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Analyze the effect of iteration of Switching Weighted Median Filter on digital image

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***Abstract*: Switching median filter is very effective in preserving edges and important image in digital image. Switching median filter first detect the noise and then apply filtering only on corrupted pixels. After applying it on images some corrupted pixels still left so in order to detect those left pixels if SMF is applied again then it is seen that it detects noisy pixel and improves the result. In this way if iteration is performed on digital image using SMF it improves the result greatly. Here iterative effect is studied on standard gray scale image at higher noise density and result comes out with high image quality.**

***Keywods*: SWMF (switching weighted median filter), SMF (Switching Median Filter), PSNR (Peak signal to noise ratio).**

I. INTRODUCTION

Impulse noise corrupts digital images during image acquisition and transmission due to camera sensors or noisy channels. Median filter has become the most popular and dominant method for impulse noise removal and image restoration because of its noise suppression ability. In median filter, every pixel is replaced by the median of the gray-level value of its neighbors. However, both noise and noise-free pixels are modified and results in blurring and loss in some important details in the image [1]-[3],[6]. In camera or on a computer, most algorithms for converting image sensor data to an image also involve some form of noise reduction. The actual differences in pixel values constitute noise or real photographic detail. It is not possible to judge these differences perfectly by any algorithm, so there is often a tradeoff made between noise removal and preservation of fine. In general, low-contrast pixels look similar to noise [2].

This issue can be rectified by using "Switching Median Filtering" (SMF). Two sequential steps in SMF are—noise detection and filtering. Detection is based on a priori threshold value which decides whether a median filter should be applied or not. In the filtering step, corrupted pixels are replaced by median filter values while uncorrupted pixels are left unmodified, thus the accuracy of the noise detection is critical to the final image restoration result [1][4]. After application of SWMF on digital image it is seen that some corrupted pixels are untouched, this decreases the quality of image but if SWMF is applied again and again on the recovered image of the previous operation, detection progressively detected more and more corrupted pixels and thus more corrupted pixels are recovered. This iteration is very impressive in detection of noise and it improves the quality of image greatly.

II. SWMF FILTER

Switching median filter uses a threshold value to detect the noise in the pixel. If the intensity difference between the center pixel value and median value in the window is greater than the threshold value then center pixel is considered as a *noisy* pixel and replaced by median value, otherwise center pixel is considered as *non-noisy* and remain unchanged [2],[5].

Difference in intensity between the center pixel value and median value in the window is given by,

$$\Delta x = |x(i,j) - x_{med}| \qquad (1)$$

Where median value in the window x_{med} is given by

$$x_{med} = \{x(i-N, j-N), \dots . w_c * x(i,j), \dots . x(i-N, j-N \qquad (2)$$

Here w_c is the weight of the center pixels.

Suppose {X} is the noisy image and (2N+1) × (2N+1) is the sliding window size, centered at (i, j). The adjustment of the center pixel is given by following equation,

$$y(i,j) = \begin{cases} x_{med}, & \Delta x \geq T_i \\ x(i,j), & \Delta x < T_i \end{cases} \qquad (3)$$

$y(i,j)$ is the recoverd image with preserve edges.

III. EXPERIMENTAL PROCEDURE

Standard test gray scale image of cameraman is used for testing the performance of SWMF filter. Simulation is performed in MATLAB. Density of Salt and pepper impulse noise is maintained in image by using standard MATLAB function.

The steps of experimental procedure are as follows:

1) Read standard test image and converted into a matrix filled with gray scale values corresponds to test image.
2) Add salt and pepper noise of required density.
3) Apply filter on corrupted image.
4) Calculate PSNR from original and restored image using equation (4).

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5) Apply iteration on the recovered image and repeat steps 3 and 4.
6) Repeat step 2 to 5 by changing noise density.

Noise density is varied from 40% to 90 % and 10 times iteration is performed using SWMF.

IV. RESULTS & DISCUSSIONS

PSNR CALCULATION: If $O(i,j)$ is the original image, $R(i,j)$ is the corrupted image then PSNR of the corrupted image is given by following formula [3],[5],

$$PSNR = 10\log_{10}\frac{(Imax)^2}{\frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}(O(i,j)-R(i,j))^2} \quad (4)$$

Here M and N denotes the resolution of the image. Resolution of Cameraman image is 256x256 therefore M=N=256 and Imax is the maximum gray scale level that is 255 which represents white color.

PSNR is calculated at different noise density level by applying iteration and the result is shown in table 1 below,

Figure 1 shows standard gray scale cameraman image which is used for experimentation. Generally at higher noise density level it is hard to recover image. Therefore in this analysis image is corrupted with salt & pepper impulse noise with noise density level varies from 40% to 90%. PSNR is calculated by changing the noise density level and by performing multiple iteration on last recovered image using SWMF and tabulated in Table 1. Table 1 indicates that with increase in number of iteration PSNR increases as well as improves the quality of image. This improvement can be seen on the plot between number of iteration and PSNR as shown in figure 2.

Figure 1: Original Image of Cameraman

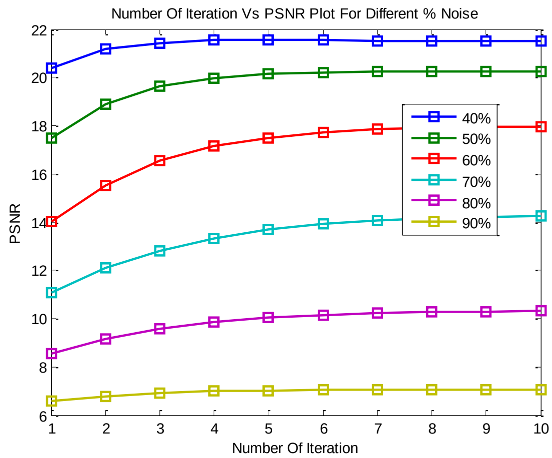

Figure 2: Number of iteration Vs PSNR plot by varying noise density level from 40% to 90$ for cameraman image

Table 1
PSNR values of recovered CAMERAMAN image for various noise density level and iteration using SWMF filter

Percentage noise	Number of iteration									
	1	2	3	4	5	6	7	8	9	10
40	20.3953	21.2024	21.4371	21.5322	21.5538	21.5329	21.5296	21.5243	21.5210	21.5197
50	17.4666	18.9018	19.6166	19.9687	20.1420	20.2184	20.2459	20.2540	20.2564	20.2626
60	14.0157	15.5241	16.5471	17.1379	17.4878	17.7253	17.8470	17.9045	17.9358	17.9527
70	11.0896	12.0967	12.7928	13.3070	13.6779	13.9200	14.0823	14.1738	14.2246	14.2667
80	8.55502	9.16874	9.56596	9.84661	10.0327	10.1588	10.2315	10.2649	10.2884	10.3051
90	6.56176	6.78201	6.90523	6.98353	7.02279	7.04212	7.05073	7.04966	7.04631	7.0378

Table 2
Noisy and Recovered CAMERAMAN image for noise density level varied from 40% to 70% with no iteration and 10 times iteration using SWMF filter

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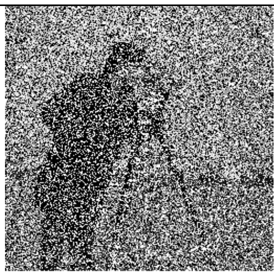
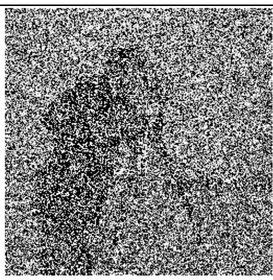
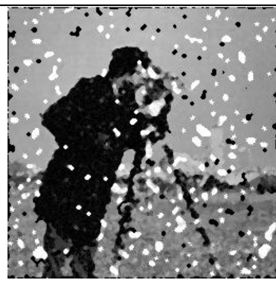
Noise Percentage	Noisy image	1 iteration	10 iteration
40			
50			
60			
70			

Table 2 shows the visual effect of improvement due to iteration. In table 2, images corrupted with higher density of salt and pepper impulse noise from 40% to 70% are shown in column 2, filtered image with no iteration and with 10 times iteration are shown in column 3 and 4 respectively. It can be seen that column 4 images are much better than column 3 images which shows that iteration works successfully on the images while filtering using SWMF filter.

V. CONCLUSION

Switching median filter is very effective in reducing noise even at high noise density. It preserves edges and important image details successfully but it is hard to remove noise completely. After experimentation it is seen that results are very impressive visually as well as quantitatively. Iteration progressively reduces noise after each iteration and results in quality image. It is very useful to embed iteration in SWMF to improve quality of filtered image.

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