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A Content Based Noise Removal Using Non Linear Filter for the Elimination of Outliers in Mammogram Images for Effective Identification of Lesion.

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ABSTRACT

A novel non-linear filter algorithm for the elimination of salt and pepper noise present in the digital mammogram using decision based 4 neighbors referred unsymmetrical trimmed variants in mammogram images is proposed for noise filtering and effective enhancement of digital mammograms. The algorithm initially checks for noise, if found noisy the corrupted pixel is replaced by the truncated statistic of the current processing window. The purpose of this work is to present an analysis and application of decision based 4 neighbors referred unsymmetrical trimmed variants for image noise cancellation. Here we make use of the unsymmetrical trimmed variants for the removal of high density salt and pepper noise. The results of proposed method are being compared with the other existing methods, and the comparison will try to show better performance in terms of PSNR, IEF, MSE, SSIM, Pratt's FOM, Normalized cross correlation (NCC), University quality index (UQI) metric.

Keywords: Unsymmetrical trimmed variants· Salt and pepper noise ·Mammogram image denoising.

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INTRODUCTION

In the process of image acquisition and transmission, the digital images are often corrupted with impulse noises. This is mainly because of the errors in the sensors or in the communication channel. It is highly imperative that this noise be removed prior to its subjection for further processing, such as edge detection, image segmentation, object recognition, and classification of lesions. Presence of noise sometimes leads to wrong conclusions. Noise removal part helps the radiologist in getting an effective and timely identification of lesions. Various methods have been developed for impulse noise removal from corrupted images. Median filters have been extensively used for the removal of impulse noises. They are simple yet very effective in the removal of salt- and Pepper-type impulse noise. Median filters often tend to modify good pixels too; therefore, impulse detection algorithms play a crucial role in noise removal. In [1] an efficient two-phase method for salt-and-pepper noise removal. In the first phase, adaptive median filter is used to detect the contaminated pixels. Then in the second phase, the candidate pixels will be restored by minimizing a regularization functional. To end of this, a spectral conjugate gradient method is considered. In order to restore the image from the above stated noises an appropriate algorithm must be chosen such that the restored image is as close to the original image. Images are often corrupted by outlier noise due to poor image sensors or faulty communication channels. Most of the outlier noise filtering methods [2] comprises of order static filters using the rank-order information of an appropriate set of noisy input pixels. These are usually based on the cascaded decision based filter for the removal of high density in image and video is proposed. The proposed scheme operates in two levels. First level is a decision based median filter and the later employs a decision based unsymmetrical trimmed variants. In the first stage the corrupted pixels are found and replaced by the median of the current processing window. The second level again inspects for the occurrence of outliers and eliminates them using unsymmetrical trimmed variants depending upon the content of the current processing window.

The Main idea of the proposed work is to formulate an algorithm that eliminates the outliers for high density outlier noise. The proposed algorithm is found to exhibit excellent noise elimination capability for noise densities as high as 90%. In recent years, several standard and special filters were proposed but every filter has its own drawbacks. In [3] Contourlet Transform (CT)method that reduces the speckle noise in SAR (Synthetic Aperture Radar) images. Filters such as standard median filter (SMF) [5], Center weighted median filter (CWF) [5], weighted median filter, and Threshold decomposition filter methods were used uniformly across the image even when the pixel is noise free. In Threshold decomposition filter (TDF) [4] the pixels are decomposed based on various threshold levels and subjected to Boolean operation. The TDF algorithm fared well only at low noise densities but performs diminishes at medium and high noise densities. An adaptive Median filter (AMF) [5] eliminates the above drawbacks but because of the increasing window size lead to blurring of images.

Alpha trimmed mean filter (αTMF) is a class of Non Linear filters that are used to remove the impulse noise using a parameter called "α". The parameter "α" refers to trimming factor that controls the number of values to be trimmed. It is a symmetrical filter where trimming is done symmetric at either ends. When "a" value is increased, the ability of the filter to remove the impulse noise is further increased and vice versa. The main advantage of the above algorithm is that it works for low density salt and pepper noise. The flaws of the above approach is that, when the image is corrupted by Salt and Pepper noise as high as 50% the algorithm fails because even the uncorrupted pixels are trimmed and Blurring of edges takes place and hence fine detail of the image is lost [2]. Progressive switched median filter (PSMF) [6] used a fixed threshold and hence procuring a strong decision is very difficult. The algorithm fails at medium and high noise densities. Decision based algorithm (DBA) [6] worked well at low and medium noise densities. Under high noisy environment, the algorithm used the neighbourhood pixel for replacement of noisy median. This replacement degrades the image quality by inducing streaks. Recently cascaded algorithm was introduced which employed two stages of filtering. The first stage was a decision based algorithm followed by an unsymmetrical trimmed median (CUTMF) or midpoint (CUTMPF) algorithm [7]. The former when applied blurs the edge; the later provided a smeared edge at very high noise densities. From the above literatures the algorithm proposed either works only for low noise densities or blur the edges owing to the large window sizes or induce an artefact while eliminating the high density noise. Hence a suitable algorithm should be formulated that detects, eliminates the outlier and preserves the edges at high noise densities in mammogram images. The organization of the paper is as follows. The II Section deals with the proposed algorithm. The III Section deals with simulation results and discussions. The IV section gives the conclusion of the work.

Our method is concerned with the removal of the salt and pepper noise. Many algorithms have been presented like median filtering and adaptive median filtering. In B-spline wavelets are used for the noise removal. Here a method to work with salt and pepper noise using second generation wavelets had been discussed. Most of the algorithms used for the salt and pepper noise removal replaces the original value with the median and lead to lot of distortion in the image. After the removal of the noise, the edges get jittered and the details of the image should be preserved so that the image is intact. When an image is corrupted by salt and pepper noise, the intensity values change to 0 and 255. To test the effectiveness of proposed algorithm, the images corrupted up to 95 % of salt and pepper noise are used.

PROPOSED ALGORITHM

The Decision based unsymmetrical trimmed variants filter (DBUTVF) initially detects impulse and corrects it subsequently. All the pixels of an image lie between the dynamic ranges [0,255]. If the processed pixel holds minimum (0) or maximum (255), pixel is considered as noisy and processed by DBUTVF else as not noisy and the pixel is unaltered.

Step 1: Choose 2-D window of size 3x3. The processed pixel in current window is assumed as pxy.
Step 2: Check for the condition 0 < pxy < 255, if the condition is true then pixel is considered as not noisy and left unaltered.
Step 3: If the processed pixel pxy holds 0 or 255 i.e. (pxy=0 or pxy =255) then pixel pxy is considered as corrupted pixel. Convert 2D array into 1D array. Sort the 1D array which is assumed as Sxy.
Step 4: When pixel is noisy there happens to be two possible cases. Check for the number of corrupted pixel inside the current processing window. It is denoted as count.
Case 1) if the count value <=3 inside the current processing window then the corrupted pixel is replaced with median of unsymmetrical trimmed output.
Case 2) if the count value is greater than 3 then the noisy pixel is replaced with mean of Fth and Lth value of the rank ordered unsymmetrical trimmed output. If entire pixels inside the processing window are 0 or 255 then pixel value is retained considering it as texture.
Step 5: Steps 1 to 4 is repeated until all pixels of the entire image is processed.

SIMULATION RESULTS AND DISCUSSION

The Quantitative performance of the proposed algorithm is evaluated based on Peak signal to noise ratio (PSNR), Mean square error (MSE), Structural similarity Index metric (SSIM) which is given in equations 1,2 ,3 respectively

$$\mathbf{PSNR} = 10 \log_{10}\left(\frac{255^2}{MSE}\right) \text{---------} \quad (1)$$

$$\mathbf{MSE} = \frac{\sum_i \sum_j (r_{ij} - x_{ij})^2}{\mathrm{MXN}} \text{-----} \quad (2)$$

Where **r** refers to Original image, **n** gives the corrupted image **x** denotes restored image, **M x N** is the size of Processed image.

$$\mathbf{SSIM(x, y)} = \frac{(2\mu_x\mu_y + C_1)(2_{xy} + C_2)}{(\mu_x^2 + \mu_y^2 + C_1)(\frac{2}{x} + \frac{2}{y} + C_2)} \text{-----------} \quad (3)$$

Where **µX** is the average of **x**, **µY** is the average of **y**, ***σ*x** Standard deviation of **x**, ***σ*y** is the Standard deviation of **y**. C 1 = (K1L) 2, C2= (K2L) 2 two variables to stabilize the division with weak denominator; L the dynamic range of the pixel values (for an 8 bit image it takes from 0 to 255), Kl =0.0 1 and K2=0.03 by default. The existing algorithms used for comparison are SMF, AMF, CWF, TDF, PSMF, DBA, Alpha trimmed mean filter, Cascaded filters. The qualitative performance of the proposed algorithm is tested on various images (Images are chosen as per the details of the image).

Quantitative analysis is made by varying noise densities in steps of ten from 10% to 90% on images and comparisons are made in terms of PSNR, MSE, IEF and SSIM. Results and graphs are given in Table I, II, III, IV and figure 5, 6, 7, 8 respectively. Figure 2, 3, 4 gives the qualitative performance of the proposed algorithm on greyscale image. All the simulation is done in i5-2410M CPU with an operating frequency of 2.30 GHz with a 4GB RAM capability. From the table I we infer that for the proposed algorithm PSNR value is better indicating how much the algorithm eliminates salt and pepper noise effectively even at high noise densities. Table II gives a lower Mean square error (MSE) even at very high noise densities, From Table III we find the Structural similarity index metric (SSIM) of the proposed algorithm is very close to one at low noise densities. At high noise densities the SSIM of the proposed algorithm is very good and outclass all the standard and existing filters.

ND in %	SMF	AMF	DBUT MPF	MDBU TMF-GM	DBUT VF	BPLINE	PA
10	37.7	35.5	45.3	46.2	46.1	40.4	47.5
20	29.9	34.9	43.0	43.5	43.4	38.7	44.5
30	23.5	33.1	41.4	41.1	41.8	38.1	42.9
40	18.5	32.1	39.9	38.2	39.5	37.1	40.2
50	14.8	26.3	38.5	36.2	37.7	30.9	38.1
60	12.0	21.8	36.9	34.1	36.2	30.6	36.6
70	9.35	16.7	34.8	31.0	34.3	31.2	34.1
80	7.47	13.1	32.0	27.9	31.6	27.7	31
90%	5.95	10.1	27.9	20.4	27.2	28.2	26.9

Table I: Quantitative performance (PSNR) of the various algorithms on Mammogram image corrupted by salt and pepper noise

ND in %	SMF	AMF	DBUTMP F	MDBUTM F- GM	DBUTVF	BPLINE	PA
10	200.2	77.8	1196	1474	1402	382	1971
20	68.4	216.6	1396	1533	1533	514	1955
30	23.4	210.6	1419	1331	1541	666	1995
40	9.7	223.7	1361	932	1228	687	1440
50	5.2	74.3	1193	721	1013	214	1107
60	3.2	31.1	1022	523	862	240	948
70	2.1	11.1	722	301	663	321	637
80	1.5	5.6	435	170	397	164	347
90	1.2	3.1	192	34	164	204	151

Table II: Quantitative performance (IEF) of the various algorithms on Mammogram image corrupted by salt and pepper noise

ND in %	SMF	AMF	DBUTMPF	MDBUTMF-GM	DBUTVF	BSPLINE	PA
10	11	29	2	2	2	6	1
20	65	21	3	3	3	9	2
30	285	32	5	5	4	10	3
40	914	40	7	10	7	13	6
50	2134	151	9	15	11	52	10
60	4080	426	13	25	15	56	14
70	7549	1383	21	51	24	49	24
80	11641	3160	40	104	45	109	51
90	16508	6373	104	591	121	98	132

Table III: Quantitative performance (MSE) of the various algorithms on Mammogram image corrupted by salt and pepper noise

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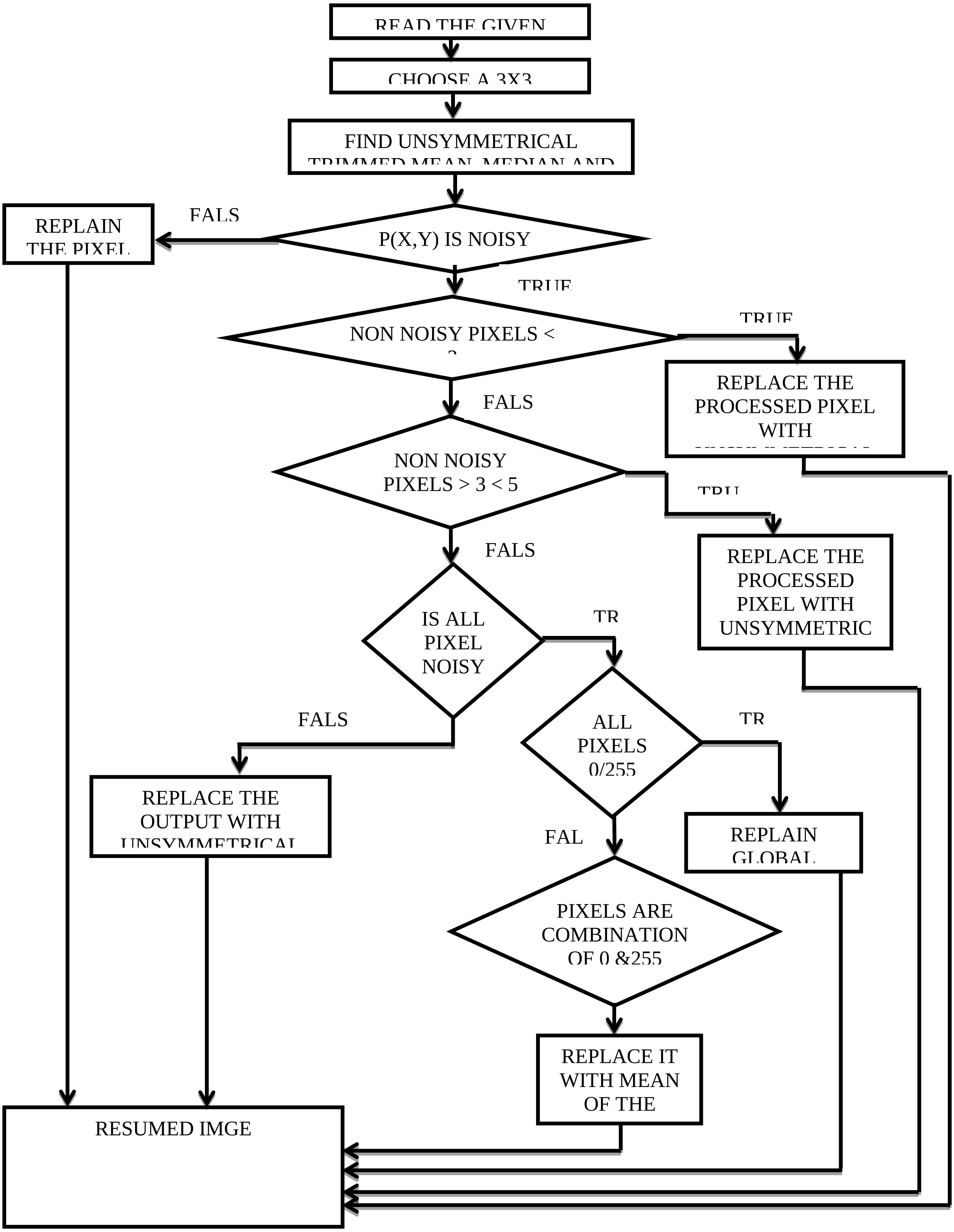

Figure l. Illustration of the proposed methodology

ND in %	SMF	AMF	DBUTMPF	MDBUTMF- GM	DBUTVF	BPLINE	PA
10	0.95	0.98	0.95	0.96	0.95	0.94	0.96
20	0.9	0.97	0.94	0.95	0.94	0.93	0.95
30	0.75	0.95	0.93	0.94	0.93	0.92	0.94
40	0.46	0.92	0.92	0.92	0.92	0.91	0.93
50	0.23	0.84	0.9	0.89	0.9	0.79	0.92
60	0.09	0.67	0.89	0.85	0.88	0.79	0.89
70	0.03	0.44	0.85	0.77	0.84	0.78	0.86
80	0.01	0.3	0.8	0.67	0.79	0.67	0.79
90	0.01	0.24	0.68	0.52	0.68	0.65	0.67

Table IV: Quantitative performance (SSIM) of the various algorithms on Mammogram image corrupted by salt and pepper noise

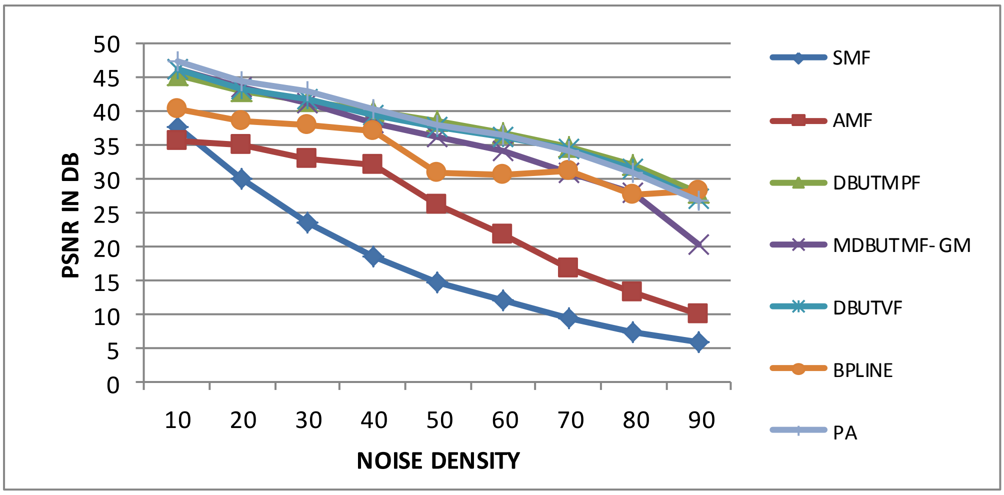

Figure 2 Graphical performances (PSNR) of the proposed algorithm on Mammogram Image Image corrupted by Salt and pepper noise

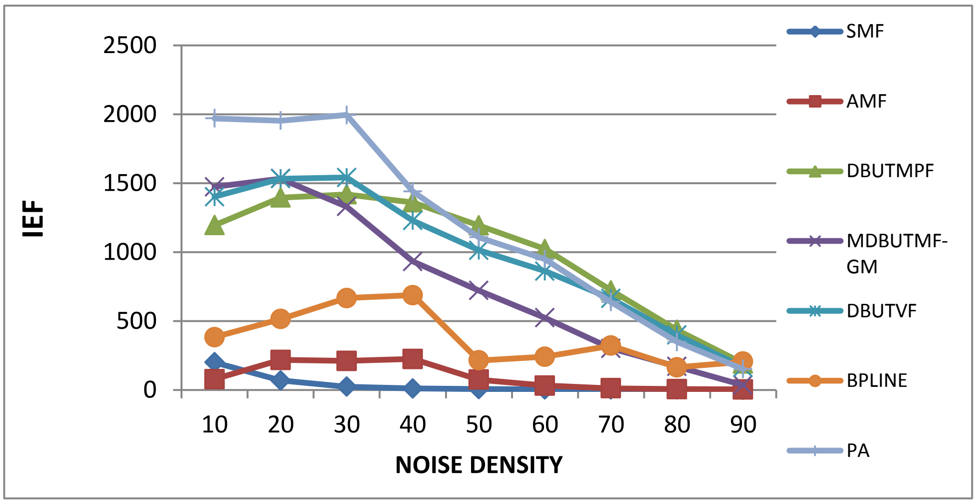

Figure 3 Graphical performances (IEF) of the proposed algorithm on Mammogram Image Image corrupted by Salt and pepper noise

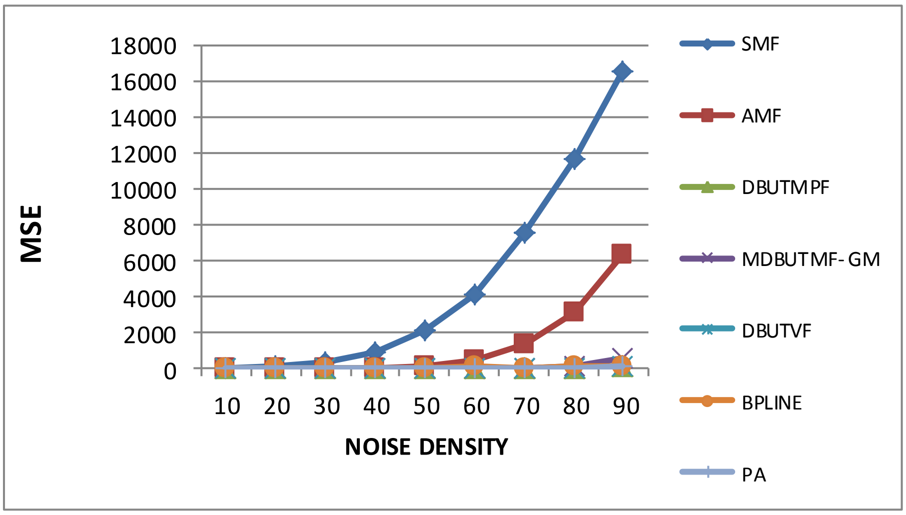

Figure 4 Graphical performances (MSE) of the proposed algorithm on Mammogram Image Image corrupted by Salt and pepper noise

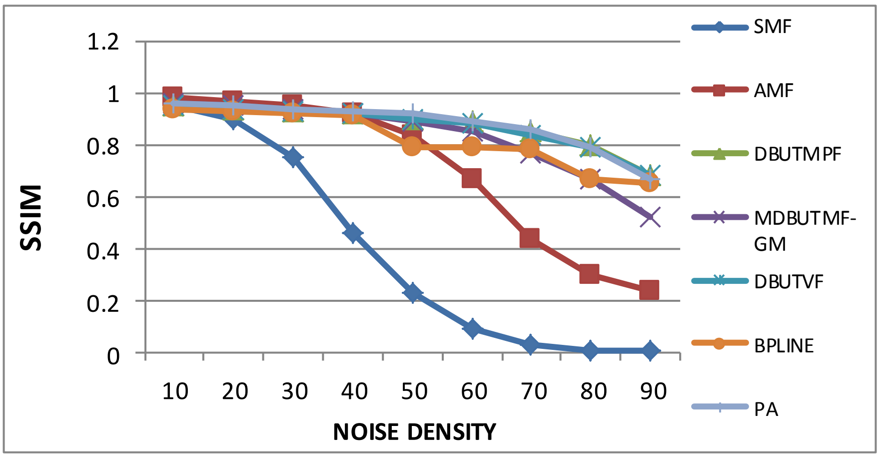

Figure 5 Graphical performances (SSIM) of the proposed algorithm on Mammogram Image Image corrupted by Salt and pepper noise

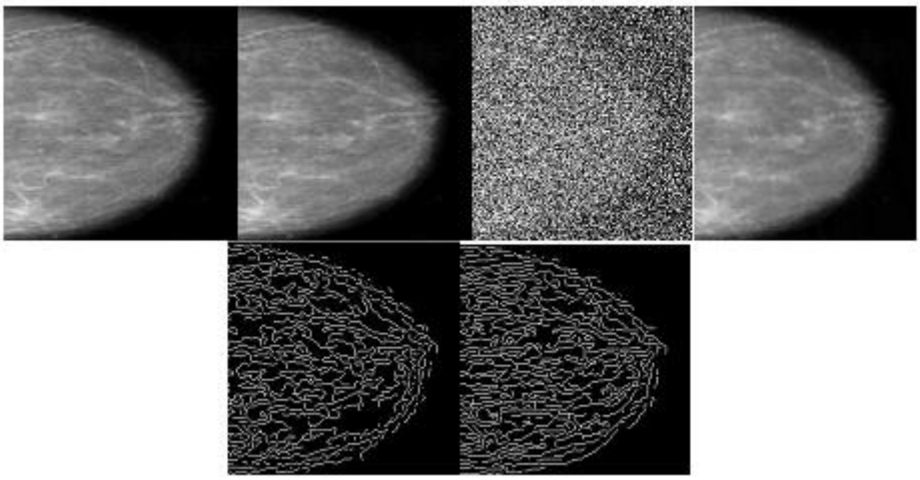

Figure 6: Qualitative performance of the proposed algorithm on Mammogram Images corrupted by 70% Salt and pepper noise

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CONCLUSION

This paper deals with a decision based Unsymmetrical Trimmed Variant Non linear algorithm for the removal of high density outlier noise. The proposed algorithm found to perform better with the standard and existing algorithms but excels well at very high noise densities. The proposed algorithm has a good PSNR and MSE on images justifying the quantitative measure. The excellent SSIM value gives the proposed algorithm an edge over other algorithms in terms of structural and edge preservation of the restored image. The proposed algorithm also performs well in colour images. At very high noise densities other algorithms induce streaks or blurring or fading during noise elimination. The proposed algorithm found to work better even at high noise densities with better detail preservation. Effective noise cancellation means effective segmentation of breast lesion.If the breast lesion is clearly segmented then by using decision making algorithms we can classify the lesion as carcinoma one or not. In this regard i hope that my work will help other researchers to remove false positive cases. In feature classification of lesion can be experimented with the existing methodologies normally used in medical image processing field.

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