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Salt and Pepper Noise Removal by Using Improved Decision Based Algorithm

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ABSTRACT: Noise introduced in the image can damage the image as well as it can cause loss of important informations, to avoid these problems image filtering techniques are used .These filtering techniques has their own advantages and disadvantages.

The most common noise in the image is Salt and Pepper noise. There are different filtering techniques to remove salt and pepper noise efficiently, but there are problems to remove this noise at high density. Therefore ,here a technique is presented that will provide better results and holds the originality of the image at high density.

The proposed technique is based on Decision Based Algorithm and the result performance is compared with Median Filter, Hybrid Median Filter and Adaptive Median Filter . Two images are used for the work ,which are fruit and baboon. The metric of comparison is determined by using Mean Square Error method. Hence the result of this study has shown that the proposed filter can remove Salt and Pepper noise efficiently with at different density and restored the originality of the pixel.

KEYWORDS: salt and pepper noise, decision based algorithm, filtering technique .

I. INTRODUCTION

In today's era where data transmission and receiving all are very fast as well as accurate is in demand, to achieve this digital signal processing is needed. This DSP is needed in image processing where images undergoes different process as the requirement. During image processing the challenges is filtering an image ,which includes removal of noise and restoring the originality of the pixel. This Noise is unwanted and random signals generally appears in image during image acquisition because of light levels and sensor temperature [1]. Corruptions and quality of image degrades due to presence of noise. [2]. Salt and Pepper noise is very common noise present in the image, this type of noise is also known as shot noise, impulse noise and spike noise resulting in image distortion and blurring[5]. Due to presence of this type of noise important information of the image lost and further image analysis cannot be performed.

This salt and pepper noise is having two values either '0' or '1' means maximum or minimum intensity .Maximum intensity means black pixel and minimum intensity means white pixel , which resembles like salt and pepper scattered in image. Hence ,image filtering technique is required to remove salt and pepper noise. Image filtering technique is applied according to the application requirements.

Main aim of image filtering technique is to remove the noise efficiently and maintain the originality of the image .There are two types of filtering techniques one is linear filter and other is non-linear filter.

Linear filter is only suitable for additive noise [9]. Therefore, nonlinear filtering technique is applied for a better results for removing Salt and Pepper noise. Median filter is generally used for nonlinear noise removal and smoothing operation.[10]. If the noise intensity is higher than 20% this Median filter does not work well, due to this there will be chance of missing some informations and edge informations[11] and it may also changes non noisy pixel to other value different to original value that can remove some important details of the image [12]. The drawbacks of Median filter is overcome by Weight Median Filter (WMF) and Center Weight Median Filter (CWMF) [13]. WMF [14] and CMWF [15] works same as Median filter but the difference is that these two filters give more weight to certain pixels on the filtering window. The results of these two filters provides better image details but the main drawback is that these filters are ,it will process all the pixel without checking whether it is noisy pixel or not. Adaptive Median Filter (AMF) [16] is introduced to overcome this problem. It can increase the window size dynamically to remove noise. Blurring effect arises with this filter is when the window size increase. [17].Although, AMF also has unsatisfactory performance at high intensity noise but this drawback can be overcome by Decision Based Algorithm (DBA) [18],which can remove high density salt and pepper noise. This Decision Based Algorithm (DBA) will select only noisy pixels to be



processed while the non-noisy pixels are remained unchanged or unprocessed. In this algorithm the noisy pixels will be replaced with the median of the remaining neighbourhood pixels in the 3 x 3 window. The output image of DBA technique, at high density is blur. Many techniques have been introduced based on DBA to further improve the outcome of the filter at high density noise. Among all the Ben Filter technique proves that it has better performance than Adaptive Center Weight Median (ACWM), AMF, DBA and Modified Decision Based UnSymmetric Trimmed Median Filter (MDBUTMF). It provides a good result in preserving the pixel value, but at high density, this filter still does not produce a clear image and contains blurred image at certain point. In this research, a technique based on DBA is proposed that can improve the efficiency of salt and pepper noise removal and preserve the originality of the pixel. This filter is tested on the fruit and baboon images. The performance of the filter is then compared with Med Filter, HMF, AMF and Ben Filter by using Mean Square Error (MSE) method.

II. METHODOLOGY

In this research, different densities of salt and pepper noise starting from 10% to 90% is removed by using an Improved Decision Based Median Filter (IDBMF). In this the pixel value of images is between 0 to 255 and the image uses 8 bit or grayscale images. In this algorithm neighbouring pixel '+' is taken as processing window and use 'replicate' padding method. The use of '+' neighbours are because it is more significant and contained more data compared to other types of neighbourhood since it is only one-unit distance from the processing pixel and adjacent to each other. Let $P[i,j]$ is the pixel that being processed and (i,j) is the position of the pixel, then '+' neighbours are at position $P[i-1,j]$, $P[i,j-1]$, $P[i,j]$, $P[i,j+1]$ and $P[i+1,j]$ as illustrated in Fig. 1.

	$P_{i-1,j}$	
$P_{i,j-1}$	P_{ij}	$P_{i,j+1}$
	$P_{i+1,j}$	

Fig. 1. Illustration of '+' neighbours as processing window.

The IDBMF technique can be classified into three cases.

Case 1 : When the pixel is free from noise, pixel whose value is $0 < P_{ij} < 255$, will remain unchanged. Therefore the originality can be remain, instead of changing all the pixel value without checking whether it is noisy or not.

Case 2 : when the processing pixel is noisy pixel and the processing window contain pixels with value is 0 (pepper noise) and 255 (salt noise). In this all the pixels are not noisy pixels, remove all the noisy pixel from the '+' neighbours processing window. Here, the median value is calculated from the remaining pixels as the replacement pixel at point P_{ij} . The noisy pixels are removed to ensure that the new pixel values are noise free pixels.

Lastly, Case 3 : When all the pixels in the processing window are noisy pixel and processing pixel is a corrupted pixel. Hence, the midpoint of the processing window is calculated and placed as the new pixel value. In this case the midpoint value is taken because the pixel value contained in the processing window are all mixed of 0 or 255, at least the new calculated pixel value is noise free pixel. Else, if the pixel value contained in the processing window are all 0 or all 255, the value will still be the same because of the original value of the pixel in the image itself and it may be the value of the noisy pixel. Fig. 2 shows the flowchart of IDBMF technique. Input image $0 < P(i,j) < 255$ Select '+' neighbours as processing window Is selected window contain all noisy pixels, 0 or 255 yes no yes no Replace $P(i,j)$ with the midpoint of the processing window Replace $P(i,j)$ with the median of the remaining pixels Remove the pixels with value 0 and 255 Output image .

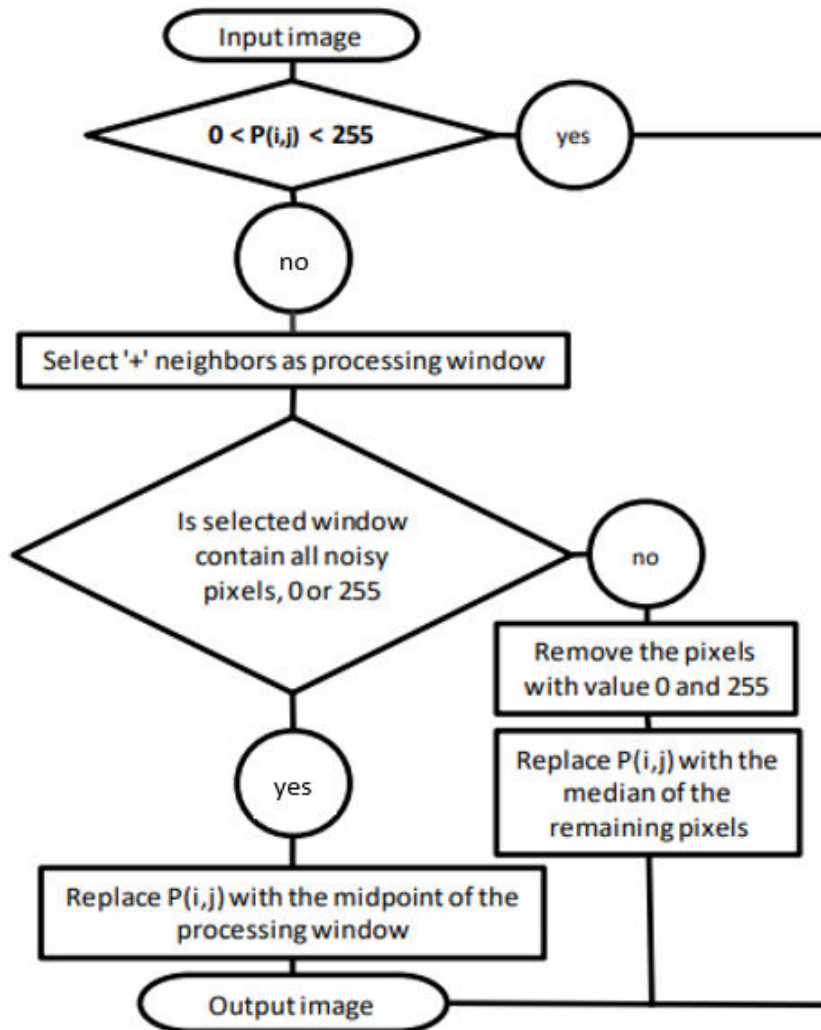


Fig. 2. Flowchart of IDBMF technique.

The algorithm of IDBMF can be described as follows:

- 1) Step 1: If selected pixel, P_{ij} , is noise free pixel, $0 < P_{ij} < 255$, it remains unchanged.
- 2) Step 2: If selected pixel, P_{ij} , is noisy pixel, 0 and 255, check the processing window.
- 3) Step 3: If the processing window contains certain pixels that is noisy, 0 and 255, or none of pixels in the '+' neighbours are noisy then remove all the noisy pixels from the processing window and calculate the median of the remaining pixels in neighbourhood as the new pixel value, P_{ij} .
- 4) Step 4: If the processing window contains all noisy pixels, 0 and 255, then calculate the midpoint of all the pixels in the processing window and replace it as the new pixel value at P_{ij} .

III. RESULTS AND DISCUSSION

The results of the proposed algorithm are presented in this section. For research three images are used, which are the lead frame, fruit and baboon images. In these images noise are added with different densities of salt and pepper noise.



Density varies from 10% to 90%. Quantitative comparisons are done, to determine the performance of IDBMF method that is MSE method. The metric for comparison is shown as follows:

The other techniques that have been used to compare the performance with IDBMF are HMF, AMF and Ben Filter technique.

Matlab R2014a is used for simulation of the images. Table I shows the MSE values of all the techniques. IDBMF techniques is compared with 3 other techniques at different densities of noise. From the table, it is clear that IDBMF has the lowest amount of MSE values at different density which implies that the IDBMF performance is best for removing Salt and Pepper noise in lead frame image among other the techniques. The second filtering technique that has good performance in Ben Filter is followed by AMF. IDBMF has better performance at 90% of noise density compared to other techniques.

TABLE I. COMPARISON OF MSE VALUE FOR LEAD FRAME IMAGE

Noise Density (%)	HMF ($\times 10^4$)	AMF ($\times 10^4$)	Ben Filter ($\times 10^4$)	IDBMF ($\times 10^4$)
10	5.75	2.20	0.72	0.31
20	17.52	4.00	1.70	0.87
30	41.62	7.64	3.53	1.88
40	89.99	12.70	6.50	3.77
50	164.28	19.79	11.03	7.05
60	285.90	32.24	18.51	13.36
70	427.98	47.99	31.37	24.40
80	595.95	77.75	53.92	44.01
90	799.39	137.10	111.02	82.00

The result of MSE values when using fruit image as input image is shown in Table II. It can be seen that HMF filter has the poorest performance with high value of MSE. Meanwhile, IDBMF technique is the most effective technique in removing Salt and Pepper noise that produces low amount of MSE value. The closest value with IDBMF is Ben Filter. However, at 10% density of noise, Ben Filter has almost 10 times higher value of MSE compared to IDBMF.

TABLE II. COMPARISON OF MSE VALUE FOR FRUIT IMAGE

Noise Density (%)	HMF ($\times 10^4$)	AMF ($\times 10^4$)	Ben Filter ($\times 10^4$)	IDBMF ($\times 10^4$)
10	1.56	0.53	0.14	0.01
20	5.06	0.84	0.33	0.25
30	17.70	1.45	0.67	0.53
40	42.59	2.62	1.26	1.01
50	87.58	3.96	2.12	1.70
60	156.26	6.76	3.62	2.96
70	240.17	10.41	5.60	4.65
80	339.34	18.32	12.05	9.23
90	447.93	38.68	33.20	21.40

The next study is focused on the performance of the filter when the baboon image is used as an input image. The MSE value of each filter is expressed in Table III. As seen in the table, the highest accomplishment in removing Salt and Pepper noise and the lowest amount of MSE value produced for each density is IDBMF. Ben Filter also performs as good as IDBMF with the MSE value that nearly close with IDBMF's MSE value.



TABLE III. COMPARISON OF MSE VALUE FOR BABOON IMAGE

Noise Density (%)	HMF ($\times 10^4$)	AMF ($\times 10^4$)	Ben Filter ($\times 10^4$)	IDBMF ($\times 10^4$)
10	10.35	8.39	2.20	1.69
20	19.38	10.41	4.57	3.72
30	41.36	13.28	7.30	6.10
40	84.49	17.17	10.51	8.99
50	155.39	22.15	14.07	12.27
60	259.34	28.03	18.93	16.61
70	394.03	36.72	24.77	22.00
80	555.48	47.36	32.51	29.07
90	736.46	67.69	46.82	39.66

According to all the three table, this study has proven that the IDBMF works well in removing Salt and Pepper noise with low amount of MSE produced for each noise density in all three images tested. Apart from the quantitative test by using MSE method, the visualization test by using human eyes also shows that IDMF provide a better view and more clear image after removing the noise compared to other techniques. Table IV shows the comparison of the output images of different type of image filtering techniques for baboon image at 20%, 40%, 60%, 80% and 90% density of Salt and Pepper noise. Ben Filter is almost as good as IDBMF in producing a good image. However, at 90% of noise density, the image has blurred a bit compared to IDBMF as shown in Table IV.

TABLE IV. COMPARISON OF OUTPUT IMAGE FOR BABOON IMAGE

Noise Density (%)	HMF	AMF	Ben Filter	IDBMF
20				
40				
60				
80				
90				



IV. CONCLUSION

In this paper, an improved technique based on DBA has been proposed and is known as IDBMF. This IDBMF can remove Salt and Pepper noise and restores the originality of the image better than HMF, AMF, and Ben Filter. The proposed technique removes Salt and Pepper noise from 10% up to 90% of noise density. The input images used are the lead frame, fruit and baboon images. The experimental result based on MSE method shows that IDBMF produces the lowest amount of MSE value which can be described as the best among other compared techniques. The second filtering technique that performs well and almost as good as IDBMF is Ben Filter followed by AMF. On the other hand, the filters that perform poorly in this study is HMF. Besides that, IDBMF also produces more clear viewing image even at high density noise in which normally the filtering technique starts to blur the image and cause an extra method in the algorithm. Therefore, this technique should be implemented in various vision based system and inspection system algorithm especially in pre-processing stage to remove the noise and produce more quality image.

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