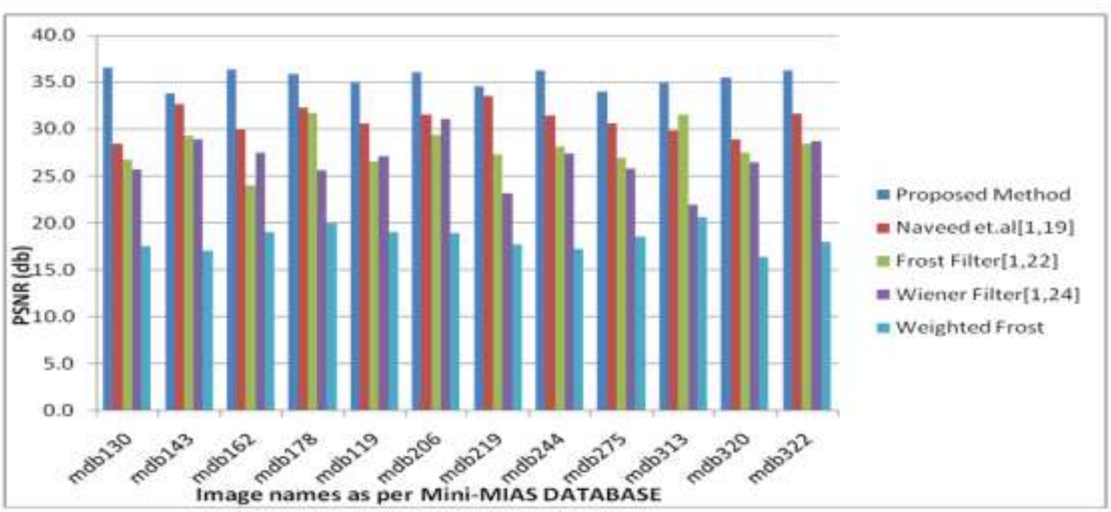

FIGURE 6B. PSNR Comparison of proposed Method with Existing Methods

V CONCLUSION

The statistical factors MSE and PSNR determine the quality of the restored images. The restored image quality is highly concerned with decreased MSE and increased PSNR. In this proposed method the restored images exhibited very low noise levels and high PSNR values. PSNR values above 30 db are highly acceptable and hence the early detection of breast cancer is made easy.

The Proposed filter produced relatively good results for every mammographic image. After the series of experiments for various mammograms, it gave very good transformed images which were very close to the original images. Therefore, the proposed method showed that the quality of transformed images are very much helpful for early detecting breast cancer, further processing such as Object recognition, Feature Extraction, Segmentation, Classification, etc. Moreover the proposed method reduces the computational complexity and cost of further Image processing Techniques.

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