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A METHOD OF IMPULSE NOISE DETECTION BY USING LAPLACIAN-GAUSSIAN FILTER ADAPTED WITH GENETIC ALGORITHM

Maisaa Husam Al_anizy

Department of Computer Science, College of Medicine, University of Al_Mustansria. Baghdad-Iraq

Abstract
In this paper, impulse noise detector found in an image by using Laplacian-Gaussian filter is proposed. The LG filter used for smoothing the noise in image. The flat parts of contour, detected by a set of different threshold for noise detected to perform the task of removing impulse noise. Finally, based on the genetic algorithm, the genetic learning the process adjusts the parameters of image base. Based on the criteria of Peak Signal to Noise Ratio(PSNR), Mean Square Error(MSE) and Mean Absolute Error(MAE) to achieves a better performance that proposed method performs significantly better than traditional methods.
Keywords: laplacian Gaussian, Genetic Algorithm, PSM filter.

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1. Introduction

Digital image is digitized to convert it to a form which can be stored in a computer memory or on some form of storage media such as hard disk or CD-ROM. This digitization procedure can be done by scanner, or by video camera connected to a frame grabber attached to computer. Once the image has been digitized, it can be processed by various image processing operations. Image processing operations [1] can be roughly divided into three major categories, Image Compression, Image Enhancement and Restoration and Measurement Extraction. Image compression involves in reducing the amount of memory needed to store a digital image. Image restoration is the process of taking an image with some known information, or estimated features, degradation, and restoring it to its original

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appearance. Image restoration is often used in the field of photography or publication where an image was somehow degraded, but need to be improved before it is printed. Image enhancement (IE) improves images visually. The main advantage of IE is the removal of noise in the images[2].

1.2 Noise in Images

Image noise is the random variation of brightness or color information in images produced by the sensor and circuitry of a scanner or digital camera. Image noise can also originate in film grain and in the unavoidable shot noise of an ideal photon detector. Image noise is generally regarded as an undesirable by-product of image capture. Although these unwanted fluctuations are known as "noise" by analogy with unwanted sound, they are inaudible and actually beneficial in some applications, such as dithering. Impulsive noise (like, salt and pepper noise) is caused by sharp, sudden disturbances in the image signal; its appearance is randomly scattered white or black (or both) pixels over the image. Figure (1) shows an original image and its variant after corrupted with salt and pepper noise. Noise filtering can be viewed as removing or smoothing the noise exit in the degraded image, so that the original image can be viewed. Noise filtering can be viewed as handling the value of every noisy pixel in the image[3].

Figure 1:right (Original Image), left (Noisy)

Impulse noise is caused by malfunctioning of same picture element in camera sensors, faulty memory locations in hardware, or transmission in a noisy channel. Two common types of impulse noise are the salt-and-pepper noise and the random valued noise. For images corrupted by salt-and-pepper noise (respectively random-valued noise), the noisy pixels can take only high and the low values (respectively any random value) in the dynamic range. There are many research for restoration of images corrupted by impulse noise.

The median filter was one of the most popular nonlinear filter for removing impulse noise, that is has a efficiency power of denoising[3]. Over the last two decades, there is a significant improvement in the deployment of median filters. However, when noise probability of occurrence is over 20%, some details and edges of the original image are smeared by the filter. Different remedies of the median filter have been proposed to make it adaptive median filter, the multistate median filter, or the median filter based on homogeneity information. These so-called "decision-based" or "switching" filters[4] firstly, they identify the possible noisy pixels and then replace them using the median filter or its variants, while leaving all other pixels unchanged. These filters are good for detecting noise even at a high noise level. Their main drawback is that the noisy pixels are replaced by some median value in their vicinity without taking into account local features such as the possible presence of edges. Hence details and edges are not recovered satisfactorily, especially when the noise level is high.

2.1 Conventional Methods of Impulse Noise

In this study, will deal with random value and fix value of impulse noise. First, the image degraded by impulse noise with fixed value $x(i;j)$ is defined as follows. For two level impulse noise (salt and pepper) the noise image is:

$$x(i,j) = \begin{cases} x_0(i,j) & :probability\ 1-q \\ 0 & :probability\ q/2 \\ 255 & :probability\ q/2 \end{cases} \quad ....(1)$$

Here, $(i;j)$ represents the coordinates of the image pixel, $x_0(i;j)$ is the original pixel value, q is the noise probability.

Also, the image may degraded by one level random valued impulse noise $x(i;j)$ it is defined as follows:

$$x(i,j) = \begin{cases} x_0(i,j) & :probability\ 1-q \\ h & :probability\ q \end{cases} \quad ....(2)$$

Here, h is uniform distribution within [0,255].

2.2 PSM (Progressive Switching Median) Filter

The impulse detector is developed by prior information on natural image, a noise free image should be locally smoothly varying, and is separated by edges. The noise considered by algorithm is only salt–pepper (in our study) impulsive noise which means: 1) only a proportion of all the image pixels are corrupted

while other pixels are noise-free and 2) a noise pixel takes either a very large value as a positive impulse or a very small value as a negative impulse. In this paper, we use noise ratio R(0 < R > 1) to represent how much an image is corrupted. For example, if an image is corrupted by R = 30% impulse noise, then 15% of the pixels in the image are corrupted by positive impulses and 15% of the pixels by negative impulses.

Two image sequences are generated during the impulse detection procedure. The first is a sequence of gray scale images $\{x_i^{(0)}\}, \{x_i^{(1)}\}, \dots \{x_i^{(n)}\}$ where the initial image $\{x_i^{(0)}\}$ is the noisy image to be detected, $x_i^{(0)}$ denotes the pixel at position $i = (i_1, i_2)$ in the initial noisy image and $x_i^{(n)}$ represents the pixel value at position i in the image after the nth iteration. The second is a binary flag image sequence, $\{f_i^{(0)}\}, \{f_i^{(1)}\}, \dots \{f_i^{(n)}\}$ where the binary value $f_i^{(n)}$ is used to indicate whether the pixel i has been detected as an impulse, i.e., $f_i^{(n)} = 0$ means the pixel i is good and $f_i^{(n)} = 1$ means it has been found to be an impulse. Before the first iteration, should assume that all the image pixels are good, i.e., $f_i^{(0)} = 0$

In the nth iteration (n=1,2,…), for each pixel $x_i^{(n-1)}$, first find the median value of the samples in a $W_D \times W_D$ window centered about it. If used Ω_i^W to represent the set of the pixel within a $W \times W$ window centered about i.

$$\Omega_i^W = \{j = (j_1, j_2) | i_1 - (W-1)/2 \leq j_1 \leq i_1 + (W-1)/2, i_2 - (W-1)/2 \leq j_2 \leq i_2 + (W-1)/2\} \dots (3)$$

A structure of the PSM filter is shown in(Fig 2). The PSM filter consists of the noise detector and the noise filter. In the noise detector, the current pixel x(i, j) is judged whether it is corrupted by an impulse noise or not using neighborhood pixels. First, a median value of neighborhood pixels m(i,

j) is obtained. Next, a binary flag image P(i, j) is given by

$$P(i,j) = \begin{cases} 1 & |x(i,j) - m(i,j)| \geq T_D \\ 0 & otherwise \end{cases} \dots (4)$$

Where T_D is a threshold of the noise detection P(i, j) = 1 means x(i, j) is corrupted by an impulse noise. On the other hand, P(i, j) = 0 means x(i, j) may be a good pixel. If T_D is small, almost noises are detected. However, good pixels are regarded as a noise pixel. On the other hand, in case that T_D is large, the mis-detection is decreased with increasing the undetection. In the noise filter, x(i, j) is processed based on the binary flag image. The noise filter processes to only noise pixels using neighborhood good pixels. Since the noise filter processes based on the binary flag image, the PSM filter performs satisfactorily in removing impulse noise. Therefore, the performance of the noise filter depends on the binary flag image[3].
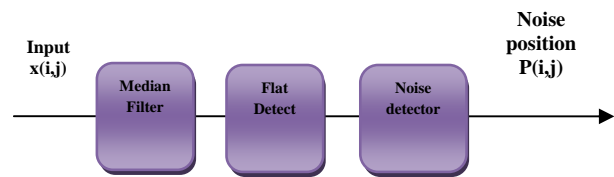

Figure 2: PSM noise detector

A) x(i; j) is the input signal of an image and n is the location of noise in the image. of image noise in the iteration of calculated by function $f_n(i; j)$ which used to detect impulse noise of image nth and filtered by the function $y_n(i; j)$ that when their initial values are determined using the following equations:

$$y_0(i,j) = x(i,j) \dots (5)$$

$$f_0(i,j) = 0 \quad \dots (6)$$

B) $y_n(i; j)$ and $f_n(i; j)$ are updated as follows:

$$f_n(i,j) = \begin{cases} f_{n-1}(i,j) & if \ |y_{n-1}(i,j) - m_{n-1}(i,j)| < T_D \\ 1 & otherwise \end{cases} \dots (7)$$

$$y_n(i,j) = \begin{cases} m_n(i,j) & if \ f_n(i,j) \neq f_{n-1}(i,j) \\ y_{n-1} & if \ f_n(i,j) = f_{n-1}(i,j) \end{cases} \dots (8)$$

The $m_{n-1}(i; j)$ is an image, and $y_{n-1}(i; j)$ is around

median value, T_D is the threshold for detecting impulsive noise value.

C) When n= N, set,

$$P(i,j) = f_n(i,j) \ldots (8)$$

As the noise position image P(i; j) are obtained, must keep consideration that if (n<N then, n= n+1). Here, N is the number of iterations to be set in advance. The recovery unit is obtained by performing the detection of the noise P(i; j), and possibility of removing impulsive noise. Also, by using only the pixel processing is not degraded by noise in the restoration process, get a better image processing than conventional median filters. However, in the case of random-valued impulse noise, the performance of the noise detector is significantly reduced. If the random-valued impulse noise is located in the middle of order statistics, the noise detector cannot detect the noise and the undetection is increased. If TD is set to small in order to decrease the undetection, the mis-detection is increased. Therefore, the random-valued impulse noise detection is more difficult than the fixed-valued impulse noise detection.

3. Proposed Study

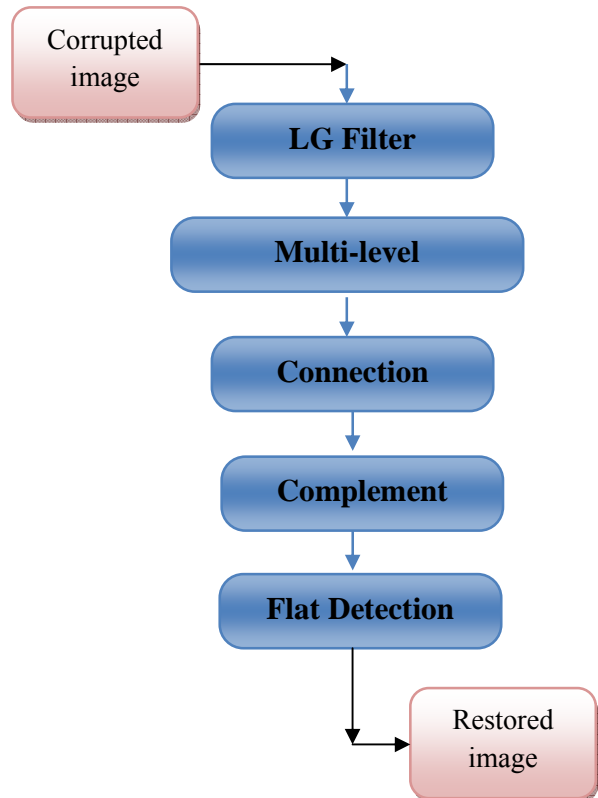(Figure 3) shows the configuration of a noise detector proposed in this study.

Figure 3: LG flat extraction filter based

3.1 Median Filter

The corrupted images by impulse noise, makes direct flat edge detection process be incorrectly detects edge and considered as a noise. In this study in order to detect the false noise and removes impulsive noise using median filter as a pretreatment, LG false contour is suppressed in the filter, thereby improving the detection accuracy of the flat.

3.2 - Flat Detector for Gaussian

In this study, the LG performed using the flat edge detection filters, in reference [5] LG used five methods of filtering to detect the edge of the flat portion. (Figure 3) shows the flow of detection filter, the flat detector, LG filter, multilevel process, connection process, and completion processing all are done by flat detection part.

3.2.1 LG filter

The Laplacian of an image has largest magnitudes at peaks of intensity and has zero crossings at the points of inflection on an edge. Different versions of the digital Laplacian have different noise performance characteristics but because it is always sensitive to noise, the

Laplacian is often applied to an image that has first been smoothed with an approximation of a Gaussian smoothing filter. However, the computation of the zero crossings is complicated in general and although zero crossing positions are correct for ideal edges, errors as large as the standard deviation of the Gaussian can occur in other cases. The zero-crossing detected edges often include many small closed loops because a threshold, if applied, is very small and the weak edges at the closed boundaries of many small minor regions are detected. The components of the F-type of LG filters are determined in F(i; j) as defined follows:

$$F(i,j) = \frac{k}{4\pi\sigma^2}\left(1 - \frac{i^2 + j^2}{2\sigma^2}\right)exp\left(-\frac{i^2 + j^2}{2\sigma^2}\right) \ldots (8)$$

Here, σ^2 distributed, and k is a constant. The LG filter contour detection performance parameters can be adjusted by σ. If the outline can detect small details, σ can be detected only for large rough edge.
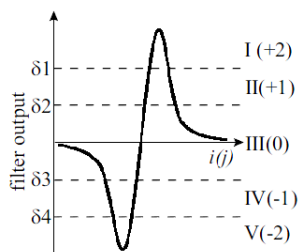

Figure 4: LG filter output 5 values

If the performance of image can be adjust, the σ fixed at appropriate value to improve the accuracy of contour detection in subsequent processes.

3.2.2 Multilevel Process

The processing of LG filtering is performed by using multilevel threshold values. In this study, the two by two neighborhood filter providing a positive and a negative threshold, and the five values of output of the LG filter are (+2; +1; 0; -1; -2). In the case of two single threshold value is difficult to separate the contours and flat, it is strictly necessary to set the threshold for it again. For that, increasing the threshold for the result of multilevel processing, is believed to be flat and

easy for separation of the contours. (Figure 4) shows the output of the LG filter and output of five values of threshold. One filter output value 4 threshold($\delta 1 \sim \delta 4$) is divided into five regions.

Here, the output values are ordered as shown (I, II, III, IV, and V).

3.2.3 The Consolidation Process

As discussed in 3.2.2, the levels (II and IV) detect the outline of the area within the region, and are connected to processing. To performing consolidation process is by stores where the contour is considered; and the noise and other flat parts are removed. Consolidation process is conducted as follows:
* (I) is coupled to (II) to replace all.
* (V) is coupled to (V) to replace all.
* All other (III*II) to replace all (IV).
(II * IV) are connected, if not connected to pixel will treated as a noise.

3.2.4 Completion Processing

The complete process used to detect the pixels that seem to be missing parts of the contour. Now, to complement of the missing pixels of the outline can be determined as:

1. The pixel III (8 pixels, I and V) is close to (1) and if it exist, the pixel (VI) will be replaced.
2. The pixel III (4 pixels, I and V) was near there and in the direction from the target pixel to pixel (6)
3. The pixel III (8 pixels, VI and I) in the vicinity of the pixel, or if there is a combination of (VI and V) will replace with the (VI) pixel. Here, Figure 5 (a), (b) shows the vicinity around (4 to 8).
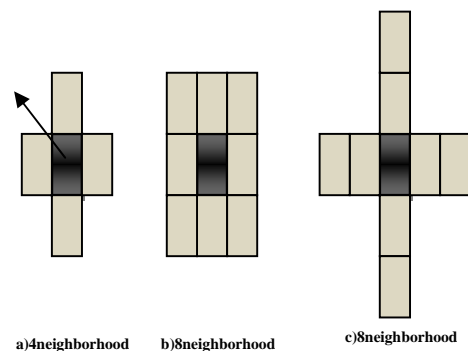
Center pixel

a)4neighborhood   b)8neighborhood   c)8neighborhood

Figure 5: The neighborhood filter

3.2.5 Flat Detection Process

Here are filled in based on results of 3.2.4, to detect the flat edge. Complementary images treated (I * V * VI, and III) are present in the pixel. Among the pixels around the edges (I * V, and VI) as a supplement to the edge pixel, (I * V * VI) as part of the contour pixel detected. On the other hand, (III) is a pixel not related to the contour pixels.

3.3 Noise Detection

The noise detector, make a determination based on the detection result of the flat. Where it is determined that the flat part has a small variation of pixel values near the treatment is considered a small difference between neighboring pixels and pixel processing of non-degradation. Thus, equation (5) TD threshold for even less likely to occur to reduce the false positive, T_D made a decision to reduce the noise. On the other hand, where the contour is determined, the large variation of pixel values near the handle, and tend a large difference between neighboring pixels and pixel processing, even the non-degradation. Therefore, in order to suppress the occurrence of false positives, T_D make a determination to increase the noise. Here, the flat We found that the LG flat filter by setting a different threshold in the contour, while suppressing the increscent of false positives can be reduced undetected.

3.4 Learning Parameters Using Genetic Algorithm

The proposed method has been used in the process of the six thresholds for noise detection and treatment of multi-level treatment. When considering the set value of thresholds, the search space becomes very large space that can be said to traverse almost impossible. Therefore, in this study as a method of determining threshold, the genetic algorithm (GA)[5] used. The GA set a facilitate to effect the detection of threshold noise as possible, and GA is conducted on multilevel and noise detection processes.

4. Simulation

To confirm the effectiveness of the proposed method, noise detection is performed using the actual image. In this study as a measure of detection accuracy, detection rate and can not properly detect the impulsive noise using the false positive rate would determine the noise and non-

degraded pixels incorrectly. The PSNR is used as an indicator of restoration accuracy. The size of the detector Median filter window is 3 to 3. In addition, set the values of LG filter as k=16 and σ = 0.9.

4.1 Learning Parameters

In this study, GA as a simple GA[7] used to study the parameters. (Table 1) shows the parameters for GA learning.

Table 1: GA Parameters

Gene length	48bit
Population	50
Crossover rate	0.1
Mutation rate	0.01
Generations exit	150

4.2 Noise Detection

Noise detection is performed for the actual image, and compared with the conventional method for the detection results, which confirm the effectiveness of the proposed method. As a conventional method, PSM filter detector [3] is used. Conventional parameters of the restored image PSNR is set as highest value. When the false positive rate is added, indicating that there is non-detection rate, and this detected by using the proposed flat against the contours of false positives to occur while using the larger threshold T_D, the flatness of the false positives are less, that cause a small threshold because the noise was detected. Therefore, the proposed increase of false positives, and considered to reduced undetected.

4.3 Image Restoration

Based on the information that obtained by detection the noise position compared with the proposed detector, PSM filter [4] to verify the effectiveness of the detector performs which actual restoration of the degraded image restoration. The pulse noise is equal to or higher than conventional 2dB PSNR. In addition, the random valued impulse noise compared with the conventional method and the PSNR be up to 5dB higher. The proposed method compared with conventional methods undetected has decreased significantly. When using the results of the proposed noise detection, removal may be due to noise than conventional methods. In addition, if there is a small difference between neighboring pixels and the noise, fixed rate is not detected in conventional method, but in the proposed method

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the fixed rate of undetected is suppressed. Thus, in a random valued impulse noise, the proposed method improved the PSNR which mean improves the detection accuracy. Finally, the visual evaluation of the restored image shown in (figure 6) q = 10% impulsive noise by adding random values of Salt/pepper noise, and the detection results for each detector PSM filter, image restoration shown (figure 6) (c) and (d) a more conventional flat portion (such portion of the background) stands out residual noise. On the other hand, the proposed method, the residual noise is significantly reduced in the flat part that.

The proposed method is almost the same while reducing the false positives with the conventional method, which is greater than the conventional method to reduce undetected. As a result, the outline is stored in the same level as conventional methods of noise is considered to be flat while it was eliminated than the conventional method.

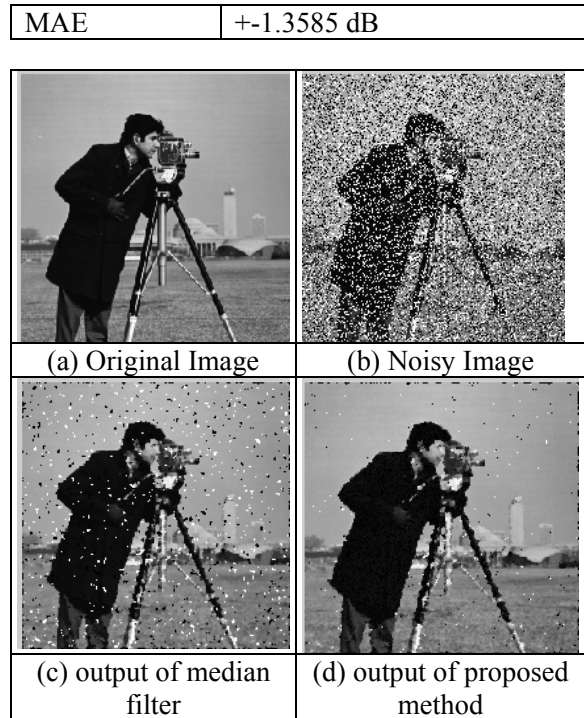These results also confirmed the effectiveness of the proposed method visually.

MAE	+-1.3585 dB

(a) Original Image	(b) Noisy Image
(c) output of median filter	(d) output of proposed method

Figure 7:Restore Image method at noise=40

These results also confirmed the effectiveness of the proposed method visually.

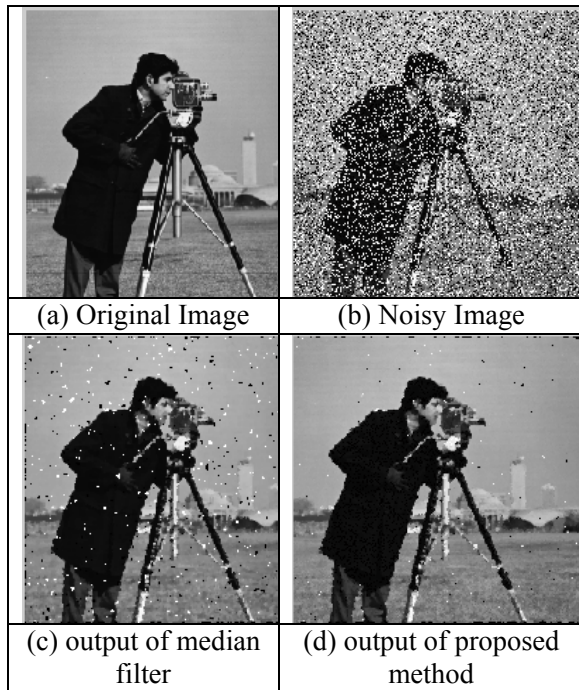**Table 3: Result of proposed method at noise=40**

PSNR	+20.9785 dB
MSE	+519.0701 dB
MAE	+-1.5727 dB

(a) output of median filter	(b)output of proposed method

Figure 8: Restore Image method at noise=45

Table 4: Result of proposed method at noise=45

PSNR	+20.9785 dB
MSE	+519.0701 dB
MAE	+-1.5727 dB

(a) Original Image	(b) Noisy Image
(c) output of median filter	(d) output of proposed method

Figure 6:Restore Image method at noise=35

Table 2: Result of proposed at noise=35

PSNR	+22.0020 dB
MSE	+410.0886 dB

(a) output of median filter | (b) output of proposed method
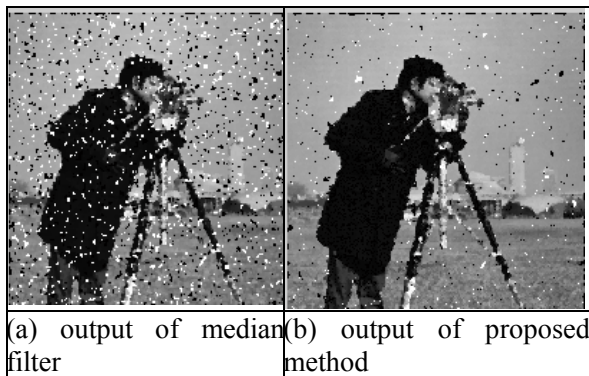
Figure 9: Restore Image at noise=50

Table 5: Result of proposed method at noise=50

PSNR	+18.6656 dB
MSE	+884.1351 dB
MAE	+-2.4695 dB

(a) output of median filter | (b) output of proposed method
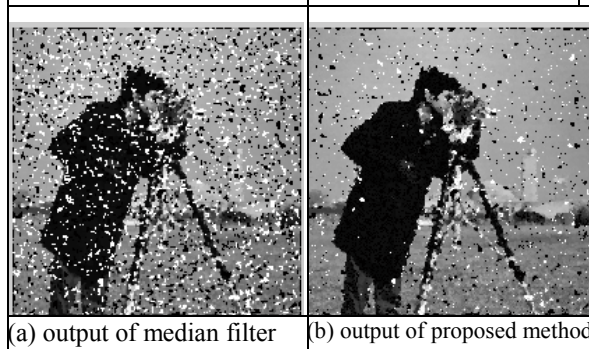
Figure 10:Restore Image method at noise=60

Table 6: Result of proposed method at noise=60

PSNR	+15.9197 dB
MSE	+1663.8422 dB
MAE	+-3.6282 dB

5. Conclusion

In this study, the LG (laplacian Gaussian) filter proposed impulse noise filter based detector by using a filter without noise emphasis can be detected contour of the flat portion of the image. The flat parts of the contour detected by setting different thresholds for each noise, also the random valued impulse noise; it is possible to suppress the noise which is not detected in the flat part. In addition, the GA (Genetic Algorithm) is used to learning the parameters were used to improve the accuracy of noise detection.

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