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A Novel Fuzzy Based Filter for Removing Impulse Noise from Highly Corrupted Image

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ABSTRACT :Standard median filter (SMF) and its conventional variants are not capable of removing the impulse noise from the highly corrupted images. Therefore restoration of high density impulse noise corrupted image by switching-based median filter like Progressive switching median filter(PSMF)and boundary discriminative noise detection(BDND) median filter have been proposed in the past. In this paper a novel fuzzy based approach has been proposed for removing the impulse noise from the highly corrupted image. Comparisons carried out in this paper between proposed method and Standard median filter, shows its ability to remove the noise from the highly corrupted image.

Keywords: Impulse Noise[1], Median Filter[2], Fuzzy membership function[3], Fuzzification[4], Neighbouring pixels[5].

1. INTRODUCTION

Noise in image is produced during the process of transmission and acquisition.
Gaussian, multiplicative, impulse or salt and pepper noise are some of the common noise by which images are corrupted. Removing these noises from the image is desirable for getting good and noise free image. In the past [1-7] various filter which are based on computing the median are used for removing the noise from the image. The filter based on computing the median have disadvantage of producing the edge blurring and hence required some new approach for suppressing the noise. Later on some author also proposed adaptive approach based median filter for removing the salt and pepper noise [8-10].Main advantage of adaptive approach is that it removes the noise without blurring the edges of the image. Another disadvantage of conventional approach based median filter is that it is not able to distinguish between corrupted and non corrupted pixel. Later on some author suggested a new approach [11] which first detect the corrupted pixel and then apply the median operation only on the corrupted pixel. Main Advantage of this method is that it modifies only the corrupted pixel while the uncorrupted pixel remains intact.Noise in any image,impulse noise is basically produced due to fault in memory, error in transmission and scanning operation[12-13].Standard median filter is able to remove the low density impulse noise from the image but as the noise density increase it starts showing poor performance. In the past few years, Fuzzy based method has emerged as a new approach for removing the noise from the image [14-16].
In this paper a novel method of impulse noise removal algorithm has been proposed which is based on computing the difference between neighbourhood pixel around the central pixel and then applying the fuzzy rule on these difference to compute the correction factor which later on added to the central pixel to get the modified pixel value.

5. THE PROPOSED FILTER

For filtering out the impulse noise from the image corrupted with impulse noise, a fuzzy inference system has been designed.This system take the 4-neighbors of the central pixel using 3x3 window operation and compute the difference D1,D2,D3,D4 as defined in algorithm part.These differences is then fuzzified by rule base Fuzzy inference system(FIS). Then using some predefined fuzzy rule base as given in Table 1, a correction factor P_{Corr} is computed as by taking the centroid of resulting membership function. Mandani method has been chosen as the defuzzification method. The block diagram of this approach is shown in Figure 4.

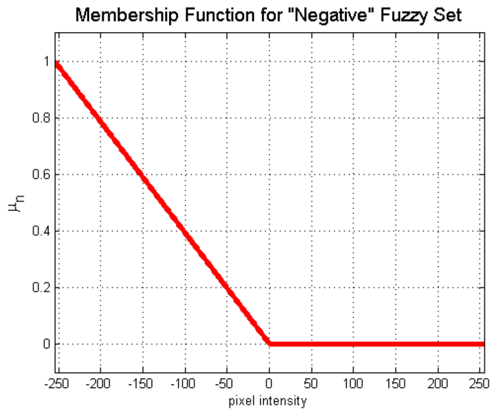


Figure 1 “Negative” fuzzy set f or difference value

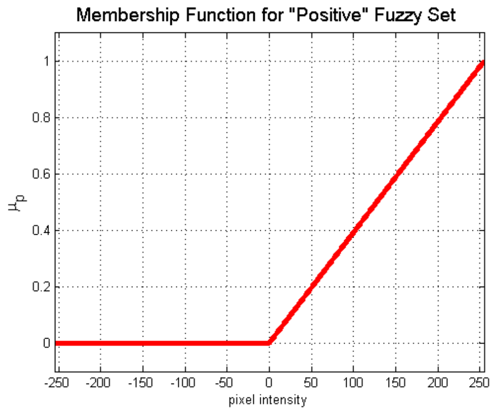


Figure 2“Positive” fuzzy set for difference value

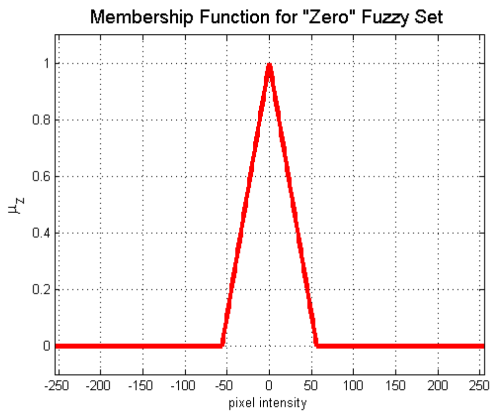


Figure 3 “Zero” Fuzzy set for output value

In order to convert the difference value into fuzzy plane, two fuzzy set i.e. Negative and Positive has been defined by the membership function which is shown in Figure 1 and Figure 2 while the membership function for output value is shown in Figure 3.
Steps for algorithm are as follows-

Step 1- Read the Image

Step2- Convert it to Gray scale

Step3-Add the noise

Step4- Apply a 3x3 window over image one by one.

Step5- Take the differences of each of the 4-neighbours with the centre pixel as shown in Figure 4

P(x-1,y-1)	P(x-1,y)	P(x-1,y+1)
P(x,y-1)	P(x,y)	P(x,y+1)
P(x+1,y-1)	P(x+1,y)	P(x+1,y+1)

Figure 4 Illustration of taking pixel difference

and the information from the differences of each of the 4-neighbors with the centre pixel is taken as D2,D4,D6,D8.

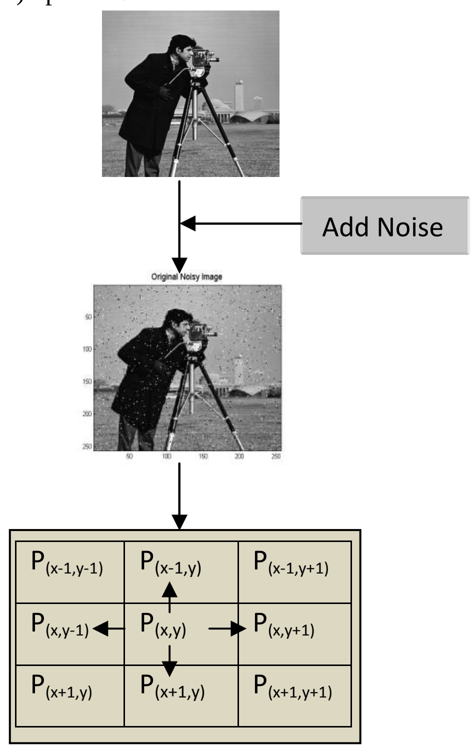
D2= P(x-1,y)- P(x,y)

D4= P(x,y+1)- P(x,y)

D6= P(x+1,y)- P(x,y)

D8= P(x,y-1)- P(x,y)

Step6- Fuzzify these difference value into different degree of positive and negative.
Step 7 – Compute the firing strength by fuzzy t-norms (MIN) operator.



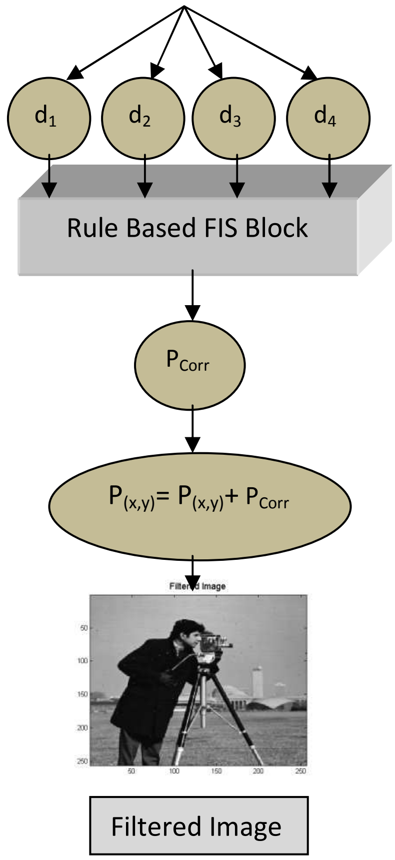


Figure 5 Block diagram of proposed method

Step 8 –Compute the aggregate resultant output by applying the s-norm operator(MAX).
Step 9 –Defuzzify the resultant output by using centroid method to get the correction factor $P_{Corr.}$
Step 10 – Add this correction factor to central pixel value to get the corrected pixel value.

Table 1 Fuzzy Rule

D1	D2	D3	D4	P_{Corr}
Positive	Positive	Positive	Positive	Positive
Positive	Positive	Positive	Negativ e	Positive
Positive	Positive	Negativ e	Positive	Positive
Positive	Negativ e	Positive	Positive	Positive
Negativ e	Positive	Positive	Positive	Positive
Negativ e	Negativ e	Negativ e	Negativ e	Negativ e
Negativ e	Negativ e	Negativ e	Positive	Negativ e
Negativ e	Negativ e	Positive	Negativ e	Negativ e
Negativ e	Positive	Negativ e	Negativ e	Negativ e
Positive	Negativ e	Negativ e	Negativ e	Negativ e
Otherwise				Zero

PERFORMANCE PARAMETER

Mean squared Error (MSE) and Peak signal to noise ratio (PSNR) are the two parameter which are computed for testing the efficiency of the proposed fuzzy based algorithm in removing impulse noise from the image. A Comparison has also been carried out between Standard median filter(SMF) and Fuzzy based proposed method.

$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - I'(i,j)]^2$$

$$PSNR(in\ dB) = 10log_{10}\left(\frac{Max^2}{MSE}\right)$$

$$= 20log_{10}\left(\frac{Max^2}{\sqrt{MSE}}\right)$$

$$= 20log_{10}(Max) - 10log_{10}(MSE)$$

9. EXPERIMENTAL RESULTS

In order to check the performance of this proposed method the coin.tif image is taken as a test image and the result obtained by proposed method is compared to the standard median filter method(SMF) provided in IP tool box of Matlab This image is then corrupted with different percentage of impulse noise. After which Proposed algorithm and Standard median filter (SMF) method is applied in this corrupted image. Mean squared error (MSE), Peak signal to noise ratio (PSNR) and execution time is computed for both the method for comparing the performance.The whole process was implemented in a computer system having 2GB RAM, dual core processor with MATLAB ver 7.0 as a platform.

Table2: Comparison of PSNR for proposed and SMF method

Impulse Noise (in percentage)	PSNR for Proposed method	PSNR for Standard Median Filter (SMF) method
10	40.181	28.563
20	37.074	25.046
30	35.152	21.098
40	32.143	17.39
50	28.245	13.801
60	23.22	10.903
70	17.957	8.7534
80	12.831	6.9185
90	8.4847	5.55

Table 3 MSE for different noise density

Impulse Noise (in percentage)	**MSE for Coin Image (256 X 256)**	
	Noisy Image	**Filtered Image by Proposed method**
10	**1984**	**6.23**
20	**4118.5**	**12.756**
30	**6167.8**	**19.856**
40	**8140.1**	**32.598**
50	**10055**	**97.405**
60	**12174**	**309.79**
70	**14217**	**1040.8**
80	**16042**	**3388.3**
90	**18184**	**9217.4**

Table 4 Comparison of MSE for Proposed and SMF method.

Impulse Noise (in percentage)	**MSE for Coin Image (256 X 256)**		
	Noisy Image	**Filtered Image**	**SMF method**
10	**2388.8**	**6.23**	**90.53**
20	**4808.8**	**12.756**	**203.47**
30	**7184.4**	**19.856**	**505.00**
40	**9563.2**	**32.598**	**1305.7**
50	**11904**	**97.405**	**2710.2**
60	**14452**	**309.79**	**5282.3**
70	**16869**	**1040.8**	**8664.4**
80	**19213**	**3388.3**	**13220**
90	**21485**	**9217.4**	**18117**

Computed PSNR, MSE, and CPU Time are shown in Table 1, Table 2 , Table 3 and table 4. A graph between Noise percent and PSNR for different method was sketched and shown in Figure 3. Figure 4 depicts the graph between MSE and noise percent for noisy image and filtered image obtained by proposed method. Graph between MSE and different noise percent for proposed method and SMF method is shown in figure 5.

From graphs shown in Figure 3,Figure 4 and Figure 5 along with the Table 1, Table2 and Table 3 it is clear that the performance proposed method is much better than the SMF method in filtering out the noise from the corrupted image.

Table 4 shows the CPU time comparison for proposed method and SMF method and it is clear that the proposed method takes little bit more time to produce the final result.

Table 5 CPU Time Comparison for Proposed and SMF method

Impulse Noise (in percentage)	CPU time for Proposed method (in second)	CPU time for SMF method (in second)
10	2.42	0.18
20	2.51	0.10
30	2.51	0.09
40	2.53	0.10
50	2.53	0.11
60	2.57	0.11
70	2.59	0.15
80	3.07	0.15
90	3.18	0.15

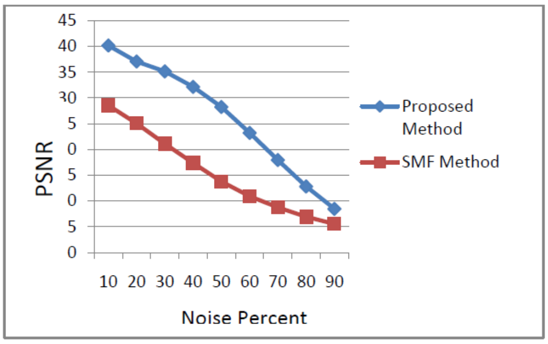


Fig. 6: PSNR Comparison for proposed and standard Median Method (SMF)

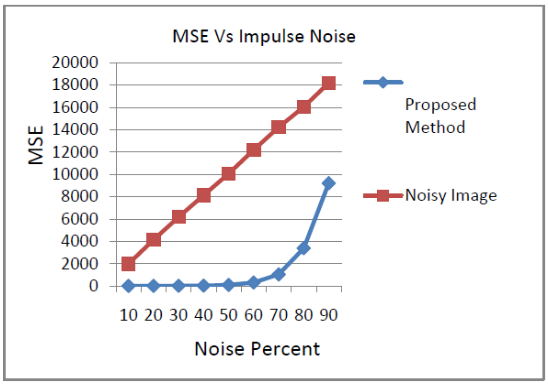


Fig. 7: MSE Vs Impulse Noise for coin (256 X 256) image

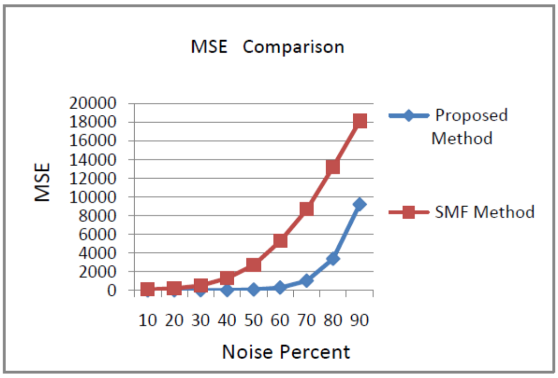
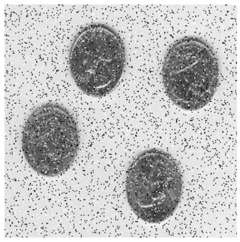


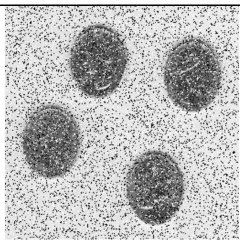
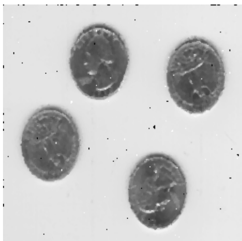
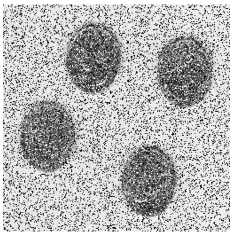
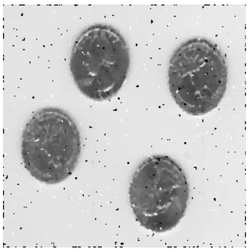
Fig. 8 MSE comparison for proposed and SMF method

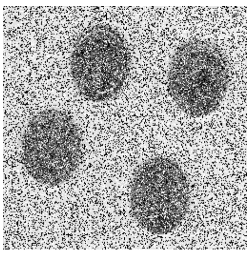
10. PROPOSED FILTER OUTPUT FOR VARIOUS NOISE DENSITIES.

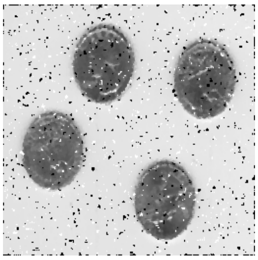
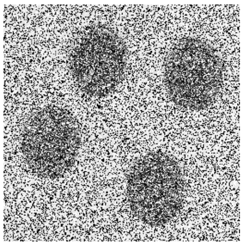
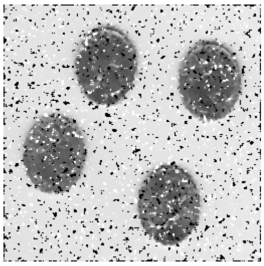
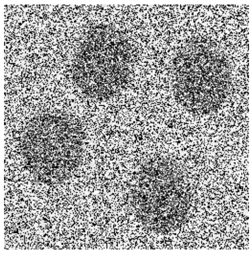
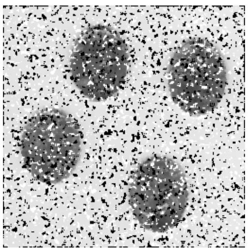
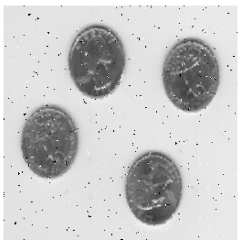
Coin image is impregnated with impulse noise percentages of 10 to 90. The visual results obtained using the two algorithms are summarized in the Table 5. From these tables we can observe that the performance of proposed method for removing impulse noise is better than the Standard method .

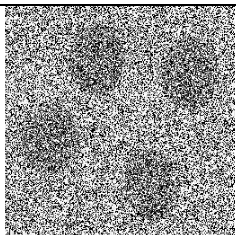
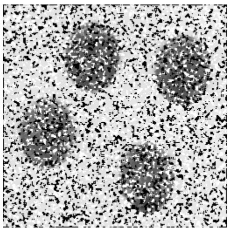
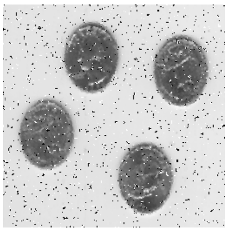
Table 5 Visual Result of all the three method with different noise densities

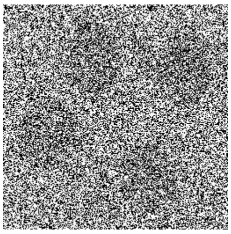
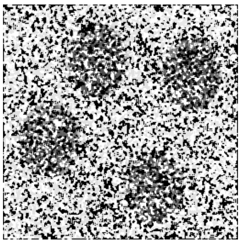
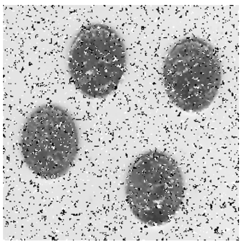
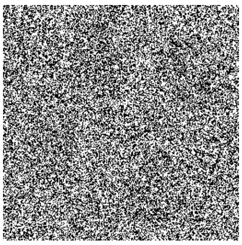
Original image 	Original image, Noise=10% 
Result of SMF Method 	Result of Proposed Method 
Original image	Original image, Noise=20%

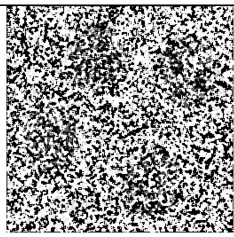
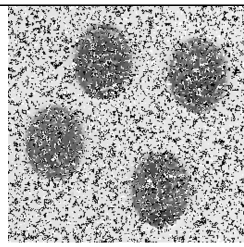
	
Result of SMF Method 	Result of Proposed Method 
Original image 	Original image, Noise=30% 
Result of SMF Method 	Result of Proposed Method 

Original image 	Original image, Noise=40% 

Result of SMF Method 	Result of Proposed Method 
Original image 	Original image, Noise=50% 
Result of PSMF Method 	Result of Proposed Method 
Original image 	Original image, Noise=60% 
Result of SMF Method 	Result of Proposed Method 
Original image	Original image Noise=70%

	
Result of SMF Method 	Result of Proposed Method 

Original image 	Original image, Noise=80% 
Result of SMF Method 	Result of Proposed Method 
Original image, Noise=90% 	Original image, Noise=90% 
Result of SMF Method	Result of Proposed Method

11. CONCLUSION

From the result obtained by applying proposed fuzzy based method and standard median filter method to the image impregnated by different noise density, it can be concluded that the performance of proposed fuzzy method in removing the impulse noise is much better than the performance of standard median filter method. It is also evident from the result that the proposed median filter is capable of suppressing the noise even for the image corrupted with high density noise.

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