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Edge Detection with Detail Preservation for RVIN Using Adaptive Threshold Filtering Method

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Abstract: *Images are often corrupted by impulse noise in the procedures of image acquisition and transmission. In this paper we proposes a method for effective detection of noisy pixel based on median value and an efficient algorithm for the estimation and replacement of noisy pixel, the replacement of noisy pixel is carried out twicewhich provides better preservation of image details. The presence of high performing detection stage for the detection noisy pixel makes the proposed method suitable in the case of noiselevels as high as 60% to 90% random valued impulse noise; the proposed method yields better image quality.*
Index Terms: *Mean square error, Peak signal to noise ratio, Median filter, Random valued impulse noise.*

I. Introduction

Digital image processing is used in many areas. Noise removal in digital images is important in many fields.Digital images are often corrupted by impulse noise due to a noisy channel or faulty image acquisition device, much research has been done on removing such kind of noise. In the field of image processing, digital images very often get corrupted by several kinds of noise during the process of image acquisition. The objective is to suppress the impulse noise while preserving the edge detail information.

The most commonly used approach to performanceevaluation of image denoising techniques typically combinesvisual inspection and objective measurements based on thecomputation of pixel wise differences between the original andthe processed image, such as mean squared error (MSE) andpeak signal-to-noise ratio (PSNR). Since MSE and PSNR bythemselves cannot characterize the behavior of a filter withrespect to noise cancellation and detail preservation, a visualanalysis of the filtered pictures is often reported in researchpapers to highlight these important features. In an image transmission process, there are a lot of noises which are usually divided into three groups: Gaussian noise, balanced noise and impulse noise. Impulse noise displays as random white or black dots on an image. It corrupts the image and seriously affects the visual effects. Therefore, the impulse noise reduction has important significance to image processing.

Random valued impulse noise will generate impulses whose gray level values lies within a fixed range. The random-valued impulse noise is more difficult to remove due to the random distribution of noisy pixel and its value lies between 0 and 255. Most of the filters related to image denoising have two stages namely a detection stage and a replacement stage. Detection stage detects noisy pixel while replacement stage replaces the noisy pixel by estimated value. Noise detection is a key part of a filter, so it is necessary to detect whether the pixel is noisy or noise free. Only noisy pixels are manipulated to de-noising processing.

Standard median filters were used initially, but after that switching based median filters were developed which provides better results than standard median filter. Any other result oriented standard median filters were developed, like weighted median filter, Centre weighted median filter [14], SDROM filter [9], rank conditioned rank selection filter [13], adaptive median filter and many other improved filters. The consequences of median filter also depend on the size of filtering window. Larger window has the great noise suppression capability, but image details (edges, corners, fine lines) preservation is limited, while a smaller window preserves the details but it will cause the reduction in noise suppression. Noise detection is a vital part of a filter, so it is necessary to detect whether the pixel is noisy or noise free. Only noisy pixels are subject to de-noising and noise free pixels remains untouched.

This paper proposes efficient method for the removal of random valued impulse noise. The proposed method is divided into two part detection process and a filtering process. Detection process detects the noisy pixels by using the absolute difference and filtering process filter the noisy pixel by replacing it with median value. The outline of the paper isas follows. Section II, noise model,Section III, proposed project flow, Section IV proposed method, Section V, simulations and results and Section VIprovides the conclusion.

II. Noise Model

Two common types of the impulse noise are theFixed-Valued Impulse Noise (FVIN), also known as Salt and-Pepper Noise (SPN), and the Random-Valued Impulse Noise (RVIN). They differ in the possible values which noisy pixels can take. The FVIN is commonly modeled by

$$(Y_{ij}) = \begin{cases} X_{i,j} & \text{with probabilty } p \\ (0,255) & \text{with probabilty } 1-p \end{cases} \quad \text{.......... ....(1)}$$

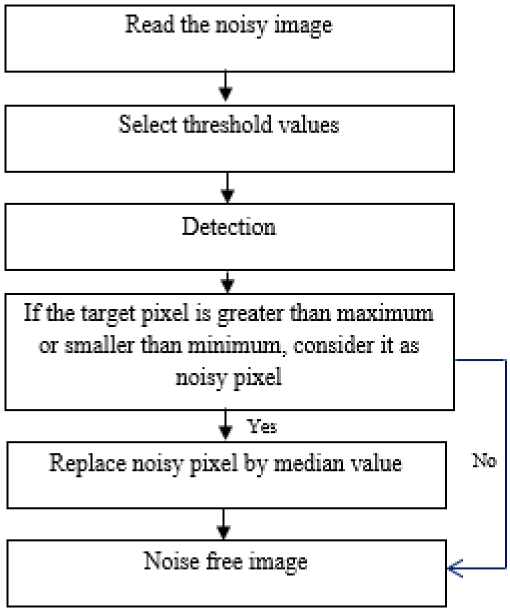
Where x(i,j) and y(i,j) denote the intensity value of the original and corrupted images at coordinate (i,j), respectively and p is the noise density. This model implies that the pixels are randomly corrupted by two fixed extreme values, 0 and 255 (for 8-bit grey-scale images), with the same probability [3].

A model is considered as below:

$$(Y_{ij}) = \begin{cases} (0,m) & \text{with probabilty } p1 \\ X_{i,j} & \text{with probabilty } 1-p \\ (255-m,255) & \text{with probabilty } p2 \end{cases} \quad \text{.......... ..(2)}$$

Where p = p1 + p2. We refer to this model as Random valued Impulse Noise (RVIN).

III. PROPOSED PROJECT FLOW



A. Selection of Threshold

The threshold values used must be selected based on the previous knowledge or experimental results of different digital images and is inversely proportional to noise density. Two adaptively calculated threshold values are utilized to get excellent results.

B. Evaluation Metrics

Our main objectives are to evaluate an output final image that is close to the original image. This can be achieving by comparing the Peak Signal to Noise Ratio (PSNR) values of both the output image and the original image systematically. To amplify the quality of restored image, Mean square error (MSE) and peak signal-to-noise ratio (PSNR) quality measure is utilized.

1. Mean square error (MSE)

The mean square error or MSE of an estimator is one of different ways to evaluate the difference between values implied by an estimator and the true values of the quantity being estimated under the MSE.

2. Peak Signal to Noise Ratio (PSNR)

The Peak Signal-to-Noise Ratio (PSNR) is an important metric to measure the objective dissimilarity of the filtered output from the original uncorrupted image.

IV. PROPOSED METHOD

The feature of the proposed median filter is described in this section which shows the efficient de-noising of highly corrupted images. The algorithm consists of two stages. In the first stage, the noisy pixels are detected by two dynamically calculated thresholds determined by median of each row, column. Its ability to detect noisy pixel withprecision even when multiple impulses are present within the sliding window.

In the second stage, if a pixel is considered to be noisy, it is substituted by performing a non-linear prediction from the neighbourhood pixels in the current window by calculating median prior to estimation. Then the noisy pixel is replaced by the median value of the pixels within the current window. The sliding window can be assumed 3X3 matrix, which has three rows, three columns and two diagonals as shown below:

Table I: Filtering window of size 3x3

	Column 1	Column 2	Column 3
Row 1	X_1	X_2	X_3
Row 2	X_4	X_5	X_6
Row 3	X_7	X_8	X_9

The proposed method executes in the following steps:
Step 1: Read the corrupted image and select a sliding window size of 3X3.
Step 2:Exclude the central pixel 'X_5' for 3X3 filtering window, and then calculate the maximum and minimum for the remaining 8 pixel in the filtering window.

$$\mathrm{Min}[X_r] = \min [X_1, X_2, X_3, X_4, X_6, X_7, X_8, X_9]$$
$$\mathrm{Max}[X_r] = \max [X_1, X_2, X_3, X_4, X_6, X_7, X_8, X_9]$$

Step 3: Detect whether the pixel is noisy or noise free. Now three conditions arise:
(a) If the value of target pixel lies between max and min value of current window then it is treated as noise free pixel.

$$\mathrm{Max}\ [X_r] > X_5 > \mathrm{Min}\ [X_r] \text{ - (Noise free pixel)}$$

(b) If the value of target pixel is greater than maximum or smaller than minimum, then it is treated as noisy pixel.

$$X_5 > \mathrm{Max}\ [X_r] \text{ or } X_5 < \mathrm{Min}\ [X_r] \text{ - (Noisy pixel)}$$

(c) If the value of target pixel equals the minimum or the maximum, means.

$$X_5 = \mathrm{Max}\ [X_r] \text{ or } X_5 = \mathrm{Min}\ [X_r]$$

Then we will determine whether it is an edge or a noisy pixel. For this detection process the filtering window will be divides the window into three rows and three columns.

Step 4: For each window, calculate the median value of each row and column denoted as

$$\text{Row } (M_{R1}, M_{R2}, M_{R3}) \text{ and Column } (M_{C1}, M_{C2}, M_{C3})$$

Step 5: Calculate the maximum threshold (Th_{max}) and minimum threshold (Th_{min}) using the medians calculated in the step 3.

$$Th_{max} = \max [M_{R1}, M_{R2}, M_{R3}, M_{C1}, M_{C2}, M_{C3}]$$
$$Th_{min} = \min [M_{R1}, M_{R2}, M_{R3}, M_{C1}, M_{C2}, M_{C3}]$$

Step 6: Check whether the value of the target pixel lies between Thmax and Thmin

$$Th_{max} > X_5 > Th_{min}$$

- If the above condition is true then it is considered as noise free pixel and goes to Step 3.
- If the above condition is false, then the pixel is treated as a noisy pixel and proceeds to Step 7.

Step 7: Calculate the median value of the current window.
Step 8: Replace the targeted noisy pixel (X_5) by the median value calculated in step 7.
Step 9: If the whole image is not processed, then go to step 3 otherwise advances to step 10.
Step 10: Stop.
Step 11: This whole phenomena we will apply for all 3X3 windows.

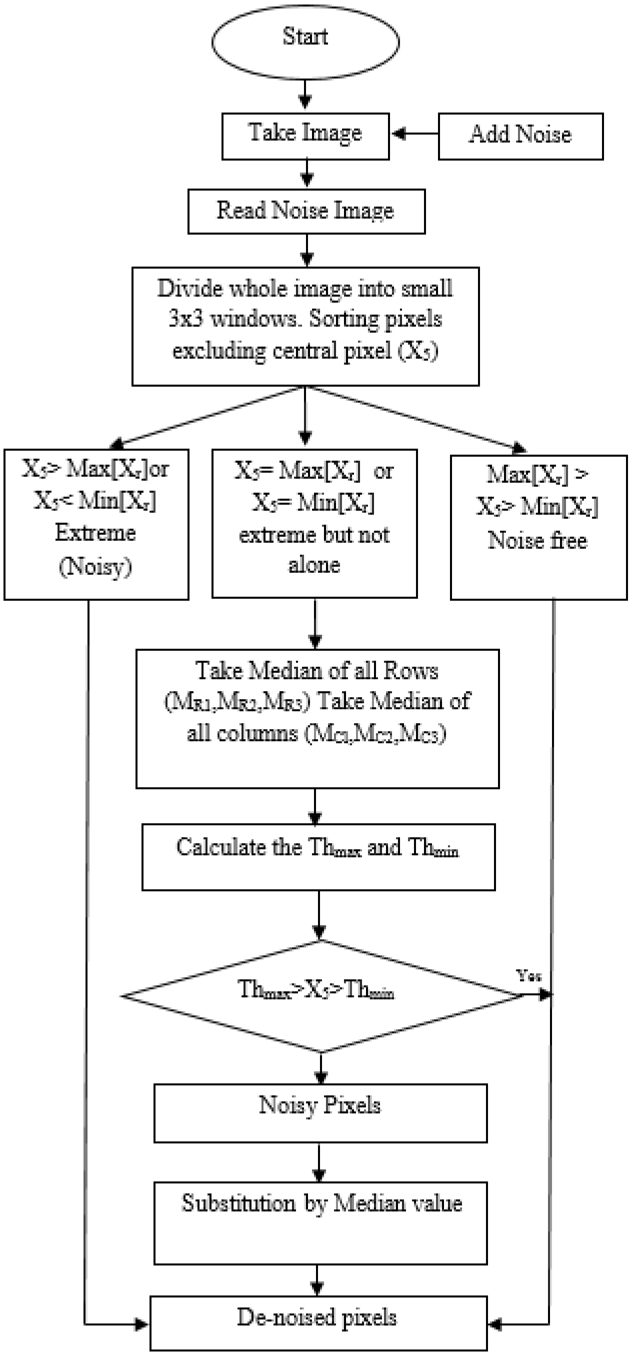


Fig.1Flow chart of proposed method for filtering window size 3x3.

Fig 2(a)Original Mandrill Image and Image Edge

Fig 2(b) 50% Noisy Image, Restored image and Restored Image edge

Fig 2(C) 60% Noisy Image, Restored image and Restored Image edge

Fig 2(d) 70% Noisy Image, Restored image and Restored Image edge

Fig 2(e) 80% Noisy Image, Restored image and Restored Image edge

Fig 2(f) 90% Noisy Image, Restored image and Restored Image edge

V. SIMULATION AND RESULTS

We performed this method on Matlab R2012b. This proposed method yields better results for high density noisy images. The performance of proposed method for removal of randomvalued impulse noise is shown in this section, here weconsidered standard test image Mandrill size 256X256 forsimulation purpose.All of these images are artificiallycorrupted by random valued impulse noise and images arecorrupted by high density of noise varying from 50 to 90 %.

The PSNR is expressed as:

$$PSNR = 10\log_{10}\frac{(255)^2}{\text{MSE}}$$

Where MSE (Mean Square Error) is

$$MSE = \frac{\sum_{i=1}^{m} \sum_{j=1}^{n} \{Z(i,j) - A(i,j)\}^2}{m \times n}$$

The results in the Table II clearly show that the PSNR of proposed method is much enhanced at high density of noise.As the density of noise increasing, the response of proposedfilter is becomes improved in contrast of other filters like Median filter (MF) [5], Centre weighted median filter (CWM) [14], Progressive switching median filter (PSMF) [10], Impulse Rejecting Filter (IRF), Signal dependent rank order median filter (SDROM), Recursive adaptive center weighted median filter (RACWM) [12], Tri-state median filter (TSM) [11]. This method is tested on Mandrill image of size 256X256 shown in fig 2(a). The figure 2(b), 2(c), 2(d), 2(e), 2(f), shows Noisy Mandrill image corrupted by 50%, 60%, 70%, 80% and 90% respectively, restored image and restored image edge denoised by proposed method.

Table IIComparison of PSNR values of different filters forMandrill image

De-noising Methods	Noise Density				
	50%	60%	70%	80%	90%
MF	14.7	12.3	10.9	8.3	6.8
CWM	12.9	10.9	9.1	7.7	6.6
PSM	19.5	15.3	11	8.9	6.5
SDROM	14.3	11.8	9.6	7.9	6.6
IRF	14.7	12.3	9.9	8.2	6.8
RACWM	20.2	18.2	15.4	12.4	8.8
TSM	12.6	10.5	8.6	7.2	6.2
Dual Median	24.05	23.26	22.65	22.17	21.71
Proposed Filter	**34.9**	**34.1**	**33.5**	**32.9**	**32.3**

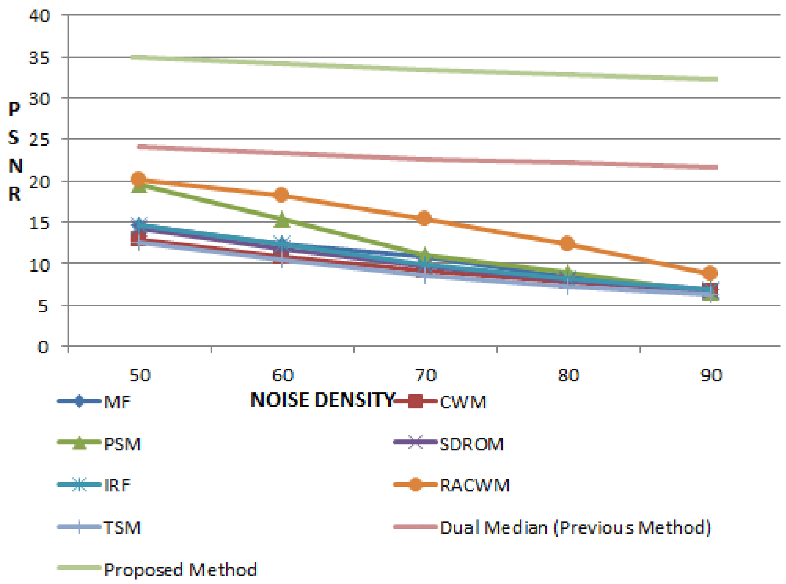


Fig.3 Graphical representation of PSNR of differentfilters at different noise density.

VI. CONCLUSION

In this paper median filtering is used for image de-noisingand edge preservation is used to improve peak signal to noiseratio (PSNR) and reducing mean square error (MSE) values.This method is proposed for the removal of random valuednoise from the gray scale images. The algorithm consists oftwo stages. In the first stage detection of noisy pixel is carriedout and in second stage noisy pixel is replaced by medianvalue using median filtering. The noisy pixels are detectedwith reference to three different condition which results ineffective detection. The experimental results show theproposed scheme performs better than other previous schemes. We have utilized the concept of maximum and minimum threshold to identify both edges and noisy part of image. It produces good PSNR and reduced MSE for highly corrupted images, especially for more than 50% noise density. The main advantage of our method is that two thresholds used and the threshold values can attentively update according to the noise density of filtering window. Threshold values will be disparate for different noise density methods as compare to other de-noising methods have either single threshold value or threshold having constant value throughout the image irrespective of density of noise. Our method shows good performance at different noise level. Also less complex sorting algorithm require because small number of elements are need to sort for the selection of minimum, maximum and median values.

Table III Comparison of MSE values of different filters for Mandrill image

De-noising Methods	Noise Density				
	50%	60%	70%	80%	90%
MF	2203.3	3829	5285.4	9617.9	13585.6
CWM	3334.8	5285.4	7999.8	11042.8	14225.9
PSM	729.6	1919	5165.1	8376.8	14557.2
SDROM	2104.1	3918.1	6967.5	10071.1	14557.2
IRF	2415.9	4296.1	7129.8	10545.8	14225.9
RACWM	620.9	984.1	1875.3	3741.8	8571.9
TSM	3573.3	5795.3	8975.9	12390.2	15598.4
Dual Median	285.8	301.5	346	392.7	448.2
Proposed Method	**20.74**	**25.78**	**28.38**	**32.82**	**37.81**

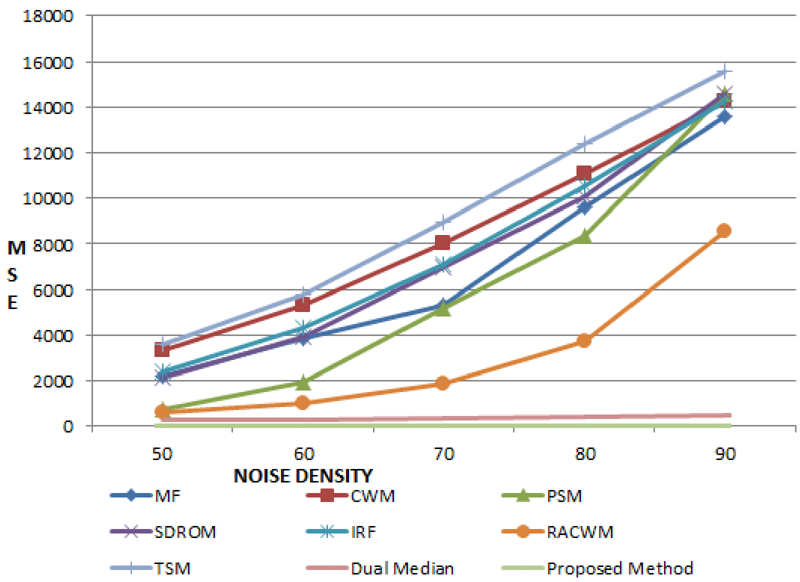


Fig.4 Graphical representation of MSE ofdifferent filters at different noise density.

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