# Efficient Removal of Impulse Noise Using Variable Threshold Value

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**Abstract-**Images are corrupted by impulse noise which caused by analog to digital converter and also by bit error in transmission. The key aim is to remove the impulse noise and also preserves the edge. In this paper we present a modify simple edge preserved and denoising (MSEPD) with variable threshold value. Extensive simulation shows it provides better PSNR ratio over other techniques.

**Keywords**- *Impulse noise, Image denoising ,variable threshold*

## I. INTRODUCTION

Many noises can be occurred in an image. Noise is an error mainly occurred during image acquisition and transmission. . Digital images are prone to a variety of noise. There are several ways that noise can be occurred in an image. For e.g. If the image is acquired directly in a digital format, the mechanism for gathering the data (such as a CCD detector) can introduce noise. Transmission of electronic data can introduce noise. Some noises are Gaussian noise, Rayleigh noise, Gamma noise, Exponential noise, Impulsive noise and so on. In this paper we had taken Impulse noise into consideration.

Digital images through sensors or communication channels are often interfered by Impulse noise. Impulse Noise get added into images in various steps such as image acquisition, recording and transmission. Impulse noise is also called as "salt and pepper " noise since the noise is generally in the form of "dark spots on bright background" and bright spots on dark background", the values of pixels of the noise are '0' and '255' i.e., the "minimum" and "maximum" values in gray scale respectively.

So, our aim is to efficiently remove this impulse noise and improve the image quality in a free manner. The rest of the paper is organized as follows section II: previous works, section III: A simple Impulse Noise Removal Technique, section IV: Results, section V: Conclusion, section VI: References.

## II. PREVIOUS WORKS

A Large number of techniques have been proposed to remove impulse noise while preserving image details. Many of the earlier works employ the standard median filter or its modifications are used because of their noise suppression capability. However, these approaches might blur the image since both noisy and noise free pixels are modified. To avoid the damage on noise-free pixels, an efficient switching strategy has been proposed in the paper.

In general, the switching median filter [1] consists of two steps: 1) impulse detection and 2) noise filtering. It locates the noisy pixels with an impulse detector and then filters them rather than the whole pixels of an image to avoid the damage on noise-free pixels. Generally, the denoising methods for impulse noise suppression can be classified into two categories: lower-complexity techniques [2]-[9] and higher-complexity techniques. The former uses a fixed-size local window and requires a few line buffers. Furthermore, its computational complexity is low and can be comparable to conventional median filter or its modification. The latter yields visually pleasing images by enlarging local window size adaptively. In this paper, we focus only on the lower complexity denoising techniques because of its simplicity and easy implementation. In [2], Zhang and Karim proposed a new impulse detector (NID) for switching median filter. NID used the minimum absolute value of four convolutions which are obtained by using 1- DLaplacian operators to detect noisy pixels. A method named as differential rank impulse detector (DRID) is presented in [3]. The impulse detector of DRID is based on a comparison of signal samples within a narrow rank window by both rank and absolute value. In [4], Luo proposed a method which can efficiently remove the impulse noise (ERIN) based on simple fuzzy impulse detection technique. An alpha-trimmed mean-based method (ATMBM) was presented in [5]. It used the alpha-trimmed mean in impulse detection and replaced the noisy pixel value by a linear combination of its original value and the median of its local window. In [6], a decision-based algorithm (DBA) is proposed to remove the corrupted pixel by the median or by its neighboring pixel value according the proposed decisions. In [11] a system based on simple edge preserved denoising technique (SEPD) is proposed which uses fixed threshold for edge detection. Now we propose a system in this paper which uses a variable threshold for edge detection.

## III. A SIMPLE IMPULSE NOISE REMOVAL TECHNIQUE

Assume that the current pixel to be denoised is located at Coordinate (i,j) and denoted as $P_{i,j}$ and its luminance values before and after the denoising process are represented as $f_{i,j}$ and $\bar{f}_{i,j}$ , respectively. If it is corrupted by the fixed-value impulse noise, its luminance value will jump to be the minimum or maximum value in gray scale. Here, we adopt a 3*3 mask W centering on $P_{i,j}$ for image denoising. In the current , we know that the three denoised values at coordinates(i-1,j-1),(i-1,j) and(i-1,j+1) are determined at the previous denoising process and the six pixels at coordinates(i,j-1),(i,j) ,(i,j+1),(i+1,j-1), (i+1,j) and(i+1,j+1) are not denoised yet, as shown in Fig. 1. A pipelined hardware architecture is adopted in the design, so we assume that the denoised value of $P_{i,j-1}$ is still in the pipeline and not available. Using the 3 *3 values in W, MSEPD will determine whether $P_{i,j}$ is a noisy pixel or not. If positive, MSEPD locates a directional edge existing in and uses it to determine the reconstructed value $f_{i,j}$; otherwise , $f_{i,j} = \bar{f}_{i,j}$

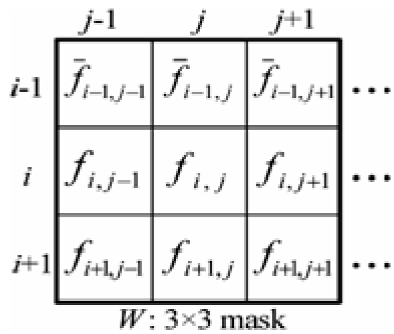



Figure1. 3*3 mask

MSEPD is composed of three components: extreme data detector, edge-oriented noise filter and impulse arbiter.

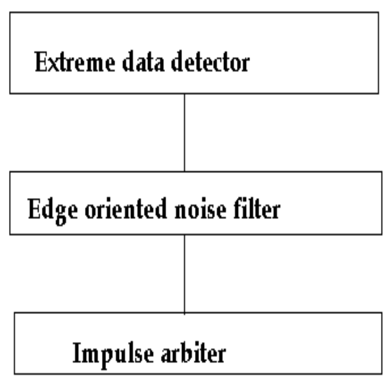



Figure 2. Basic Block Diagram

The extreme data detector detects whether the subject pixel is noisy or not, if found noisy then the pixel is passed to edge oriented noise filter and impulse arbiter, if not the two stages i.e., edge oriented noise filter and impulse arbiter are skipped and the original value of the subject pixel is retained. The edge oriented noise filter processes the subject pixel with a particular algorithm so that the noise detected can be eliminated and the denoised value is obtained. The impulse arbiter checks whether the denoised value and the original value of the subject pixel are separated by a variable threshold value so that it can consider that there is no edge present. If the denoised pixel value is inside the threshold value range then the original value of the subject pixel is retained assuming that an edge is located at that particular point. In this way the proposed filter works and the following sections cover the extreme data detector, edge oriented noise filter and impulse arbiter

### *a)* EXTREME DATA DETECTOR:

The extreme data detector detects the minimum and maximum luminance values (MIN in W and MAX in W) in those processed mask W and determines whether the luminance values of $p_{i,j}$and its five neighboring pixels are equal to the extreme data. If a pixel is corrupted by the fixed-value impulse noise, its luminance value will jump to be the minimum or maximum value in gray scale.
If $f_{i,j}$ is not equal to MIN in W or MAX in W,thenpi,j is a noise-free pixel and the steps for denoisingp$_{i,j}$ are skipped. If $f_{i,j}$ is equal to MIN in W or MAX in W , we set to Φ to 1, check whether its five neighboring pixels are equal to the extreme data, and store the binary compared results into B where( B= $b_0$,$b_1$, $b_2$, $b_3$, $b_4$).

### *b)* EDGE ORIENTED NOISE FILTER:

The edge-oriented noise filter observes the spatial correlation between pixels pinpoints a directional edge and uses it to generate the estimated value of the current pixel. To decide the edge, 12 directional differences, from to $D_1$ to $D_{12}$ is considered. Only those composed of noise-free pixels are taken into account to avoid possible misdetection. The five neighboring pixels of the current pixel pi,j to be processed ,are arranged with thirty two different combinations. If a bit in B is equal to 1, it means that the pixel related to the binary flag is suspected to be a noisy pixel.
Directions passing through the suspected pixels are discarded to reduce misdetection. In each condition, at most four directions are chosen for low-cost hardware implementation. If there appear over four directions, only four of them are chose according to the variation in angle.

$$D_1 = \left|\bar{f}_{i-1,j-1} - \bar{f}_{i,j-1}\right| D_2 = \left|\bar{f}_{i-1,j-1} - \bar{f}_{i+1,j+1}\right|$$
$$D_3 = \left|\bar{f}_{i-1,j-1} - \bar{f}_{i+1,j}\right|$$

$$D_4 = \left|\bar{f}_{i+1,j} - \bar{f}_{i+1,j+1}\right| D_5 = \left|\bar{f}_{i-1,j} - \bar{f}_{i+1,j}\right|$$
$$D_6 = \left|\bar{f}_{i-1,j} - \bar{f}_{i+1,j-1}\right|$$

$$D_7 = \left|\bar{f}_{i-1,j+1} - \bar{f}_{i+1,j}\right| D_8 = \left|\bar{f}_{i-1,j+1} - \bar{f}_{i+1,j-1}\right|$$
$$D_9 = \left|\bar{f}_{i-1,j+1} - \bar{f}_{i,j-1}\right|$$

$$D_{10} = \left|\bar{f}_{i,j-1} - \bar{f}_{i,j+1}\right| D_{11} = \left|\bar{f}_{i,j-1} - \bar{f}_{i+1,j+1}\right|$$
$$D_{12} = \left|\bar{f}_{i,j+1} - \bar{f}_{i+1,j-1}\right|$$

Figure 3: Directions

| *B* | the chosen directions | *B* | the chosen directions |
|---|---|---|---|
| 00000 | $D_2, D_5, D_8, D_{10}$ | 10000 | $D_2, D_5, D_8, D_{12}$ |
| 00001 | $D_3, D_5, D_8, D_{10}$ | 10001 | $D_1, D_5, D_8, D_{12}$ |
| 00010 | $D_2, D_8, D_{10}, D_{12}$ | 10010 | $D_2, D_4, D_8, D_{12}$ |
| 00011 | $D_1, D_6, D_8, D_{10}$ | 10011 | $D_1, D_6, D_8, D_{12}$ |
| 00100 | $D_2, D_5, D_7, D_{10}$ | 10100 | $D_1, D_2, D_5, D_7$ |
| 00101 | $D_3, D_5, D_7, D_{10}$ | 10101 | $D_1, D_5, D_7$ |
| 00110 | $D_2, D_4, D_9, D_{10}$ | 10110 | $D_1, D_2, D_4$ |
| 00111 | $D_1, D_9, D_{10}$ | 10111 | $D_1$ |
| 01000 | $D_2, D_5, D_8, D_{11}$ | 11000 | $D_2, D_5, D_6, D_8$ |
| 01001 | $D_3, D_5, D_7, D_9$ | 11001 | $D_3, D_5, D_6, D_8$ |
| 01010 | $D_2, D_6, D_8, D_{11}$ | 11010 | $D_2, D_4, D_6, D_8$ |
| 01011 | $D_6, D_8, D_9$ | 11011 | $D_6, D_8$ |
| 01100 | $D_2, D_5, D_9, D_{11}$ | 11100 | $D_2, D_4, D_5, D_7$ |
| 01101 | $D_3, D_5, D_9$ | 11101 | $D_3, D_5, D_7$ |
| 01110 | $D_2, D_4, D_9, D_{11}$ | 11110 | $D_2, D_4$ |
| 01111 | $D_9$ | 11111 | N/A |

N/A: not available

Figure 4.Mapping Table

If $p_{i, j-1}$, $p_{i, j+1}$ , $p_{i+1, j-1}$ , $p_{i+1, j}$ and $p_{i+1, j+1}$ are all suspected to be noisy pixels (B=11111) , no edge can be processed, so (the estimated value of $p_{i,j}$ ) is equal to the weighted average of luminance values of three previously denoised pixels and calculated as

$$\left(\overline{f}_{i-1,j-1} + 2 \times \overline{f}_{i-1,j} + \overline{f}_{i-1,j+1}\right)/4$$

In other conditions except when B=1111 the edge filter calculates the directional differences of the chosen directions and locates the smallest directional difference among them ($D_{min}$) among them. The smallest directional difference implies that it has the strongest spatial relation with $p_{i,j}$ , and probably there exists an edge in its direction. Hence, the mean of luminance values of the two pixels which possess the smallest directional difference is treated as $f\hat{}_{i, j}$ .

For example if B =10011, it means that $f_{i,j-1}$ , $f_{i+1,j}$ , and $f_{i+1,j+1}$ are suspected to be noisy values. Therefore $D_2$-$D_5$, $D_7$ and $D_9$-$D_{11}$ are discarded because they contain those suspected pixels (see Fig. 3). The four chosen directional differences are $D_1$, $D_6$ ,$D_8$and $D_{12}$ (see Fig. 4). Finally, $f\hat{}_{i,j}$ is equal to the mean of luminance values of the two pixels which possess the smallest directional difference among $D_1$,$D_6$ ,$D_8$ and $D_{12}$ .

### *c)* IMPULSE ARBITER:

A pixel ,whose value is MIN in W or MAX in W might be identified as a noisy pixel even if it is not corrupted. In order to overcome this drawback , we add Impulse Arbiter to reduce the possibility of misdetection.

The inputs are subject pixel "$f_{i,j}$", denoised value " $\hat{f}_{i,j}$", "$f_{i+1,j-1}$ , $f_{i+1,j}$ " ," $f_{i+1,j}$ ,$f_{i+1,j+1}$". The main aim of impulse arbiter is to compare the difference of denoised value and the original subject pixel value with a threshold value. The threshold value is calculated by taking the following difference "$f_{i+1,j-1}$-$f_{i+1,j}$ " ," $f_{i+1,j}$ - $f_{i+1,j+1}$" the result is "x" and "y" respectively. If the difference of $f_{i,j}$ and $\hat{f}_{i,j}$ is within the range of "x" or "y" then we assume that there is a possible edge and the original pixel value is retained instead of the denoised value. If the difference is greater than the range of "x" or "y", we take the denoised value as the new value for that pixel and denotes the final output of the complete process.

The main difference between the previous technique and this proposed technique of variable threshold lies in this module of "impulse arbiter" where the previous technique takes a fixed threshold of '20' for all the pixels and sometimes does not hold good for all of the pixels processed . So, by this "variable threshold method" we obtained better results both visually as well as with respect to PSNR.

$$x= f_{i+1,j-1} - f_{i+1,j}$$

$$y = f_{i+1,j} - f_{i+1,j+1}$$

if ( $f_{i,j}$ - $\hat{f}_{i,j}$ ) >(x | y)

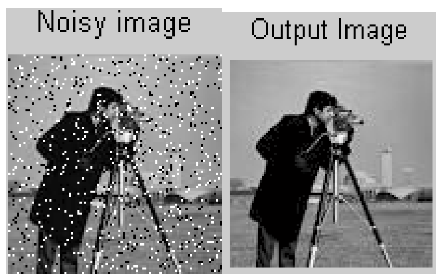
$\bar{f}_{i,j} = \hat{f}_{i,j}$ /Noisy pixels/

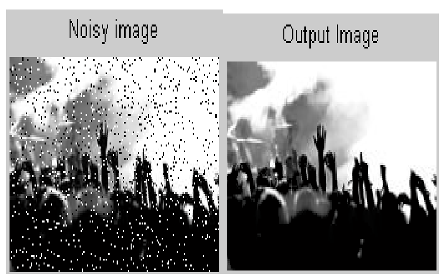
else

$\bar{f}_{i,j}=f_{i,j}$ /Nois free pixels /

Figure 5.Pseudocode of Impulse Arbiter

## IV. RESULTS


The PSNR ratio of the above images are by using SEPD technique it has 35.16(a),33.08(b),36.80(c) and by using modify SEPD it has 36.88(a),37.16(b),38.90(c). From the above results we can say that this technique(MSEPD) has a better PSNR compared to previous techniques.

## V. CONCLUSION

In this paper, a simple impulse noise removal technique“Modify simple edge preserved denoising technique “ (MSEPD) with variable Threshold value is proposed.The extensive experimental results demonstrate that our technique achieves excellent performance in terms of quantitative evaluation and visual quality. The main difference between SEPD and modify SEPD lies in impulse arbiter with variable threshold values.

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