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Performance of various Denoising Techniques on Dense Glandular Mammogram

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Abstract:
Digital Mammogram is the major technique to detect breast cancer. Computer aided techniques helps to enhance mammogram images for better detection to radiologist. A patient who has dense breast tissue is opaque to X-ray hence mammogram is brighter such mammogram are dense glandular mammogram. When compared to fatty mammogram early finding of breast cancer is difficult in dense glandular mammogram. This paper gives a comparison study of various spatial filters used in pre-processing techniques for dense glandular, fatty glandular and fatty mammogram. Noise in the mammogram arises due to various factors such as poor illumination, capturing, movement of patient and circuit failure. Various filters are used to remove noise and improve the quality of image. Result concludes filter performance varies for different noises by comparing values of minimum mean squared error (MSE), maximum Peak signal to noise ratio (PSNR) and high structural similarities (SSI).

Keywords: *Mammogram, Breast cancer, Denoising, Pre-processing, Peak signal to Noise ratio, Mean squared error, Adaptive median filter.*

I. INTRODUCTION

Breast cancer is a disease where breast cells develop randomly. Breast cancer type depends on the type of breast cell turns into malignant cell. Origin of breast cancer can be from any parts of the breast. Breast anatomy defines (a) lobules, which are milk producing glands, (b) ducts, they are capillary tubes where milk is transferred to nipple and (c) connective tissue, they are fatty and fibrous tissue that holds everything intact and gives the shape. Ducts and lobules are primary place where cancer originates.

In India, most common cancer among female is breast cancer [1]. Cancer statistics results say for every two women diagnosed for breast cancer, one woman dies. When compared to US in India [2] out of 28 women 1 gets breast cancer. In urban 1 out of 22 women & in rural 1 out of 60 is diagnosed for breast cancer. Women in the age group of 30 plus get diagnosed for this disease. Stage Zero Breast Cancer is the mainly primitive form of breast cancer, medically tagged as Ductal Carcinoma In Situ (DCIS). Cancer cells exist inside the milk ducts within the breast, but have not diffuse to the peripheral breast tissues or organs are called DCIS. Indian Council of Medical Research (ICMR) report says more than one lakhs breast cancer patients were identified for a year.

II. Mammogram

A mammogram is an X-ray image taken especially for the breast. Screening mammography is an explicit type of breast imaging that employ low intensity x-rays to identify cancer early, before women acquaintance symptoms. Doctors use a mammogram to observe for early gesture of breast cancer. ***Digital mammography***,[12] also called full-field digital mammography (FFDM), is a mammography technique where a solid state detector converts x-rays into electrical signal which can be viewed in a computer. It helps radiologist and medical electronic engineer to analyse easily.

Lobules which produce milk and are habitually called glandular tissue. Ducts are the capillary tubes that take milk to the nipple from the lobules. Fibrous tissue & fat give breasts their dimension and contour and grip the other structures in place.[14]

Mammograms are broadly classified into three category [3] Fatty (F), Fatty-glandular (G) and Dense-glandular (D). Breast which has more fatty tissue and very less glandular tissue allows x-ray to pass easily, so it appears dark. Such mammograms are called fatty mammogram shown in figure 1 (a) In fatty mammogram cancer can be detected easily because it appears white.

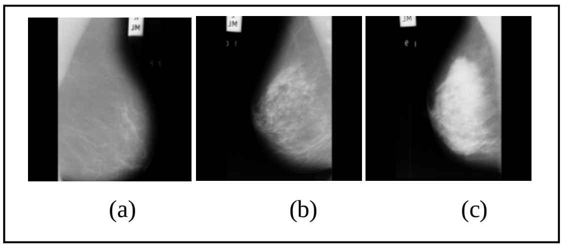

Fig.1 (a) mdb006-Fatty mammogram
(b) mdb007-Fatty glandular mammogram
(c) mdb003-Dense glandular mammogram
Courtesy: Mammographic Image Analysis Society (MIAS) – UK

Breast which has fatty tissue and glandular tissue allows x-ray moderately. Such mammogram appears dark and glandular tissues are visible. Cancer tissues are visible but less likely smaller cancer cell and micro calcification. Figure 1(b) is fatty glandular mammogram.[14]

Breast which has dense glandular tissue occurs in women. X-ray can't pass through breast tissue so it appears white and bright as in figure 1(c). Cancer tissue may blend with glandular tissue so it is difficult to identify. [15]

III. Various Sources Of Noise In Mammogram

Noise in the mammogram occurs due to various factors. It may occur in image acquisition due to following sources they are

•Very low dose x-ray has less quantum counts results in quantum noise [4] is also called Poisson noise.

•Dust particle in the source, acute change in signal strength or excess heat in components results in Salt & Pepper noise, Impulse noise or Spike noise [5].

•Speckle noise [6] is a multiplicative noise occurs due to dust in the image source.

•X-ray's behaviour varies due to vary in quantity of photons [7] which results in Photon or Poisson noise.

• Electronic circuit and sensors creates additive Gaussian noise [7] which resembles Gaussian distribution.

Original Mammogram Image from Mammographic Image Analysis Society (MIAS) is shown in figure 2. Mammogram mdb058 image were added with various noises and noisy mammogram images is given in figure 3.

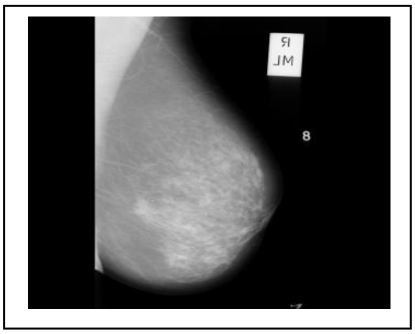

Fig.2 mdb058-Dense Glandular with ill defined malignant mammogram
Courtesy: MIAS – UK

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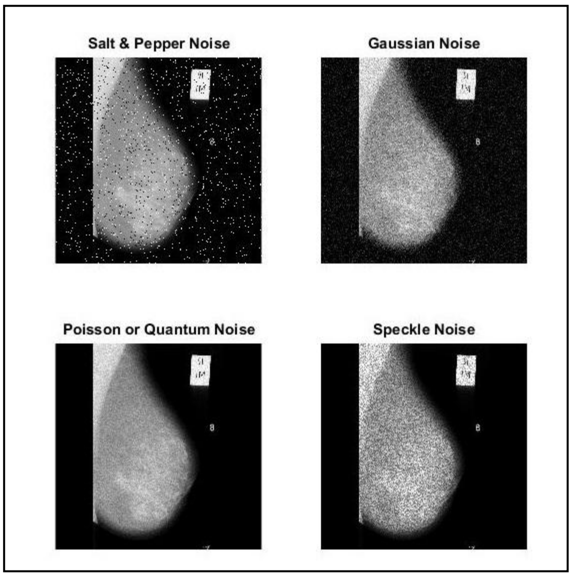

Fig.3 mdb058-Dense Glandular with Various noises

IV. Denoising Techniques

Denoising technique is removal of noise in the image. It is also a part of image enhancement. Denoising can be implemented either in time domain that is special domain or in frequency domain. In most of the conditions spatial filtering were preferred by operating on neighbourhood pixel and predefined operation on a given pixel.[13]

A. *Smoothing or Average filter*

It is a linear filter which gives average or mean assessment of the neighbourhood pixel as its response. It is a smoothing filter or low pass filter in the frequency domain. Mask window for averaging is defined as w and image is represented as f, then response of the filter for location x,y can be given as

$$g(x,y) = \frac{\sum_{s=-a}^{a}\sum_{t=-b}^{b} w(s,t)f(x+s,y+t)}{\sum_{s=-a}^{a}\sum_{t=-b}^{b} w(s,t)}$$

Dense mammogram mdb105 which has asymmetric abnormality classified as malignant, centred about coordinates (516,279) having approximated pixel radius 98. This mammogram added with speckle noise of variance 0.04 and filtered by average filter. Result of above operation is shown in the figure 4.[11]

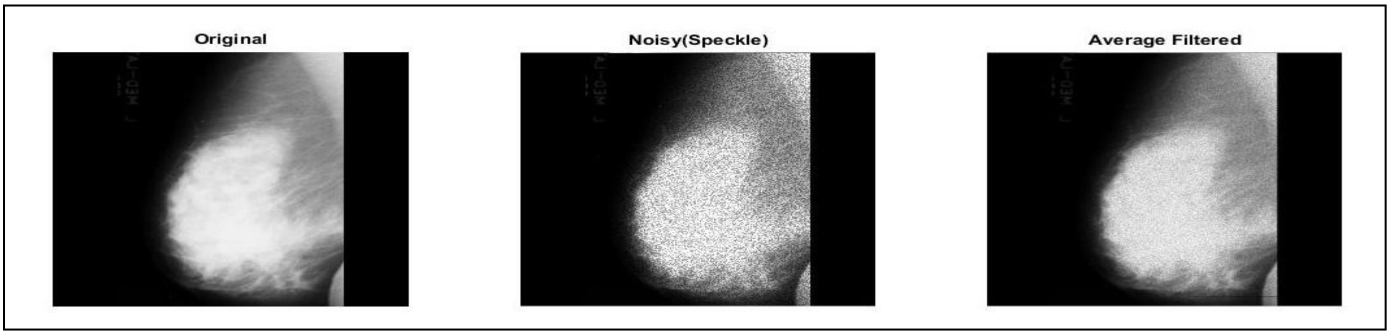

Fig.4 mdb105-Denoised Dense Glandular by Mean filter

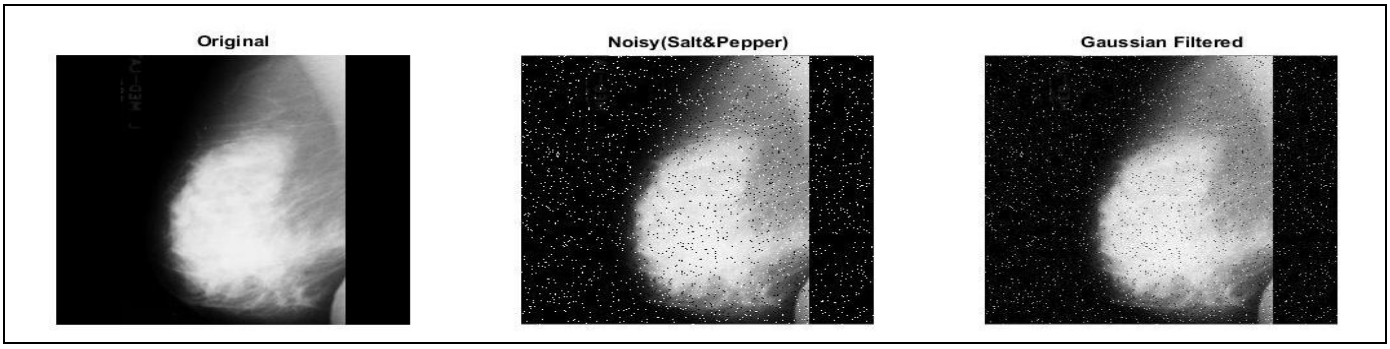

Fig.5 mdb105-Denoised Dense Glandular by Gaussian filter

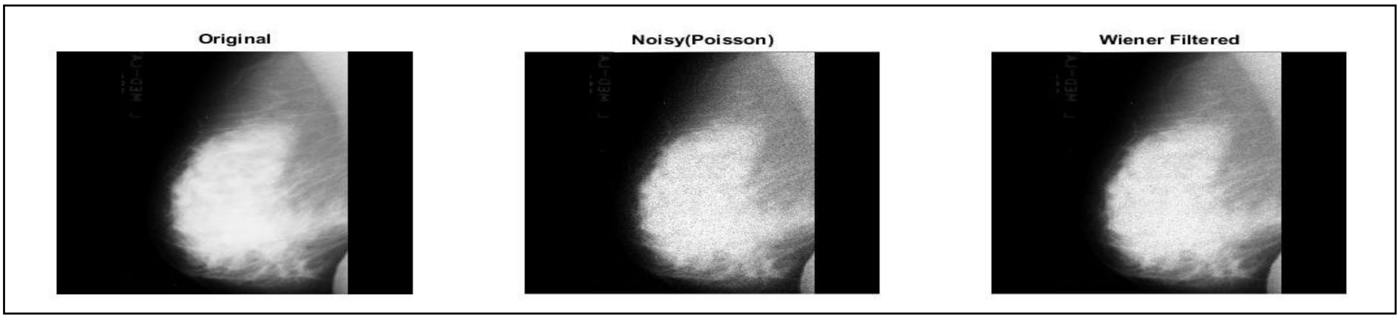

Fig.6 mdb105-Denoised Dense Glandular by Wiener filter

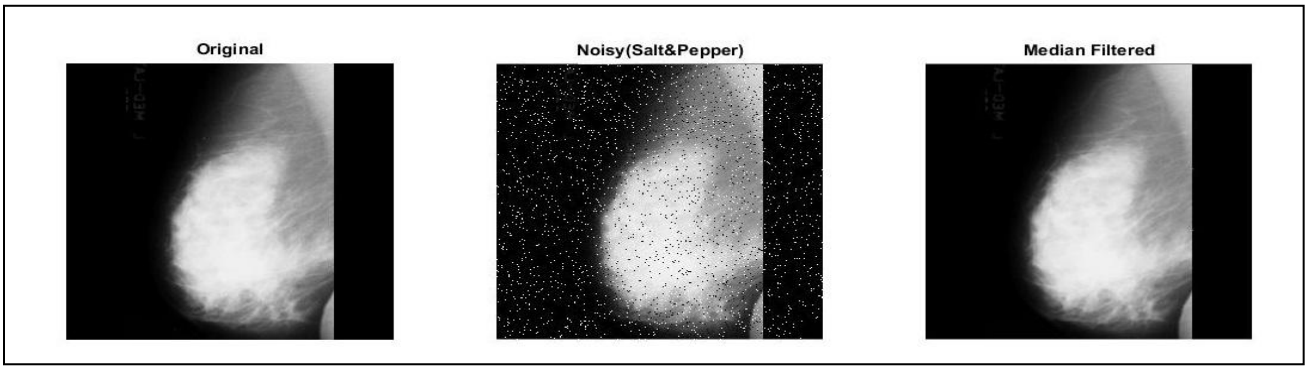

Fig.7 mdb105-Denoised Dense Glandular by Median filter

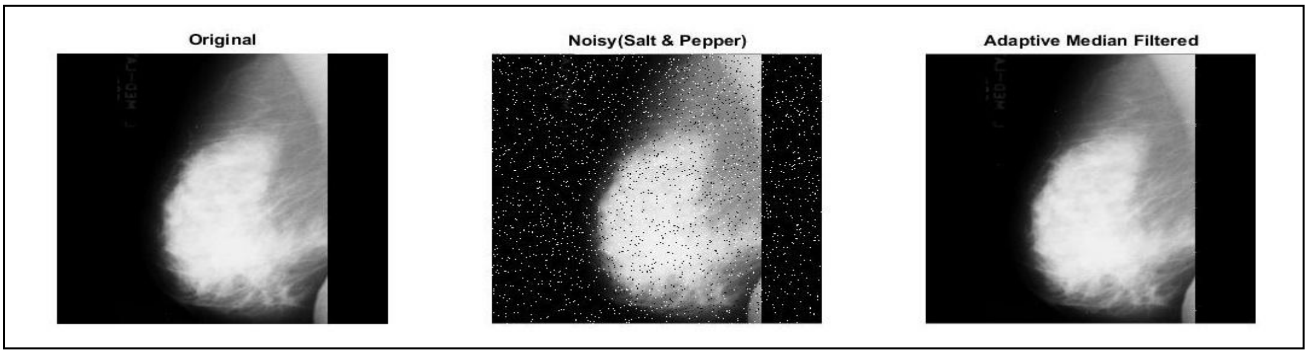

Fig. 8 mdb105-Denoised Dense Glandular by Adaptive median filter

B. Gaussian Filter

Gaussian filter mask is created by the Gaussian function with standard deviation σ derived for the location *x*,*y* can be given as

$$g(x, y) = \frac{1}{2\pi\sigma^2} . e^{-\frac{x^2+y^2}{2\sigma^2}}$$

Mask of size 3 x 3 with standard deviation 0.5 created by above function is convolved with noisy mammogram. Dense glandular mammogram with 5 percentage salt and pepper noise is filtered by Gaussian filter. The result of above operation is shown in the figure 5 [9]

C. Wiener Filter

Wiener filter is a FIR low pass filter. Wiener mask is created by local estimated variance of neighbourhood pixels. [8]

$$\mu = \frac{1}{3 X 3} \sum a(x, y)$$

Where a is neighbourhood pixel

$$g(x, y) = \mu + \frac{\sigma^2 - v^2}{\sigma} . (a(n, m) - \mu)$$

Mask created by wiener function is convolved with noisy mammogram. Dense glandular mammogram with Poisson noise having mean 10 is filtered by

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Wiener filter. The result of above operation is shown in the figure 6

D. Median Filter

The best statistic filter is median filter. Amplitude of the given pixel is modified with median pixel amplitude of the neighbourhood pixels. Calculation of median value for the given window size can be shown as

$$g(x,y) = \underset{(s,t)\epsilon\, g(x,y)}{\text{median}} \{g(s,t)\}$$

This filter is best for both Unipolar and bipolar impulse noise. Dense glandular mammogram with 5 percentage salt and pepper noise is filtered by Median filter [10]. The result of above operation is shown in the figure 7

E. Adaptive median filter

Median filter can perform over impulse noise to the maximum of noise density 0.2 that is 20 %. If bipolar impulse noise density is more than 20 % then we should increase the window size for the better result. [8] Adaptive median filter varies its window size based on certain condition given below

Consider the following notations

Z_{min} = minimum intensity pixel value in given x,y window.

Z_{max} = maximum intensity pixel value in given x,y window.

Z_{med} = median of intensity pixel value in given x,y window.

Z_{xy} = intensity pixel value in given coordinate x,y.

wsmax = maximum window size.

Adaptive median filter algorithm is shown below:

Stage A:

$A_1 = Z_{med} - Z_{min}$

$A_2 = Z_{med} - Z_{max}$

If $A_1 > 0$ && $A_2 < 0$,

Implement stage B

Else increase the window size by 2

If window size ≤ wsmax repeat stage A

Else output Z_{med}

Stage B:

$B_1 = Z_{xy} - Z_{min}$

$B_2 = Z_{xy} - Z_{max}$

If $B_1 > 0$ && $B_2 < 0$,

Output Z_{xy}

Else output Z_{med}

Dense glandular mammogram with 5 percentage salt and pepper noise is filtered by Adaptive median filter. The result of above operation is shown in the figure 8

V. Result

Dense Glandular mammogram ***mdb105*** from MIAS data bank is taken as the reference image. It has asymmetric abnormality classified as malignant, centred about coordinates (516,279) having approximated pixel radius 98.

Different noises were included to reference mammogram such as **Salt and Pepper** noise with noise density 5 percent. **Poisson** noise with 10 mean. **Speckle** noise which is multiplicative noise with 0 mean and 0.04 variance. **Gaussian** noise with 0 mean and 0.01.Spatial filter is implemented for noisy dense glandular mammogram with five filters as mean, Gaussian, wiener, median & adaptive median filters. Standard parameters like peak signal to noise ratio (PSNR), mean squared error (MSE) and structural similarity index (SSIM) were calculated and shown in table II to V. Adaptive median filter shows significant improvement in result when salt & pepper noise percentage is increased from 5 % to 40 %. Results are tabulated in table I

TABLE I. DENOISED RESULT OF VARIOUS FILTERS FOR 40 % SALT & PEPPER NOISE FOR MDB105

Salt & Pepper	**Median**	**AMF**
PSNR	17.81	**35.45**
SSIM	49.13	**98.32**
MSE	5.81	**0.77**

Filtered mammogram image for 40 % noise probability is shown in the figure 9 & 10.

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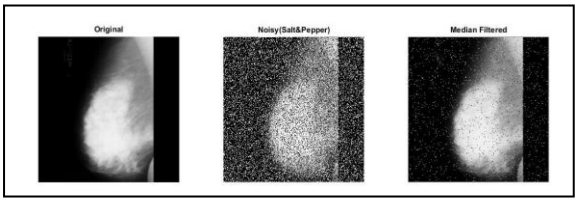

Fig. 9. mdb105-Denoised for 40% salt and pepper noise by median filter

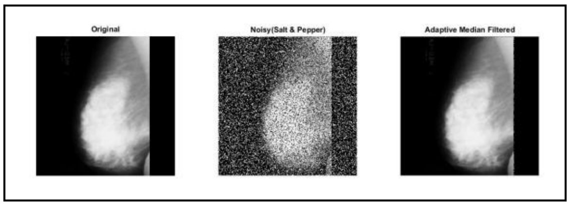

Fig. 10 mdb105-Denoised for 40% salt and pepper noise by Adaptive median filter

MIAS data bank has hundreds of mammogram images with detail of character of tissue, abnormality class, severity of abnormality such as benign or malignant, coordinates of middle of anomaly and approximate radius in terms of pixel. We took 119 gray scale mammogram images, which has 54 Fatty Glandular, 36 Dense Glandular and 29 Fatty Mammogram. Different types of noise were included and filtered. To analyse variation in the performance of each filter for different images we took minimum, maximum and average value. Results are shown in table VI to IX and graphs are plotted for all 119 mammogram with its average value shown in figure 11 to 14.

We have considered 15 mammograms which were classified as normal, with 5 mammograms each in Fatty, Fatty Glandular and Dense Glandular mammogram. All 15 mammograms were introduced with noise and filtered with best filter as decided from 119 mammogram result. A comparison graph were plotted and shown in figure 15 to 18.

TABLE II. DENOISED RESULT OF VARIOUS FILTERS FOR 5% SALT & PEPPER NOISE FOR MDB105

Salt & Pepper	**Mean**	**Gaussian**	**Wiener**	**Median**	**AMF**
PSNR	25.53	20.51	18.60	39.77	**40.14**
SSIM	41.92	30.43	29.58	98.83	**99.30**
MSE	39.75	23.86	12.86	0.41	**0.22**

TABLE III. DENOISED RESULT OF VARIOUS FILTERS FOR SPECKLE NOISE FOR MDB105

Speckle	**Mean**	**Gaussian**	**Wiener**	**Median**	**AMF**
PSNR	**30.23**	25.73	25.15	27.01	24.20
SSIM	**79.29**	67.51	69.91	71.18	65.13
MSE	**12.99**	30.31	28.65	27.90	30.81

TABLE IV. DENOISED RESULT OF VARIOUS FILTERS FOR POISSON NOISE FOR MDB105

Poisson	**Mean**	**Gaussian**	**Wiener**	**Median**	**AMF**
PSNR	**36.21**	33.57	33.82	35.57	32.49
SSIM	**92.34**	81.39	83.41	89.58	80.04
MSE	**4.23**	12.58	10.62	6.13	13.31

TABLE V. DENOISED RESULT OF VARIOUS FILTERS FOR GAUSSIAN NOISE FOR MDB105

Gaussian	**Mean**	**Gaussian**	**Wiener**	**Median**	**AMF**
PSNR	27.85	24.74	26.37	**28.79**	24.43
SSIM	32.96	15.59	23.15	**39.93**	16.68
MSE	73.26	80.52	79.36	**43.04**	74.80

TABLE VI. DENOISED RESULT OF VARIOUS FILTERS FOR 20 % SALT & PEPPER NOISE FOR 119 MAMMOGRAM.

Salt & Pepper	**Mean**			**Gaussian**			**Wiener**			**Median**			**AMF**		
	Min	Max	Avr	Min	Max	Avr	Min	Max	Avr	Min	Max	Avr	Min	Max	Avr
PSNR	17.37	18.78	18.02	13.59	14.61	14.07	14.78	15.84	15.29	29.38	31.32	30.39	33.15	42.73	**38.25**
SSIM	4.52	13.77	9.03	1.93	5.47	3.35	3.89	10.99	7.34	93.22	95.35	94.37	98.57	99.48	**99.07**
MSE	106.3	143.4	126.5	76.32	99.28	88.51	106.3	143.7	126.4	0.50	1.29	0.85	0.18	0.63	**0.38**

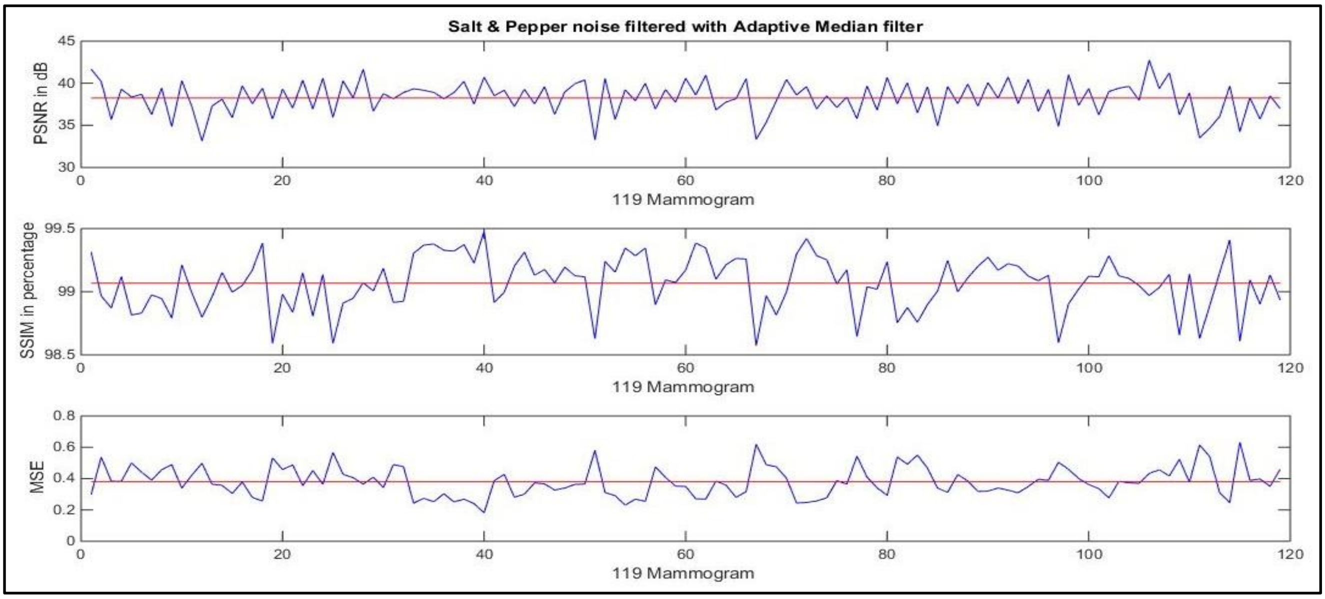

Fig. 11. Plot of 20 % Salt & Pepper noise with Adaptive Median filter

TABLE VII. DENOISED RESULT OF VARIOUS FILTERS FOR SPECKLE NOISE FOR 119 MAMMOGRAM.

Speckle	**Mean**			**Gaussian**			**Wiener**			**Median**			**AMF**		
	Min	Max	Avr	Min	Max	Avr	Min	Max	Avr	Min	Max	Avr	Min	Max	Avr
PSNR	29.00	36.07	**32.25**	25.03	31.48	27.68	24.77	29.62	26.44	26.34	33.15	29.11	23.44	29.83	26.04
SSIM	74.82	93.94	**84.82**	60.05	**90.41**	75.53	63.60	**90.02**	76.91	65.30	**91.58**	78.79	57.28	**89.41**	73.47
MSE	5.15	20.40	**12.01**	10.24	41.15	25.03	11.05	36.53	23.88	8.09	33.07	19.89	10.61	42.33	25.87

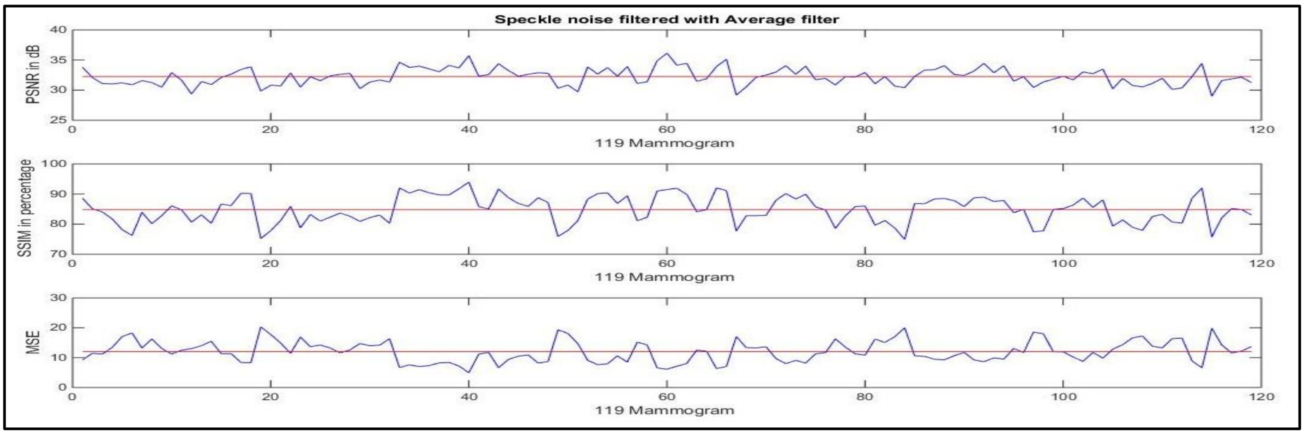

Fig. 12. Plot of Speckle noise with Mean filter

TABLE VIII. DENOISED RESULT OF VARIOUS FILTERS FOR GAUSSIAN NOISE FOR 119 MAMMOGRAM

Gaussian	Mean			Gaussian			Wiener			Median			AMF		
	Min	Max	Avr	Min	Max	Avr	Min	Max	Avr	Min	Max	Avr	Min	Max	Avr
PSNR	27.17	28.25	27.62	24.48	25.06	24.78	26.04	26.69	26.26	28.33	30.09	**29.14**	24.10	24.94	24.51
SSIM	15.51	**39.75**	29.20	8.20	20.08	14.29	10.49	31.23	20.67	34.74	43.73	**39.48**	11.05	20.48	15.60
MSE	67.17	100.34	81.55	78.83	91.45	84.56	73.08	96.89	85.44	42.40	43.49	**42.99**	73.75	81.64	78.19

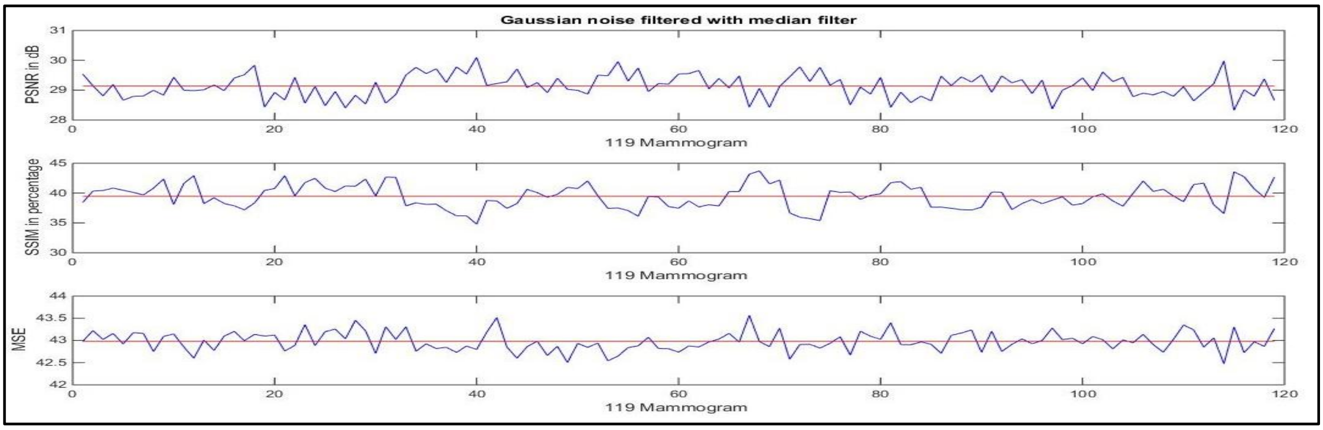

Fig. 13. Plot of Gaussian noise with Median filter

TABLE IX. DENOISED RESULT OF VARIOUS FILTERS FOR POISSON NOISE FOR 119 MAMMOGRAM

Poisson	Mean			Gaussian			Wiener			Median			AMF		
	Min	Max	Avr	Min	Max	Avr	Min	Max	Avr	Min	Max	Avr	Min	Max	Avr
PSNR	32.86	40.11	**36.94**	32.67	38.81	35.19	33.63	36.87	35.15	33.97	41.85	37.39	31.68	38.15	34.32
SSIM	90.93	97.64	**94.20**	78.13	94.69	86.31	81.84	93.67	87.62	88.08	**96.96**	92.37	76.68	94.13	85.28
MSE	1.50	6.03	**3.45**	3.89	15.24	9.25	4.95	11.57	8.15	1.74	7.19	4.32	4.13	16.11	9.84

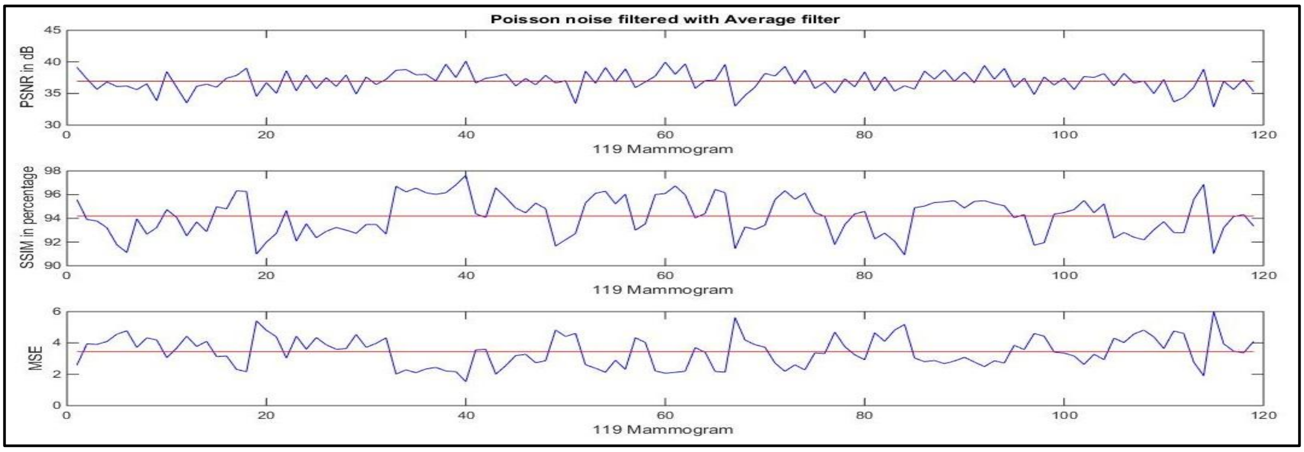

Fig. 14. Plot of Poisson noise with Average filter

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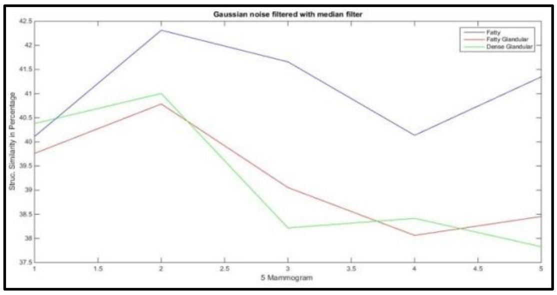

Fig. 15. Gaussian Noise filtered with Median Filter

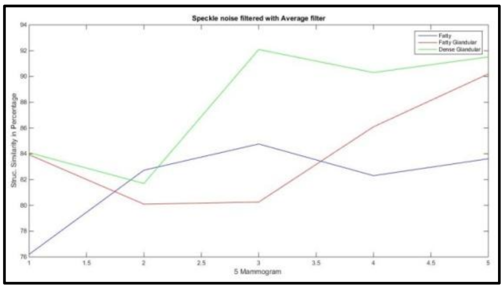

Fig. 16. Speckle Noise filtered with Average Filter

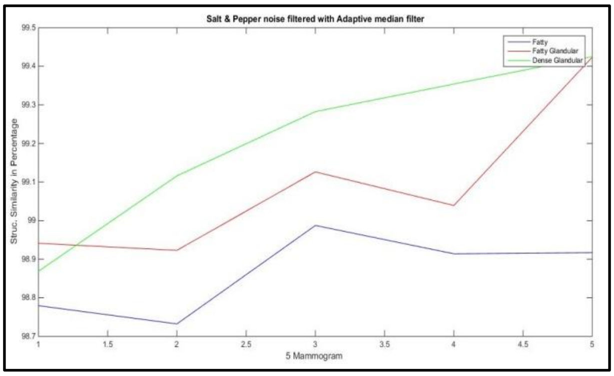

Fig. 17. Salt & Pepper Noise filtered with Adaptive Median Filter

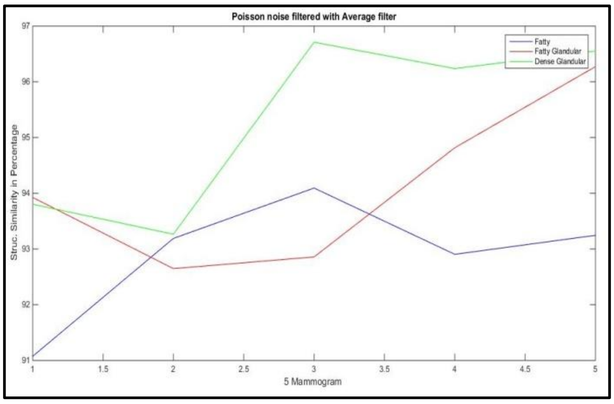

Fig. 18. Poisson Noise filtered with Average Filter

VI. Conclusion

Various noises and their origin were discussed in this paper, noisy dense glandular mammogram were Denoised by various filters and their results were compared. Adaptive median filter shows best result for Salt & Pepper (impulse) noise when compared to others. It also proved that, its performance is best for higher noise probability. Mean or Average filter gives its superlative performance for both Speckle and Poisson noise. Median filter gives better result for Gaussian noise. Adaptive median couldn't perform well in Gaussian distribution because of increase in window size.

Mammograms differ by their tissue density, character of the benign and self noise, so filter performance can vary from image to image. To conclude we decided to implement in large data bank. We took 119 mammograms from MIAS data bank and implemented the same procedure for all 119 samples. Results were calculated in a matrix. Minimum, Maximum and Average value of PSNR, SSIM and MSE were taken. From above result we conclude that, adaptive median filter shows its top performance for salt & Pepper noise with 20 % noise probability. Speckle noise can be removed with Average filter. Other filters were also not bad in their performance. Median filter with 3 x 3 arrays gives best result for Gaussian noise. Average filter gives a better result for Gaussian noise. Poisson noise can be reduced significantly by Average filter.
When we compare 5 mammogram results Dense Mammogram gives better result for most of the noises except Gaussian noise. Fatty mammogram gives best Denoised result for Gaussian type noise and Dense Glandular mammogram gives best Denoised result for all other types of noise. Dense mammogram were brighter visually but it doesn't affect the performance of denoising tools.
As a future work, we can compare the performance with frequency domain filters.

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Reference

1. Anushree Tripathi ; Krishna Misra, "Stilbene analogues as inhibitors of breast cancer Stem cells through P-glycoprotein efflux; A 3D quantitative structure-activity relationship study (Inhibitory activity of stilbenes analogues on breast cancer stem cells)", 2016 International Conference on Bioinformatics and Systems Biology (BSB), ISBN: 978-1-5090-2261-8, 4-6 March 2016.
2. Samreen Sultana , Rahila Rawoof, "A Comparative Study on Breast Cancer and its Associated Risk Factors", International Journal for Research in Applied Science & Engineering Technology (IJRASET), vol. 06 Issue V eISSN: 2321-9653, May 2018.
3. R. Radha ; Kushal Batra ; Sachin Sekhar, "Classification of Mammogram Images: A Survey", 2018 4th International Conference on Computing Communication and Automation (ICCCA), eISSN: 2642-7354, vol. 05, Issue 14-15 Dec. 2018.
4. S. Kannan, N. P. Subiramaniyam, A.T.Rajamanickam, A. Balamurugan, "Performance comparison of noise reduction in Mammogram Images", International Journal of Research in Engineering and Technology, eISSN: 2319-1163, vol. 05, Issue 02, Feb 2016.
5. Rohit verma, Dr. Jahid ali, " A Comparative study of various types of image noise and efficient noise removal techniques", International Journal of Advanced Research in Computer Science and Software Engineering, ISSN: 2277 128X, Vol.3, Issue 10, Oct 2013.
6. Chandrika Saxena, Prof. Deepak Kourav, "Noises and Image Denoising Techniques: A Brief Survey", International Journal of Emerging Technology and Advanced Engineering, ISSN 2250-2459, Vol. 4, issue 3, Mar 2014.
7. Athira P, Fasna K.K, Anjaly Krishnan, "An overview of mammogram noise and denoising techniques", International Journal for Engineering research and General science, ISSN 2091-2730, Vol. 4, Issue 2, Mar 2016.
8. Ardra Mariya Joseph, Grace John M., Anto Sahaya Dhas, "Mammogram Image Denoising Filters: A Comparative Study", Proc. IEEE Conference on Emerging Devices and Smart Systems (ICEDSS 2017), eISBN978-1-5090-5555-5 , 3-4 March 2017
9. Jisna Jose, Ms.Anusha Chacko, D.Anto Sahaya Dhas, "Comparative Study Of Different Image Denoising Filters For Mammogram Preprocessing International Conference on Inventive Systems and Control (ICISC-2017), eISBN 978-1-5090-4715-4, 19-20 Jan. 2017.
10. R. Vijayarajan ; S. Muttan, "Clustering performance analysis of FCM algorithm on iterative relaxed median filtered medical images", 3rd International Conference on Advances in Recent Technologies in Communication and Computing (ARTCom 2011), eISBN: 978-8-19106-918-1, 14-15 Nov. 2011.
11. Ardra Mariya Joseph ; M. Grace John ; Anto Sahaya Dhas, "Mammogram image denoising filters: A comparative study", 2017 Conference on Emerging Devices and Smart Systems (ICEDSS), eISBN: 978-1-5090-5555-5, 3-4 March 2017.
12. P. Shanmugavadivu S, G. Lakshmi Narayanan, "Psychoanalysis Of Characteristic Contrast Enhancement Of Digital Mammogram Image", 2017 Second International Conference on Electrical, Computer and Communication Technologies (ICECCT), eISBN: 978-1-5090-3239-6, 22-24 Feb. 2017.
13. B. K. Thote ; K. C. Jondhale, "Improved denoising technique for natural and synthetic images", 2016 International Conference on Signal and Information Processing (IConSIP), eISBN 978-1-5090-1522-1, 6-8 Oct. 2016.
14. R. Sangeetha ; K. Srikanta Murthy, "A novel approach for detection of breast cancer at an

early stage using digital image processing techniques", 2017 International Conference on Inventive Systems and Control (ICISC), eISBN 978-1-5090-4715-4, 19-20 Jan. 2017.

15. Yao Lu ; Jia-Yu Li ; Yu-Ting Su ; An-An Liu , "A Review of Breast Cancer Detection in Medical Images 2018 IEEE Visual Communications and Image Processing (VCIP), ISSN: 1018-8770, 9-12 Dec. 2018.