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 propose 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 twice which 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 noise levels 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 performance evaluation of image denoising techniques typically combines visual inspection and objective measurements based on the computation of pixel wise differences between the original and the processed image, such as mean squared error (MSE) and peak signal-to-noise ratio (PSNR). Since MSE and PSNR by themselves cannot characterize the behavior of a filter with respect to noise cancellation and detail preservation, a visual analysis of the filtered pictures is often reported in research papers 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: 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 parts: 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 is as follows. Section II, noise model, Section III, proposed project flow, Section IV proposed method, Section V, simulations and results and Section VI provides the conclusion.

II. NOISE MODEL

Two common types of the impulse noise are the Fixed-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
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:

$$
(Y)_{ij} = \begin{cases} 
X_{i,j} & \text{with probability } p \\
(0,255) & \text{with probability } 1 - p 
\end{cases}
$$

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

III. PROPOSED PROJECT FLOW

1. Read the noisy image
2. Select threshold values
3. Detection
4. If the target pixel is greater than maximum or smaller than minimum, consider it as noisy pixel
5. Replace noisy pixel by median value
6. Noise free image

IV. PROPOSED METHOD

The feature of the proposed median filter is described in this section which shows the efficient denoising 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 with precision 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 neighborhood 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

<table>
<thead>
<tr>
<th></th>
<th>Column 1</th>
<th>Column 2</th>
<th>Column 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Row 1</td>
<td>X_1</td>
<td>X_2</td>
<td>X_3</td>
</tr>
<tr>
<td>Row 2</td>
<td>X_4</td>
<td>X_5</td>
<td>X_6</td>
</tr>
<tr>
<td>Row 3</td>
<td>X_7</td>
<td>X_8</td>
<td>X_9</td>
</tr>
</tbody>
</table>

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.

\[
\begin{align*}
\text{Min}[X_r] &= \min [X_1, X_2, X_3, X_4, X_6, X_7, X_8, X_9] \\
\text{Max}[X_r] &= \max [X_1, X_2, X_3, X_4, X_6, X_7, X_8, X_9]
\end{align*}
\]

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.

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

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

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

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

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

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

Row (M_{R1}, M_{R2}, M_{R3}) 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.

\[
\begin{align*}
\text{Th}_{\text{max}} &= \max [M_{R1}, M_{R2}, M_{R3}, M_{C1}, M_{C2}, M_{C3}] \\
\text{Th}_{\text{min}} &= \min [M_{R1}, M_{R2}, M_{R3}, M_{C1}, M_{C2}, M_{C3}]
\end{align*}
\]

Step 6: Check whether the value of the target pixel lies between Th_{max} and Th_{min}

\[\text{Th}_{\text{max}} > X_5 > \text{Th}_{\text{min}}\]

- 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.

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

Fig 2(a) Original Mandrill Image and 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 random valued impulse noise is shown in this section, here we considered standard test image Mandrill size 256x256 for simulation purpose. All of these images are artificially corrupted by random valued impulse noise and images are corrupted by high density of noise varying from 50 to 90%.

The PSNR is expressed as:

\[
PSNR = 10 \log_{10} \left( \frac{255^2}{MSE} \right)
\]
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 proposed filter 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>
<thead>
<tr>
<th>De-noising Methods</th>
<th>Noise Density</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>50%</td>
</tr>
<tr>
<td>MF</td>
<td>14.7</td>
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<tr>
<td>CWM</td>
<td>12.9</td>
</tr>
<tr>
<td>PSM</td>
<td>19.5</td>
</tr>
<tr>
<td>SDROM</td>
<td>14.3</td>
</tr>
<tr>
<td>IRF</td>
<td>14.7</td>
</tr>
<tr>
<td>RACWM</td>
<td>20.2</td>
</tr>
<tr>
<td>TSM</td>
<td>12.6</td>
</tr>
<tr>
<td>Dual Median</td>
<td>24.05</td>
</tr>
<tr>
<td>Proposed Filter</td>
<td>34.9</td>
</tr>
</tbody>
</table>

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

VI. CONCLUSION

In this paper median filtering is used for image de-noising and edge preservation is used to improve peak signal to noise ratio (PSNR) and reducing mean square error (MSE) values. This method is proposed for the removal of random valued noise from the gray scale images. The algorithm consists of two stages. In the first stage detection of noisy pixel is carried out and in second stage noisy pixel is replaced by median value using median filtering. The noisy pixels are detected with reference to three different condition which results...
ineffective detection. The experimental results show the proposed 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

<table>
<thead>
<tr>
<th>De-noising Methods</th>
<th>Noise Density</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>50%</td>
</tr>
<tr>
<td>MF</td>
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<tr>
<td>CWM</td>
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<td>PSM</td>
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<td>SDROM</td>
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<tr>
<td>RACWM</td>
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<tr>
<td>TSM</td>
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<tr>
<td>Dual Median</td>
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<tr>
<td>Proposed Method</td>
<td>20.74</td>
</tr>
</tbody>
</table>

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

REFERENCES


