A MEDIAN BASED DIRECTIONAL CASCADED WITH MASK FILTER FOR REMOVAL OF RVIN

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ABSTRACT

In this paper A Median Based Directional Cascaded with Mask (MBDCM) filter has been proposed, which is based on three different sized cascaded filtering windows. The differences between the current pixel and its neighbors aligned with four main directions are considered for impulse detection. A direction index is used for each edge aligned with a given direction. Minimum of these four direction indexes is used for impulse detection under each masking window. Depending on the minimum direction indexes among these three windows new value to substitute the noisy pixel is calculated. Extensive simulations showed that the MBDCM filter provides good performances of suppressing impulses from both gray level and colored benchmarked images corrupted with low noise level as well as for highly dense impulses. MBDCM filter gives better results than MDWCMM filter in suppressing impulses from highly corrupted digital images.

KEYWORDS

A Modified Directional Weighted Cascaded-Mask Median filter (MDWCMMF), Median Based Directional Cascaded-Mask filter (MBDCMF), PSNR, SNR, Median, gray & color image.

1. INTRODUCTION

Impulse noise is often introduced into images during image acquisition and transmission [13,14]. Depending upon the noise values, it can be classified as the easier-to-restore salt-and-pepper noise and the more difficult random-valued impulse noise [10]. Among all kinds of methods for impulse noise, the median filter [11, 12] is used widely because of its high computational efficiency and effective noise suppression capability [8]. However, it uniformly replaces the gray-level value of every pixel by the median of its neighboring pixels. Consequently, some desirable details are also removed, especially when the window size is large. In order to improve the median filter, many filters with an impulse detector have been proposed. In this paper a modified filter is used for removal of random-valued impulse noise which performs well in restoration of high valued random impulse noise from both the gray and color images.

In an image, distinct gray levels are to be like their neighbors. So if a pixel value got corrupted, then considering its neighboring gray values we can restore the actual value. This filter (MBDCMF) replaces the value of a pixel by the median of gray levels of neighborhood pixels of that pixel with a certain weight (1 or 2) and the pixels in the minimum weighted direction considering all the cascaded windows.

DOI : 10.5121/ijist.2012.2412

The minimum weighted direction is one of the four directions (as shown in Figure.1) in which the sum of absolute differences of gray level values between the pivot(central) pixel value and its neighboring pixel values is minimum.

RGB color space is used as the basic color space for the color images. In RGB model colors are represented as a 3-D vector, with red as first element, green as second and blue as third element. The organization of this paper is as follows. The new impulse detector is formulated in section 2. Section 3 described the filtering framework.Section 4 provides a number of experimental results to demonstrate the performance of the proposed MBDCM filter. Conclusions are drawn in section 5.

2. IMPULSE DETECTOR

A noise-free image consists of locally smoothly varying areas separated by edges. Here, we only focused on the edges aligned with four main directions as shown in Figure 1.

Let $S_k^{(7)}$(k=1 to 4) denote a set of coordinates aligned with the kth direction centered at (0,0), taking (7×7) window, i.e.,

S_1={(-3,-3),(-2,-2), (-1,-1), (0,0), (1,1), (2,2),(3,3)}
S_2={(0,-3),(0,-2), (0,-1), (0,0), (0,1), (0,2),(0,3)}
S_3={(3,-3),(2,-2),(1,-1),(0,0), (-1,1), (-2,2),(-3,3)}
S_4={(-3,0),(-2,0), (-1,0), (0,0), (1,0), (2,0),(3,0)} (1)

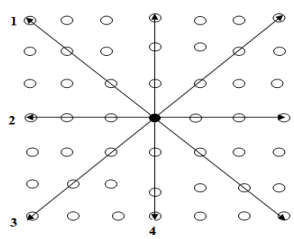


Figure 1: Alignment of edges in four directions in (7×7) window

Let $S_k^{(5)}$ (k=1 to 4) denote a set of coordinates aligned with the kth direction centered at (0,0), taking (5×5) window, i.e.,

S_1={(-2,-2), (-1,-1), (0,0), (1,1), (2,2)}
S_2={(0,-2), (0,-1), (0,0), (0,1), (0,2)}
S_3={(2,-2),(1,-1),(0,0), (-1,1), (-2,2)}
S_4={(-2,0), (-1,0), (0,0), (1,0), (2,0)} (2)

Let $S_k^{(3)}$ (k=1 to 4) denote a set of coordinates aligned with the kth direction centered at (0,0), taking (3×3) window, i.e.,

S_1={(-1,-1), (0,0), (1,1)}
S_2={(0,-1), (0,0), (0,1)}
S_3={(1,-1),(0,0), (-1,1)}
S_4={(-1,0), (0,0), (1,0)} (3)

Now in a 7×7 window centered at (i, j), for each direction, define $d_{i,j}^{(p)(k)}$ as the sum of all weighted absolute differences of gray-level values between $y_{i+s,\, j+t}$ and $y_{i,\, j}$ with (s,t) ϵ $S_k^{(p)}$ for all k from 1 to 4, p={7,5,3}. Considering that for two pixels whose spatial distance is small, their grey-level values should be close to each other, we will weight the absolute differences between the two closest pixels with a larger value $w_{s,t}$ is very large, it will cause that $d_{i,j}^{(p)(k)}$ is mainly decided by the differences corresponding to $w_{s,t}$. Thus we have eq.4,

$$d_{i,\, j}^{(p)(k)} = \sum_{(s,\, t)} w_{s,t} * | y_{i+s,\, j+t} - y_{i,\, j} |, \quad 1 \le k \le 4, (s,t) \in S_k^{(p)} \tag{4}$$

Where

$$w_{s,t} = \begin{cases} 2, & (s,t) \in \Omega^3 \\ 1, & \text{otherwise} \end{cases}$$

$\Omega^3 = \{(s, t) : -1 \le s, t \le 1\}$,
P={3,5,7}.

Here, $d_{i,\, j}^{(p)(k)}$ are the direction indexes. Each direction index is sensitive to the edge aligned with a given direction. Then, the minimum of these four direction indexes is used for impulse detection, which can be denoted as in eq. 5.

$$r_{i,j}^{(p)} = \min \{ d_{i,\, j}^{(p)(k)} : 1 \le k \le 4, p=\{3,5,7\}\}, \tag{5}$$

We can find that by employing a threshold T_p, (p={3,5,7}), we can identify the impulse in each window from the noise-free pixels, no matter which are in a flat region, edge or thin line. Then, the pixel $y_{i,\, j}$ will be noisy if at least one of the following conditions holds

- $r_{i,j}^{(7)} > T_7$
- $r_{i,j}^{(5)} > T_5$
- $r_{i,j}^{(3)} > T_3$
-

The pixel $y_{i,\, j}$ will be noise free otherwise.

3. FILTER

After impulse detection, we replace the noisy pixels by the calculated median values of the window depending upon the four directions. For this first calculated the standard deviation $\sigma_{i,j}^{(p)(k)}$ of grey-level values for all $y_{i+s,j+t}$ with (s,t) ϵ $S_k^{(p)}$ (k= 1 to 4), {p=7,5,3}, respectively. Let take eq.6 as under

$$L_{i,j}^{(p)} = \min \{ \sigma_{i,j}^{(p)(k)} : k= 1 \text{ to } 4, p=\{3,5,7\} \} \tag{6}$$

Since the standard deviation describes how tightly all the values are clustered around the mean in the set of pixels, $L_{i,j}^{(p)}$ shows the pixels aligned with this direction are the closest to each other. Therefore the center value should also be close to them in order to keep the edges intact.
Three median values are calculated using the eq.7 as below

$m_{i,j}^{(7)} = \text{median} \{ w * y_{i+s,\, j+t} , y_{i+p1,\, j+q} : (s,t) ,(p1,q) \in S_k^{(7)}\}$
$m_{i,j}^{(5)} = \text{median} \{ w * y_{i+s,\, j+t} , y_{i+p1,\, j+q} : (s,t) ,(p1,q) \in S_k^{(5)}\}$
$m_{i,j}^{(3)} = \text{median} \{ w * y_{i+s,\, j+t} , y_{i+p1,\, j+q} : (s,t) ,(p1,q) \in S_k^{(3)}\}$

where

$$w = \begin{cases} 2, & \text{if } -1 \le (s,t) \le 1 \\ 1, & \text{otherwise} \end{cases}$$

(s, t) pixels are on the minimum direction
And

$$-1 \le (p1,q) \le 1 \text{ ; where } (p1, q) \ne (s,t). \tag{7}$$

Now, we can give the output of the proposed filter as in eq.8.

$$u_{i,j} = \begin{cases} \text{Min}(u2, u3), & \text{if } L_{i,j}^{(3)} = L_{i,j}^{(5)} \\ u1, & \text{otherwise} \end{cases} \tag{8}$$

$$u1 = \alpha_{i,j} * y_{i,j} + (1 - \alpha_{i,j}) * m_{i,j}^{(7)}$$

where,

$$\alpha_{i,j} = \begin{cases} 0, & \text{if } r_{i,j}^{(7)} > T_7 \\ 1, & \text{if } r_{i,j}^{(7)} \le T_7 \end{cases}$$

$$u2 = \alpha_{i,j} * y_{i,j} + (1 - \alpha_{i,j}) * m_{i,j}^{(5)}$$

where,

$$\alpha_{i,j} = \begin{cases} 0, & \text{if } r_{i,j}^{(5)} > T_5 \\ 1, & \text{if } r_{i,j}^{(5)} \le T_5 \end{cases}$$

$$u3 = \alpha_{i,j} * y_{i,j} + (1 - \alpha_{i,j}) * m_{i,j}^{(3)}$$

where,

$$\alpha_{i,j} = \begin{cases} 0, & \text{if } r_{i,j}^{(3)} > T_3 \\ 1, & \text{if } r_{i,j}^{(3)} \le T_3 \end{cases}$$

Then substitute

$$y_{i,j} = u_{i,j}$$

$$T = \begin{cases} T_3, & \text{for } (3 \times 3) \text{ window} \\ T_5, & \text{for } (5 \times 5) \text{ window} \\ T_7, & \text{for } (7 \times 7) \text{ window} \end{cases}$$

So, for ensuring high accuracy of the detection, we applied our method recursively and iteratively with decreasing threshold (T=T*0.8), starting with the value T=510, and iterated until T ≥ arithmetic mean of all the pixel values on the minimum direction of the corresponding window.

4. RESULTS

Different gray and color (RGB) benchmark images have been taken for the experimental purpose. Noises have been injected randomly into the original images to produce noisy images. The enhancement filter restores images from these noisy images. Figure 2.a and 2.b are original benchmarked Elaine and Lenna gray images. Figure 2.c and 2.d are original benchmarks, Lenna and Baboon color images. Figure 2.e, Figure 2.g are the noisy images, with 40% and 60% noise density, of gray Lenna where PSNR is 13.93dB and 12.57dB respectively that of Figure 2.f and Figure 2.h are the filtered image using MBDCMF where the PSNR is 24.49 dB and 22.07 dB respectively. Figure 2.i shows 40% corrupted gray Elaine benchmark image whose PSNR value is 14.13 dB and after applying MBDCMF on it, the PSNR obtained is 26.15 dB (Figure 2.j). Figure 2.k shows 30% noise integrated image of color Lenna where PSNR is 14.49. Applying MBDCMF on it PSNR increases to 25.97 dB (Figure. 2.l). Figure 2.m shows 60% noisy color Lenna image, whose PSNR is 12.09 dB. Figure 2.n is obtained from Figure 2.m after applying MBDCMF and its PSNR is 22.57 dB. Figure 2.o shows 60% corrupted Baboon (RGB) benchmark image whose PSNR value is 12.27 dB but when MBDCM filter has been applied on it, the PSNR obtained is 18.32(Figure 2.p) from where we may infer that MBDCM filter may obtain good results in random and high noise removal from gray and color images.

Table 1 shows the comparative PSNR using various filters PWMAD[4], ACWM filter[2,3], AMF[8], MDWCMMF[1] including proposed MBDCM filter applied on Lenna gray image corrupted by various percentages of noise density.

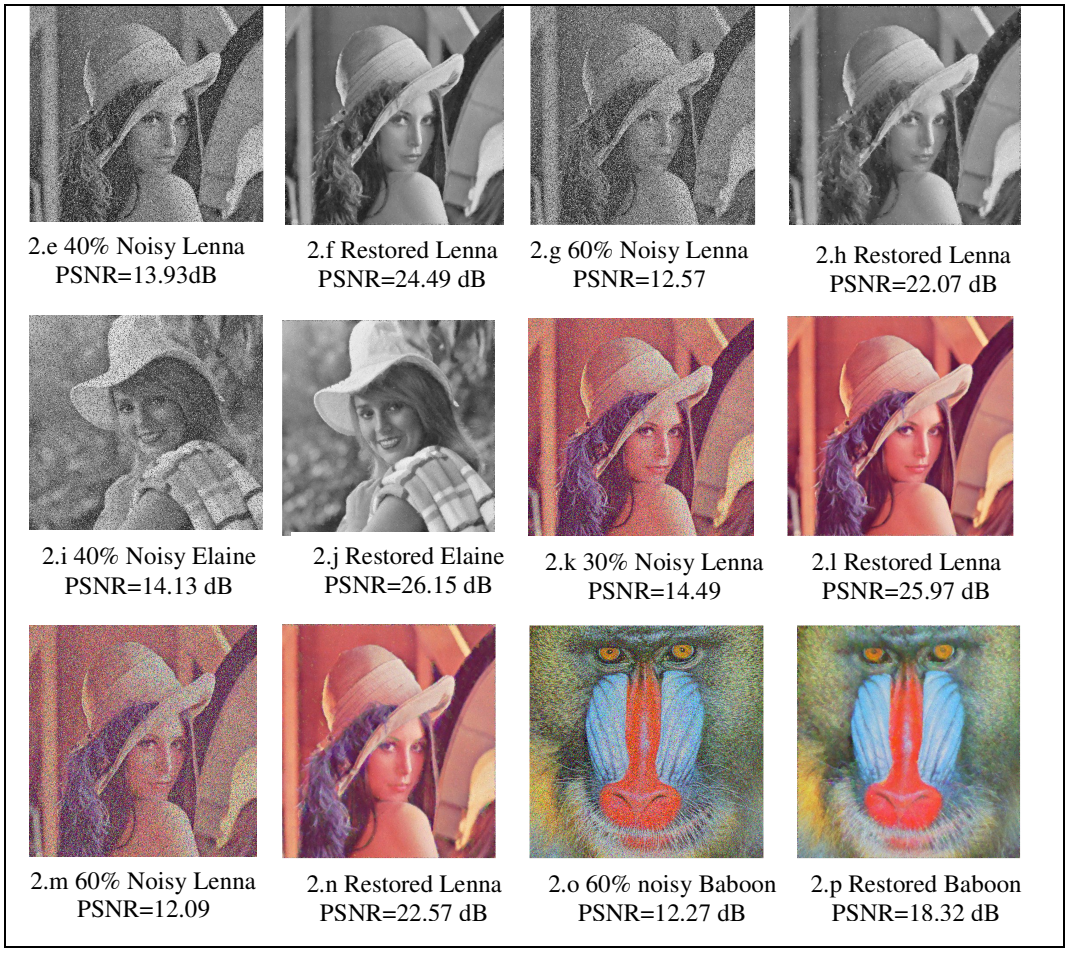
Table 2 shows the comparative PSNR using various filters AVMF[27], IIA[17], MFF[18], ATMED[22], GMED[22], TMAV[22], FSB[26], IFCF[24], MIFCF[24], EIFC[24], SSFCF[24], FIRE[18], PWLFIRE[19], DSFIRE[16], FMF[22], HAF[25], AWFM[23], MDWCMMF[1] including proposed MBDCM filter applied on color Lenna image corrupted by various percentages of noise density.

Table 3 shows the effect of applying MBDCM filter of various images corrupted by 40% noise. From the table it is also clear that the MBDCM filter works better for high value of random impulse noise.

Figure 3. shows the comparative performance of the proposed MBDCM filter applied on gray Lenna corrupted with different levels of impulses among some other existing filters.

Figure 4. shows the comparative performance of the proposed filter applied on Elaine and Goldhill images corrupted with 40% random impulses among some other existing filters.

2.a Original Elaine 2.b Original Lenna 2.c Original Lenna 2.d Original Baboon



Figue 2: Visual effect of results using MBDCMF on gray and colour images.

Table 1. Comparative results in PSNR of different algorithms applied to "Lenna" gray image corrupted by various rayes of Random-valued impulse noise

Filters	**PSNR of restored image in dB**					
	10% Noise	**20% Noise**	**30% Noise**	**40% Noise**	**50% Noise**	**60% Noise**
PWMAD	34.86	30.58	25.94	22.41	19.42	17.08
ACWM filter	-	36.07	32.59	28.79	25.19	21.19
AMF	28.06	26.79	24.03	23.17	21.99	-
MDWCMMF	31.14	28.16	26.08	24.45	22.96	21.46
Proposed	27.02	27.20	25.77	24.49	23.28	22.07

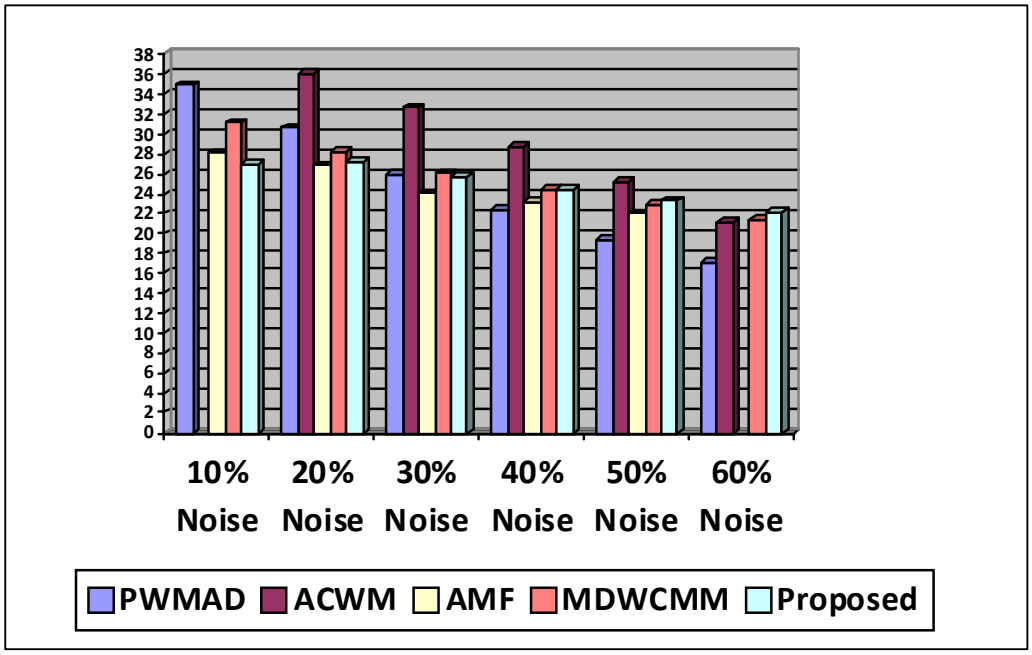


Figure 3:Comparison among various filters applied on gray Lenna corrupted with different levels of impulses

Table 2. Comparative results in PSNR of different algorithms applied to "Lenna" COLOR image corrupted by various rayes of Random-valued impulse noise

Filters	**PSNR of restored image in dB**						
	3%	**5%**	**10%**	**15%**	**20%**	**25%**	**30%**
AVMF	37.3	36.2	33.9	32.1	30.3	27.8	25.6
IIA	34.3	33.5	30.6	27.3	24.9	23.5	22.0
MFF	28.8	28.5	27.8	27.0	26.1	25.0	23.8
ATMED	30.3	29.9	28.8	27.8	26.6	25.3	24.1
GMED	31.2	31.0	30.1	29.3	28.2	26.7	25.3
TMAV	31.0	30.7	29.8	28.7	27.4	25.9	24.5
FSB	30.7	30.6	29.8	29.1	28.1	26.6	25.3
IFCF	30.7	30.4	29.4	28.7	27.8	26.6	25.6
MIFCF	30.9	30.6	29.4	28.5	27.4	26.1	25.0
EIFCF	30.5	30.3	29.4	28.7	27.8	26.6	25.6
SSFCF	30.3	30.1	29.3	28.4	27.1	25.6	24.2

FIRE	34.3	32.6	29.7	27.6	25.7	23.9	22.4
PWLFIRE	31.1	28.8	25.5	23.4	21.7	20.4	19.1
DSFIRE	30.5	28.6	25.8	24.1	22.7	21.6	20.6
FMF	36.4	24.8	31.9	30.2	28.5	26.4	24.9
HAF	29.6	29.2	27.8	26.6	25.2	24.0	22.7
AWFM	31.3	30.8	29.3	28.0	26.2	24.7	23.1
MDWCMMF	34.98	33.38	30.70	28.98	27.66	26.56	25.62
Proposed	31.60	30.91	29.50	28.46	27.52	26.73	25.97

Table 3. Comparative results in PSNR of different algorithms applied to various kinds of gray images corrupted with 40% of random-valued impulse noise

Filters	**PSNR of restored image in dB**			
	Elaine	**Goldhill**	**Pepper**	**Airplane**
PWMAD	24.66	24.16	24.63	24.37
Trilateral	19.38	19.14	19.53	19.54
TSM	20.26	20.02	20.14	19.37
MDWCMMF	24.86	24.88	23.96	23.20
Proposed	26.15	25.23	24.40	23.33

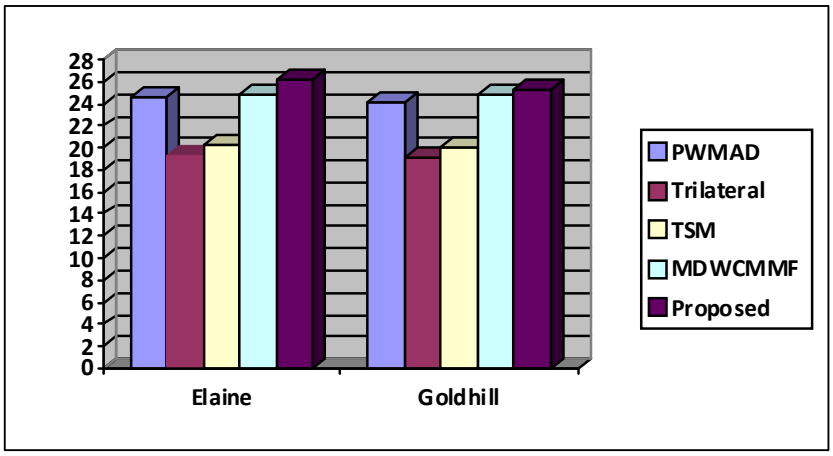


Figure 4. Comparison among various filters applied on various images corrupted with 40% noise

5. CONCLUSIONS

In this paper, we proposed a median based directional cascaded with mask filter, for removal of random-valued impulse noise and compared the same with MDWCMMF[1]. It makes full use of the characteristics of impulses and edges to detect and restore noises. Simulation results showed that the filter performs better than various existing median-based filters in terms of subjective quality in restored images and in objective evaluations in terms of PSNR (dB) and gives better results than MDWCMM filter in suppressing impulses from highly corrupted digital images.

ACKNOWLEDGMENT

The authors expressed deep sense of gratitude to the IIPC Project of AICTE, Government of India and to the department of CSE, University of Kalyani where the computational work has been carried out.

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