AN ITERATIVE UNSYMMETRICAL TRIMMED MIDPOINT-MEDIAN FILTER FOR REMOVAL OF HIGH DENSITY SALT AND PEPPER NOISE

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Abstract

An Iterative Unsymmetrical Trimmed Midpoint-Median Filter for Removal of High Density Salt and Pepper Noise in gray scale images is presented in this paper. This efficient filtering technique is implemented in two phases. In the first phase, the proposed midpoint median filter is applied to the noisy pixels iteratively two times iteratively. In the second phase, the Modified Decision based Mean Median Filter (MDBMMF) is applied to the output of first phase. Simulation results prove that the proposed algorithm performs better than various recent denoising methods in terms of PSNR, IEF and MSE. From the qualitative analysis it can be observed that the proposed algorithm helps in retaining the edge details with high efficiency.

Keywords: *Impulse noise, Salt and Pepper noise*

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1. INTRODUCTION

During acquisition and transmission of image signal, the noise generated can degrade the image quality. Such type of noise is called impulse noise. Impulse noise is of two types: salt and pepper noise and random valued noise. Salt and pepper noise is the main cause of image quality degradation where the noisy pixels take either the maximum or minimum value in a dynamic range. Salt and pepper noise is generally caused by faulty memory locations, malfunctioning of pixel elements in the camera sensors or timing errors in the digitization process [1]. Denoising is a very important pre-processing task in image processing. The main aim of image denoising is to restore the corrupted image. Various filters have been proposed for removal of salt and pepper noise [2]. Median Filter is the most popular filter for removal of salt and pepper noise in images due to its computational speed and denoising capability at low noise densities. Denoising capability of median filter depends on the window size i.e. increased window size enhances its denoising capability but causes blurring of image and loss of image features [3]. Decision Based Algorithm (DBA) provides better results than median filters and its enhancements [4] [5]. It first detects the noisy pixels and replaces that noisy pixel with the median of neighborhood pixels in the window. DBA has a problem that it takes corrupted pixels while calculating the median. Decision based Unsymmetric Trimmed Median Filter (DBUTMF) was proposed to eliminate the problem of DBA in which the corrupted pixel is replaced by the median value of the pixels in 3x3 window. But before calculating median, the corrupted pixels are trimmed from the current window. It gives better performance than MF and DBA, but it has a problem that restored image is not of good quality at noise densities of more than 80% [6]. Modified decision based Unsymmetrical Trimmed Median Filter (MDBUTMF) was proposed which calculates the unsymmetrical trimmed median value, but if a window contains all corrupted pixels, then it calculates the mean of the corrupted pixels [7]. A new filter for removal of salt and pepper noise was proposed which calculates the mean of the window if all pixels are corrupted and when some of the pixels are corrupted then it calculates the unsymmetric trimmed mean value [8]. A Modified Decision based Mean Median Filter (MDBMMF) for removal of high density salt and pepper noise was proposed, which gives better results than MF, DBA and DBUTMF [9]. MDBMMF calculates the unsymmetrical trimmed median value if all pixels in window are not noisy otherwise it calculates the mean value and it replaces the processing pixel with this new value in image. This new value will be in the processing window of next pixel. A Non Linear Filter was proposed which replaces the corrupted pixel with the midpoint mean of preprocessed pixels if the window contains all corrupted pixels and if the window contains some ,not all, corrupted pixels then it uses the unsymmetric trimmed median value to replace the corrupted pixel [10].

In this paper, a new algorithm is proposed which efficiently removes the high density salt and pepper noise. This proposed algorithm shows effective performance with better Peak Signal to Noise Ratio (PSNR) and Image Enhancement Factor (IEF) than the existing algorithms. This paper is organized in four sections. Section 2 explains the proposed method. Section 3 explains the simulation results and performance analysis. Conclusion and future scope is explained in section 4.

2. THE PROPOSED METHOD

Iterative Unsymmetrical Trimmed Midpoint-Median Filter (IUTMMF) algorithm is developed for the efficient restoration of gray scale images that are corrupted by salt and pepper noise. This algorithm is implemented in two phases. In the first phase midpoint-median filter is applied on the noisy image iteratively two times. In the second phase, modified decision based mean median filter (MDBMMF) is applied on the output of first phase.

2.1 First Phase: Iterative Unsymmetrical Trimmed Midpoint-Median

Algorithm explained below is applied twice iteratively on the output of first iteration on whole image.

In this phase, value of every pixel is checked and a window of size 3x3 around the processing pixel is used. The three different cases that can occur are illustrated below:

Case 1: If the processing pixel i.e. the center pixel of 3x3 window is noise free i.e. if the value of processing pixel is neither "255" nor "0" as shown in Fig-2.1, then the pixel is not processed and the algorithm moves to next pixel.

125	255	0
0	**(154)**	142
178	150	255

Fig-2.1: window of gray scale image containing noise free pixel as processing pixel.

Case 2: If the processing pixel is noisy i.e. the value of pixel is either "0" or "255", then neighborhood of processing pixel in 3x3 window is checked. If all of the neighboring pixels are not corrupted with salt and pepper noise, then store the value of the pixels in a 1-D array. Remove the corrupted pixels (i.e. pixels with value "0" or "255") from the array. Two cases that are considered are discussed below:

Case 2.1:

If the numbers of noise free pixel in 1-D array are greater than 4 as shown below in Fig-2.2.1, then take the median of the 1-D array and replace the processing pixel with the median value.

155	150	135
255	**(0)**	165
135	255	240

Fig- 2.2.1: window of gray scale image containing noisy processing pixel and noise free neighboring pixels more than 4.

Case 2.2:

If the numbers of noise free pixels in 1-D array are less than 5 as shown below in Fig-2.2.2, then replace the processing pixel with the midpoint mean value. Midpoint mean value is calculated by dividing the sum of maximum value and minimum value of array by 2.

255	0	135
255	**(0)**	165
135	255	240

Fig- 2.2.2: window of gray scale image containing noisy processing pixel and noise free neighboring pixels less than 5.

Case 3: If the processing pixel is noisy i.e. the value of pixel is either "0" or "255" then neighborhood of processing pixel in 3x3 window is checked. If all the neighboring pixels are corrupted with salt and pepper noise (i.e. either "0" or "255") as shown in Fig-2.3, then the pixel value is not altered and left for processing in second iteration.

0	255	255
0	**(0)**	0
255	0	255

Fig- 2.3: window of gray scale image containing all noisy pixels.

2.2 Second Phase: Modified Decision based Mean Median Filter (MDBMMF)

The output of first phase is supplied as input to this phase. The value of every pixel is checked and a window of size 3x3 around the processing pixel is used. The three different cases that can occur are illustrated below:

Case 1: If the processing pixel i.e. the center pixel of 3x3 window is noise free i.e. if the value of processing pixel is neither "255" nor "0" as shown in Fig-2.4, then the pixel is not processed and the algorithm moves to next pixel.

125	255	0
0	**(154)**	142
178	150	255

Fig-2.4: window of gray scale image containing noise free pixel as processing pixel.

Case 2: If the processing pixel is noisy i.e. the value of pixel is either "0" or "255", then neighborhood of processing pixel in 3x3 window is checked. If all of the neighboring pixels are not corrupted with salt and pepper noise as shown in Fig- 2.5, then store the value of the pixels in a 1-D array. Remove the corrupted pixels from the array. Then take the median of the remaining pixels and replace the processing pixel with the median value.

155	255	135
125	**(0)**	0
135	255	240

Fig-2.5: window of gray scale image containing noisy processing pixel and some noise free neighboring pixels.

Case 3: If the processing pixel is noisy i.e. the value of pixel is either "0" or "255" then neighborhood of processing pixel in 3x3 window is checked. If all the neighboring pixels are corrupted with salt and pepper noise (i.e. either "0" or "255") as shown in Fig- 2.6, then take the mean of the values of pixels in the selected window and replace the processing pixel with mean value.

0	255	255
0	**(0)**	0
255	0	255

Fig-2.6: window of gray scale image containing all noisy pixels.

3. RESULTS AND ANALYSIS

Various algorithms described in section 1 and the proposed IUTMMF algorithm has been applied on standard grayscale image of size 512 X 512 pixels for comparison. The results were evaluated both qualitatively and quantitatively. In order to evaluate performance of the algorithm quantitatively the noise free image is used for comparison with the denoised image produced by the above methods.

The metrics used for evaluation are Mean Square Error (MSE), Peak Signal to Noise Ratio (PSNR) and Image Enhancement Factor (IEF).

$$\textbf{MSE}= \frac{\sum\sum(Y(i,j)-Y'(i,j))^2}{M*N}$$

$$\textbf{PSNR}= [10\log_{10}\frac{255^2}{MSE}]$$

$$\textbf{IEF}= \frac{\sum\sum\left(N(i,j)-Y(i,j)\right)^2}{\sum\sum\left(Y'(i,j)-Y(i,j)\right)^2}$$

In the above equations M * N is the size of the image, Y denotes the original image, Y**'** denotes the denoised image and N is the noisy image.

MSE, PSNR and IEF are calculated for the test image with their noisy and denoised counterparts respectively. Hence, we get a good amount of comparison between the noisy and denoised images keeping the set standard image intact. Fig-3.1 shows test image of size 512 X 512 pixels and image format is .png which is original images applied for denoising.

Lena.png

Fig-3.1: original images of size 512 x 512.

Quantitative analysis is made by varying noise densities in steps from 10% to 95% on test image and MSE, PSNR and IEF are calculated. Quantitative results and graphs are shown in Table-3.1, Table-3.2, Table-3.3 and Chart-3.1, Chart-3.2, Chart-3.3 respectively.

From the Table-3.1 and Chart-3.1 it is inferred that the PSNR value is high for the proposed algorithm which eliminates salt and Pepper noise effectively even at high noise densities.

Table-3.1: Performance comparison of PSNR at various noise densities for Lena image.

Noise Level	MDBU TMF	UTM F	MDBM MF	MM F	PA
10%	43.12	42.64	43.14	43.12	43.12
20%	39.07	39.15	39.39	39.07	39.09
30%	36.7	37.09	36.87	36.73	36.81
40%	34.7	35.22	34.48	34.98	35.21
50%	32.21	32.7	32.36	32.92	33.51
60%	28.76	28.99	30	30.92	31.96
70%	24.63	24.71	27.69	28.21	30.48
80%	20.28	20.3	24.75	24.81	28.71
90%	15.97	15.97	20.37	21.14	26.07
95%	13.92	13.92	16.85	19.1	23.84

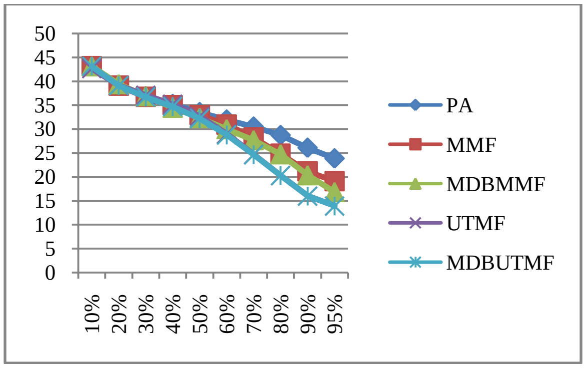


Chart-3.1: PSNR vs Noise Density.

From Table-3.2 and Chart-3.2 an excellent image enhancement factor, even at very high noise densities as high as 95% can be observed.

Table-3.2: Performance comparison of IEF at various noise densities for Lena image.

Noise Level	MDB UTM F	UTM F	MDB MMF	MMF	PA
10%	578.38	517.58	582.54	578.38	578
20%	458.69	468.13	492.93	458.85	461.6
30%	397.66	434.12	412.01	399.75	407.2
40%	334.26	377.36	317.16	356.55	375.9
50%	235.86	264.27	243.76	277.51	318.3
60%	127.89	134.8	170.19	210.16	267
70%	57.48	58.59	117.1	130.98	221.4
80%	24.2	24.31	67.5	68.74	168.8
90%	10.08	10.08	27.72	33.15	103.3
95%	6.64	6.64	13.03	21.92	65.24

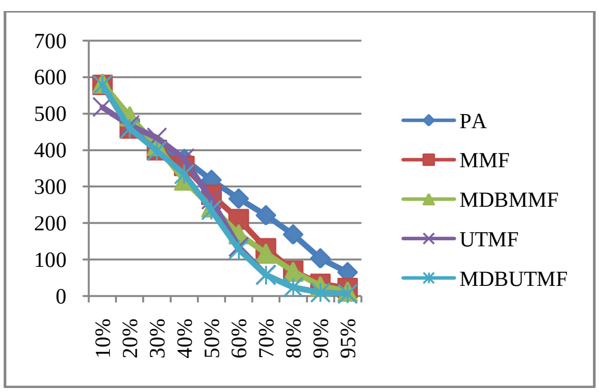


Chart-3.2: IEF vs Noise Density.

From Table-3.3 and Chart-3.3 it can be observed that mean square error is also very less for proposed algorithm at high noise densities.

Table-3.3: Performance comparison of MSE at various noise densities for Lena image.

Noise Level	MDB UTMF	UTMF	MDBM MF	MMF	PA
10%	3.18	3.56	3.17	3.18	3.19
20%	8.11	7.95	7.52	8.11	8.06
30%	13.97	12.8	13.45	13.9	13.65
40%	22.2	19.66	23.32	20.81	19.74
50%	39.35	35.12	38.05	33.47	29.16
60%	87.03	82.56	65.52	52.96	41.68
70%	225.52	221.24	111.41	98.96	58.56
80%	613.78	611.1	219.23	216.16	88.01
90%	1655	1654	601.67	503	161
95%	2656	2656	1352	805	270

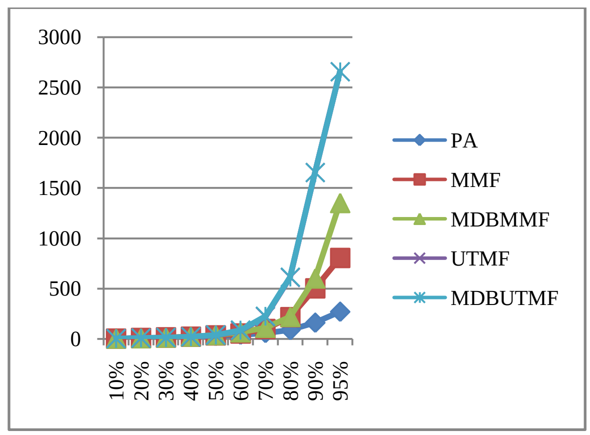


Chart-3.3: MSE vs Noise Density.

Qualitative performance of the proposed IUTMMF algorithm with other algorithms are shown below in Fig-3.2, Fig-3.3, Fig-3.4, Fig-3.5 and Fig-3.6 at noise densities of 10%, 40%, 80%, 90% and 95% respectively :

(a) (b) (c) (d) (e) (f)

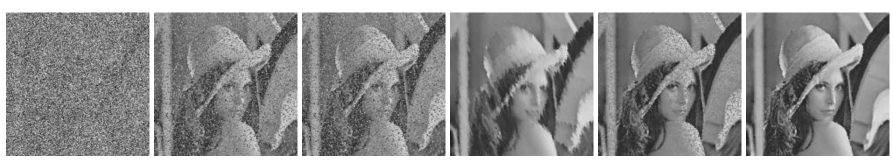
Fig-3.2: result for lena image of size 512x512 at 10% noise density (a) noisy image (b) MDBUTMF output (c) UTMF output (d) MDBMMF output (e) MMF output (f) IUTMMF output

(a) (b) (c) (d) (e) (f)

Fig-3.3: result for lena image of size 512x512 at 40% noise density (a) noisy image (b) MDBUTMF output (c) UTMF output (d) MDBMMF output (e) MMF output (f) IUTMMF output

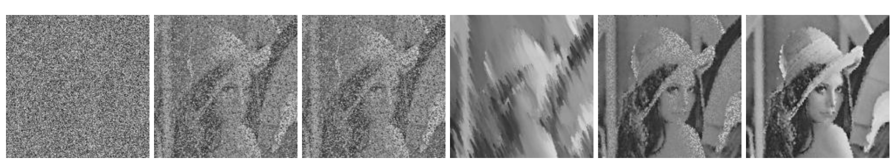
(a) (b) (c) (d) (e) (f)

Fig-3.4: result for lena image of size 512x512 at 80% noise density (a) noisy image (b) MDBUTMF output (c) UTMF output (d) MDBMMF output (e) MMF output (f) IUTMMF output



(a) (b) (c) (d) (e) (f)

Fig-3.5: result for lena image of size 512x512 at 90% noise density (a) noisy image (b) MDBUTMF output (c) UTMF output (d) MDBMMF output (e) MMF output (f) IUTMMF output



(a) (b) (c) (d) (e) (f)

Fig-3.6: result for lena image of size 512x512 at 95% noise density (a) noisy image (b) MDBUTMF output (c) UTMF output (d) MDBMMF output (e) MMF output (f) IUTMMF output

Various algorithms as discussed above Modified Decision Based Unsymmetrical Trimmed Median Filter(MDBUTMF), Unsymmetrical Trimmed Mean Filter(UTMF), Modified Decision based Mean-Median Filter(MDBMMF), Mid-point Median Filter(MMF) and the proposed Iterative Unsymmetrical Trimmed Midpoint-Median(IUTMMF) Filter have been implemented using Matlab. The snapshot of the same is shown below in Fig- 3.7.

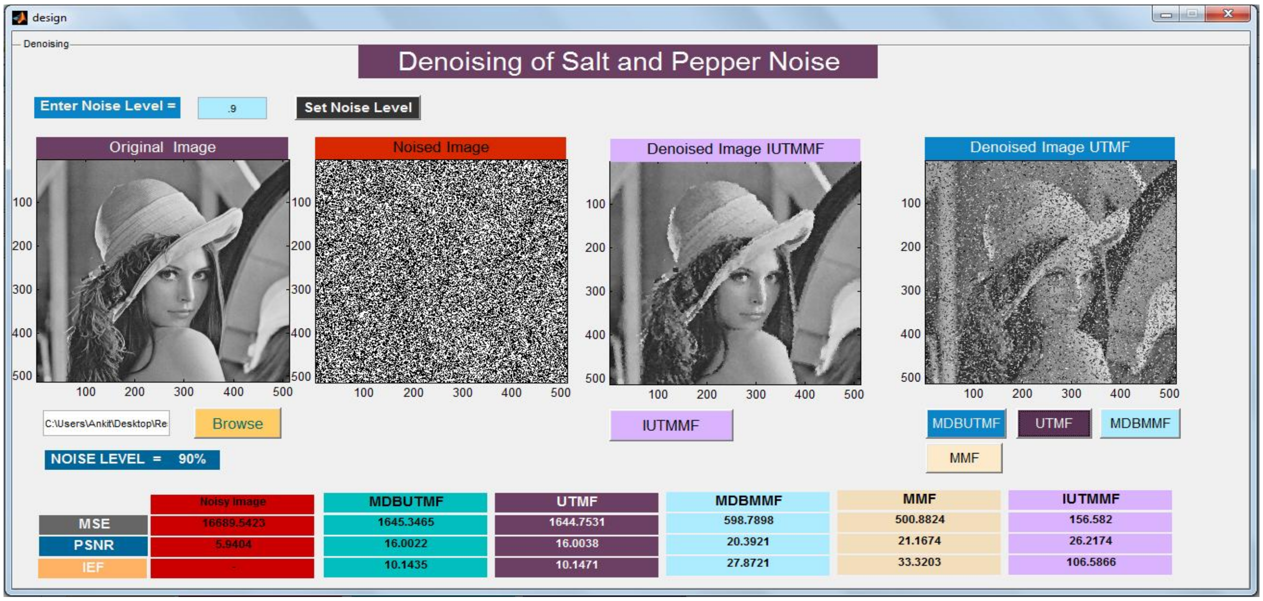


Fig-3.7: snap shot of graphical user interface for lena image at 90% noise density

4. CONCLUSIONS

An Iterative Unsymmetrical Trimmed Midpoint-Median Filter (IUTMMF) algorithm is proposed which gives better performance than Modified Decision Based Unsymmetrical Trimmed Median Filter (MDBUTMF), Unsymmetrical Trimmed Mean Filter(UTMF), Modified Decision based Mean Median Filter(MDBMMF) and Midpoint-Median Filter(MMF) algorithms in terms of PSNR,IEF and MSE. The performance of these algorithms is compared with the proposed IUTMMF for low, medium and high noise densities for grayscale images. Even at high noise density levels the IUTMMF gives better results in comparison with other existing algorithms. IUTMMF gives better results at noise densities up to 95%. Qualitative and quantitative results are discussed above in this paper.

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BIOGRAPHIES

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