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A New Spatial Domain Filter for Impulse Noise Removal with Improved Accuracy Based on Multiple Conditions

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Abstract**: *Numerous filtering methods are proposed for Impulse noise removal, it is an important task in the field of image restoration. The familiar spatial domain algorithm to remove impulse noise is Standard Median Filter (SMF). Most of the existing algorithms are based on median filtering and recent algorithms are Modified Hybrid Median Filter (MHMF) and New Modified Hybrid Median Filter (NMHMF). These two are worked up to 20% noise density. In this paper proposed a new` algorithm for impulse noise removal above 20% noise density conditions with different samples of images. The implementation of proposed method compares with known existing methods by comparing Mean Square Error (MSE) and Peak Signal to Noise Ratio (PSNR).***

Keywords: Impulse noise, SMF, MHMF, NMHMF, MSE, PSNR.

I. INTRODUCTION

Digital image is having MxN pixel values ranging from 0 to 255 in 8-bit gray scale image. Generally, Noise happened in digital images during transmission and reception the images through the noisy channel. Impulse noise is particular kind of noise and frequently existing in digital images which happens due to the image acquisition, sudden disturbances, processing and A/D conversion. Essentially, impulse noise can be classified into two types called as Fixed-Valued Impulse Noise (FVIN) and Random-Valued Impulse noise (RVIN) [5]. The FVIN has two corrupted pixel values minimum (0) or maximum value (255) and another word for FVIN is salt and pepper noise.

$$FVIN = \begin{cases} 0; with\ probability\ P \\ 255; with\ probability\ 1-P \end{cases}$$

The RVIN is uniformly distributed in the range of 0 to 255 and it is closes to adjacent pixels.

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II. LITERATURE REVIEW

Impulse noise removal is difficult task in digital images and eliminates this type of noise by different existing filtering techniques those are classified into Linear filtering techniques and Non-Linear filtering techniques. Linear Filtering technique is simple to design but the disadvantage is loss of image details [4].

A. Standard Median Filter (SMF)

In Median filter [1-3], it is a one kind of Non-Linear filtering technique and it arranges all the pixel values are in increasing or decreasing order and then find the median value. The target pixel value is replaced with median value. Flow of SMF is represented in Fig. 1.

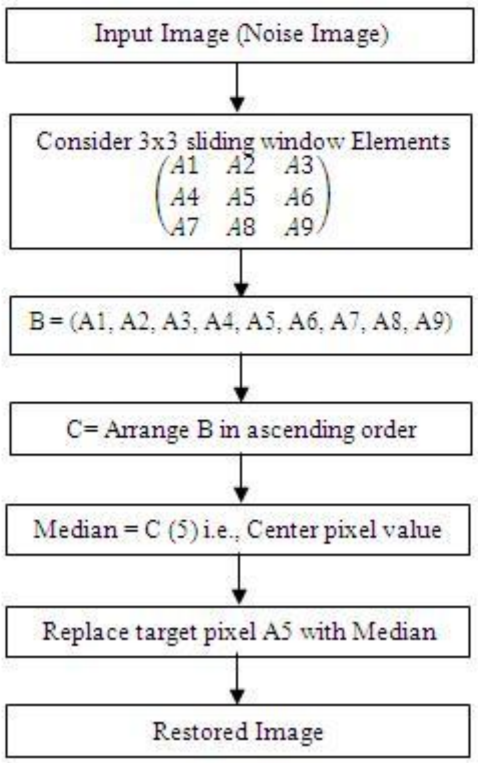

Fig. 1: Flow of SMF Algorithm

The failing of median filter is losses the lines and edges of the image [1-3]. To rectify the median filter disadvantage, introduce different filters based on median filter but theses filters are takes a computation period is high.

B. Hybrid Median Filter (HMF)

In this method [1], restores the image from the known input image pixel values by finding median between target pixel A5 and median of each diagonal in 3x3 sliding window represented with K1 and K2.

Steps involved in HMF as shown in Fig. 2. This method is applied on input RVIN image within the range 0-20%.

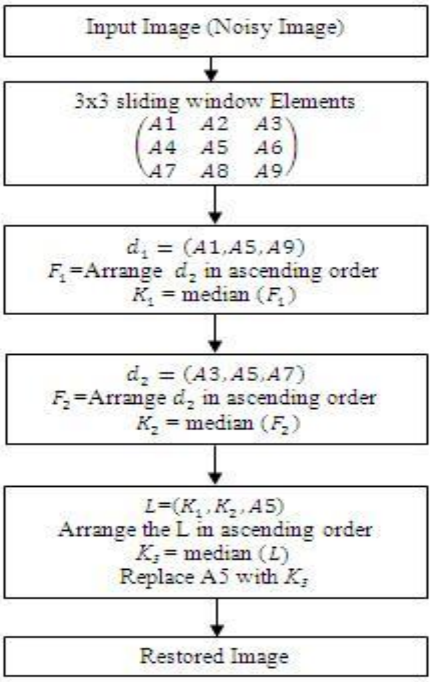

Fig. 2: Flow of HMF Algorithm

C. Modified Hybrid Median Filter (MHMF)

In this method [1] find the median value K1 from 3x3 sliding window values. Diagonal medians K2 and K3 are determined same as HMF. Finally, replace target pixel with median value between K1, K2 and K3. Steps involved in MHMF as shown in Fig 3. The shortcoming of MHMF is performed well on Random-Valued Impulse Noise only.

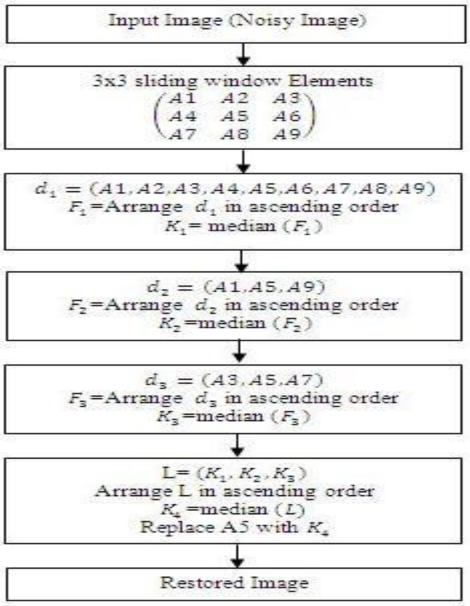

Fig. 3: Flow of MHMF Algorithm

D. New-Modified Hybrid Median Filter (NMHMF)

In this method [3], proposed a new model of RVIN adding to image is defined as follows

$$I_1 = A * \left(p * rand\left(size(I)\right)\right)/(1+p)$$
$$A = 100$$
$$A\ is\ Multiplication\ factor\ to\ improvise\ noise\ values$$
$$p = Noisevariancevariesfrom\ 0\ to\ 1$$
$$I = Originalimage$$
$$I_1 = Noisemodel$$

Noise image = Original image (I) + Noise Model (I1)

This method [3] uses 3x3, 5x5 and 7x7 sliding window mechanisms individually to restore the image from input noise image. The steps involved in this method explained with 3x3 sliding window. It finds total five median elements from which one of the median elements is K1from 3x3 sliding window values, two are K2 and K3 from diagonal pixel values, other two median elements are K4, K5 from horizontal pixel values and vertical pixel values. Finally, target pixel A5 replace with median value between five median elements explained. The flow of NMHMF is shown in Fig. 4. It is applied on image affected with RVIN and FVIN up to the range 0-20%.

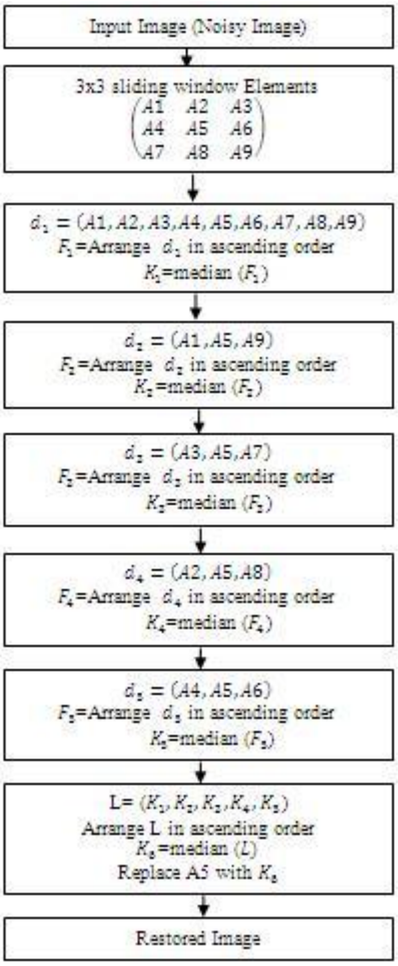

Fig. 4: Flow of NMHMF Algorithm

III. PROPOSED METHOD

To improve accuracy of digital image restoration, in this paper proposed a new spatial domain filter with multiple conditions verification.

In HMF, MHMF and NMHMF target pixel replace with median value of its particular sliding window. Proposed method identifies a draw back in those existing methods that is, if the median value is noise i.e. 0 or 255. So, the main task in the proposed method is to verify medians in NMHMF are noise values or not.

ALGORITHM:

Step1: Initially, consider a 3x3 sliding window and find the median K1 from the pixel values in the window and check the condition K1= 0 or 255.

Step2: If K1condition satisfies then find K2, i.e., median value from first diagonal of window and check the condition K2= 0 or 255.

If condition K1 is not satisfied replace target pixel A5 with K1.

Step3: If K2 condition satisfies then find K3, i.e., median value from second diagonal of window and check the condition K3= 0 or 255.

If condition K2 is not satisfied replace target pixel A5 with K2.

Step4: If K3 condition satisfies then find K4, i.e., median value from horizontal values of window and check the condition K5= 0 or 255.

If condition K4 is not satisfied replace target pixel A5 with K4.

Step5: If K5 condition satisfies then, check K5 = 0, if it's satisfied replace target pixel A5 with value '1'. Otherwise replace target pixel A5 with value '254'.

If condition K5 is not satisfied replace target pixel A5 with K5.

Fig 5 represents the flow of proposed filter and it tests on image degraded with RVIN & FVIN up to the noise density range 0-70%.

IV. SIMULATION REULTS

MHMF, NMHMF and proposed method are implemented in MATLAB and verify those three methods on gray scale house and boat images of its sizes are 256x256 and 512x512. In this paper, image restoration is performed with MHMF [1], NMHMF [3] and proposed method up to 70% noise density under RVIN and FVIN circumstances. The accuracy of restored images of these methods compared in terms of Mean Square Error (MSE) and Peak Signal to Noise Ratio (PSNR).

Mathematical representation of Peak Signal to Noise Ratio is represented by the Equation (1):

$$PSNR(dB) = 10log_{10}\left(\frac{max_i{}^2}{MSE}\right) \quad (1)$$

Where

$$max_i = maximum\ value\ of gray\ scale\ image$$
$$MSE = MeanSquareError$$

and Mean Square Error is

$$MSE = \frac{1}{MN}\sum_{i=0}^{M-1}\sum_{j=0}^{N-1}\|x(i,j) - y(i,j)\|^2 \quad (2)$$

Where

$$x(i,j) = original\ image$$
$$y(i,j) = Restored\ image$$
$$M = Numberof\ rows\ in\ the\ image$$
$$N = Number\ of\ columns\ in\ the\ image$$

Equation (2) gives the mathematical representation of the Mean Square Error (MSE) which is used for the measurement of PSNR. The flow of the proposed algorithm is shown in the following Fig. 5.

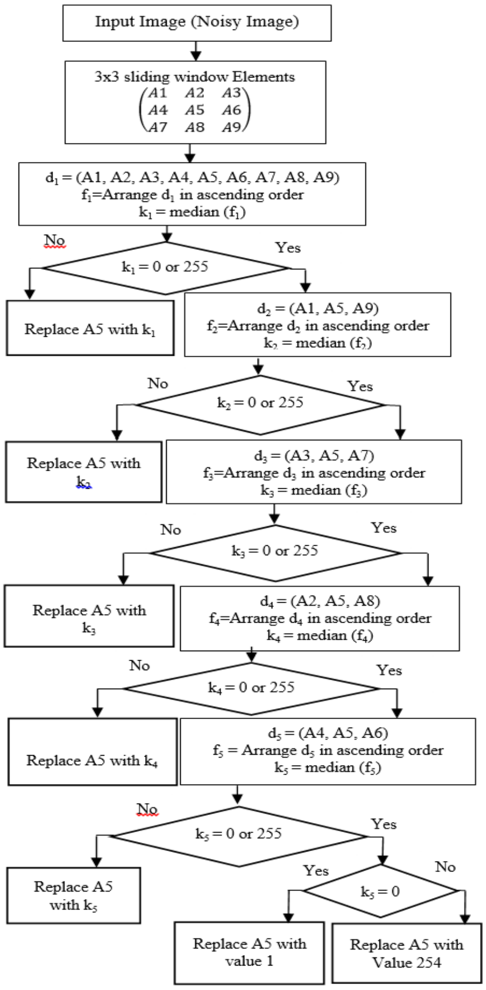

Fig. 5: Flow of Proposed Algorithm

Table-1: MSE and PSNR (dB) Values of House Image for FVIN

Noise Density (%)	MHMF		NMHMF		PROPOSED FILTER	
	MSE	***PSNR***	***MSE***	***PSNR***	***MSE***	***PSNR***
10	82.91	28.94	56.60	30.60	36.57	32.49
20	259.96	23.98	179.80	25.50	64.87	30.01
30	696.76	19.70	567.55	20.59	129.00	27.02
40	1516.1	16.32	1357.0	16.80	269.62	23.82
50	2911.1	13.49	2698.9	13.81	625.39	20.16
60	4868.9	11.25	4710.6	11.40	1263.3	17.11
70	7542.1	9.35	7459.0	9.40	2600.7	13.97

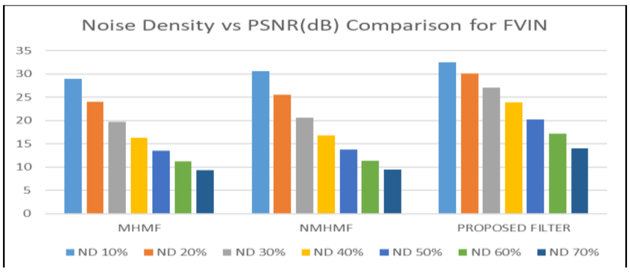

Fig 5.a Comparison of House Image for FVIN

Table 2: MSE and PSNR (dB) Values of Boat Image for FVIN

Noise Density (%)	MHMF		NMHMF		PROPOSED FILTER	
	MSE	***PSNR***	***MSE***	***PSNR***	***MSE***	***PSNR***
10	94.97	28.35	71.90	29.50	67.28	29.85
20	265.53	23.88	205.10	25.00	98.59	28.19
30	675.09	19.71	545.13	20.72	159.78	26.16
40	1503.3	16.36	1333.8	16.87	301.23	23.34
50	2880.7	13.53	2713.7	13.79	615.47	20.23
60	4829.9	11.29	4679.6	11.42	1302.2	16.98
70	7587.3	9.32	7517.3	9.37	2706.5	13.81

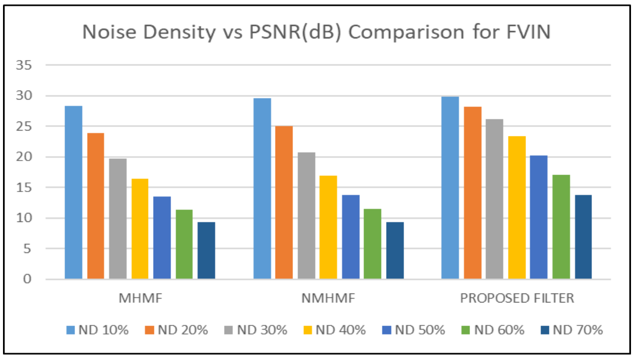

Fig 5.b Comparison of Boat Image for FVIN

Fig 6: From left to right column 1: Noise density, column 2: FVIN boat image, column 3: MHMF Image, column 4: NMHMF Image and column 5: Proposed Filtered Image

Table 1 and 2 represent qualitative results (MSE and PSNR) of gray-scale house and boat images affected with FVIN. Fig 5.a and Fig 5.b shows the bar chart of PSNR (dB) values of restored image by MHMF, NMHMF and Proposed algorithm when image affected with FVIN from 10% to 70% Noise Density (ND). From this, the acceptable PSNR value (i.e. 20dB) of restored image attained by MHMF upto 20% Noise Density, NMHMF with 3x3 sliding window upto 30% Noise Density and proposed algorithm upto 50% Noise Density.

Fig 6 shows restored gray-scale boat image affected with 10, 30, 50 and 70% of fixed-valued impulse noise.

Table 3 and 4 represent qualitative results (MSE and PSNR) of gray-scale boat and house images affected with RVIN.

Table 3: MSE and PSNR (dB) Values of Boat Image for RVIN

Noise Density (%)	MHMF		NMHMF		PROPOSED FILTER	
	MSE	***PSNR***	***MSE***	***PSNR***	***MSE***	***PSNR***
10	80.25	29.12	63.60	30.00	70.75	29.63
20	259.13	24.03	111.30	27.60	107.96	27.79
30	304.80	23.29	168.53	25.86	154.29	26.24
40	445.57	21.64	230.93	24.49	205.71	24.99
50	594.67	20.38	295.03	23.43	256.28	24.04
60	734.23	19.47	355.26	22.61	306.20	23.27
70	876.72	18.70	416.57	21.93	355.30	22.61

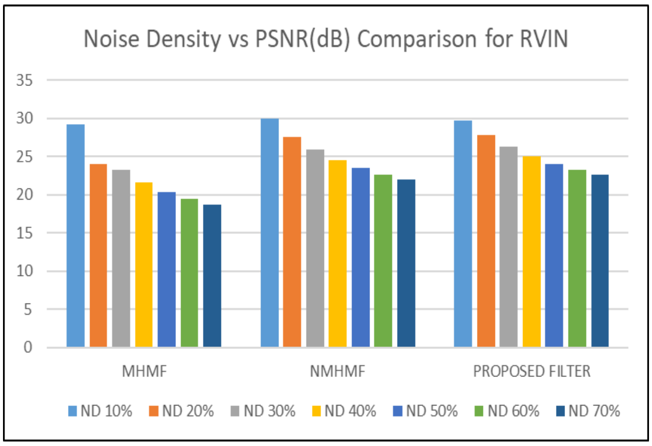

Fig 6.a Comparison of Boat Image for RVIN

Table 4: MSE and PSNR (dB) Values of House Image for RVIN

Noise Density (%)	MHMF		NMHMF		PROPOSED FILTER	
	MSE	***PSNR***	***MSE***	***PSNR***	***MSE***	***PSNR***
10	51.08	31.08	41.10	31.90	42.43	31.85
20	122.69	27.28	89.50	28.60	81.12	29.03
30	161.18	26.05	147.24	26.45	127.33	27.08
40	230.53	24.50	212.77	24.85	179.90	25.58
50	297.34	23.39	276.30	23.71	231.75	24.48
60	369.05	22.45	345.0	22.75	285.64	23.57
70	431.12	21.78	405.68	22.04	335.63	22.87

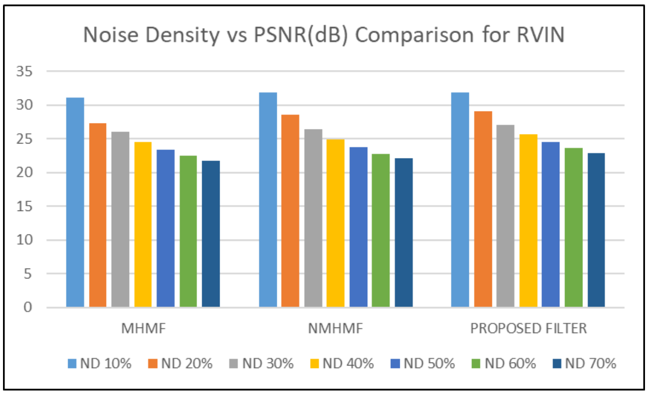

Fig 6.b Comparison of House Image for RVIN

Fig 6.a and Fig 6.b shows the bar chart of PSNR (dB) values of restored image by MHMF, NMHMF and Proposed algorithm when image affected with RVIN from 10% to 70% Noise Density (ND). From this, MHMF, NMHMF and proposed algorithm attained acceptable PSNR (20dB) value of restored image but the proposed algorithm gives better PSNR when compared with MHMF and NMHMF with 3x3 sliding window.

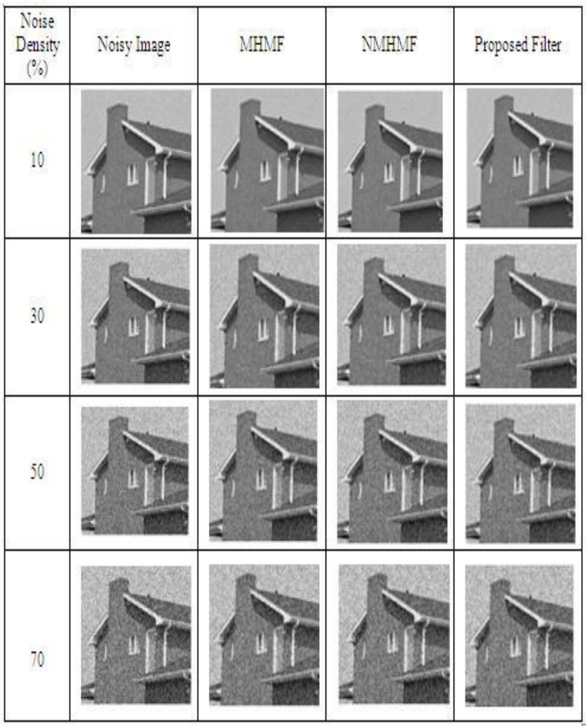

Fig. 7: From left to right column 1: Noise density, column 2: RVIN house image, column 3: MHMF Image, column 4: NMHMF Image and column 5: Proposed Filtered Image

Fig 7 shows restored gray-scale house image affected with 10, 30, 50 and 70% of random-valued impulse noise.

V. CONCLUSION

In this paper, presented a new spatial domain filtering method with multiple conditions hence it has capability of detecting noise pixels accurately and increase the quality of restored image. This method is suitable for restoring the image which is degraded by both Random and Fixed valued impulse Noise. The proposed method attained acceptable and better PSNR at higher noise density conditions compared with well-known previous methods MHMF and NMHMF with 3x3 sliding window; so, this proposed method is suited for restoring satellite images which are affected by high density Random valued impulse noise and Fixed valued impulse noise.

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