Removal of Random Valued Impulse Noise using Modified Switching Median Filtering Technique

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***Abstract*—An effective nonlinear filtering technique is proposed for removal of random valued impulse noise. The Boundary Discriminative Noise Detection(BDND)is one of the effective switching median filtering technique for impulse noise removal. However , there are some drawbacks in BDND which degrades the performance. In this paper proposed a method called Adaptive BDND with modifications in BDND technique. Experimental results demonstrates the better performance of proposed method and shows better preservation of image details.**

Keywords*— *Impulse noise, Noise detection, Switching Median filter.

I. INTRODUCTION

In digital Image Processing, removal of noise is a highly demanded area of research. Impulsive noise is common in images which arise at the time of image acquisition and or transmission of images .The intensity of impulse noise is either low or high on pixel, this has a tendency to degrade the image quality and loss of details in an image. This noise will contaminate pixels in different intensity levels. Median filter is one of the best filter under non linear filtering technique for removal of impulse noise than any other filters as this preserves image details better than many other filters . These filtering techniques are applied on pixels to backup the original pixels values and bring down the noisy pixels in an image. Generally , median filters apply median operation to all pixels unconditionally without considering corrupted or uncorrupted.

As a result of operation on uncorrupted pixels in the image, the quality of the image gets degraded .For solving this problem the noise detection technique is introduced before filtering operation in median filtering and applying filtering operation only to corrupted pixels .With this idea many methods under median filtering has been introduced. Standard Median filter performs better only at low noise density and edge details are not preserved well [4]. Adaptive median filter also worked well only at low noise density by expanding window size and that leads to blurring and edge details of original image is also not preserved[5] .To overcome this Decision based filters are introduced but that also produced streaking effects due to continuous replacement of neighboring pixels[18]. Fuzzy techniques are introduced but computation complexity is more in fuzzy[26].Conventional median filtering also performs unconditionally on every pixels so the image quality gets degraded. Thersholding filters [22] bring down the misclassification of uncorrupted pixels with the help of efficient noise detection. To address the issue of non-adaptive to the given noise density and misclassification of pixels NASM (Noise Adaptive Switching Median filtering) technique was introduced, but it worked well with only 10% to 50% of density .So the powerful method of Boundary Discriminative Noise Detection is implemented for high noise density but there were also some drawbacks in filtering step that degraded the image quality[2].

The BDND algorithm proceeds like first identifying each pixel as “uncorrupted “or “corrupted”. The detection of the pixel with the help of flag ‘0’ indicating uncorrupted and ‘1’ indicating corrupted pixel in an image.To accomplish this objective the pixels around the considered centered pixel will be clustered to three groups as Low density pixels,Medium density pixels ,High density pixels with the help of boundary values b1 and b2,if the pixel belong to medium density cluster it is considered as uncorrupted pixel while other clusters represent highly corrupted or less corrupted.

Once the noise map is determined the BDND also impose a condition on window size .The uncorrupted pixels in the estimated current window should be greater than or equal half of total number of pixels in the window else the window is expanded one pixel in all directions. If the uncorrupted pixels are found to be less then the window is expanded until the condition is satisfied .Hence this window expansion leads to more blurring and image details are not preserved well. Hence some modifications are needed in BDND algorithm to reduce blurring and to preserve edges and image details.

The proposed Adaptive BDND have been introduced with some modifications in the so that better performance is achieved. The rest of the paper is organized as follows. The proposed algorithm method in section II. The performance evaluation for proposed method is made in section III . Finally the paper conclusion is made in section IV.

II. PROPOSED ALGORITHM

In this section we discuss about the proposed algorithm in which modifications are introduced in the BDND algorithm. Firstly, as the window expands the blurring is introduce so to reduce blurring effect the window expansion should be kept minimum .Secondly ,the Euclidean distance is calculated in the current window with that center pixel intensity value is replaced. Third, pixel being replaced as median should be correlated with its neighboring pixels .

The algorithm first proceeds with clustering of pixels according to the intensity level of pixels. The pixels are clustered as lower intensity ,higher intensity ,medium intensity .The pixels under medium intensity are considered as uncorrupted pixel while other pixels are corrupted as per intensity .These are clustered by determining boundary values b1 and b2.If the pixel values are of 0<Xij< b1 then they are lower intensity values,if the pixel values are of b1<Xij<b2 then they are middle clustered and uncorrupted ones while if the pixel values are of b2<Xij<255 , they are of high intensity noisy pixels.

Hence as the Boundary Discriminative consist of two iterations to be invoked conditionally .In summary the steps to be proceeded are :

STEP 1:Select a window of 21*21 which is centered around the current pixel.

STEP 2:Sort the pixels in the current window in ascending order and find the median value in the sorted order .

STEP 3:Calculate the intensity difference for adjacent pixels in the sorted ordered pixels.

STEP 4:For the pixel intensity between 0 to median value in the sorted order with in that range find the maximum intensity difference value and mark it as b1.

STEP 5:Same way calculate the other boundary with values from median to 255 and with maximum intensity difference mark b2.

STEP 6:Now the pixels are clustered according to their intensity level. The second condition is invoked with smaller size window if the pixel is not an uncorrupted pixels.

STEP7:In the invoked second condition the window size is reduced and steps 2 to 5 are repeated.

STEP 8:If then also the pixel does not fall under uncorrupted category then it is considered as corrupted pixel.

Hence the pixels are estimated according to their intensity and now filtering process is as follows as the BDND has important parameter of window size. The condition is if the window does not have uncorrupted pixels more than half the pixels in the window then the window is expanded outwards by one pixel in all directions. So this expansion leads to the blurring in an image and does not preserve the image details properly. So to avoid this situation a binary flag is done as indicating 0 for corrupted and 1 for uncorrupted pixels . If the noise presence is high in the window, the window expansion is stopped if uncorrupted pixel is greater than half of (1-noise density) with total amount of pixels[2].

The second process is i) if the center pixel is corrupted the value should be replaced by a new value by computing Euclidean distance within the current window between center pixel and uncorrupted pixel by the formula

$$D_t = \left|\sqrt{K_t^2 + L_t^2}\right| \, where\, t = 1,2,3 \dots\dots s \quad (1)$$

Where K_t^2 and L_t^2 are spatial coordinates of uncorrupted pixel.(K,L) are integers of range(-1<K<1 and -1<L<1).The center pixel coordinates will be zero for Kand L.

ii)The computed distance is converted to weight by formula

$$H_t = \frac{D_t}{\sum_{t=1}^{s} D_t} \quad (2)$$

iii)The center pixel is now replaced with value calculated from equation

$$b_t = \sum_{t=1}^{s} H_t P_t \quad (3)$$

Where P_t is intensity values of uncorrupted pixel in the current window.

The third condition is to check with pixel relationship as the replacing median pixel has to be considered with neighbourhood pixels in the window so that there should not be any large deviation of median and its neighbouring pixels.

The pixel relationship condition has to be checked with

$$d(k) = |s(k) - i| + |t(k) - j| \quad (4)$$

Where s(k) and t(k) are row and column indices of pixels and with d(k)

$$A_{ij} = y_{ij} + \frac{1}{D}\sum_{k=1}^{N_u} \frac{v_u(k) - y_{ij}}{d(k)} \quad (5)$$

Where A_{ij} is a adjustment term by having y_{ij} is relation between the pixel values to sum of uncorrupted value subtracted from y_{ij} to the factor that is inversely proportional to distance d(k).The adjustment term can be positive or negative that can be calculated with difference of values of intensity difference from uncorrupted pixel value $v_u(k)$. With this the pixel value is adjusted such that the median is not deviated from neighborhood pixels.

III.EXPERIMENTAL EVALUATION

In this section some evaluation results are shown by comparing with different techniques .The important parameter to be considered here is Peak to Signal Noise Ratio and Mean Squared Error.

PSNR:

PSNR is usually to measure the difference between the original image and output image such that if high value of

PSNR indicates low distortion in the output image. The formula to calculate PSNR and MSE is

$$PSNR = 10LOG_{10}\left(\frac{255^2}{\frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N} Z_{ij} - X_{ij}}\right) \quad (6)$$

$$MSE = \sum_{i=1}^{M} . \sum_{j=1}^{N} \frac{Z_{ij} - X_{ij}}{M * N} \quad (7)$$

Where M and N are number of row and columns .Hence the simulated outputare shown at Fig 1.

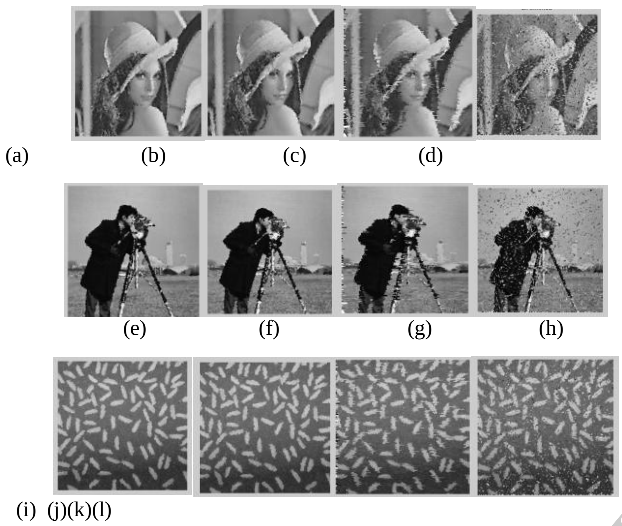

Fig 1. output image of 80% noise:(a)lena of proposed method (b)lena of BDND (c)lena of DBA (d)lena of Untrimmed(e) cameraman of proposed method (f) cameraman of BDND (g) cameraman of DBA (h) cameraman of Untrimmed (i) rice of proposed method (j) rice of BDND (k) rice of DBA (l) rice of Untrimmed.

Now mathematically evaluated and obtained PSNR value are shown in the table given belowas TABLE I,TABLE II,TABLE III

.TABLE I.PSNR OF LENA IMAGE WITH DIFFERENT FILTERING TECHNIQUES

% NOISE DENSITY	UNTRIMMED	DBA	BDND	PROPOSED METHOD
10	35.51	32.3	40.44	45.02
20	31.4	28.38	36.65	41.3
30	26.49	24.79	34.01	38.84
40	22.64	23.06	32.14	36.65
50	19.22	21.12	30.81	34.8
60	16.7	18.13	29.17	33.23
70	13.83	15.49	27.5	31.92
80	10.92	12.02	25.7	30.05
90	9.24	12.95	23.4	27.32

TABLE II.PSNR OFCAMERMAN IMAGE WITH DIFFERENT FILTERING TECHNIQUES

%NOISE DENSITY	UNTRIMMED	DBA	BDND	PROPOSED METHOD
10	30.89	0.69	35.18	36.01
20	27.12	1.52	31.8	33.68
30	24.78	2.44	29.38	30.9
40	20.92	3.49	27.92	29.56
50	17.88	4.74	26.13	27.1
60	14.88	6.32	24.9	26.7
70	12.48	8.08	23.69	24.92
80	8.95	11.36	22.27	23.45
90	6.65	16.54	20.98	21.02

TABLE III.PSNR OFRICE IMAGE WITH DIFFERENT FILTERING TECHNIQUES

%NOISE DENSITY	UNTRIMMED	DBA	BDND	PROPOSED METHOD
10	33.5	36.09	37.56	39.9
20	29.27	32.45	34.9	35.86
30	26.28	29.29	30.09	33.25
40	22.27	26.78	29.98	31.24
50	20.05	25.37	27.32	29.89
60	17.68	22.37	26.07	28.11
70	15.33	18.2	24.86	26.59
80	12.67	16.64	22.48	24.84
90	11.35	11.32	21.98	22.47

IV. CONCLUSION

In this paper we have proposed the effective noise removal technique which preserves image details better than many existing techniques. The proposed algorithm gives good PSNR result in presence of high percentage of noise density. Thus our method is highly effective under high noise density than many existing techniques. Further this has to be improved by preserving more image details and improving PSNR.

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