Robust Algorithm for Impulse Noise Reduction

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Abstract– **This Paper presents highly efficient two phase schema for removing impulse noise. In the first phase, robust algorithm for noise detection is used to identify noisy pixels. In the second phase, the image is restored using special noise control algorithm. Efficiency of algorithm is tested by comparing with most powerful AMF (Adaptive Median Filter), DBA (Decision Based algorithm) and MTND (Median Type Noise Detector). An experimental result shows that the proposed algorithm works efficiently up to 99% of noise ratio.**

Keyword- Impulse Noise, Adaptive Median Filter, Image Enhancement and Noise Detection.

I. INTRODUCTION

Noise reduction is a two step process 1) noise detection and 2) noise replacement [1-3]. In first step, location of noise is detected and in second step, detected noisy pixels are replaced by estimated value. In literature so many algorithms are proposed but with low noise condition (up to 50% noise ratio), such algorithms works well but in high noise conditions performance of these algorithms is poor. To improve the range of noise reduction, AMF (Adaptive Median Filter) [4], DBA (Decision Based Algorithm) [5] and MTND (Median Type Noise Detector) [6] algorithms are proposed. The drawback of these algorithms is that, it uses different window size for different noise ratios and the calculation of window size requires noise ratio and vice versa. Hence algorithm becomes incomplete and it is impossible to use it in real time applications without having the complete knowledge about noise ratio or else we have to take fixed maximum window size. If the window size is large it increases the performance of low noise ratio and decreases the performance of high noise ratio and vice versa. Proposed algorithm provides consistent performance in very low and high noise conditions up to 99%. Proposed algorithm does not require prior knowledge about noise ratio hence this algorithm is complete.

II. PROPOSED ALGORITHM

In high noise condition density of noisy pixels and number of non-isolated noisy pixels increases. Hence the transmission of noise signal from one pixel to another pixel is more. To stop the flow of noise signals, prior knowledge of noisy pixels is used. Proposed algorithm contains two Phases, First phase detects the noisy pixels and second Phase replaces noisy pixels by non noisy estimated value.

A. Noise Detection

To detect noisy pixels present in Corrupted image (Ic) algorithm 1 is used and the information about the corrupted pixels are stored in binary image (NL) and Window (WL) of size 2L+1 is used to scan Ic. Initial values of all pixels present in NL are initialized to 0. Initialize the value of window size L to 1 and The Ic is scanned by WL. Center pixel of WL i.e. Ic(x, y) is considered as test pixel. Ic(x, y) is non-corrupted if the value of Ic(x, y) is greater than WLmin and less than WLmax otherwise Ic(x, y) is corrupted pixel. WLmin and WLmax are the minimum and the maximum values of pixels present in WL. If pixel Ic(x, y) is corrupted then 1 is stored in NL(x, y). Calculate the no of 0's present in NL and store it in a variable CL. C1 means number of non-corrupted pixels present in Ic when window size L=1. If CL value is less than or equal to C(L-1) then Image NL contains the information of noisy pixels. If NL(x, y) is 0 means pixel Ic(x, y) is not corrupted else Ic(x, y) is corrupted pixel.

Algorithm 1

```
Step1.  Take Corrupted Image (Ic).
Step2.  Initialize L=1.
Step3.  Scan Ic by Window (WL), Initialize all NL(x, y) to 0 and
        Consider the center Pixel Ic(x, y) of WL as Test pixel.
Step4.  Calculate WLmin and WLmax of WL using rest of Ic(x, y).
Step5.  If Ic(x, y) <=WLmin and Ic(x, y)>=WLmax then Ic(x, y) is
        Corrupted pixel.
Step6.  If Ic(x, y) is corrupted pixel then set NL(x, y) = 1 else set
        NL(x, y) = 0.
Step7.  Calculate no of 0's present NL and store in CL.
Step8.  If CL>C(L-1) then increment Window size L=L+1 and
        repeat step 3 to step8.
Step9.  Binary Image NL is a final Noise image.
Step10. Stop.
```

B. Noise Replacement

To calculate the replacement value of noisy pixels, algorithm 2 is used. Noisy pixels are replaced using varying size window (WL). Replacement value is calculated without considering the values of surrounding noisy pixel values present in WL hence replacement value is not corrupted by neighboring corrupted pixels.

Algorithm 2

```
Step1.  Take corrupted image Ic.
Step2.  Scan Ic using window WL. Initialize L=1.
Step3.  If WL contains less than 2 Non noisy pixels then increment
        L=L+1 and repeat step3 until L=Lmax..
Step4.  Compute WLmed from window (WL) using neighboring
        uncorrupted pixels and store Ic(x, y)=WLmed.
Step5.  Steps 2 to 5 are repeated until the processing is completed
        for entire Ic.
Step6.  Stop.
```

III. PERFORMANCE EVALUATION

To evaluate performance of proposed algorithm Lena, Pepper and Camera images are used. Performances measurements MSE (Mean Square Error), MAE (Mean absolute Error) and PNSR (Peak signal to noise ratio) are calculated. Figure 1 shows restoration results of proposed algorithm for Lena images of different amount of noise ratio. Visibility of output of 99% noisy Lena image clearly shows that efficiency of algorithm is very high. Figure 2, 3and 4 shows restoration results of different filters and visibility of proposed algorithm outputs clearly shows that efficiency of proposed algorithm is high compared to other algorithms. Calculated values of MAE, MSE and PSNR using equations (1), (2) and (3) for Lena 550x550 image are shown in table I, II and III. MAE and MSE of proposed algorithm are low. Compared to other algorithms PSNR and average PNSR values of proposed algorithm are high. Graphical analyses of results are shown in figure 5, 6 and 7.

$$\text{MAE} = \frac{\sum_{I}\sum_{j}(\text{Xij} - \text{Rij})}{(\text{M x N})} \qquad (1)$$

$$\text{MSE} = \frac{\sum_{I}\sum_{j}(\text{Xij} - \text{Rij})^{2}}{(\text{M x N})} \qquad (2)$$

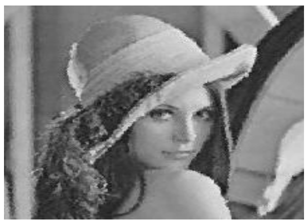
$$\text{PSNR} = 10\log10 \times \frac{255\text{x}255}{\text{MSE}} \qquad (3)$$

Where

X	-	Original Image.
R	-	Restored Image
M x N	-	Size of Image.
MAE	-	Mean Absolute Error.
MSE	-	Mean Square Error.
PSNR	-	Peak Signal to Noise Ratio.

(a) PA 30% noise.

(b) PA 60% noise.


(c) PA 90% noise.

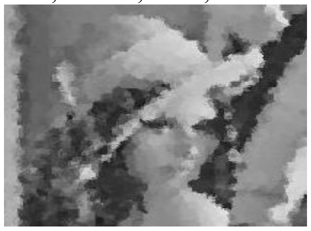
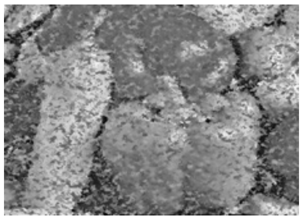
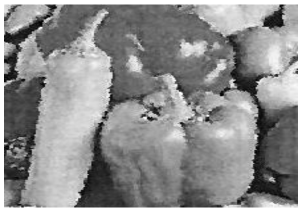
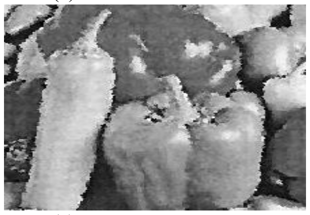

(d) PA 99% noise.

Figure1.Restoration results of proposed algorithm (PA) for 550 X 550 Lena image.


(a) AMF


(b) DBM


(c) MTND

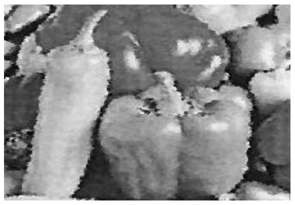
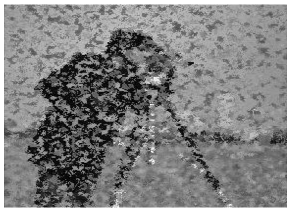
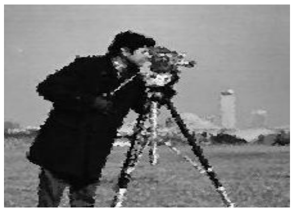
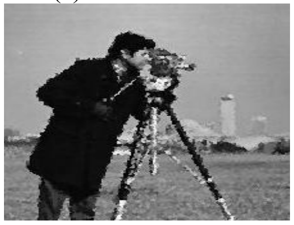

(d) PA

Figure2.Restoration results of different filters for 550 X 550 Pepper image with 85% of noise ratio.


(a) AMF


(b) DBM


(c) MTND

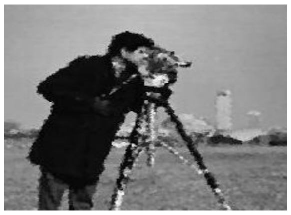
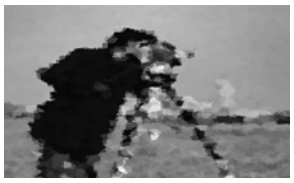

(d) PA

Figure3.Restoration results of different filters for 550X550 Camera image with 85% of noise ratio.


(a) PA(PSNR=19.18)

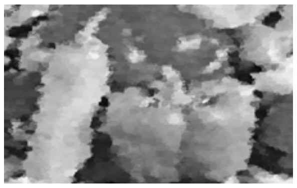

(b) PA(PSNR=18.25)

Figure4.Restoration results of PA for Camera and Peppers images with 99% of noise ratio.

TABLE I: COMPARISON OF MAE

Noise Ratio	AMF	DMB	MTND	PA
10	0.42	0.36	0.19	0.19
20	0.70	0.56	0.43	0.42
30	1.08	0.83	0.70	0.71
40	1.56	1.2	1.07	1.05
50	2.15	1.64	1.52	1.44
60	2.85	2.17	2.08	1.89
70	3.91	2.84	2.77	2.51
80	6.08	3.73	3.78	3.40
90	12.68	5.39	5.62	5.11
Avg	3.49	2.08	2.02	1.86

TABLE II: COMPARISON OF MSE

Noise Ratio	AMF	DMB	MTND	PA
10	3.58	2.67	1.35	1.28
20	7.48	4.9	3.59	3.43
30	1.08	8.59	6.27	6.47
40	22.57	13.67	11.03	10.52
50	34.83	20.57	17.31	15.62
60	51.73	29.61	26.47	22.23
70	86.01	43.01	39.78	33.96
80	191.17	65.30	64.77	54.14
90	597.5	124.47	23.81	106.8
Avg	110.66	34.76	32.71	28.28

TABLE III: COMPARISON OF PSNR

Noise Ratio	AMF	DMB	MTND	PA
10	42.59	43.86	46.83	47.05
20	39.38	41.20	42.58	42.78
30	36.70	38.79	40.16	40.22
40	34.59	36.77	37.70	37.91
50	32.71	34.99	35.75	36.20
60	30.99	33.42	33.90	34.66
70	28.78	31.80	32.13	32.82
80	25.31	29.98	30.02	30.80
90	20.37	27.18	27.20	27.84
Avg	32.38	35.33	36.55	36.70

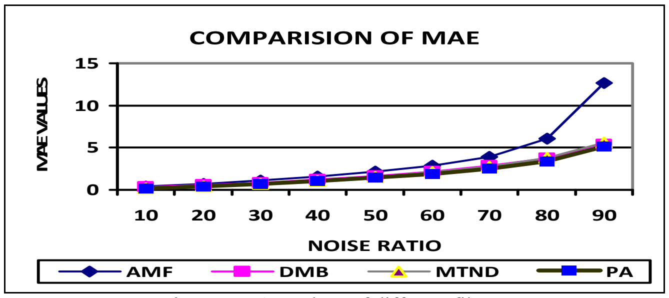


Figure5. MAE values of different filters.

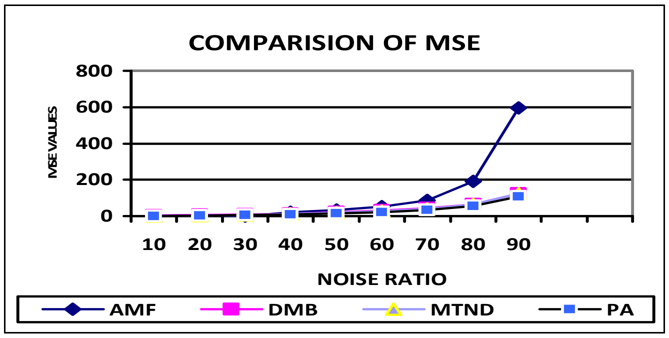


Figure6. MSE values of different filters.

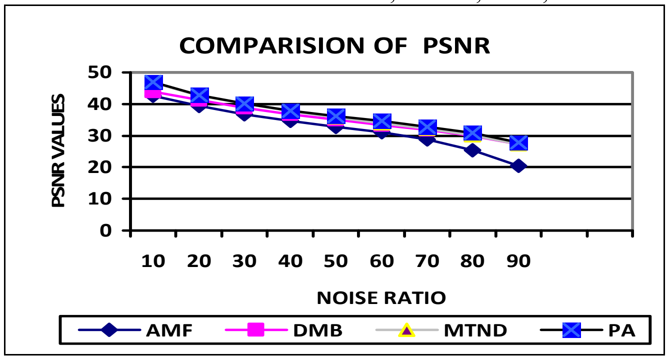


Figure7. PSNR values of different filters.

TABLE IV: RESULTS OF LENA 512X 512 IMAGES

Noise Ratio	PSNR of Corrupted Image(db)	MAE	MSE	PSNR of Restored Image(db)
10	15.43	0.19	1.41	46.65
20	12.43	0.44	3.41	42.76
30	10.69	0.74	6.48	40.02
40	9.46	1.09	10.79	37.80
50	8.46	1.51	16.45	35.97
60	7.65	2.02	24.77	34.19
70	6.99	2.62	35.14	32.67
80	6.43	3.54	57.15	30.56
90	5.91	5.37	117.3	27.44

IV. CONCLUSION

In this paper a highly efficient and robust algorithm for impulse noise removing is proposed. Proposed algorithm controls the flow of noise signal and produce consistent and very high output. Experimental results shows that efficiency of algorithm is very high compared to other algorithms and it has average MAE=1.86, MSE=28.28 and PSNR=36.70. Proposed algorithm works well in both the low and the high noise ratio up to 99%. Proposed algorithm is ultimate solution for impulse noise reduction because it maintains consistency in performance. Finally proposed algorithm is complete means it works without prior knowledge about noise ratio or specified window size. In future efficiency of algorithm can be increased by using soft computing tools.

REFERENCES

[1] N E Nahi and A Habbi,” Decision –Directed recursive image Enhancement, ” IEEE Transactions circuit systems Vol CAS-2 PP 286-293 Mar 1975.

[2] J S Lee, “Digital image enhancement and noise filtering by use of local statistics “, IEEE Transactions pattern analysis. Vol PAMI-4, PP 141- 149, Mar, 1982.

[3] subg-Jea KO and Yong Hoon, “Center Weighted Median Filters and Their applications to image enhancement”, IEEE Transactions on circuits and systems vol 38, no 9, September 1991.

[4] H Hwang and R A Haddad,”Adaptive Median Filter: New Algorithms and Results”, IEEE Transactions on image processing Vol 4 No 4 April 1995.

[5] K.S. Srinivasan and D. Ebenezer,” A New Fast and Efficient Decision-Based Algorithm for Removal of High-Density Impulse Noises”, IEEE Signal Processing Letters Vol 14 No 3 March 2007.

[6] Raymond H Chan, Chung-Wa Ho, and Mila Nikolova, ”Salt-and-Pepper Noise Removal by Median-Type Noise Detectors and Detail-Preserving Regularization”, IEEE Transactions on image processing Vol 14 No 10 April 2005.