Random Valued Impulse Noise Reduction using Optimized Thresholding

C.Nivedityaa
Assistant Professor, Department of ECE
Karpagam Institute of Technology, Coimbatore, India.
nivedityaa@gmail.com

***Abstract* – In this paper, we present a novel method for the removal of impulse noise from digital images. In proposed filter, threshold is computed locally from image pixels intensity values in a sliding window and a detail preserving noise filter. Initially, detection phase classifies any possible impulsive noise pixels. Subsequently, the filtering phase replaces the detected noise pixels where fuzzy reasoning is employed to deal with uncertainties. Results show that proposed method provides better performance in terms of PSNR and MAE than many other median filter variants for random-valued impulse noise.**

Keywords- Random Valued Impulse Noise, PSNR,MAE, Fuzzy Reasoning, Uncertainty.

I. INTRODUCTION

A. Image Denoising

Digital images play an important role both in daily life applications such as Satellite television, Magnetic Resonance Imaging, Computer Tomography as well as in areas of research and technology such as geographical information systems and astronomy .Digital images are often corrupted by different types of noise during its acquisition and transmission phase.

The most common types of noise corrupting the digital images are Gaussian noise and Impulse noise. Median filtering is an efficient nonlinear technique used for impulse noise removal. Conventional filters such as Gaussian filter used for Gaussian noise removal smooths the noise but blur the edges. To overcome these drawbacks nonlinear methods are proposed.

Some degree of noise is always present in any electronic device that transmits or receives a signal. For television this signal is the broadcast data transmitted over cable or received at the antenna; for digital cameras, the signal is the light which hits the camera sensor. Even though noise is unavoidable, it can become so small relative to the signal that appears to be nonexistent.

The overall noise characteristics in an image depend on many factors, including the type of sensor, pixel dimensions, temperature, exposure time, and speed. So Image Denoising is a fundamental problem in the field of image processing. The goal of image denoising is to remove the noise while retaining the important signal features. The denoising of a natural image corrupted by Gaussian noise is an important problem in image processing. Image denoising still remains a challenge for researchers because noise removal introduces artifacts and causes blurring of the images.

B. Random Valued Impulse Noise

There are different kinds of noises that will affect an image during transmission through channels, malfunctioning of camera sensors etc. The explanation about different kinds of noises is to know about types of noises that are affecting the images.

The present project deals with impulse noise and a special kind of noise called random valued impulse. The normal values of impulse noise is 0 or 255, Where as the noise value of random valued impulse noise can be of any number between 0 to 255,0 or 255.This noise is introduced into the image by replacing the noise free pixels in the original image by some random values . To find the noise value in a given image which is affected by random valued impulse noise (RVIN), the procedure is as follows:

1) To find the pixel values of all the pixels present in an image.
2) To increment the count if pixel values are same.
3) Finally the pixel value which is having maximum count will be treated as the noise value of the image which is affected by random valued impulse noise.

II. RELATED WORK

Wenbin Luo [1] proposed the new impulse noise removal technique to restore digital images corrupted by impulse noise. The algorithm is based on fuzzy impulse detection technique, which can remove impulse noise efficiently from highly corrupted images while preserving image details. The proposed method used to remove impulse noise in many consumer electronics products such as digital cameras and digital television (DTV) for its performance and simplicity.

Yiqiu Dong [2] presented an image statistic for detecting random-valued impulse noise. By this statistic, most of the noisy pixels can be modified in the corrupted images. Combining it with an edge-preserving regularization, a powerful two-stage method can be obtained for denoising random-valued impulse noise, even for noise levels as high as 60%.

Kenny Kal Vin Toh [3] presented a new fuzzy switching median (FSM) filter employing fuzzy techniques in image processing. The proposed filter is able to remove salt-and- pepper noise in digital images while preserving image details and textures very well. By incorporating fuzzy reasoning in correcting the detected noisy pixel, the low complexity FSM filter is able to outperform some well known existing salt-and- pepper noise fuzzy and classical filters.

Haidi Ibrahim [4] proposed a simple, yet efficient way to remove impulse noise from digital images. This novel method comprises two stages. The first stage is to detect the impulse noise in the image. In this stage, based on only the intensity values, the pixels are roughly divided into two classes, which are “noise-free pixel” and “noise pixel”. Then, the second stage is to eliminate the impulse noise from the image. In this stage, only the “noise-pixels” are processed. The “noise-free pixels” are copied directly to the output image. The method adaptively changes the size of the median filter based on the number of the “noise-free pixels” in the neighborhood.

Pinar Civicioglu [5] presented a novel method for the suppression of Random-Valued Impulsive Noise from corrupted images. The proposed method is composed of an efficient noise detector and a pixel-restoration operator. The noise detector has been used to discriminate the uncorrupted pixels from the corrupted pixels. The noise-free intensity values of the corrupted pixels have been computed by using Triangle-Based Linear Interpolation and the values of tuning parameters of the proposed method have been optimized with Differential Evolution algorithm.

Kenny Kal Vin Toh [6] proposed a novel two-stage noise adaptive fuzzy switching median (NAFSM) filter for salt-and-pepper noise detection and removal. Initially, the detection stage will utilize the histogram of the corrupted image to identify noise pixels. These detected “noise pixels” will then be subjected to the second stage of the filtering action, while “noise-free pixels” are retained and left unprocessed. Then, the NAFSM filtering mechanism employs fuzzy reasoning to handle uncertainty present in the extracted local information as introduced by noise.

Fabrizio Russo [7] presented a new operator which adopts a fuzzy logic approach for the enhancement of images corrupted by impulse noise. The proposed operator is based on two-step fuzzy reasoning, and it is able to perform a very strong noise cancellation while preserving image details very well. The new fuzzy filter is favourably compared with other nonlinear operators in the literature.

Yiqiu Dong et.al [8] proposed new impulse detector, which is based on the differences between the current pixel and its neighbours aligned with four main directions. Then, we combine it with the weighted median filter to get a new directional weighted median (DWM) filter.

III. OBJECTIVE OF THE PROPOSED FILTER

The proposed filter operates on impulse noise densities without jeopardizing image fine details and textures. Fast and automated algorithm is focused. The proposed filter does not require any tedious tuning or time consuming training of parameters as well. No priori Threshold is to be given. Instead, the threshold is computed locally from image pixels intensity values in a sliding window using weighted statistics. More precisely, the weighted mean value and the weighted standard deviation are estimated in the current window. The weights are the inverse of the distance between the weighted mean value of pixels in a given window and the considered pixel. A result is that impulse noise does not corrupt the determination of these statistics from which the Threshold is derived. Noise-free pixels are relatively easy to be selected by utilizing the binary decision. A limit for window is set to contain a minimum number of pixels avoid loss of image details .In filtering mechanism, the proposed filter adopts fuzzy reasoning to deal with uncertainties present in the local information. These uncertainties, e.g. thin lines or pixels at edges being mistaken as noise-pixels, are caused by the nonlinear nature of impulse noise. The fuzzy set is processed by calculating local information to produce a suitable fuzzy membership value.

IV. PROPOSED ALGORITHM

In an image contaminated by random-valued impulse noise, the detection of noisy pixel is more difficult in comparison with fixed valued impulse noise, as the gray value of noisy pixel may not be substantially larger or smaller than those of its neighbours. Due to this reason, the conventional median-based impulse detection methods do not perform well in case of random valued impulse noise. The numerical Threshold value is defined a priori or chosen after many data dependant tests. The literature shows that an optimal threshold in the sense of the mean square error can be obtained for most real data. However, Threshold suitable for a particular image is not necessarily adapted to another one. To overcome this problem, the following algorithm is proposed,

Step 1: Read the input image and add Random Valued Impulse Noise to the image.

Step 2: Compute the weighted mean value of the window.

$$M(i,j) = \frac{\sum_{m,n} w_{m,n} \quad X_{i+m,j+n}}{\sum_{m,n} w_{m,n}} \qquad (1)$$

Step 3: Weighted standard deviation is calculated using the weighted mean value.

$$\sigma(i,j) = \sqrt{\frac{\sum_{m,n} w_{m,n} \left(X_{i+m,j+n} - M(i,j)\right)^{\wedge}2}{\sum_{m,n} w_{m,n}}} \qquad (2)$$

Step 4: Threshold is obtained from the above statistical parameters which is given by

$\propto \times\ \sigma(i,j)$, $\propto = 1$

Step 5: Noisy pixel is found when difference between centre pixel and weighted mean exceeds threshold.

Step 6: Binary flag represents as follows:
1- Noisy pixel
0- Noise free pixel.

Step 7: Compute the median value for noise free pixels.

Step 8: Determine absolute difference.
$D(i,j) = \max\{d^1(m,n)\}$
Where $d(m,n) = \frac{|x(m,n) - x(i,j)|}{255} ; x(n,m) \in W^{(x)}(i,j)$
$x(i,j)$ centre pixel in window. (3)

Step 9: Compute the fuzzy membership value $F(i,j)$

$$F(i,j) = \begin{cases} 0 & : D(i,j) < T_1 \\ \frac{D(i,j) - T_1}{T_2 - T_1} & : T_2 \le D(i,j) < T_1 \\ 1 & : D(i,j) \ge T_2 \end{cases} \quad (4)$$

Step 10: Compute the restoration term $y(i,j)$ as follows:
$$y(i,j) = F(i,j).M(i,j) + [1 - F(i,j)].x(i,j) \quad (5)$$

V. PERFORMANCE EVALUATION

A. *Peak-Signal-To-Noise Ratio*

The phrase Peak Signal to Noise Ratio, often abbreviated PSNR, in an engineering term for the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. Because many signal have a very wide dynamic range, PSNR is usually expressed in terms of the logarithmic decibel scale.

The PSNR is most commonly used as a measure of quality of reconstruction of lossy compression codes. The signal in this in case is the original data, and the noise is the error introduced by compression when comparing compression codes it is used as an approximation to human perception of reconstruction quality, therefore in some cases one reconstruction may appear to be closer to the original than another, even though it has a lower PSNR (a higher PSNR would normally indicate that the reconstruction) is of higher quality. One has to be extremely careful with the range of validity of this metric; it is only conclusively valid when it is used to compare results from the same codec and same content.

B. *Mean Square Error*

It is most easily defined via the MSE which for two M x N monochrome images I and K where one of the images is considered noisy and approximation of the other is defined as

$$MSE = \frac{1}{MN} \sum_{i=0}^{M-1} \sum_{j=0}^{N-1} ||I(i,j) - K(i,j)||^2$$

$$PSNR = 10 \log_{10} \frac{255}{MSE}$$

The maximum possible pixel value is 255.

C. *Mean Absolute Error*

Since the PSNR by itself cannot characterize the detail preservation behavior of a filter the mean absolute error (MAE) is used to focus on the detail preserving characteristic of the filter. The MAE is defined in as:

$$MAE = \frac{1}{MN} \sum_{i=0}^{M-1} \sum_{j=0}^{N-1} |I(i,j) - K(i,j)||^2$$

D. *Results*

In order to access the performance of the proposed scheme the Lena and Goldhill image with 512 x 512 are used as test images. Restoration performance of different filters with different noise rate is compared distinctly. The test images are corrupted with RVIN.

This chapter summarizes all the experimental results obtained in adopting the proposed method and existing method on the random valued impulse noise to achieve the expected result and the performance is compared. In order to know about the performance of the proposed filter, their results have been tabulated. The efficacy of the proposed method is demonstrated by extensive simulations. The experimental results exhibit significant improvement in the performance over several other methods.

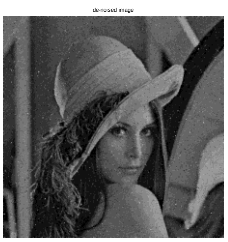
Original Image

Noisy Image

LENA IMAGE: COMPARISON OUTPUTS FOR 30% NOISE

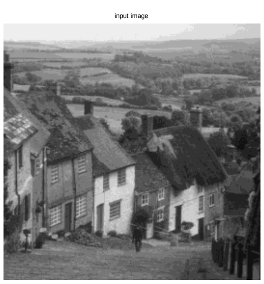
IMAGE	METHODS

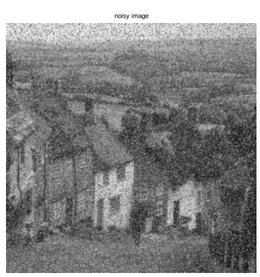
ADAPTIVE SWITCHING WEIGHTED MEDIAN FILTER



DIRECTIONAL WEIGHTED MEDIAN FILTER

PROPOSED FILTER

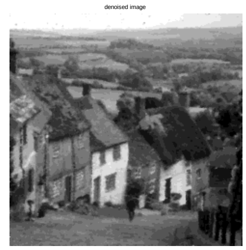




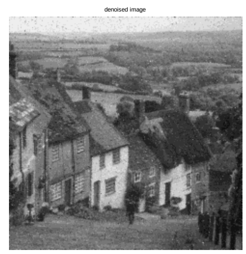
Original Image **Noisy Image**

GOLD HILL: COMPARISON OUTPUTS FOR 30% NOISE

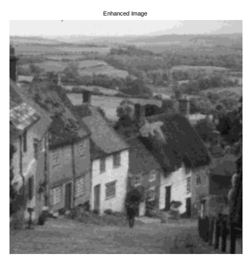
IMAGE	METHODS



ADAPTIVE SWITCHING WEIGHTED MEDIAN FILTER



DIRECTIONAL WEIGHTED MEDIAN FILTER



PROPOSED FILTER

TABLE 1.PSNR COMPARISON FOR LENA IMAGE

NOISE DENSITY (%)	ASWM	DWM	PROPOSED METHOD
10	31.3616	38.4189	40.6894
20	30.9620	35.8884	39.4522
30	29.7613	33.3384	37.2461
40	28.7812	29.7475	34.0187
50	23.3325	25.3009	30.3648

TABLE 2.PSNR COMPARISON FOR GOLD HILL IMAGE

NOISE DENSITY (%)	ASWM	DWM	PROPOSED METHOD

10	27.7835	32.9778	36.0342
20	27.6082	31.4507	35.4217
30	27.8107	30.0299	34.5431
40	25.8845	28.2136	33.0024
50	23.8107	25.5338	30.2986

VI. CONCLUSION

The proposed method does not need an a priori Threshold as in the case in classical Switching Median filter to detect noisy pixels. Instead, Threshold is computed locally from image pixels grey values in a sliding window**.**Fuzzy reasoning is embedded as part of its filtering mechanism, which permits us to exploit the effectiveness of fuzzy paradigm in handling imprecise local information. Extensive simulation results verify its excellent impulse detection and detail preservation abilities by attaining the highest PSNR and lowest MAE values across a wide range of noise densities. Thus rampant loss of image is reduced without jeopardizing image fine details.

REFERENCES

[1]. W. Luo, "Efficient removal of impulse noise from digital images," IEEE Trans. Consumer Electron., vol. 52, no. 2, pp. 523-527, May 2006.
[2]. Y. Dong, R. H. Chan, and S. Xu, "A detection statistic for random-valued impulse noise," IEEE Trans. Image Process., vol. 16, no. 4, pp. 1112-1120, Apr. 2007.
[3]. K. K. V. Toh, H. Ibrahim, and M. N. Mahyuddin, "Salt-and-Pepper Noise Detection and Reduction Using Fuzzy Switching Median Filter," IEEE Trans. Consumer Electron., vol. 54, no. 4, pp. 1956-1961, Nov. 2008.
[4]. H. Ibrahim, N. S. P. Kong, and T. F. Ng, "Simple adaptive median filter for the removal of impulse noise from highly corrupted images," IEEE Trans. Consumer Electron., vol. 54, no. 4, pp. 1920-1927, Nov. 2008.
[5]. P. Civicioglu, "Removal of random-valued impulsive noise from corrupted images," IEEE Trans. Consumer Electron., vol. 55, no. 4, pp. 2097-2104, Nov. 2009.
[6]. K. K. V. Toh and N. A. Mat Isa, "Noise adaptive fuzzy switching median filter for salt-and-pepper noise reduction," IEEE Signal Process. Lett., vol. 17, no. 3, pp. 281-284, Mar. 2010.
[7]. F. Russo and G. Ramponi, "A fuzzy filter for images corrupted by impulse noise," IEEE Signal Process. Lett., vol. 3, no. 6, pp. 168-170, June 1996.
[8]. Y. Dong and S. Xu, "A new directional weighted median filter for removal of random-valued impulse noise," IEEE Signal Process. Lett., vol. 14, no. 3, pp. 193-196, Mar. 2007.
[9]. J. Zhang, "An efficient median filter based method for removing random valued impulse noise," Digit. Signal Process., vol. 20, no. 4, pp. 1010-1018, July 2010.
[10]. Smaïl Akkoul, Roger Lédée, Remy Leconge, and Rachid Harba, "A New Adaptive Switching Median Filter", IEEE Signal Processing Letters, 2010, pp.587 - 590.