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TWO PHASE WEIGHTED ADAPTIVE MEAN FILTER FOR HIGH DENSITY IMPULSE NOISE REDUCTION

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ABSTRACT

This Paper presents highly efficient high density impulse noise removing algorithm by combining good the features of impulse noise removing algorithms. This paper presents two step noise reduction process. In first stage efficient noise detection algorithm is used to detect the noisy pixels present in corrupted image. In second stage features such as distance and directions of pixels are used in calculating the replacement values of noisy pixels. Efficiency of algorithm is tested by comparing with efficient existing algorithms. An experimental result shows that the proposed algorithm works with very high density noise up to 98% of noise ratio.

Keywords: *Impulse Noise, Adaptive Median Filter, Image Enhancement, Noise Detection.*

1. INTRODUCTION

Impulse Noise is a non-uniformly distributed noise. It modifies only the selected pixels from the image, keeping remaining pixels unchanged. Impulse noise produces the dot spots or patches on the image. Impulse noise has the property of either leaving pixel unmodified with probability (1-P) or replacing it altogether with a probability P. The sources of impulse noise are usually the result of error in transmission system, Faulty sensors present in storage or capturing devices, Atmospheric or man -made disturbances.

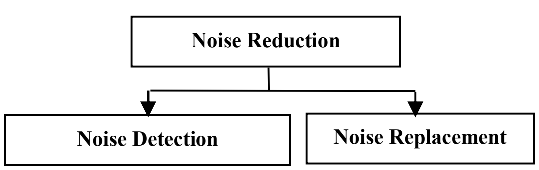

Figure1. Steps of Noise Reduction

Noise reduction is a two-step process 1) noise detection and 2) noise replacement [1-3]. In first step location of noise is identified and in second step detected noisy pixels are replaced by estimated value. In literature so many algorithms are proposed but in low noise condition (up to 50% noise ratio) algorithms works well but in high noise conditions performance of algorithms are 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. Drawback of algorithms uses different window size for different noise ratios is calculation of window size requires noise ratio and vice versa. Hence algorithm becomes incomplete and it is not possible to use it in real time applications without having the prior knowledge of noise ratio or else we have to take fixed maximum window size. If window size is big it increases the performance of high noise ratio and decreases the performance of low noise ratio vice versa. Proposed algorithm provides consistent performance in very low and high noise conditions up to 98%. Proposed algorithm not requires prior knowledge of noise ratio hence algorithm is complete.

2. LITERATURE SURVEY

In literature so many image de-noising algorithms for correcting the images corrupted by impulse noise are proposed. In all proposed algorithms odd length square window of size WL=2K+1 is used to scan the corrupted images and to remove the noise. Odd-length window is used to get exact central pixel W (0, 0) of the window surrounded by K neighboring pixels.

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I (-1, -1)	I (-1, 0)	I (-1, +1)
I (0, -1)	I (0, 0)	I (0,+ 1)
I (+1, -1)	I (+1, 0)	I(+1, +1)

Figure 2: Window of length WL=3 and K=1

Even though different window shapes are available like rectangle, diamond etc, square shaped window are preferred the most. Central pixel W (0, 0) is also referred as test pixel, pixels surrounded by test pixel are called neighboring pixels. With the help of window, images are scanned for detecting the errors in the pixel, the pixel in the center of the window is called center pixel and the pixels surrounding that center pixel is called neighboring pixels with the help of neighboring pixels test pixel is calculated if the calculated value differ from the expected value then the pixel is said to be corrupted and is replaced by the expected value, if not same is retained. Impulse noise reduction algorithms are broadly classified in to two classes' linear and non-linear algorithms.

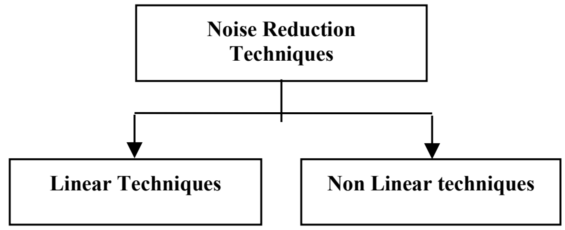

Figure 3: Classification of Reduction Techniques

In linear technique the noise reduction method is applied linearly to all the pixels in the corrupted image without checking for the corrupted pixels, whereas in non-linear methods corrupted and non-corrupted pixels are determined first then the reduction techniques are applied for correcting the corrupted pixels only, linear algorithms are time consuming and also blurs the image hence non - liner noise reduction algorithms are preferred. Some set of conditions are considered in classifying corrupted and non-corrupted pixels in non-linear algorithm.

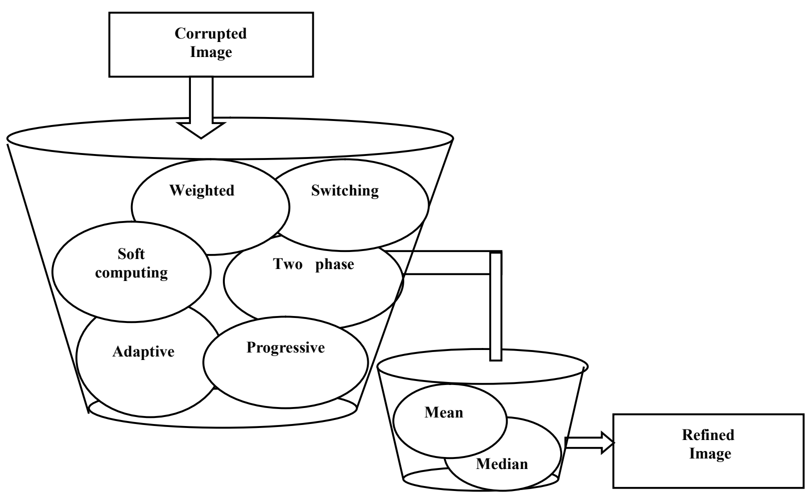

Figure 4: General View of Literature

So many value estimation techniques for corrupted pixel are available in literatures, mean and median [07], are the most popularly used techniques. In mean filter (1) average value of neighboring pixels of scanning window is used as a estimated value of test pixel whereas in median filter (2-3) neighboring pixels value are sorted in order and then the median value is used as the test pixel value. Mean filter is effective in minimizing the mean square error value of estimation. Median filter algorithm produces good visibility in restored image. So many improved versions of mean and median algorithms are proposed by adding new features to the existing algorithm. Features such as adaptive, weighted, progressive, two-phase, switching, fuzzy, neural and decision based etc.

$$I(0,0) = \frac{\sum_{n=-K}^{K}\sum_{m=-K}^{K} I(m,n)}{(2K+1)(2K+1)} \qquad (1)$$

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If N is odd

$$X = Sort(X)$$
$$I(0, 0) = X[(N+1)/2] \quad (2)$$

If N is even

$$X = Sort(X)$$
$$I(0, 0) = (X[N/2] + X[(N+2)/2])/2 \quad (3)$$

Adaptive filters [08], In adaptive filter, size of the scanning window varies until suitable or adaptable estimated value for the test pixel is obtained. Size of the window starts from some minimum value and increases until we obtain adaptable value for the test pixel. Once we obtain the adaptable value the test value is replaced by the adapted value. In adaptive filters we not only find the adaptable value but it also checks the correctness of the estimated value.

Weighted filters [09], weight based filtering (4) techniques are priority based systems, here weight means priority, are assigned to the neighboring pixels based on certain conditions usually the pixels nearer to the test pixel are assigned more weight and pixels which are away from the test pixels are assigned less weight comparatively. The low weighted pixel contributes less compared to highly weighted pixel.

$$I(0, 0) = \frac{\sum^{K}_{n=-K}\sum^{K}_{m=-K} W(m, n)\, I(m, n)}{\sum^{K}_{n=-K}\sum^{K}_{m=-K} W(m, n)} \quad (4)$$

Progressive filters [10]-This technique iteratively removes the corrupted pixels in a progressive manner, it effectively removes the corrupted pixel in a short span of time. But there may a chance of occurrence of systematic errors because the error of newly corrected pixel may be carried to the next pixel to be corrected.

Two-phase or Multi-stage filters [11], Noise removing techniques are divided into some distinct independent stages to minimize the complexity of the algorithms and to design efficient algorithm, usually in two-phase algorithms are divided into detection and reduction. In detection stage more concentration is given to locate the noisy pixel, whereas in reduction stage more concentration is given in reducing the noisy pixel. Some iteration's are repeatedly carried out to get the improved output.

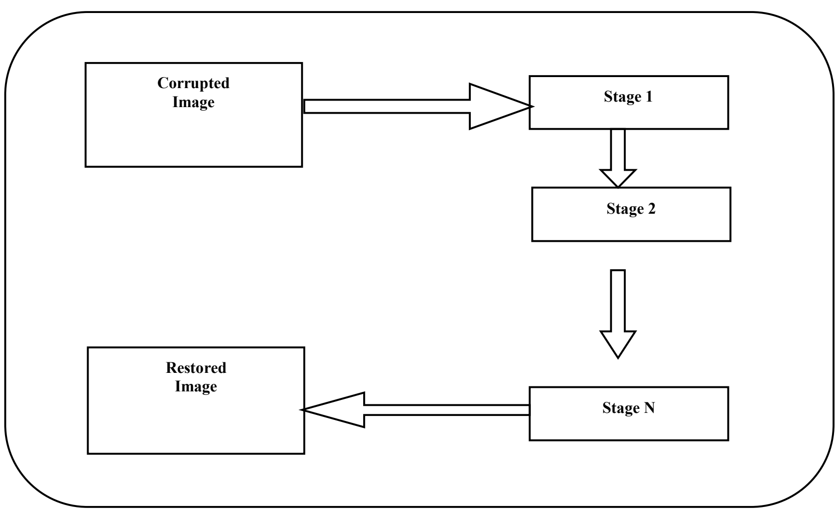

Figure 5: Multi Stage Filter

Switching filters [12], this technique employs more than one filtering techniques and based on some criteria there can be a switching from one filtering technique to another. It utilizes best features available in different filtering techniques.

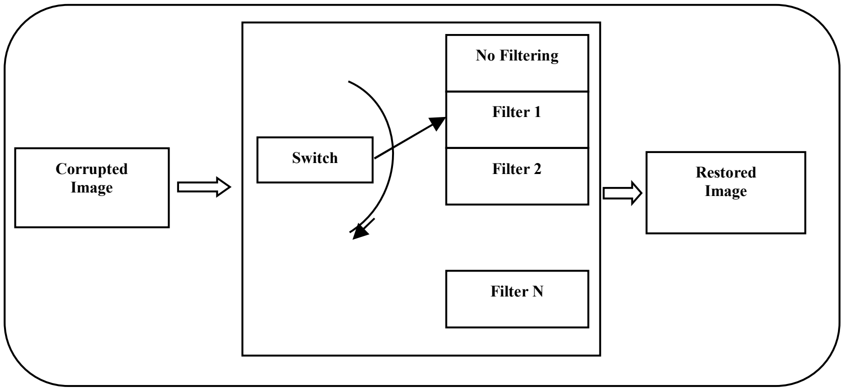

Figure 6: Switching Filter

Soft-computing filtering, now a day's soft-computing is playing a vital role in research. Soft-computing includes Data mining, Fuzzy logic [13], Neural networks [14], Decision based techniques and these are useful in identifying the cause for the generation of noise impulse, Relation between corrupted and non-corrupted image pixels ,relation between neighboring pixels [15], and other features in removing noise, Adding of these new techniques Fuzzy logic, Neural networks, Decision based are proposed.

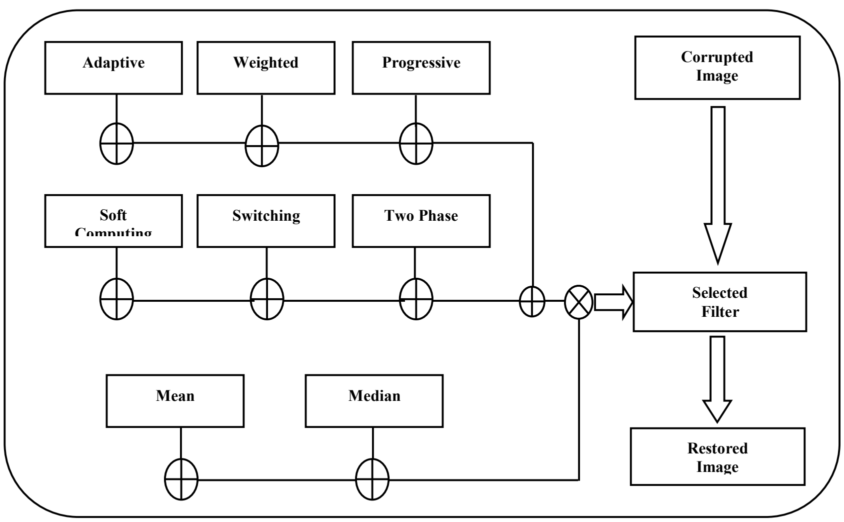

Figure 7: Technical View of Literature

Video and colour image, Now a day's black and white photographic images are being replaced by digital colour images and also videos, therefore all existing filtering algorithms are extended to support the colour images and videos, and so many impulse noise removing algorithms for colour images and videos [16], are proposed. Colour images are the combination of basic RGB colour frames. Traditional algorithms are individually applied for different algorithms to remove the colour noise. Video is a set of photographic images displayed in a constant frame rate. It follows the same technique as used in image.

❖ DRAW BACKS OF EXISTING SYSTEMS

- Existing systems uses fixed or different window size for detection of impulse noise. No algorithm is exist which can automatically calculate the required window size.
- Existing systems not provides consistent output in both low and high noise conditions. Only few algorithms efficiently handles high noise condition i.e. noise ratio more than 50%.

- Exist systems are not well suited for real time applications because of their time consuming nature.

3. PROPOSED ALGORITHM

In high noise condition, the density of noisy pixels increases and the number of non-isolated noisy pixels also increases. Hence noise signal transmission from one pixel to another pixel is more. To stop noise signal flow prior knowledge of noisy pixels are used. Proposed algorithm contains two Phases. Phase1 detects the noisy pixels and Phase 2 replaces noisy pixels by non-noisy estimated value.

3.1. NOISE DETECTION

To detect the noisy pixels present in Corrupted image (Ic) algorithm 1 is used and information about 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. To detect the corrupted pixels L value is initialized to 1 and Ic is scanned by WL. Center pixel of WL (Ic(x,y)) is considered as test pixel. Ic(x,y) is non-corrupted pixel if 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 respectively. If pixel Ic(x,y) is corrupted 1 is stored in NL(x,y) . Calculate the no of 0's present in NL and store them 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 pixel Ic(x,y) is not corrupted else Ic(x,y) is corrupted pixel.

Algorithm 1

Step01.	Take Corrupted Image (Ic).
Step02.	Initialize L=1.
Step03.	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.
Step04.	Calculate WLmin and WLmax of WL using rest of Ic(x,y).
Step05.	If Ic(x,y)<=Wmin and Ic(x,y)>=Wmax then Ic(x,y) is corrupted pixel.
Step06.	If Ic(x,y) is corrupted pixel set NL(x,y)=1 else set NL(x,y)=0.
Step07.	Calculate no of 0's present NL and store in CL.
Step08.	If CL>C(L-1) then increment Window size L=L+1 and repeat step 3 to step8.
Step09.	Binary Image NL is a final Noise image.
Step10.	Stop.

3.2. NOISE REPLACEMENT

To calculate replacement value of noisy pixels two main features such as direction and distance of neibouring pixels are used. This is based on the fact that not only the value of neibouring pixels that contribute in accurate calculation of replacement value there direction and distance from central pixel also plays an vital rule in replacement value calculation.

3.2.1 DIRECTION BASED SELECTION:

To calculate the replacement value of noisy pixel odd size window of length WL=2k+1 is used. Selected Window is divided into eight equal regions R1 to R8 in eight directions. Center pixel of window (0, 0) is considered as test pixel. Initial value of k is 1 and value of k increases until all the regions of window contains at least one uncorrupted or non-noisy pixel. Maximum value of k is 25. Figure 8 shows arrangement of pixels in window regions.

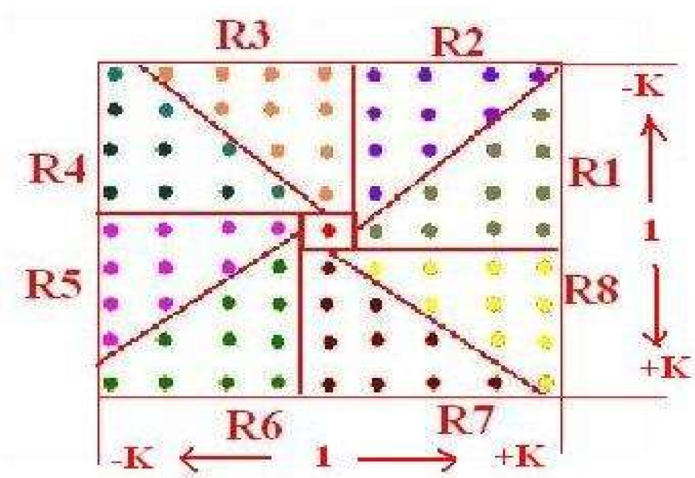

Figure8 Internal distribution of window pixels

3.2.2 DISTANCE BASED SELECTION:

Based on distance from central pixel eight neibouring nearest pixels P1 to P8 one each from eight regions are selected. Figure 9 shows the pixels of eight regions present in the window.

$$Distance\ P(m, n) = Sqrt(m*m + n*n) \quad (5)$$

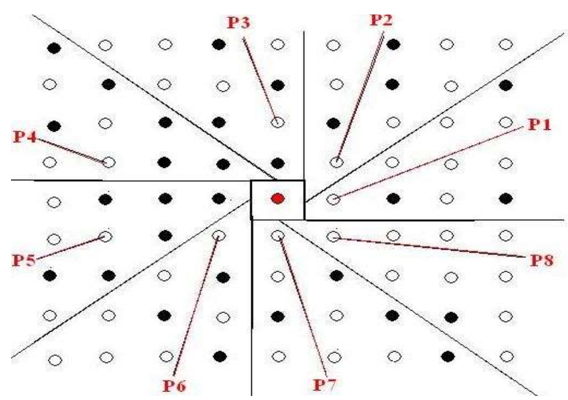

Figure9. Selected pixels from eight regions of window

3.2.3 WEIGHT CALCULATION:

Because both the value and the distance of selected neibouring pixels play vital rule in calculation of replacement value. To combine both value and distance of pixels distance Values of Pixels D1 to D8 are converted into weights W1 to W8. Weights value changes from 255 to 1. Maximum Value present in distance vector Di is considered as Wmin and Minimum Value present in distant vector Di is considered as Wmax. Nearest Pixel are assigned more weights compared to longest pixels weight is assigned to 255 and longest distance pixel weight is assigned to 1 because nearest pixel contribute more compared to longest distance pixel in calculation of replacement value.

$$Wi = 1 + ((Di - Wmin)*255/(Wmax - Wmin)) \quad (6)$$

3.2.4 *REPLACEMENT VALUE:*

To calculate the replacement value of center pixel equation 7 is used. Nearest non corrupted pixel P_i values are taken from each region from R1 to R8. Replacement value is calculated by taking weighted mean of all selected pixel values.

$$Replacement\_Value = \frac{\sum_{i=1}^{8} Wi * Pi}{\sum_{i=1}^{8} Wi} \quad (7)$$

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To restore corrupted image, corrupted image is scanned from top to bottom, row by row using odd sized window WL. In each scan check the status of central pixel I (0, 0). If it is corrupted pixel then replace its value by its replacement value.To scan window WL of size 2K+1 variable I and J are used. Min and Max values of I and J are –K and +K.

4. PERFORMANCE EVALUATION

To evaluate performance of proposed algorithm two different natural images are used. Performances measurements MSE (Mean Square Error), MAE (Mean absolute Error) and PNSR (Peak signal to noise ratio) are calculated. Figure 10 shows restoration results of proposed algorithm of pet image for different amount of noise ratio. Visibility of output of 98% noisy image clearly shows that efficiency of algorithm is very high. Figure 11 shows restoration results of different filters and visibility of outputs clearly shows that efficiency of proposed algorithm is high compared to other algorithms. Calculated values of MAE, MSE and PSNR using equations (8), (9) and (10) for pet 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 12.

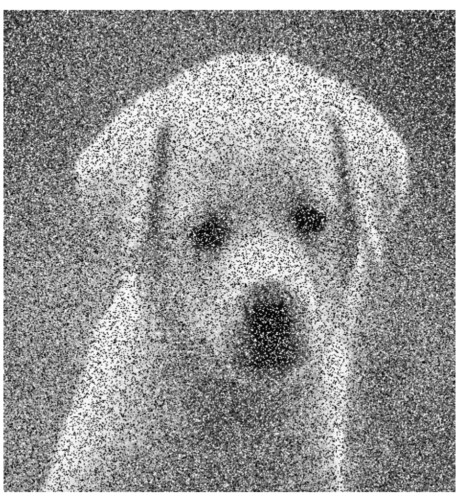
$$MAE = \frac{\sum^{M}_{i}\sum^{N}_{j} (Xij - Rij)}{(M \times N)} \tag{8}$$

$$MSE = \frac{\sum^{M}_{i}\sum^{N}_{j} (Xij - Rij)^2}{(M \times N)} \tag{9}$$

$$PSNR = 10log10 \times \frac{255x255}{MSE} \tag{10}$$

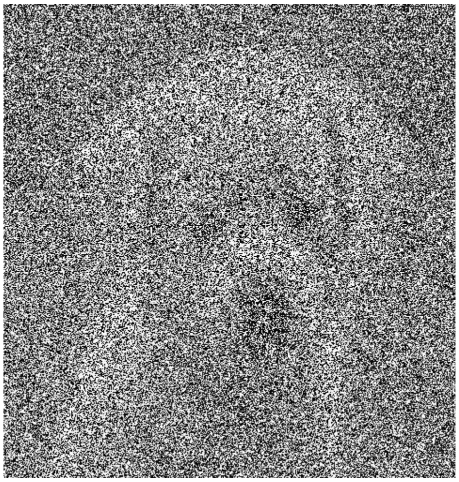
Where

- 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.



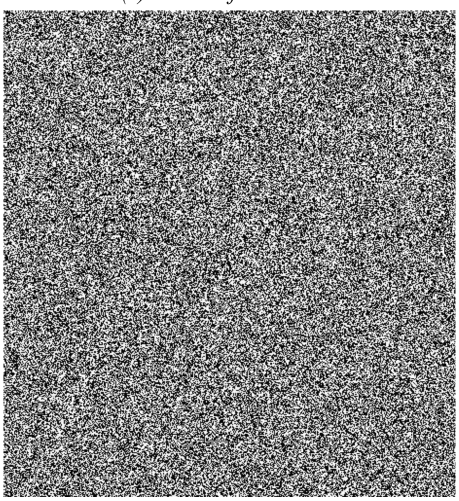
(a) 40% of Noise

(b) PA(PSNR= 44.1981)

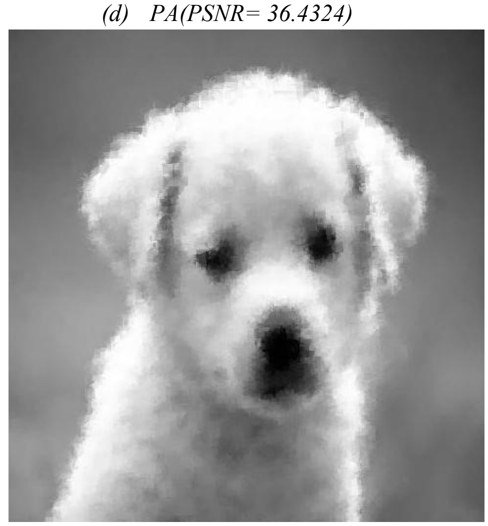


(c) 80% of Noise

(d) PA(PSNR= 36.4324)



(e) 98% of Noise



(f) PA(PSNR=27.3327)

Figure 10.Restoration results of PA for Camera, Peppers and Lena images with 99% of noise ratio.

Original Image

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(a) MTND (b) AMF

(c) DBM (d) PA

Figure 11.Restoration results of different filters for 550X550 Camera image with 85% of noise ratio.

TABLE I: Comparison of MAE

Noise Ratio	MTND	AMF	DBA	PA
10	0.21	0.24	0.23	0.12
20	0.40	0.41	0.34	0.22
30	0.65	0.63	0.50	0.35
40	0.93	0.88	0.69	0.49
50	1.24	1.22	0.94	0.67
60	1.66	1.63	1.24	0.89
70	2.26	2.23	1.60	1.20
80	3.03	3.13	2.13	1.69
90	5.02	5.04	3.10	2.56
Avg	**1.71**	**1.71**	**1.19**	**0.91**

TABLE II: Comparison of MSE

Noise Ratio	MTND	AMF	DBA	PA
10	019.94	001.16	00.99	00.39
20	034.44	002.68	01.90	00.83
30	059.18	004.72	03.28	01.60
40	078.45	007.84	04.83	02.38
50	096.74	012.37	07.45	03.69
60	130.97	020.34	11.03	05.52
70	180.46	031.04	15.28	08.56
80	244.41	055.35	24.63	14.99
90	497.94	144.63	48.34	29.46
Avg	**149.17**	**31.12**	**13.08**	**07.49**

TABLE III: Comparison of PSNR

Noise Ratio	MTND	AMF	DBA	PA
10	35.13	47.48	48.16	52.27
20	32.75	43.88	45.33	48.94
30	30.40	41.01	42.96	46.11
40	29.18	39.13	41.28	44.37
50	28.27	37.21	39.40	42.47
60	26.95	35.24	37.70	40.72
70	25.44	32.92	36.28	38.81
80	24.24	30.41	34.21	36.37
90	21.15	26.62	31.28	33.44
Avg	**28.16**	**37.10**	**39.62**	**42.61**

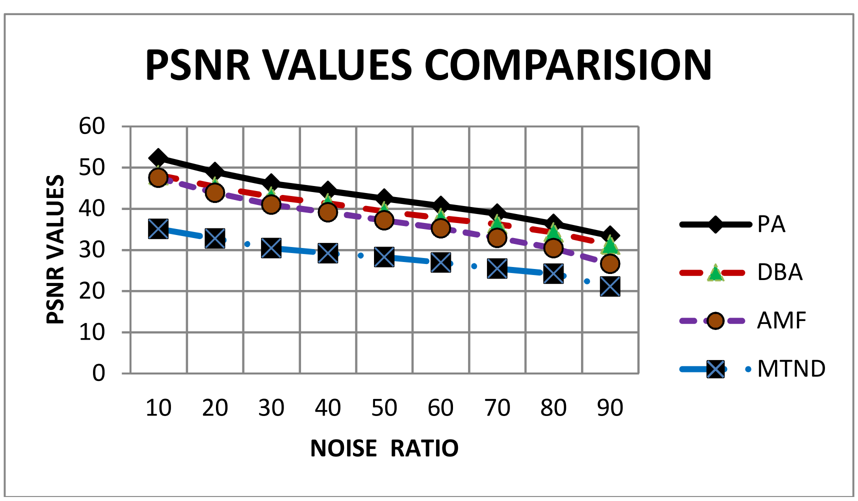

Figure12. PSNR values of different filters.

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5. CONCLUSION

In this paper a highly efficient Two Phase Weighted Adaptive Mean Filter for High Density Impulse Noise Reduction 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=0.91, MSE=07.49 and PSNR=42.6. Proposed algorithm works well in both the low and the high noise ratio up to 98%. 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 of noise ratio or specified window size.

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