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Impulse Noise Suppression and Edge Preservation of Digital Images Using Image Fusion

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ABSTRACT

Digital images often get corrupted with impulsive noise during their acquisition, transmission, or storage. Hence there is a need to recover an original image from the degraded observations making the image restoration an important field of concern. *Nonlinear filters such as median and median based filters serve to suppress the impulsive noise to the great extent. The advantages and disadvantages of these filters are commonly known and focusing on these it is necessary to mention that most of these filters are good in noise suppression, where as they fail to preserve the important details of an image such as edge information, i.e. they suppress the noise with image blurring, making it less visible leading to the depreciation of the amount of information on the image rather than increasing its quality. In recent years there has been a trend to develop more efficient procedures for improving image quality to meet the conflicting requirements of noise suppression with edge preservation. Our work considers the concept of image fusion of filtered images for impulse noise suppression and edge preservation. Image fusion is the process of combining two or more images .into a single image while retaining the important features of the image and is widely used in military, remote sensing and medical applications. In our work five different median based filtering algorithms are used individually for filtering the noisy images. Then the filtered images are fused to obtain a high quality image compared to the individually filtered images. Simulation results on a diverse set of images and the comparisons show that our work is more robust and effective than many other well-known median based filtering algorithms and combines simplicity, good filtering quality with edge preservation.*

KEYWORDS: *Salt and Pepper noise, noise suppression, image fusion, SNR, edge preservation.*

I. INTRODUCTION

Digital image restoration is a field of concern so as to recover an original scene from degraded observations. Hence developing techniques to perform the image restoration task are important. Image restoration, usually, employs different filtering techniques. Broadly, filters may be classified into two categories: Linear and Nonlinear. Order statistics filters exhibit better performance as compared to linear filters when restoring images corrupted by impulse noise. Impulse noises are short duration noises which degrade an image. Such a noise may occur during image acquisition, due to interference in the channel and due to atmospheric disturbances during image transmission. The goal of the filtering action is to cancel noise while preserving the integrity of edge and detail information. These schemes differ in their basic methodologies applied to suppress noise. Some schemes utilize detection of impulsive noise followed by filtering whereas others filter all the pixels irrespective of corruption. The schemes based on the characteristics of the filtering schemes can be classified as:

1.1 Filtering without Detection.

In this type of filtering a window mask is moved across the observed image. The mask is usually of size (2n+1)2, where '*n*' is a positive integer. Generally the center element is the pixel of interest. When the mask is moved starting from the left-top corner of the image to the right-bottom corner, it performs some arithmetical operations without discriminating any pixel.

1.2 Detection followed by Filtering

This type of filtering involves two steps. In first step it identifies noisy pixels and in second step it filters those pixels. Here also a mask is moved across the image and some arithmetical operations are carried out to detect the noisy pixels. Then filtering operation is performed only on those pixels which are found to be noisy in the previous step, keeping the non-noisy intact.

1.3 Hybrid Filtering

In such filtering schemes, two or more filters are suggested to filter a corrupted location. The decision to apply a particular filter is based on the noise level at the test pixel location or performance of the filter on a filtering mask. In our work the image is filtered in parallel with five different smoothing filters. The filtered images obtained from these smoothing filters are fused to obtain a high quality image which is free from impulse noise.

II. IMAGE NOISE

Noise is undesired information that contaminates an image. Noise appears in image from various sources. The digital image acquisition process, which converts an optical image into electrical signal that is then sampled, is the primary process by which noise appears in digital image. There are several ways through which noise can be introduced in to an image, depends on how the image is created.

2.1 Noise Model

Noise is modeled as a salt and pepper impulse noise. Pixels are randomly corrupted by two fixed extreme values, 0 and 255 (for 8-bit monochrome image), generated with same probability, that is for each image pixel at location (i , j) with intensity value $S_{i,j}$, the corresponding pixel of the noisy image will be $X_{i,j}$ in which probability density function of $X_{i\ j}$ is

$$f(x)= \begin{cases} P/2 & \text{for } X = 0 \\ 1-P & X=S_{i,j} \\ P/2 & \text{for } X = 255 \end{cases} \qquad (1)$$

where '*P*' is noise density.

III. NOISE SUPPRESSION USING FILTERS

As stated earlier, in our work five different median based filters for impulsive noise removal from the digital images are implemented whose details are given as follows:

3.1 Median I

The median filter considers each pixel in the image and in turn it looks at its nearby neighbors to decide whether or not it is representative of its surroundings. It replaces the center pixel value of the image with the median of those surrounding values. The median is calculated by first sorting all the pixel values from the surrounding neighbors in to numerical order and then replacing the pixel being considered with the middle pixel value. (If the neighborhood under consideration contains an even number of pixels, the average of the two middle pixel values is used.)

3.2 Median II

This is a median filter with threshold. In this filter the value of the center pixel of interest is first subtracted with the median value of the window under consideration. If the resultant value is greater than the predefined threshold then the center pixel is replaced with the median of the window under consideration, otherwise it is unchanged.

3.3 Progressive Switching Median (PSM) Filter - Progressive switching median filter l restores the images corrupted by salt and pepper noise. The algorithm is developed based on the following schemes:

3.3.1 Switching scheme- an impulse detector algorithm is used before filtering, thus only a proportion of all pixels will be filtered

3.3.2 Progressive method- both the impulse detection and noise filtering procedures are progressively applied through several iterations.

3.4 Multi Stage Median (MSM) Filter

Let { x (. , .) } be a discrete two-dimensional sequence, and consider the set of elements inside a(2 N + 1) X (2 N + 1) square window W centered at the (i , j)th pixel.

Define the following four subset of the window *W*,

$W_{0,1}(i , j)=\{x(i,j+k); -N \le k \le N \}$ (2)

$W_{1,1}(i,j)=\{x(i+k,j+k);-N\le k\le N\}$ (3)

$W_{1,0}(i,j)=\{x(i+k,j);-N\le k \le N \}$ (4)

$W_{1,-1}(i,j)=\{x(i+k,j-k);-N\le k\le N\}$ (5)

Suppose that $Z_k(i, j)$, *k = (1, 2, 3, 4) are* the median values of the elements in the four subsets, respectively, and

$Y_p(i,j)=\min\{Z_1(i,j),Z_2(i,j),Z_3(i,j),Z_4(i,j)\}$ (6)

$Y_q(i,j)=\max\{Z_1(i,j),Z_2(i,j),Z_3(i,j),Z_4(i,j)\}$ (7)

Then output of the multistage median filter (MSM) is defined by,

$Y_m(i,j) = \text{med}[Y_p(i,j), Y_q(i,j), x(i,j)]$ (8)

3.5 Center Weighted Median (CWM) Filter

The weighted median filter is an extension of the median filter, which gives more weights to some values within the window. The special case of weighted median filter called the center weighted median (CWM) filter. This filter gives more weights to the centeral value of a window. CWM preserves more details at the expense of less noise suppression.

IV. WAVELET FUSION

The most important issue concerning image fusion is to determine how to combine the images. In recent years, several image fusion techniques have been proposed. In our work we have used wavelet transform for the fusion of filtered images. The wavelet transform decomposes the image into low-high, high-low, high-high spatial frequency bands at different scales and the low-low band at the coarsest scale [4]. The L-L band contains the average image information whereas the other bands contain directional information due to spatial orientation. Higher absolute values of wavelet coefficients in the high bands correspond to salient features such as edges or lines. With these premises, Li et al. propose a selection based rule to perform image fusion in the wavelet transform domain. Since larger absolute transform coefficients correspond to sharper brightness changes, a good integration rule is to select, at every point in the transform domain, the coefficients whose absolute values are higher. Simple Average mechanism is a simple way of obtaining an output image with all regions in focus. The value of the pixel P (i, j) of each image is taken and added. This sum is then divided by N to obtain the average. The average value is assigned to the corresponding pixel of the output image. This is repeated for all pixel values. The Greatest Pixel Value algorithm chooses the in focus regions from each input image by choosing the greatest value for each pixel, resulting in highly focused output. The value of the pixel P (i, j) of each image is taken and compared to each other. The greatest pixel value is assigned to the corresponding pixel of the output image. This is repeated for all pixel values.

Unlike the two previous algorithms, the Simple Block Replace algorithm takes into consideration the neighboring pixels. For each pixel P (i, j) of each image its neighboring pixels are added and a block average is calculated. After comparison, the pixel from the input image with the maximum block average is copied to the output image. This is repeated for all pixel values. The wavelet based technique involves application of the 'Simple Average Algorithm' to each of the coefficients, once the images have been separated into their wavelet coefficients. After this the final output image is reconstructed from the combined coefficients. The outputs of the 'Simple Average Algorithm' are taken as the wavelet coefficients of the output image from which the output is now reconstructed.

V. RESULTS AND DISCUSSIONS

All the filters were implemented using MATLAB R2008a and tested for impulse noise corrupted 50 different grey scale images.In this paper simulation results obtained for Lena images corrupted with 20% Salt and pepper noise are presented. The noise model of equation (1) is computer simulated. All the filters considered in our work operate using 3X3, 5X5 and 7X7 processing windows depending on the amount of impulse noise density considered, i.e. 20-40%, 40-65% and 65-80% respectively.

Performances of the median based impulse noise removal filters for the images corrupted with noise densities from 20% to 80% are verified. Five median based filters are implemented : median I, median II, progressive switching median filter, multistage median filter, center weighted median filter and the outputs of these filters are fused using wavelet fusion technique. We have presented the PSNR results obtained for 'Lena' image corrupted with 20% salt and pepper noise in figure 1 and figure 2 and it is seen that impulse noise is significantly reduced and the image details have been satisfactorily preserved.

As stated earlier the noise cancellation behavior of the filtering and fusion techniques can be appreciated by the visual analysis. The subjective performance evaluation of the filtering operation is quantified and is calculated by the parameters PSNR (peak signal to noise ratio), MSE (mean square error) and MAE (mean absolute error) using the formulae given below:

$$PSNR = 10 \text{ x } \log_{10}\left(\frac{255^2}{MSE}\right) \tag{9}$$

$$MSE = \frac{1}{MN}\sum_i \sum_j \left(R_{i,j} - X_{i,j}\right)^2 \tag{10}$$

$$MAE = \frac{1}{MN}\sum_i \sum_j |R_{i,j} - X_{i,j}| \tag{11}$$

where $R_{i,j}$ and $X_{i,j}$ denote the pixel values of restored image and original image respectively and 'M X N' is the size of the image.

a	b
c	d
e	f
g	h

Fig 1 . (a) Original image (b) Noisy image with noise density of 20% (c) Output of Median I (d) Output of Median II (e) Output of CWM (f) Output of MSM (g) Output of PSM (h) Fused Output

Fig.1. Signal to Noise Ratio (in dB) of "Lena" image for different filters and fusion.

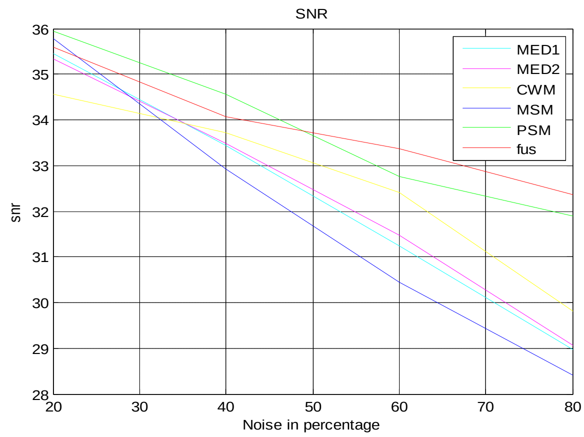

Fig.2 .Noise density Vs. Signal to Noise Ratio (db) of Lena gray scale image

VI. CONCLUSION

In this paper experiments are carried out for grey scale images corrupted with different noise densities in the range 20-80%.All the filters under consideration perform well for the images corrupted with 20% of impulse noise density. Above 20% of noise density median I, median II and multistage median filters show poor performance. Upto 40% noise density PSM, CWM filter performs well. Above 40% of density PSM and CWM show poor performance.From the experiments conducted on a variety of images viz; natural and synthetic images, it is found that few filters produce good images only in low noise condition and fail in high noise condition, few other filters work well under higher noise densities but presents blurred images. Wavelet Image fusion technique is one such technique which fuses all such images and restores the blurred and noisy images even under high noise conditions with details preserved intact.

REFERENCES

[1] R.C.Gonzalez, R.E. Wood: Digital Image Processing, Prentice Hall, India Second Edition, 2007.

[2] R.H.Laskar, B. Bhowmick, R. Biswas and S. Kar: Removal of impulse noise from color images, 2009 IEEE.

[3] James C Church, Yixin Chen and Stephen V Rice:A Spatial median filter for noise removal in digital images, 2008 IEEE.

[4] Hui Li, B.S. Manjunath, Sanjit K. Mitra: Multisensor Image Fusion Using the Wavelet Transform, Proc. first international conference on image processing, ICIP 94, Austin, Texas, Vol. I, Pages 51-55, Nov 1994.

[5] T. Chen and H. R. Wu, Adaptive Impulse Using Center-Weighted Median Filters. IEEE Signal Processing Letters, 8(1):1-3, January 2001.

[6] Z. Wang and D. Zhang: Progressive Switching Median Filter for the Removal of Impulse Noise from Highly Corrupted Images. IEEE Transactions on Circuits and Systems–II, Analog and Digital Signal Processing, 46(1):78 – 80, January 1999.

[7] Yang Yi Han, C Kang and Xin Han: An overview on pixel-level image fusion in remote sensing, IEEE conference on automation and logistics, pp.2339-2344, Aug 2007.

[8] J. Harikiran, B.Saichandana, B.Divakar: Impulse Noise Removal in Digital Images, International Journal Of Computer Applications, Vol.10-No.8, Nov 2010, pp 0975-8887.

[9] B. Chanda and D. Dutta Majumder: Digital Image Processing and Analysis, Prentice-Hall of India, 1st edition, 2002.

[10] Yang Yi Han, C Kang and Xin Han: An overview on pixel-level image fusion in remote sensing, IEEE conference, automation and logistics, pp.2339-2344, Aug 2007.

[11] Local scale control for edge detection and blur estimation: IEEE Transactions on pattern analysis and machine intelligence,Vol.20,No7,July1999.