An Overview Of Mammogram Noise And Denoising Techniques

Athira P[1], Fasna K.K[1], Anjaly Krishnan[2]

[1]P.G Scholar, [2]Assistant Professor, Thejus Engineering College

[1]E-mail: athiraponnoth@gmail.com

Abstract— Mammogram is a mammography exam used to aid in the diagnosis of breast diseases in women. This paper mainly focuses on the biomedical image processing area. Noise is an inevitable parameter that must be considered in the medical images. The main problem of mammogram is that like other medical data it is also affected with noise during the acquisition of the mammogram images. So it is a challengeable task for researchers to denoise the mammogram images while preserving the important features of the image. The main noises affecting the mammogram images are salt and pepper, guassian, speckle and poisson noise. In previous days, noises in the mammogram images are denoised by the linear methods like mean and weiner filters. But the main problem of linear filtering is that it produces blurring effect and incomplete noise filtration. To overcome this limitation nonlinear filtering techniques like wavelet based denoising were proposed. In this paper, light is thrown on some important type of mammogram noises and its denoising techniques.

Keywords— Mammogram,Denoising,Salt and pepper,Gaussian noise,Speckle noise,Poisson Noise,Mean,Median,Wavelets,Wiener filter, Adaptive transforms.

INTRODUCTION

In the recent times among the various types of cancer breast cancer is one of the leading global health concerns. Mammogram is an easy and affordable method for diagnosing the microcalcification and clinically hidden lump tissues in the breast at the early stage of cancer. Breast cancer can be defined as a malignant tumor that starts in the cells of the breast. A malignant tumor is a group of cancer cells that can grow into (invade) surrounding tissues or spread (metastasize) to distant areas of the body. The female breast is made up mainly of lobules (milk-producing glands), ducts (tiny tubes that carry the milk from the lobules to the nipple), and stroma (fatty tissue and connective tissue surrounding the ducts and lobules, blood vessels, and lymphatic vessels).Most breast cancers begin in the cells that line the ducts (ductal cancers) [3]. Sometimes the malignant tumor may begin in the cells of lobules, while a small number start in other tissues. Lobular cancers are begins in the milk carrying ducts and spreads beyond it. It is the second most common type of breast cancer. Detecting the breast cancer in the earlier stages is the most effective way to be surviving the breast cancer.Mammogarphy is used for the early detection of masses in the breast and thereby reducing the death rate. Mammogram unit uses low energy X-rays to see inside the breast.There are different types of mammography like digital mammography, computer aided detection and breast tomosynthesis.Even though there are so many methods to diagnosing the breast cancer,it remains difficult to interpret some cases. Since the mammogram images are noisy and low contrast the radiologists may confused to diagnoses the cancer. In the present, the miss diagnosis rates of the radiologists about 10-30%.

The main aim of mammogram denoising is to preserve the important features of the imge while filtering out the noise. In previous days, noises in the mammogram images are denoised by the linear methods like mean and weiner filters. But the main problem of linear filtering is that it produces blurring effect and incomplete noise filtration. To overcome this limitation nonlinear filtering techniques like wavelet based denoising were proposed. This paper presents the noise and denoising techniques on mammogram images.

The paper is structured as follows: the noise model section gives a brief description about the noise and also describes about different types of mammogram noises. It mainly consists of salt and pepper, speckle, poisson and guassian noise.Next section presents an overview of denosing techniques.Both linear and nonlinear filters are decribed in that section.

NOISE MODEL

Noise is a random fluctuation of image intensity and appears as grains in the image. The ambient conditions affect the imaging sensors in the camera. The noise may arise in the image as effects of basic physics-like photon nature of light or thermal energy of heat inside the image sensors [4]. When a noise is affected in an image the pixels in the image show different intensity values instead of true pixel values. Noise can be added to an image during accusation and transmission of image. The noisy image can be modeled as

$$g(x,y)=f(x,y)+n(x,y) \qquad (1)$$

Where f(x, y) is the original image pixel, n(x,y) is the noise and g(x, y) is the resulting noisy pixel.[1]

TYPES OF NOISES

a) Salt and Pepper Noise: Salt and pepper noise is also called impulse valued noise. Other terms are spike noise, random noise or independent noise. Due to this noise black and white dots appear in the image. The main reason behind the appearance of salt and pepper noise are sharp and sudden changes of image signal and dust particles in the image acquisition source or over heated faulty components[4]. Due to this noise image is corrupted to a small extent. When image is affected by this noise image pixel values are replaced by noisy pixel values either maximum or' minimum pixel value i.e., 255 'or' 0 respectively, if number of bits are 8 for transmission. Salt and pepper noise is present in the mammogram images because of the dust particle in the mammogram unit .This noise introduce dark and white dots in the images as shown in fig 2.

254	207	210
97	212	32
62	106	20

→

254	207	210
97	0	32
62	106	20

Fig 1: The central pixel value is corrupted by salt and Pepper noise [6]

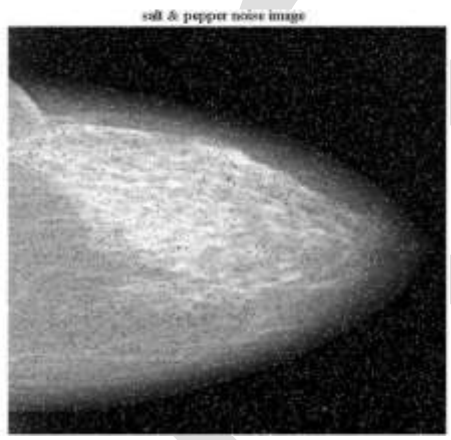

Fig 2: Salt and pepper image

b) Speckle Noise: Speckle noise can be considered as a multiplicative noise. This noise can exist in an image similar to Gaussian noise [2]. This noise can be modeled as shown below

$$J=I+n*I \qquad (3)$$

Where, J is the speckle noise image, I is the input image and n is the noise image with mean 0 and variance V [4]. This noise is due to the dust particle in the image accusation source .Fig 3 shows the image with speckle noise.

c) Poisson Noise: Poisson noise is also called photon noise. This noise is due to the statistical behavior of electromagnetic waves such as x-rays, visible lights and gamma rays. In a mammogram image poisson noise is due to the change in the number of photons in the mammogram unit.The root mean square value of this noise is proportional to the square root intensity of the image.Due to this noise different pixel of the image suffered by independent noise value. As the name indicates this type of noise has a Poisson distribution and the probability distribution function given by [9]

$$f(k,\lambda)=\lambda^{k}e^{-\lambda}/k! \qquad (4)$$

k –number of occurrences of an event

λ –Positive real number

International Journal of Engineering Research and General Science Volume 4, Issue 2, March-April, 2016
ISSN 2091-2730

Fig 3: Speckle noise image

d) Gaussian noise: This noise model follow Gaussian distribution. That means each pixel in the noisy image is the sum of the random Gaussian distributed noise value and the true pixel value. The noise is mainly due to electronic circuit noise and sensor noise[10]. Figure 4 shows the image with Gaussian noise.

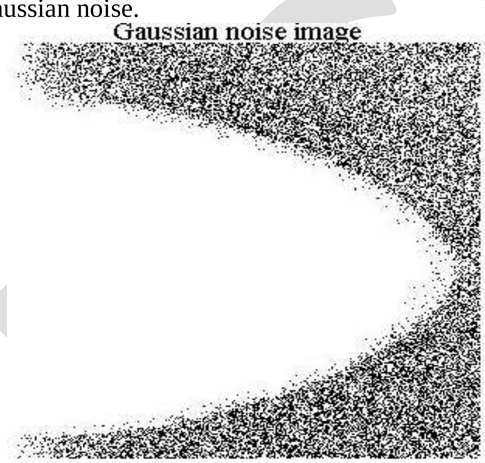

Fig 4:Gaussian noise image

This type of noise has a Gaussian distribution, which has a bell shaped probability distribution function given by

$$P(x)=1/\sigma\sqrt{2}\prod\ e^{(x-\mu)2}/2\sigma^2 \qquad (2)$$

Where P(x) is the Gaussian distribution noise in image, μ is the mean and σ is the standard deviation respectively [4]. The Graphical representation of the probability distribution function is shown in Figure 5

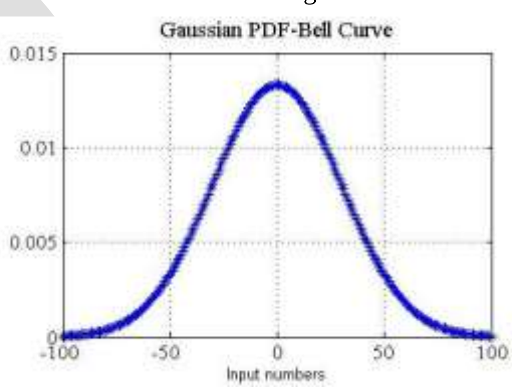

Fig 5: PDF of Gaussian noise

DENOISING METHODS

Image denoising plays an important role in image processing for the analysis of images. Image denoising can be defined as the recovery of the original image which is impure by the noise. Among the large number of denoising algorithm the best one should remove the noise completely from the image, while preserving the important features. The image s(x,y) is the original image. It is blurred by a linear operation and noise n(x,y) is added to the original image form the degraded image w(x,y). This noisy image is given to denoising technique which give the denoised image z(x,y).

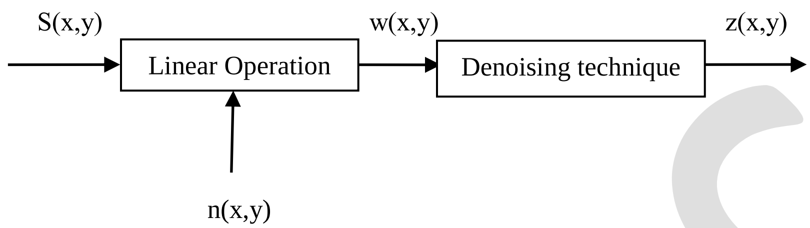

Fig 6: Denoising concept[2]

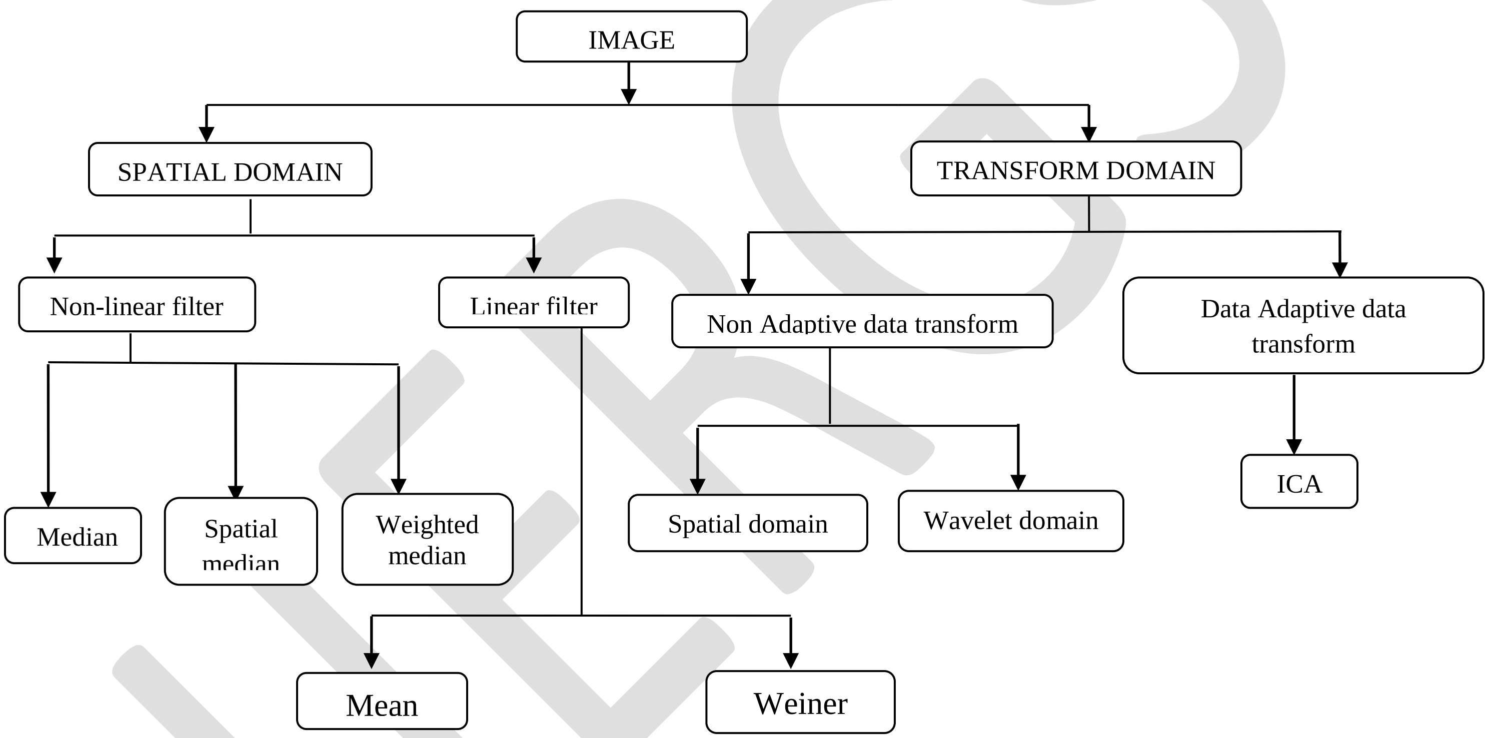

Fig 7: Classification of Image Denoising Techniques [7]

The Linear operation means the addition or multiplication of the noise n(x,y) to the signal s(x,y).Fig 7 shows the various types of denoising techniques that are used in the mammogram images.Spatial filtering methods and transform domain filtering methods are the two basic approaches in image denoising.

A)Spatial Filtering

Spatial Filtering is a traditional way to remove noise from image data .Non-linear and linear filters are the two types of spatial filters.

1)Linear Filters

Linear filters are based on the constraint of linearity which produces time varying input signals to produce output signals. Linear filter improve the images in many ways: sharpening the edges of objects, reducing random noise, correcting for unequal illumination, deconvolution to correct for blur and motion, etc. But the main problem of linear filter is that it may produce blurring effect.

1.1Mean: Mean filter is a simple averaging linear filter. In mean filter the center value in the window is replaced by a sliding window filter. Each pixel value in the image is replaced with the average value of its neighbors, including itself [6]. Mean filter is mainly used when an image is corrupted with salt and pepper noise. Mean filter changes the noise affected white and dark values closer to the pixel values of the surrounding ones. If the noise in certain region is needed to be removed mean filter is used. That is when only a part of the image needs to be processed mean filter is used. In fig 5 8, 4,7,2,1,9,5,3 and 6 are the pixel values. The mean of the pixel value is obtained by taking the average of these values. Here the mean is 5.so the central value is replaced by 5.

Unfiltered Values

8	4	7
2	1	9
5	3	6

*	*	*
*	5	*
*	*	*

8+4+7+2+1+9+5+3+6=45; 45/9=5

Fig 8: In this Center value which is previously 1 in the unfiltered value is replaced by the mean of all nine values that is 5,[6]

1.2 Wiener filter: Wiener filter is used to filter out noise that has corrupted a signal. It is based on statistical approach. For denoising wiener filter requires the spectral information of the noise and the original signal. The filters are designed according to the desired frequency response. This filter is mainly used to remove the additive noise. The main aim of wiener filter is to reduce the mean square error [6]. The two parts of wiener filter are inverse filtering part and noise smoothing part. The deconvolution and removing the noise with a compression operation are performed in the inverse filtering part

2. Non Linear Filters

Non linear filters are mainly used for removing the non additive noise. The main drawback of linear filter is that it produces blurring effect and incomplete noise filtration during the denoising of an image. To overcome this disadvantage nonlinear filters are used.

2.1 Median filter: The median filters have a moving window principle similar to the mean filter. It is a simple method which is based on the order statistics. It is used for smoothing the images. The amount of intensity variation between one pixel and the other pixel is reduced by using median filter. In this filtering method it replaces the original pixel value by the median value of some neighboring pixel. For calculating the median value first sorting all pixel values into ascending order and then replace the pixel being calculated with the middle pixel value. If the number of pixel values is even, then the average of the two middle pixel values is used to replace [6]. In the case of signal dependent noise the performance of median filtering is not satisfactory

10	5	20
14	80	11
8	3	22

3,5,8,10,11,14,20,22,80

Median (central value 80 is replaced by 11)

Fig 9: Method of Median Filter [6]

B) Transform domain

1. Non-adaptive transforms

1.1 Spatial-Frequency Filtering: Spatial frequency filtering uses low pass filters with fast fourier transform. In this method the filter is designed based on the desired frequency response. The method is time consuming and may produce artificial frequencies in the processed image.

1.1.1Wavelet transform: Wavelet transform is one of the powerful tool for signal and image processing. This arithmetic function will split the data into different frequency component[12].Since it is a multiresolution transform it give both time and frequency information. It is another form of representing an image and it does not change information content in the image. The non redundant image representation is provided by discrete wavelet transform (DWT) which also provide better spatial and spectral information. Because of this reason DWT is attracted more in image denoising.In DWT the signal is passed through two complementary filters which give approximation and detail component of the signal. This step is known as the decomposition or analysis. The inverse of this step is known as the reconstruction or synthesis. The analysis and synthesis step is done by the mathematical operation discrete wavelet transform and inverse discrete wavelet transform respectively. The original image is transformed into four pieces when DWT is applied. The four pieces are normally labeled as A1, H1, V1 and D1 as the schematic depicted in Fig.6. The A1 is called the approximation, can be further decomposed into four sub-bands. The remaining bands are called detailed components. To obtain the next level of decomposition, sub-band A1 is further decomposed [8].The main advantage of DWT is that it is a multiresolution transform. In image denoising first image is divided into different sub bands and then thresholding algorithms are applied to the wavelet coefficients. Finally inverse wavelet transform is applied which give denoised image. Wavelet transform also have some disadvantages. Lack of shift invariance and lack of directional selectivity are the two main drawback of DWT.

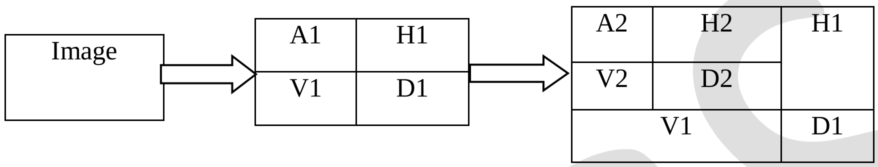

Fig.10:DWT based Wavelet decomposition to various levels[8

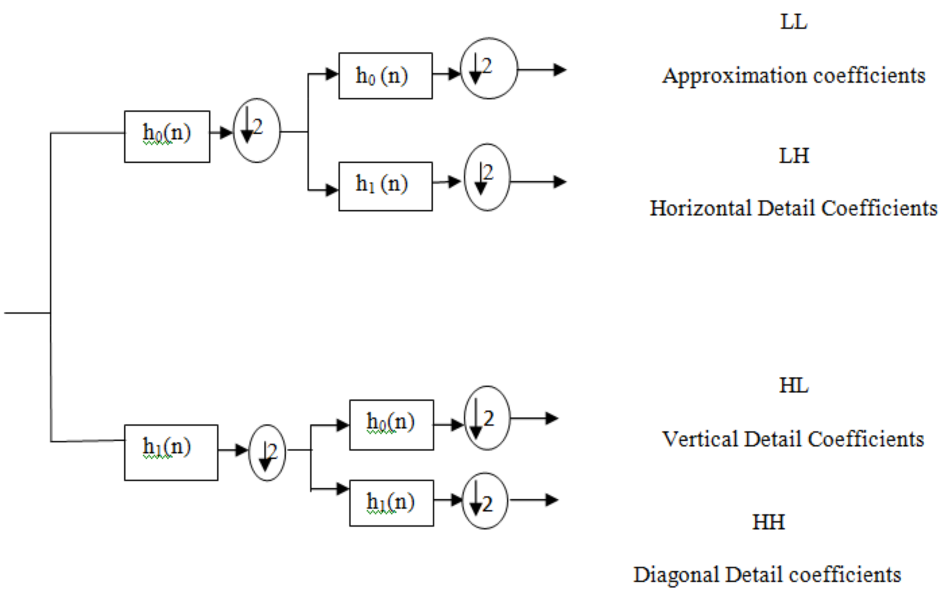

Fig 11: 2D DWT with single stage decomposition [8]

2.2 Adaptive transforms

According to the characteristics of the image inside the filter the behavior of the adaptive filter changes. Independent Component Analysis (ICA) is one of the adaptive transform which gained wide spread attention. The ICA method is used to represent a set of multidimensional data vectors in a basis in which the component are independent as possible[11] For denoising of non gaussain data ICA is used. The advantage of using ICA is that it's assumption of signal to be Non-Gaussian which helps to denoise images with Non-Gaussian as well as Gaussian distribution. One of the disadvantage of ICA when compared to wavelet transform is that it's computational cost [1].

CONCLUSION

Denoising of mammogram images is indeed a challenging task for the domain experts. The accuracy of tumor prediction mainly relies upon the efficiency of the denoising techniques. In this paper different types of mammogram noises and its denoising techniques have been discussed. It is evident from this study that gaussian, speckle,salt and pepper and poisson noises play a major role in distorting the mammogram image.As the linear filters produce blurring effect nonlinear filters are used. As per the research wavelet based denoising outperformed the linear denoising techniques.

REFERENCES:

[1] Toran Lal Sahu Mrs. Deepty Dubey" A Survey on Image Noises and Denoise Techniques" International Journal of Advanced Research in Computer Engineering & Technology (IJARCET) Volume 1, Issue 9, November 2012

[2] Chandrika Saxena, Prof. Deepak Kourav" Noises and Image Denoising Techniques: A Brief Survey" Versha Rani et al, Journal of Global Research in Computer Science, 4 (4), April 2013, 166-171

[3] Samir Kumar Bandyopadhyay" Breast Cancer Prevention and Early Detection"

[4] Mr. 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 3(10), October - 2013, pp. 617-622

[5] Ajay kumar boyat and brijendra kumar joshi" A review paper: noise models in digital image processing"signal & image processing : an international journal (SIPIJ) vol.6, no.2, april 2015

[6] Priyanka kamboj and versha rani "A Brief study of various noise model and filtering techniques "versha rani et al, journal of global research in computer science, 4 (4), april 2013, 166-171

[7] Barjinder Kaur, Manshi Shukla" Image Denoising and its Methods: A Survey" Barjinder Kaur et al, International Journal of Computer Science and Mobile Computing, Vol.3 Issue.6, June- 2014, pg. 234-238

[8] Er. Manpreet Kaur , Er. Gagndeep Kaur A P" A Survey on Implementation of Discrete Wavelet Transform for Image Denoising" International Journal of Communications Networking System

[9] Nawazish naveeda, ayyaz hussainb, m. Arfan jaffara,tae-sun choic" quantum and impulse noise filtering from breast mammogram images" computer methods and prog ram sin biomedicine 108(2012) 1062–1069

[10] Prabjot Kaur and Sheo Kumar" Survey of Image Noise Technique" SSRG International Journal of Computer Science and Engineering (SSRG-IJCSE) – EFES April 2015

[11] P.Mayo,F.Rodenas,and G.Verdu"Comparing Methods to Denoise Mammographic Images"

[12] Harish Kumar.N,Amutha.S and Dr.Ramesh Babu D.R"Enhancement of Mammographic Images using Morphology and Wavelet Transform"ISSN:2229-6093