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Impulse Noise Removal from Mammogram Images using Combiner Approach

I. Laurence Aroquiaraj [*1] and K. Thangavel [2]

[*1 2] Department of Computer Science, Periyar University,

Salem – 636 011, Tamil Nadu, India.

Email: laurence.raj@gmail.com[1], drktvelu@yahoo.com[2]

***Abstract*:** Median filter is quite effective in recovering the images confounded by salt and pepper noise. It discards outliers (impulses) effectively, but it fails to provide adequate smoothing for images corrupted with non-impulse noise. In this paper, two nonlinear techniques for image filtering, namely, New Filter I and New Filter II are proposed based on a nonlinear high-pass filter algorithm. New Filter I is constructed using a median filter, a highpass filter and a combiner. It suppresses uniform noise quite well. New Filter II is configured using midpoint filter, a median smoother of window size 3x3, the high pass filter and the combiner. Both the filters are shown to exhibit good response at the image boundaries (edges). The proposed filters are evaluated for their performance on mammogram test image and the results obtained are included

Keywords: Median filter, Midpoint filter, Nonlinear filters, Nonlinear high pass filter, combiner.

INTRODUCTION

Breast cancer is one of the major causes for the increase in mortality among women, especially in rural area and urban area. Breast cancer affects more women in urban area than rural area. Detection of early and subtle signs of breast cancer requires high quality images and skilled mammography interpretation. In order to detect breast cancer early, we need high quality images. Mammography screening method is to be effective in decreasing breast cancer mortality through the detection and treatment of early onset of breast cancer [1,3]. The diagnostic value of the decrease in percentage of immunoglobulin G1 (%IgG1) in breast cancer was analyzed with special emphasis on early tumor stages [2].

The removal of noise from image is vital role in medical image processing. Still there is no general method for noise removal from mammogram medical image. It is to be noted that the noise removal is heavily based on edge information. Each and every approach has own advantages and disadvantages. Therefore, the filters designed for image processing and analysis are required to yield sufficient noise reduction without losing the high frequency content of edges [6]. Median Filter, suggested by John Tukey in 1971, is also an effective for filtering noise having wide spectrum. It is more suitable for discarding outliers and preserving the rapidly varying edges [7]. It, however, is found to be inadequate in enhancing the New Filter I mages corrupted with non- impulse noise [5]. Gallagher, Wise and Nodes have analyzed the properties of median filters in detail [8, 9].

In this paper, two nonlinear image filtering schemes based on a nonlinear highpass filter algorithm [16] are described. The first filtering scheme - New Filter I, consists of a median filter, a highpass filter and a combiner. The second filtering scheme - New Filter II, is configured by a midpoint filter, a median smoother of window size 3x3, the highpass filter and the combiner. The proposed noise removal methods will be effective in filtering out the salt and pepper noise without removing edges.

Filtering Schemes

The mammogram image is the input to both the median filter and highpass filters. Let the two-dimensional sequence {x}, represent the image of m rows and n columns.

$$x(i,j) = y(i,j) + n(i,j) \qquad (1)$$

where i = 1,2,… ,p and j = 1,2,… , q and n(i, j) is noise. The Fig. 1 describes the filtering scheme of New Filter I for removing noise from mammogram breast image with edge preservation properties.

Median Filter

A median filter belongs to the class of nonlinear filters unlike the mean filter. The median filter also follows the moving window principle similar to the mean filter.

A 3 × 3, 5×5 or 7×7 kernel of pixels is scanned over pixel matrix of the entire image [16, 17]. The median of the pixel values in the window is computed,

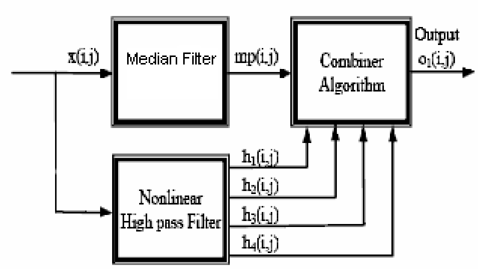

Figure1: The filtering scheme of New Filter I

and the center pixel of the window is replaced with the computed median. Median filtering is done by, first sorting all the pixel values from the surrounding neighborhood into numerical order and then replacing the pixel being considered with the middle pixel value.

Nonlinear Highpass Filter Algorithm

Nonlinear highpass filter algorithm described in [15] for 1-D signals is the one, which selects or discards the samples by comparing the absolute value of the difference in amplitude between two samples with a pre-selected threshold value. In this paper it is modified to detect and preserve horizontal, vertical, left diagonal and right diagonal edges of an image.

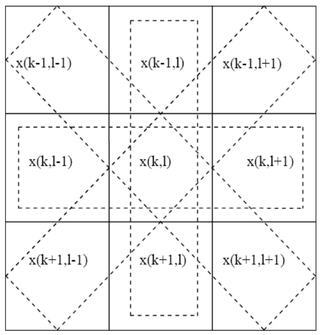

Figure 2:A space-ordered window of size 3 x 3

The highpass filter algorithm separates the image edges by sliding a space-ordered window of size 3 x 3 over the noisy input image {x}. The filter algorithm is explained using Fig. 2. The centre sample x(k,l) is detected as a horizontal edge if

$$\left|x(k,l-1)-x(k,l)\right| \geq \Delta t \quad or \quad \left|x(k,l)-x(k,l+1)\right| \geq \Delta t \qquad (2)$$

(Δt is the user defined threshold value) and is preserved in the (k,l)th location of a two dimensional array {h1}. Similarly, x(k,l) is recognized as vertical edge if

$$\left|x(k-1,l)-x(k,l)\right| \geq \Delta t \quad or \quad \left|x(k,l)-x(k+1,l)\right| \geq \Delta t \qquad (3)$$

and is preserved in an array $\{h_2\}$; it is declared as a left diagonal edge if and is preserved in an array $\{h_3\}$ and if

$$\left|x(k-1,l-1)-x(k,l)\right| \geq \Delta t \quad or \quad \left|x(k,l)-x(k+1,l+1)\right| \geq \Delta t \qquad (4)$$

$$\left|x(k-1,l+1)-x(k,l)\right| \geq \Delta t \quad or \quad \left|x(k,l)-x(k+1,l-1)\right| \geq \Delta t \qquad (5)$$

then x(k, l) is a right diagonal edge and is preserved in {h4}. If x(k, l) does not satisfy the criteria for an edge horizontally, vertically or diagonally, then it is declared a non-edge component and therefore, the (k, l)th location of $\{h_a\}$, a = 1,2,3 and 4 is stored with zero. Thus, the high pass filter detects, separates and preserves the image edges.

Combiner Algorithm

The number of samples blurred about, and including an edge sample along any direction (horizontal, vertical or diagonal) are 2N+1, where (2N+1) x (2N+1) is the window size of the median filter. The combiner algorithm, appropriately, modifies the median filter output by restoring the edges and their neighborhoods. First, the algorithm scans the array {h1}. Whenever it comes across a non-zero element, it indicates that a horizontal edge is present at the corresponding sample of the input signal. Consequently, the combiner algorithm will remove 2N+1 horizontal samples about and including that edge sample from the noisy input sequence {x} and replace the corresponding samples of the median filter output with the removed samples. This procedure is repeated for all non-zero values of {h1}. Similarly, the combiner scans the arrays $\{h_2\}$, $\{h_3\}$ and {h4} in sequence. For every non-zero element of these arrays, the combiner performs the removal and replacement of 2N+1 samples in the same way as described above except that it is done along vertical, left diagonal and right diagonal directions respectively. Let {o1} denote the output sample sequence of New Filter I

$$o_1(k,l) = \begin{cases} mp(i,j), \quad k=i, l=j \quad if\ h_a(i,j)=0, a=1,2,3,4 \\ x(i,l), k=i, l=j-N+d, d=0,1,2,...2N \quad if\ h_1(i,j)\neq 0 \\ x(k,j), k=i-N+d, l=j, d=0,1,2,...2N \quad if\ h_2(i,j)\neq 0 \\ x(k,l), k=i-N+d, l=j-N+d, d=0,1,2,...2N \quad if\ h_3(i,j)\neq 0 \\ x(k,l), k=i-N+d, l=j+N-d, d=0,1,2,...2N \quad if\ h_4(i,j)\neq 0 \end{cases}$$
(6)

where i=1,2,…,p and j=1,2,…,q. The New filter I is as effective as the median filter for removing uniform noise, with edge preserving properties.

The scheme of the filter capable of removing both uniform and impulse noise without blurring image boundaries is shown in Fig. 3.

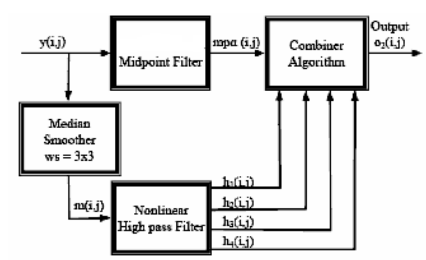

Figure3: The filtering scheme of New Filter II

The midpoint filter [3] simply computes the midpoint between the maximum and minimum values in the area encompassed by the filter:

$$f(x,y) = \frac{1}{2}\left[\max_{(s,t)\in S_{xy}}\{g(s,t)\} + \min_{(s,t)\in S_{xy}}\{g(s,t)\}\right] \qquad (7)$$

This filter works best for randomly distributed

The edge preserving part of New Filter II consists of a 3x3 square shaped median filter and a nonlinear highpass filter. Uniform plus impulse noise contaminated image {y} is the input to the median smoother, which eliminates impulses while preserving the image boundaries. Two-dimensional median filtering with a 3x3 square window is defined as:

$$f(x, y) = \underset{(s,t) \in S_{xy}}{median} \{g(s, t)\} \quad (8)$$

The combiner algorithm restores the edges and their neighbourhoods in midpoint filter output, using the outputs of the highpass and median filters in the same way as described in New filter I. Thus, the combiner produces a new sequence of samples at the output of New Filter II, denoted as {o2}.

$$o_2(k,l) = \begin{cases} mp\alpha(i,j), \quad k = i, l = j \quad if\ h_a(i,j) = 0, a = 1,2,3,4 \\ m(i,l), k = i, l = j - N + d, d = 0,1,2,...2N \quad if\ h_1(i,j) \neq 0 \\ m(k,j), k = i - N + d, l = j, d = 0,1,2,...2N \quad if\ h_2(i,j) \neq 0 \\ m(k,l), k = i - N + d, l = j - N + d, d = 0,1,2,...2N \quad if\ h_3(i,j) \neq 0 \\ m(k,l), k = i - N + d, l = j + N - d, d = 0,1,2,...2N \quad if\ h_4(i,j) \neq 0 \end{cases}$$

(9)

where i=l, 2,…. ,p and j=l, 2..., q. New Filter II is found to be robust against impulse noise. In addition, the filter preserves edge structures quite satisfactorily.

IV. Results and Discussion

Obtaining real mammogram breast cancer images for carrying out research is highly difficult due to privacy issues, legal issues and technical hurdles. Hence the ***MIAS*** database *(http://* peipa.essex.ac.uk/ipa/pix/mias/) is used in this paper to study the efficiency of the proposed filters are evaluated using mammogram breast cancer images. The performance of these two proposed filtering techniques are analyzed and discussed. The statistical measurement, such as Root Mean Square Error **(RMSE)**, **S**ignal-to-Noise Ratio **(SNR),** Peak Signal-to-Noise Ratio (**PSNR),** are used to evaluate the enhancement performance [6].

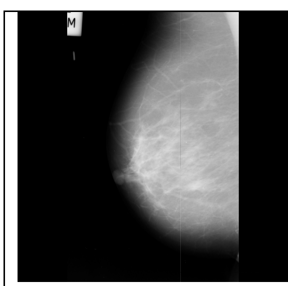

Fig. 4 Original Mammogram Image

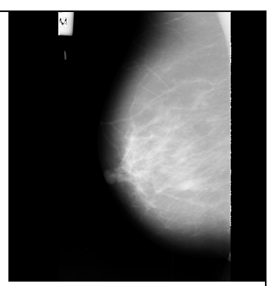

Fig. 5 New Filter I

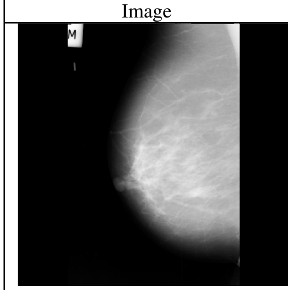

Figure 6: Median filter

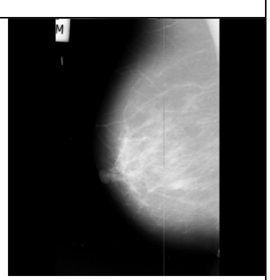

Figure 7: New Filter II

The noise level is measured by the standard deviation of the image:

$$\sigma = sqrt((1/N)\sum (b_i - b)^2), i = 1,2,3,..., N$$

(10)

where b is the mean gray level value of the original image and b_i is the gray level value of the surrounding region and N is the total number of pixel in the image. The **RMSE**, **SNR, and PSNR** are provided in the following table I.

Table I. Statistical measurement formula

Statistical Measurement	Formula
MSE	$\frac{\sum (f(i,j) - F(i,j))^2}{MN}$
RMSE	$\left[\left[\sqrt{\frac{\sum (f(i,j) - F(i,j))^2}{MN}}\right]\right]$
SNR	$10\log_{10}\frac{\sigma^2}{\sigma_e^2}$
PSNR	$20\log_{10}\frac{255}{RMSE}$

where $f(i, j)$ is original image, F(i, j) is enhanced image, σ^2 is variance of original image and σ_e^2 is variance of enhanced image. If the value of RMSE is low and the values of SNR and PSNR are larger then the enhancement approach is better. The Table II shows the computational results of proposed two filtering methods based on RMSE, SNR and PSNR for the mammogram breast images. The experiments are carried out for the 392 mammogram breast cancer images and the average results are tabulated in Table. II.

Table II. Performance analysis

Methods	RMSE	SNR	PSNR
Median Filter	**90.933**	**95.272**	**8.8879**
New Filter I	**90.653**	**19.685**	**8.9148**
New Filter II	**90.934**	**95.312**	**8.8879**

It is observed from the Table. II that New filter II produces highest SNR values where as New filter I produces the highest PSNR value. Since most of the researcher suggests considering the filter, which produces highest SNR, is the best one. Hence, New filter II out performs. Fig. 8 shows a comparison of the RMSE, SNR and PSNR average values obtained by using the proposed two filtering methods.

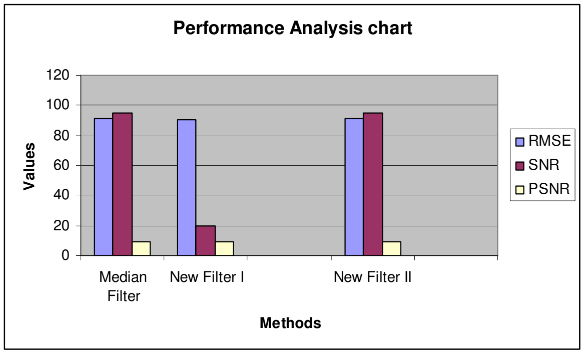

Figure8: Performance analysis chart

CONCLUSION

Two new nonlinear filtering strategies, useful for image enhancement, are described in this paper. New Filter I is noted to be effective in suppressing noise having uniform probability density function. New filter II is robust against impulse noise besides attenuating uniform noise adequately. Showed that the proposed filters, New Filter I, have good edge preservation properties and are shown to perform better than conventional filtering techniques, both objectively and subjectively.

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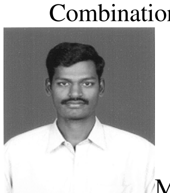
AUTHORS



Mr. I. Laurence Aroquiaraj received the M.Sc.,Computer Science from Pondicherry University, Pondicherry, India in 2002, M.Phil., degree from Manonmaniam Sundaranar University, India in 2003. He received the M.Tech., Computer Science Engineering Degree from Kalinga University, India in 2004, and Master of Computer Applications Degree from Periyar University, India in 2008. He is working as Assistant Professor in Computer Science, Periyar University, Salem, Tamilnadu, India. He is pursuing his Ph.D in Image Processing. His research interests includes medical image processing, biometrics, pattern recognition and networking.

Dr. Thangavel Kuttiannan received the Master of Science from Department of Mathematics, Bharathidasan University in 1986, and Master of Computer Applications Degree from Madurai Kamaraj University, India in 2001. He obtained his Ph. D. Degree from the Department of Mathematics, Gandhigram Rural University in 1999. He worked as Reader in the Department of Mathematics, Gandhigram Rural University, upto 2006. Currently he is working as Professor and Head, Department of Computer Science, Periyar University, Salem, Tamilnadu, India. His areas of interest include medical image processing, artificial intelligence, neural network, fuzzy logic, data mining, pattern recognition and mobile computing.