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ENHANCEMENT OFMAMMOGRAM IMAGES EFFECTIVELY USING DOUBLE FILTERING TECHNIQUE

G.R.Jothilakshmi[1] and E.Gopinathan[2]

[1]Research Scholar, Department of ECE , Vels University, Chennai, India. Jothi.se@velsuniv.ac.in
[2]Dean, School of Engineering, Vels University, Chennai, India. dean.se@velsuniv.ac,in

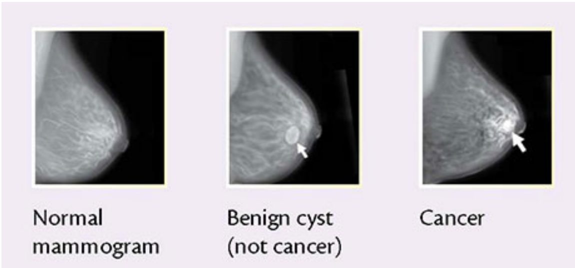
ABSTRACT

Breast cancer is the most common death causing cancer among women. Mammograms are used as a best screening tool to detect early breast cancer and processing of these images requires high computational capabilities.Due to ill-performance of X-ray hardware systems, mammographic images are generally noisy with poor radiographic resolution. This leads to improper visualization of lesion detail. Mammogram enhancementis an important preprocessing technique for identifying mass and micro-calcification. Non-linear filters are generally preferred for image enhancement applications as they provide better filtering results not only by suppressing background noise but also preserving the edges. In this paper, a mammogram image which is affected by salt and pepper noise is considered.The proposed method presents a combination of Adaptive Volterra filter withany one of existing filters like mean,median, min-max may be used for contrast enhancement of mammograms. For comparison, mammogram which is corrupted by Gaussian, Poisson and white noise is considered.These noises are eliminated using four combination of filters and the performance of filters is evaluated by calculating peak signal to noise ratio (PSNR) and Mean square error(MSE).

Key words: Adaptive Volterra filter, Peak signal to noise ratio (PSNR) and Mean square error(MSE), Digital mammogram.

INTRODUCTION

Breast cancer is the most frequently diagnosed cancer and the leading cause of cancer death among females in both developed and developing regions of the world, accounting for 23% of the total cancer cases and 14% of the cancer deaths. The incidence of breast cancer in India is on the rise and is rapidly becoming the number one cancer in females pushing the cervical cancer to the second spot.The seriousness of the situation is apparent after going through recent data from Indian Council of Medical Research (ICMR). It is reported that one in 22 women in India is likely to suffer from breastcancer during her lifetime. In America one in eight being a victim of this deadly cancer. The surveys give an alarm about the importance of early identification of breast cancer that increases the survival rate. Mammogram is picture of breast captured by using X rays. MAMMOGRAPHY is currently the most effective imaging modality for breast cancer screening.Mammography is radiographic examination that is specially for detecting breast pathology. Before classifying the mammograms into masses and micro-calcification which are again classified into benign and malignant, the preprocessing of mammograms is very much essential.



Many types of filters may be used to remove the noise in mammogram images. Medical images are affected by various types of noises like salt and pepper noise, Gaussian noise, Poisson noise etc. To remove these noises either linear or nonlinear filter may be used. But nonlinear filters gives better results than linear filters.

Mammogram enhancement is very important preprocessing work to detect any abnormalities in female breast. Previous enhancement techniques to enhance mammogram images starts with basic histogram equalization technique[1], Unsharp masking [2], Wavelet – based techniques [3].In [9], the image was enhanced using different wavelet transforms like curvelet, contourlet and non-sub sampled wavelet transforms and the performance measures like PSNR and MSE were calculated. The other techniques which are useful for mammogram enhancement are contrast stretching, power law transformation, Morphological Processing, Median Filtering, Anisotropic Diffusion Filtering, Bilateral Enhancement, Homomorphic Filtering[4] and many others. The combination of Modified histogram with homomorphic filtering is followed for contrast enhancement of mammogram images [5].DCT with USM were followed for colour image enhancement [6]. The proposed algorithm in this paper improves the image colour levels and contrast effectively without causing block artefacts. The dominant brightness level analysis was used for colour image enhancement [7]. Dominant brightness level analysis decomposes the image into several layers. DWT was then applied for calculating brightness level by using average luminance in LL sub-band. The combination of USM, Bilateral filter, CLAHE and Adaptive gain control (AGC) gave better PSNR and MSE in mammogram enhancement [9]. These techniques are useful to enhance the local contrast of mammograms.

METERIALS AND METHODS

The nonlinear filters are very much useful for not only image enhancement but also for edge preservation. The usual nonlinear spatial filters are otherwise called as order-statistics or rank filter. The examples for rank filters are mean, median, min, max filters. Even though these are nonlinear filters, these filters are suitable to remove certain type of noise and these cannot preserve edgesstrongly. But the proposed quadratic volterra filter is suitable for any kind of noise removal from the images and also efficient in edge preserving.

It is very difficult to remove high intensity noise like salt and pepper from mammogram images. It becomes essential to have a combination of two nonlinear filters for better contrast enhancement of mammogram images. In the proposed methodology, a combination of improved adaptive Volterra filter and any one of nonlinear filters like mean, median, min, max is used for better mammogram enhancement.

I.Adaptive Volterra filter: Since most of the real life and practical systems are nonlinear, the nonlinearities can be modeled by Volterra power series. An Nt$h$order Volterra filter, with input vector x[n] and output vector y[n] is realized by

$$y[n] = ho + \sum_{r=1}^{\infty}\sum_{n1=1}^{N}\sum_{n2=1}^{N}\ldots\ldots\sum_{nr=1}^{N} hr[n1,n2\ldots.nr]\, x[n-n1]x[n-n2]\ldots\ldots x[n-nr] \quad (1)$$

Where r indicates the order of nonlinearity, with r = 1implying a linear system, r = 2 implying a quadratic system and so forth. hr[n1, n2,, . . . nr] is the rth order Volterra kernel, identification of which is one of the key issues inpolynomial signal processing. h0 is the constant offset at theoutput when no input is present. The complexity of the kernel can be considerably reduced by assuming homogeneity. Also the output y[n] is linear with respect to the Volterra filter weights. Often, in practical systems, much of the nonlinearity is comprised of the quadratic components. It is thus proposed that a two dimensional quadratic filter can model and process inherent nonlinearities in medical images.

II. Two Dimensional Discrete Quadratic Volterra System

The two dimensional quadratic system with input x[n1, n2] and output y[n1, n2] is governed by the equation

$$y[n1,n2] = \sum_{m11=0}^{N1-1}\sum_{m12=0}^{N2-1}\sum_{m21=0}^{N1-1}\sum_{m22=0}^{N2-1} h1[m11,m12,m21,m22]$$

$$x[n1-m11,n2-m12]x[n1-m21,n2-m22] \qquad (2)$$

Equation (2) can be represented in the matrix form as

Y[n1,n2]=XT[n1,n2]H2X[n1,n2] (3)

The quadratic kernel H2 has N1N2×N1N2 elements and each element consists of N22 sub-matrices H(i, j) with N1 × N2elements given as

$$\begin{matrix} H(0,0) & H(0,1)\ldots. & H(0,N2-1) \\ H(1,0) & H(1,1) & H(1,N2-1) \\ \vdots & \vdots & \vdots \\ H(N2-1,0) & H(N2-1,1) & H(N2-1,N2-1) \end{matrix}$$

where each sub-matrix H(i, j) is given by

$$H(i,j) = \begin{matrix} h(0,i,0,j) & \ldots\ldots & h(0,i,N1-1,j) \\ h(1,i,0,j) & \ldots\ldots & h(1,i,N1-1,j \\ . & & \\ h(N1-1,i,0,j) & \ldots\ldots & h(N1-1,i,N1-1,j) \end{matrix} \qquad (4)$$

The important issues in Volterra systems are the identificationof the kernel H2 and its computationallyefficient implementation.

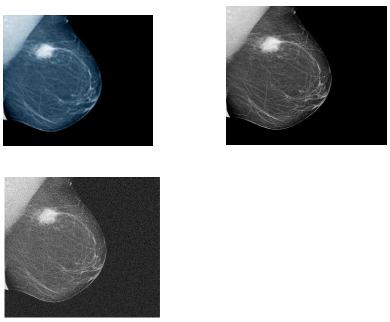
There areno general design methods for finding H2. Design of twodimensional kernels for specific applications can be done usingmethods like optimization, bi-impulse response method etc.

RESULTS AND DISCUSSION

The digital input mammogram (either black and white or colour) is considered with different size. First step is to convert the input mammogram into grey scale image. With grey scale image ,salt and pepper noise is added andthe noisy image is divided into four sub-bands like High-High(HH),High-Low(HL), Low-High(LH), and Low-Low(LL) using 2D discrete wavelet Transform(DWT).Mammogram enhancement is done with LL sub-band using combination of adaptive volterra filter and mean filter. Simultaneously MSE and PSNR are calculated. The output is compared with other combination of filters (i) adaptive volterra filter and median filter (ii)adaptive volterra filter and min filter (iii)adaptive volterra filter and max filter.Here the analysis is carried out in both frequency domain and special domain. The sameprocedure is repeated with Gaussian noise, Poisson noise, and white noise.The above steps are carried out in spatial domain without DWTand PSNR and MSE are calculated and the comparison between performance measures in spatial and frequency domain is done.

FILTERS PERFORMANCEIN FREQUENCY DOMAIN:

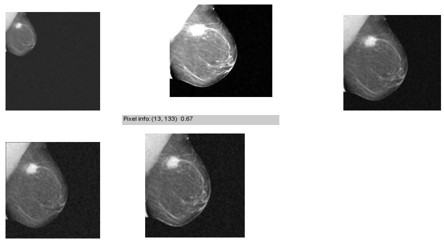
Type:1



Input mammogram Gray scale imageMammogram with white noise

ENHANCED OUTPUTS FROM VARIOUS FILTERS

LLLH

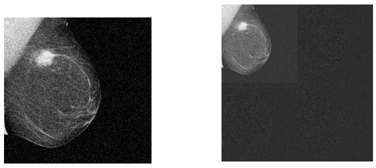


HLHH

DWT outputMedian + volterra Mean + Volterra Min+ VolterraMax + Volterra

Type :2

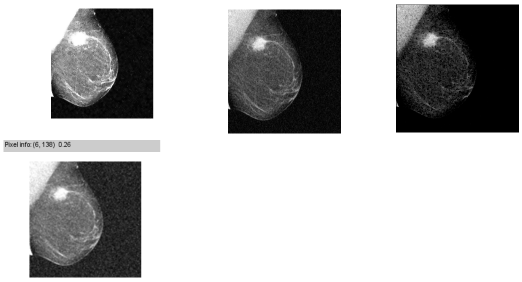
LL LH



HLHH

Mammogram with Gaussian noise DWT output

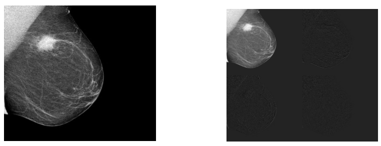
ENHANCED OUTPUTS FROM VARIOUS FILTERS



Median+ volterra Mean +Volterra Min+Volterra Max+Volterra

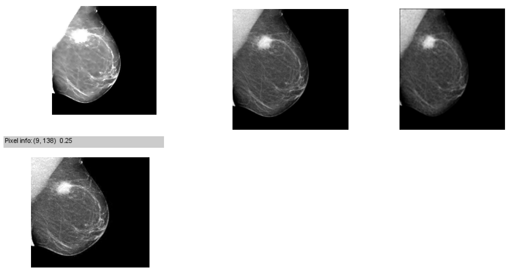
Type :3

LL LH



Mammogram with HL HH
Poisson noiseDWT output

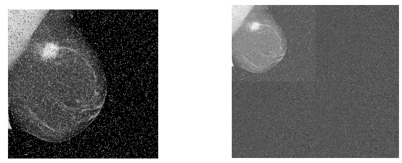
ENHANCED OUTPUTS FROM VARIOUS FILTERS



Median + Volterra Mean +VolterraMin +Volterra Max+Volterra

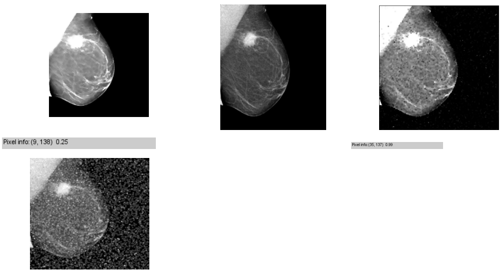
Type :4

LL LH



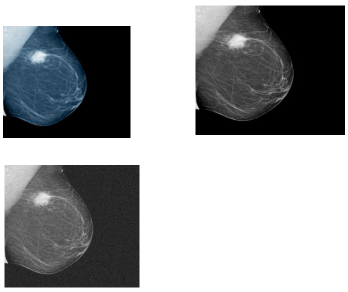
Mammogram with HL HH
salt&pepper noise DWT output

ENHANCED OUTPUTS FROM VARIOUS FILTERS



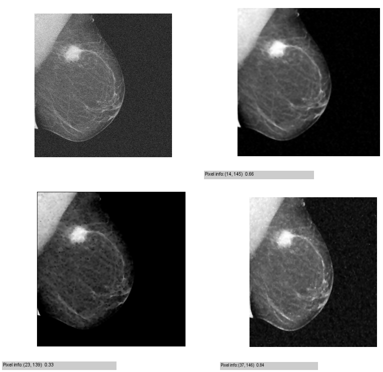
Median + Volterra Mean +Volterra Min +VolterraMax +Volterra

FILTERS PERFORMANCEIN IN SPATIAL DOMAIN : Type : 1



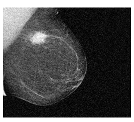
Inputmammogram Grayscaleimage Mammogram with white noise

ENHANCED OUTPUTS FROM VARIOUS FILTER



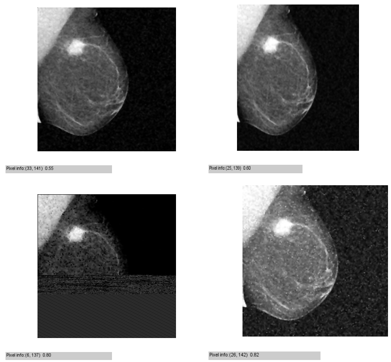
Median + VolterraMean +Volterra Min +VolterraMax +Volterra

Type:2



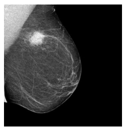
Mammogram with
Gaussian noise

ENHANCED OUTPUTS FROM VARIOUS FILTER



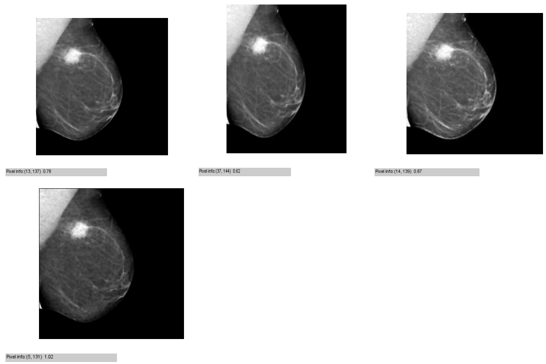
Median + VolterraMean +Volterra Min +VolterraMax +Volterra

Type 3:



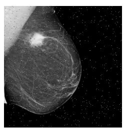
Mammogram with
Poison noise

ENHANCED OUTPUTS FROM VARIOUS FILTER



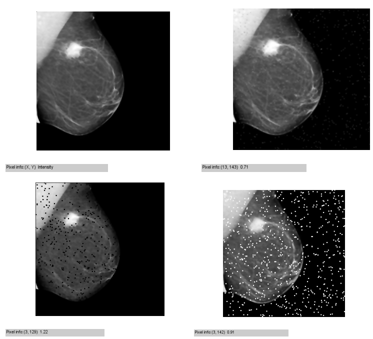
Median + VolterraMean +VolterraMin +Volterra Max +Volterra

Type 4:



Mammogram with
Salt & Pepper noise

ENHANCED OUTPUTS FROM VARIOUS FILTER



Median + Volterra Mean +Volterra Min +Volterra Max +Volterra

Table 1. MSE and PSNR calculation for various combination of filters with different noises

Combination of Filters / Types of Noise	Max+Adaptive volterra		Mean+Adaptive volterra		Median+Adaptive volterra		Min+Adaptive volterra	
Frequency Domain	**MSE**	**PSNR(dB)**	**MSE**	**PSNR(dB)**	**MSE**	**PSNR(dB)**	**MSE**	**PSNR(dB)**
Gaussian	4.8187e+03	75.0858	4.824e+03	75.0064	4.8303e+03	75.0163	4.8452e+03	74.9274
White	4.8259e+03	75.0424	4.8269e+03	75.0365	4.8351e+03	74.9874	4.8468e+03	74.9184
Poison	4.8274e+03	75.0338	4.8268e+03	75.0371	4.8350e+03	74.9880	4.84332+03	74.9469
Salt&Pepper	4.8140e+03	75.1137	4.8219e+03	75.0661	4.8348e+03	75.9895	4.9171e+03	75.5023
Spatial Domain								
Gaussian	4.8534e+03	37.4398	4.8739e+03	37.3883	4.8832e+03	37.3509	4.9078e+03	37.2785
White	4.8695e+03	37.3914	4.8741e+03	37.3778	4.8823e+03	37.3905	4.8876e+03	37.3985
Poison	4.8716e+03	37.3851	4.8739e+03	37.3783	4.8832e+03	37.3509	4.8942e+03	37.3185
Salt&Pepper	4.8655e+03	37.353	4.8740e+03	37.3781	4.8831e+03	37.4033	4.9019e+03	37.2958

CONCLUSION

This paper deals with mammogram enhancement using combination of adaptive volterra filter with mean, adaptive volterra filter with median,adaptive volterra filter with min,andadaptive volterra filter with max filter. The purpose of double filtering is to remove the high intensity noise –the salt and pepper noise. The performance measure to know the efficiency of the filter, MSE and PSNR are calculated. The analysis is carried out in both frequency and spatial domain. The PSNR in frequency domain is higher than PSNR in spatial domain for four types of combination of filters. From the Table1, it is evident that the combination of adaptive volterra filter with median gives a better result to remove the salt and pepper noise than other combination of filters, both in frequency and spatial domain. For comparison, mammogram with Gaussian, Poisson, and white noise are also considered and mammogram enhancement is performed with all four combination of filters. The corresponding MSE and PSNR are shown in the Table I.

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