An Improved Weighted Median Filter for the Image Processing Application

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Abstract: ***This paper represents a new technique for detection and removal of impulse noise from the grayscale digital images. The performance of an image filtering system depends on its ability to detect the presence of noisy pixels in the image. Most of the impulse detection techniques assume the salt & pepper noise in the images and do not work satisfactorily. A new technique is presented to improve the performance of weighted median filter or switching median filter for detection and removal of impulse noise from the grayscale digital images. The results of the proposed technique for the removal and detection of impulse noise from the gray scale images is very good rather than exiting techniques in terms of PSNR and MSE values.***

Keywords: impulse noise, impulse detection, median filter, switching median filter.

1. Introduction

Whenever an image is converted from one form to another such as, digitizing, scanning, transmitting, storing, etc., some of the degradation occurs at the output.[1] Hence, the output image suffer from a special kind of noise "salt & paper". Salt & paper significantly degrades the image quality [2]. An image denoising is used to remove the additive noise. The goal of image denoising is to estimate the original image from the noisy image. Denoising is one of the important task and pre-processing step in digital image processing. There are many median filters are available for impulse noise reduction although these methods have been improved, but the quality of denoising image is still not satisfactory [6]. But this method is too time-consuming. Most of these algorithms provide suitable and good results at smaller percent of noise levels and find difficulty with higher level noises, also this method is too time-consuming and isn't suitable for real applications[6]. The proposed technique can work in low time and have better results in PSNR metric. It introduces the artifacts and blurring of the images. So it is a challenge for the researchers to remove the impulsive noise from the gray scale images while retaining the important signal features and explore the possibilities of various denoising technique for gray scale images.

1.1 Impulse noise:

A grayscale image represented by a two-dimensional array where a location (i, j) is a position in image and called pixel. Often the grayscale image is stored as an 8-bit integer that giving 256 possible different shades of gray going from black to white, pixels can have value in [0-255] integer interval, but some pixels in an image may not have correct value and that pixels are considered as noisy pixels, (1).[1]

$$img(i,j) = \begin{cases} ORG(i,j) & with\ probability\ 1-pr \\ 0 & with\ probability\ pr_1 \\ 255 & with\ probability\ pr_2 \end{cases}$$

1.2 Impulse noise detection in conventional switching median filter

The impulse detection is based on the assumption that a noise Pixel or the center pixel in the filtering window takes a gray value which is different from the neighboring pixels. In the switching median filter, the difference of the median value of pixels in the filtering window and the current pixel value is compared with a threshold to decide about the presence of the impulse.

$$y(i,j) = \begin{cases} m_{i,j}^{x}; if\ |m_{i,j}^{x} - x(i,j)| > threshold \\ x(i,j); otherwise \end{cases}$$

Where m (i, j), *m* represents the median value of the pixels inside the filtering window. When the above scheme is applied for impulse detection, a binary flag image $\{f(i,j)\}$ is constructed such that $f(i,j)$ 1 if the pixel $x(i,j)$ is noisy and $f(i,j)$ 0 if the pixel $x(i,j)$ is noiseless [9].

1.3 Impulse noise detection in proposed filter

$$y(i,j) = m^{x}(i,j),\ if\ (x^{t}(i,j) - x(i,j) > threshold,$$
$$x(i,j),\ otherwise$$

The above proposed technique method represent that the difference of the any neighboring pixel of the filtering window and the current pixel value is compared with a threshold to decide about the presence of the impulse. if the difference is greater than the threshold value [9],the output of the current pixel value is median of neighboring pixel value inside the filtering window otherwise it remains the current pixel value in the origin. Existing technique is used the flag to denote the noisy or non-noisy pixels but in the proposed technique voting procedure is used to consider that pixel is noisy [12]. It means that majority of votes of the neighboring pixels inside the filtering window are used to decide the median[13].In first 3x3 windows, value is compared with a threshold to decide about the presence of the impulse, if the value of current pixel is greater more than 6 votes than that pixel is considered as a noisy pixel. The same process is repeated in 2x3 and 3x2,also for 4x4 window mask but in 3x2,or 2x3 window mask only greater than 3 votes are consider and on 4x4 window mask 12 votes are used to consider that pixel is noisy and replace it with the median of the neighboring of pixels in the filtering window.

2. Implementation

The implementation of the improved median filtering algorithm is used to reduce noise in the image. The simple idea is to examine the pixel values in the selected window of the input signal and replace the noisy and distorted or blurred pixels with the median/effective median. The program works by using a moving fixed 3×3 window of pixel neighborhoods. Then use the 3×2, 2x3 and 4×4 window to remove the noise from the edges of the image also create the histogram of image. The proposed algorithm achieves very good results then the exiting algorithm.

The steps of the proposed algorithm are described as below:

Step1. Read the gray scale image: First of all read the gray scale image in the MATLAB software. The proposed technique is Used the Lena gray scale image to compare the results of proposed technique with the existing technique.

Figure 1: original Lena image

Step 2: Add the "salt pepper" noise to the image
In order to test the performance rate of this proposed algorithm experiments are Performed at different noise levels ranging from 5% to 40% on two types of images. The two images Lena and cameraman are two dimensional 8-bit grayscale images. Impulse noise of different percentages ranging from 5% to 40% is added to the two types of images. Intensive simulations were carried out on the impulse noise (salt and pepper).it show fig 2.

Figure 2: noisy Lena image

A step 3.3x3 window masks is used: In the third step 3x3 matrix scanning based on median filtering. The neighboring pixels are ranked according to brightness (intensity) and the median value becomes the new value for the central pixel. Median filters can do an excellent job of rejecting certain types of noise, in particular, "shot" or impulse noise in which some individual pixels have extreme values. In this filtering operation, the pixel values in the neighborhood window are ranked according to intensity and the middle value (the median) become the output value for the pixel under evaluation. so the process is apply to the 3x3 matrix scanning based median filter to the noisy gray scale image. It remove the noise from the previously generated noisy image as fig **2**.After 3x3 matrix Scanning it show the result as in the fig **3**.

Figure 3: this image represent the filter outputs of the 3x3 window mask

I,J				
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Figure 4: represents the Filter definition of spatial domain

This figure represents the scanning process of rows and columns of the image. It means that it scan the centre pixel of the window by considering the neighborhood value. Basically this process is used in the median filters to decide the pixel is noisy or not if it has noise than discard the noisy pixel and replace it by calculating the average value of the neighboring pixel. The figure represents the output of the centre pixel if pixel is considered as a noisy in the scanning process after taking the centre pixel than calculating the median of the neighboring pixel and replaces the noisy pixel with averaging value of the neighboring pixels and discards the noisy pixel.

The figure represents the what kind of boundary effects can be on the gray scale image by using 3x3 median filters, It can also say that wither it remove the noise on the boundaries or not.

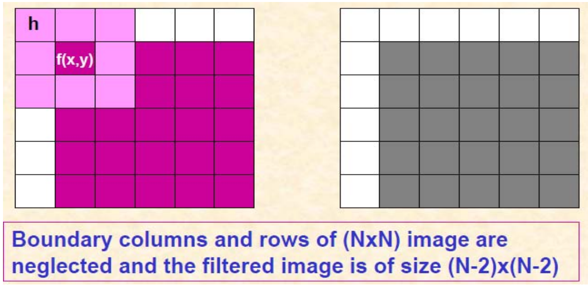

Figure 5: represents the boundary effects by using 3x3 Mask windows

The 3x3 mask window put the effects on the boundary of the gray scale image. This is the disadvantage of the 3x3 median filters because it can scan the image up to the columns-2 and row-2, therefore boundary columns and rows are neglected.

Step 4: Remove noise from the boundaries of the image by using 3x2 and 2x3 mask window. Process is same as in the previous step but in the previous 3x3 scan matrix has some disadvantage that it remove the noise from the centre of the image but some kind of noise is remain on the edges of the image. So to remove the noise from the edges of image 3x2, 2x3 matrix scanning is used Basically these mask windows are used to remove the noise on the image boundary. it produce the better quality image .The figure no. 6,7,8,9 represent the scanning process of the 2x3,3x2 window mask on the boundaries. It represent that how these mask are move on first and last row and first and last column.

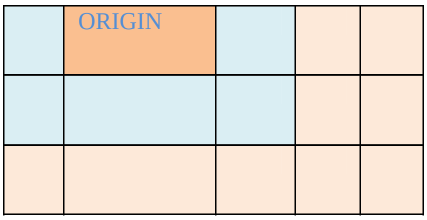

Figure 6: represents the scanning process of the 2x3 matrix scanning on first row.

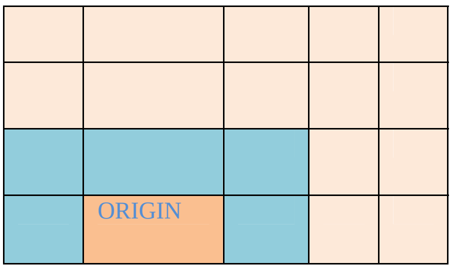

Figure 7: represents the scanning process of the 2x3 matrix scanning on last row.

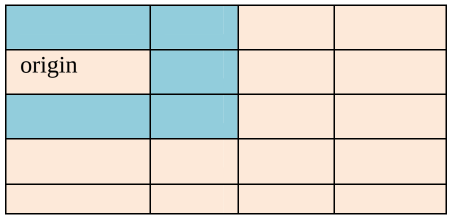

Figure 8: represents the scanning process of the 3x2 matrix scanning on first column.

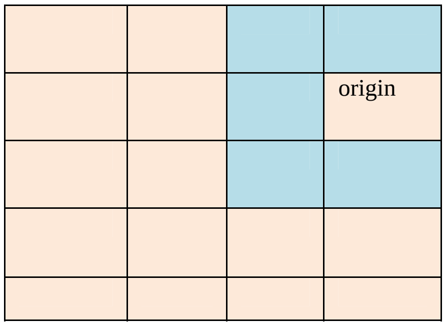

Figure 9: represents the scanning process of the 3x2 matrix scanning on last column.

Step 5: Again to improve the image quality 4x4 matrix scanning based on median filter is used and create the histogram also. Histogram is creating to show the remaining noise in the image. It shows in the fig 3.4(d). Same process is repeated again for the 4x4 matrix scanning for the removal of noise by using weighted median filter. As like in the 3x3 mask it scan the matrix up to row-2, and col-2 only. And in the process of 3x2 mask which is used only for the boundary scanning matrix.

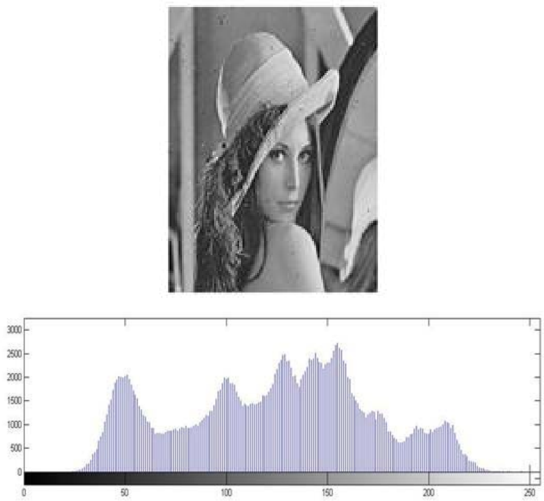

Figure 10: after apply the 3x2 and 4x4 matrix scanning based on median filter and create histogram of the image

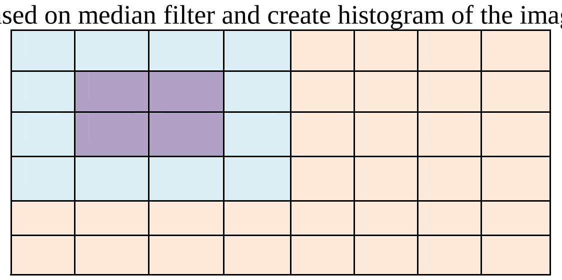

Figure 11: represents the scanning process of the 4x4 matrix scanning

So now at last it have applied the 4x4 to improve the image quality more and it will scan the matrix up to row-3, col-3 to remove the noise from the gray scale corrupted Lena image.

Step 6: By using thresholding value concept is used to remove the noise that is shown in the previous step 5.Agian it is used to improve the quality of the previously generated image in fig 10 and after removing the noise from the fig 10,it produce the fig 12 along with the histogram of the image.

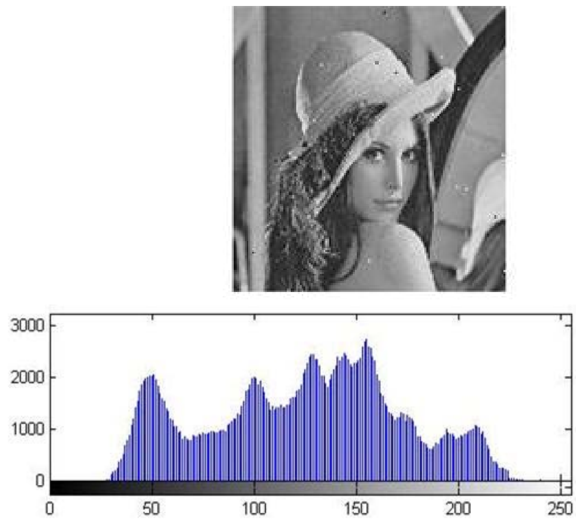

Figure 12 represent the better quality image and remaining noise is filtered by using the threshold value

3. Results and Discussions

The performance of the proposed algorithms was evaluated in terms of the visual quality, the peak-signal-to-noise-ratio (PSNR) and the stability of the performance of filters on different types of images. The experiment was carried out to study the performance of the detection schemes in identifying the noisy pixels in the Lena image at different impulse noise ratios.

PSNR=10log10 (R^2/MSE) **(1)**

$$MSE = \frac{1}{MN}\sum_{j=1}^{M}\sum_{i=1}^{N}\left(G(i,j)-F(i,j)\right)^2.$$ **[11]** **(2)**

MSE of various filters for Lena image:

Noise %	*Median*	*Switching Median*	*ISMF*	*Proposed Method*
5	75.3	42.8	39.1	4.07
10	82.7	58.4	51.4	5.13
15	96.4	83.7	72.4	7.91
20	117.9	104.5	92.3	10.08
25	141.7	138.6	126.2	12.49
30	185.6	186.3	165.8	19.57
35	236.5	252.3	227.2	24.28

Table 1: Comparison of the results MSE of Existing technique with the proposed method technique filter for the Lena image [10]

Output Results of results of different algorithms as follow:

percentage	*5*	*10*	*20*	*30*	*40*
3x3 MF(psnr)	34.88	28.14	26.52	24.12	20.25
5X5 MF(psnr)	34.46	29.75	27.52	23.83	21.61
AMF(psnr)	34.78	28.06	26.78	24.02	23.16
AWMF(psnr)	35.73	36.24	34.27	30.77	27.23
Proposed Method(psnr)	42.60	41.25	38.57	35.59	32.09

Table 2: Comparison of the results of PSNR of Existing techniques with the proposed method technique filter for the Lena image [9]

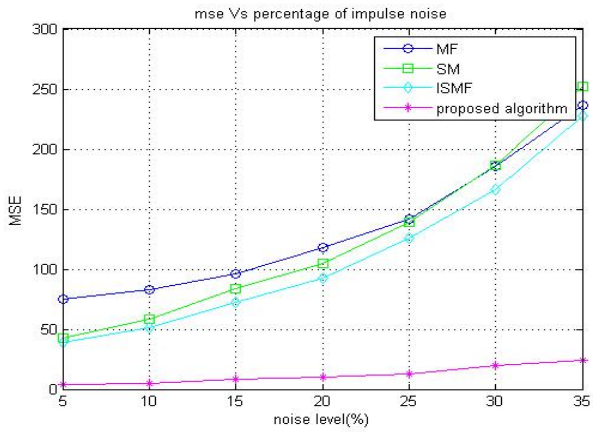

Figure 13: Variation of MSE of table 1 with respect to the impulse-noise percentage for different values on the Lena image [10]

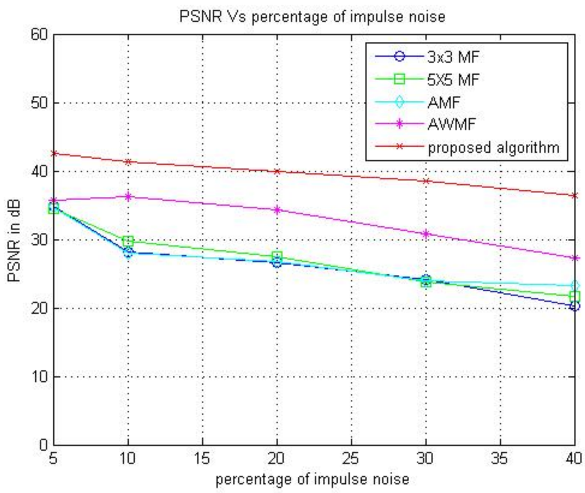

Figure 14: Variation of PSNR of table 2 with respect to the impulse-noise different percentage on the Lena image [9]

4. Conclusion

It have been concludes that the proposed filtering technique gives the better results as compared to the exiting technique. It detects and removes impulse noise in gray scale digital images. It detects noisy pixels by using voting procedure and replace noisy pixel with a median of neighboring pixels. After then remaining noise is removed by creating the histogram of that image by using threshold value. It analysis this method with PSNR (Pick Signal Noise Ratio) metric and MSE (mean square error) and visual comparison, the results show this method is very good for noise reduction as compared with the exiting technique.

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