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# A New Random Valued Impulse Noise Detection Algorthm to Eliminate Misdetection

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**Abstract:** A new detection algorithm is proposed for images that are corrupted by Random Valued Impulse Noise. In all the existing detection algorithms, the drawback encountered is 'Misdetection of noise-free pixels' The proposed algorithm eliminates misdetection of noise free pixels till 90% noise density. In filtering stage, fuzzy switching median filter is used to replace the detected noisy pixels. Simulation results reveals that Proposed algorithm works better than other state-of-the-art detection algorithms.

**Key words:** Random valued impulse noise, misdetection, median filter, fuzzy switching median filter, simulation

## INTRODUCTION

Impulse noise is generally two types: Fixed value impulse noise and Random value impulse noise . The fixed value impulse noise is otherwise referred as salt and pepper noise. In this type of noise, pixels takes the value 0 or 255. The Random Value Impulse Noise (RVIN) is the second type of impulse noise, where pixels are corrupted by values between 0 and 255 and hence it is difficult to handle RVIN (Awad, 2011). Noise removal from images isstill a challenging problem. There exist several algorithms (Civicioglu, 2009; Chen *et al*., 1999; Abreu *et al*., 1996; Ng and Ma, 2006; Akkoul *et al*., 2010; Wenbin, 2005) and each algorithm has its own advantages, assumptions and limitations. Some schemes utilize detection of impulsive noise followed by ltering where as other schemes, irrespective of corruption, lter all the pixels. The disadvantage of the later process is that it lters all the pixels irrespective of corruption. In the detection stage of all the existing algorithms, misdetection of noise free pixels occurs.

A new detection algorithm is proposed to overcome this misdetection of noise free pixels.The proposed phenomenon has been divided in two steps. First one is detection of noisy pixel and second one filtering stage. In the first stage the noise-free and noisy pixels of the corrupted image are discriminated. Now, in the noise filtering stage, the detected noisy pixels are removed using fuzzy switching median filter.

**Literature review:** Many researchers have suggested a large number of RVIN algorithms and compared their results (Civicioglu, 2009; Chen *et al*., 1999; Abreu *et al*., 1996; Ng and Ma, 2006; Akkoul *et al*., 2010; Wenbin, 2005). The main objective on all such algorithms is to remove impulsive noise while preserving image details such as edges. All such algorithms involves two–step process. Detection followed by filtering. Noisy and noise-free pixels are discriminated in detection stage. In most cases, Median filter being the most popular non-linear filter is involved in filtering stage (Jain, 1989).

For comparative analysis Single Threshold Detection Algorithm (STDA) (Seetharaman and Vijayaragavan, 2012), Dual threshold Detection Algorithm (DTDA) (Shrivastavav and Changlani, 2015), Condition Based Detection Algorithm (CBDA) (Ramadan, 2014), Optimal Direction Based Detection Algorithm (ODBA) is considered (Awad, 2011) .

In case of STDA (Seetharaman and Vijayaragavan, 2012) detection stage involves predefined single threshold to determine noisy and noise free pixels followed by filtering. Here, the range of pixel values used for identifying the noisy pixels will be large. This may increase the possibility of incorrect detection. In case of DTDA (Shrivastavav and Changlani, 2015) two threshold values are employed to detect noisy pixels in the detection stage. Threshold values are not predefined and it depends on the sliding window pixel values. Here, the noisy pixels are identified in a relatively narrow range and thus the probability of incorrect detection are reduced. In detection stage of CBDA (Ramadan, 2014) two conditions have to be met to determine whether an image pixel is noisy or not. In conditon basedalgorithm , detection part is stronger compared to single and dual threshold based

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algorithms. In ODBA (Awad, 2011) ,four directions which involves centre pixel is consid ered in detection stage.Size of the sliding window to be considered here is larger compared to previous algorithms. Hence the computation time is more.

## MATERIALS AND METHODS

**Noise model:** The noise type considered here is more realistic and general than the well-known xed valued impulsive noise that takes a value of 0or 255 (salt and pepper noise) (Ng and Ma, 2006). The Probability density function of noise model considered is expressed as :

$$f(C_{i,j}) = \begin{cases} ND/2 & 0 \le C_{i,j} < d \\ 1-ND & C_{i,j} = Vi,j \\ ND/2 & 225-d < C_{i,j} \le 225 \end{cases}$$

Where $C_{i,j}$is the (i,j)th pixel in the corrupted image. $O_{i,j}$ is the (i,j)th pixel in the original image and ND is the noise density. The dynamic range of the pixel values is between 0 and L-1, where L is $2^n$ and n is number of bits per pixel.

**Proposed work:** In the algorithms discussed above, the drawback encountered in all the cases is misdetection of noise free pixels ie., Noise free pixels are also detected as noisy which is thus referred as 'Misdetection of noise free pixels'.The main objective of the proposed work is to eliminate the drawback of misdetection. Let C be the image corrupted of size MxN and C(x, y) denotes the intensity value at pixel location (x, y). A sliding window of size W is considered. W = 2K+1 where K is initially '1'.

**Detection stage:** The Proposed algorithm works as follows :

**Step 1:** A sliding window of size 3*3 is applied to the corrupted image. Consider four subwindows in the chosen sliding window.

| | | |
|---|---|---|
| 0 | 1 | 2 |
| 1 | 0 | |
| 2 | | |

$S_1 = \{(0, 0), (0, 1), (1, 0), (1, 1)\}$
$S_2 = \{(0, 1), (0, 2), (1, 1), (1, 2)\}$
$S_3 = \{(1,0), (1, 1), (2, 0),(2, 1)\}$
$S_4 = \{(1,1) ,(1,2),(2,1),(2,2) \}$

**Step 2:** Sum of the absolute differences between centre pixel and other pixels is computed for each subwindow. (1,1) is the centre pixel location in the case considered. The Window corresponding to the minimum value (among the four ) is defined as the optimum window.

**Step 3:** Calcuation of thresholds for the defined optimum window Where:

Threshold 1 = Max {Average of rows and columns of optimum window}
Threshold 2 = Min {Average of rows and columns of optimum window}

**Step 4:** Condition for detection. Based on the conditions a mask is defined. Noise value with 1 represents pixel is corrupted. Noise value with 0 represents pixel is noise-free (uncorrupted):

$$\text{Noise}(x,y) = \begin{cases} 1 & \text{if (CP > Threshold 1 and CP < Threshold2 and Prob\_Noisy=1)} \\ 0 & \text{if (CP < Threshold 1 or CP >Threshold 2 and Prob\_Noisy=0)} \end{cases}$$

Where CP- Centre pixel. Threshold 1 and Threshold 2 are defined as above. 'Probability to be a noisy pixel' (Prob Noisy) is defined as follows.

$$\text{Prob\_Noisy} = \begin{cases} 1 & \text{if } 0 = CP < d \text{ or } 255\text{-}d < CP = 255 \\ 0 & \text{Otherwise} \end{cases}$$

Centre Pixel (CP) considered may be a noisy pixel if CP satisfies the above defined condition and it sets to 0 otherwise.

**Step 5:** When equality cases occur for CP with respect to thresholds defined i.e., 3 equality cases can be considered here. 1. CP<Threshold 1 & CP = Threshold 2
2. CP > Threshold 2 & CP = Threshold 1
3.CP = Threshold 1 & CP = Threshold 2

When any of the above case is met, following steps are implemented

**Step 6:** Consider four directions in the chosen sliding window which includes the centre pixel (Central row, central column, right diagonal, left diagonal).

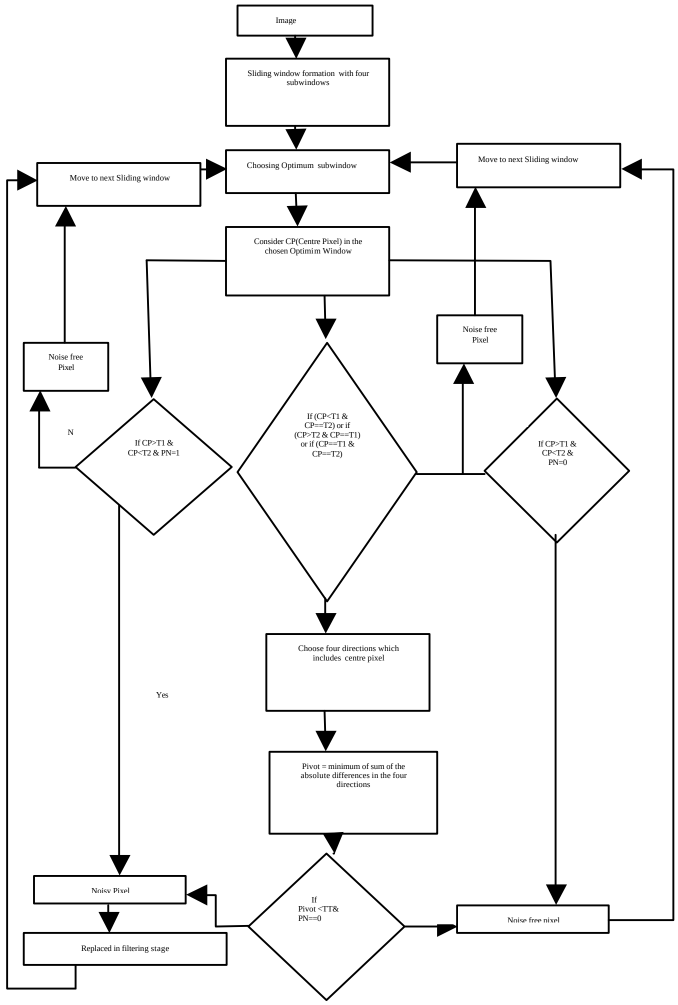


Fig. 1: Dectection stage-block diagram

Central row = { (1,0) ,(1,1),(1,2) }
Central column = { (0,1) ,(1,1),(2,1) }
Right diagonal = { (0,2) ,(1,1),(2,1) }
Left diagonal = { (0,0) ,(1,1),(2,2) }

Sum of the absolute differences between centre Pixel and other pixels is computed for each direction which results in four values.

**Step 7:** Minimum value among the four values computed above is considered to be pivot value.

**Step 8:** Based on the pivot value , detection condition is defined as follows

$$Noise(x,y) = \begin{cases} 0 & \text{if Pivot} < \text{Threshold T \& Prob\_Noisy=0} \\ 1 & \text{Otherwise} \end{cases}$$

Threshold T = Max {Average of all the rows and columns in the sliding window considered}. Pivot and Prob-Noisy is defined as above.

**Filtering stage:** In the recent years, Fuzzy switching median filter is the most probably used filter. Compared to other filters, fuzzy switching median filter gives better results. So filtering stage utilizes fuzzy switching method by Toh and Isa (2010). Figure 1 shows the block diagram of detection stage of proposed algorithm. In Fig. 1 given CP represents the Centre Pixel,$T_1$,$T_2$,TT represents the Threshold 1 and Threshold 2 and Threshold T. PN represents the Prob Noisy. The pixels which are marked noisy are replaced in the filtering stage. Noise-free pixels are retained the same without any modification. Thus, only noisy pixels are considered in filtering stage which are replaced in fuzzy switching median filtered output.

## RESULTS AND DISCUSSION

The simulation results are obtained for Lena image of size 256x256. Comparative analysis is done for the proposed algorithm with various other algorithms discussed in section III using Peak Signal to Noise Ratio (PSNR), Mean Square Error (MSE) and SSIM values (Structural Similarity Index). For illustration purpose , here a portion of Lena image (5x5) is considered with 50% noise density and misdetection of noise-free pixels is discussed below. According to the defined noise model equal probability of salt and pepper noise is added here.'detected' matrix values with 1 represents corrupted pixel and 0 represents Uncorrupted pixel. cImage represents corrupted image pixel values.

$$\text{Original} - \text{Image} = \begin{matrix} 99 & 90 & 125 & 117 & 82 \\ 86 & 92 & 142 & 138 & 95 \\ 88 & 65 & 104 & 89 & 128 \\ 81 & 60 & 86 & 89 & 153 \\ 80 & 48 & 94 & 139 & 90 \end{matrix}$$

$$\text{cImage} = \begin{matrix} 252 & 4 & 125 & 117 & 82 \\ 86 & 254 & 251 & 138 & 95 \\ 88 & 253 & 104 & 3 & 128 \\ 255 & 60 & 4 & 89 & 251 \\ 3 & 48 & 2 & 139 & 90 \end{matrix}$$

In this case , 252 4 254 251 95 253 3 255 4 251 3 2 in cImage reprents the corrupted pixels and the other pixels are noise-free pixels.

$$\text{detected} - \text{single} - \text{threshold} = \begin{matrix} 1 & 1 & 0 & 0 & 1 \\ 0 & 1 & 1 & 0 & 0 \\ 0 & 1 & 0 & 1 & 0 \\ 1 & 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 0 & 1 \end{matrix}$$

$$\text{detected} - \text{dual} - \text{threshold} = \begin{matrix} 1 & 1 & 0 & 0 & 1 \\ 1 & 1 & 1 & 0 & 0 \\ 1 & 1 & 0 & 1 & 0 \\ 1 & 0 & 1 & 0 & 1 \\ 1 & 0 & 1 & 0 & 1 \end{matrix}$$

Table 1: MSE Values for various algorithms for Lena image

| Noise Density% | Simple Median | CBDA | DTDA | STDA | Proposed Algorithm |
|---|---|---|---|---|---|
| 10 | 20.2532 | 2.5712 | 6.1220 | 12.5215 | 2.4218 |
| 20 | 22.2043 | 5.7286 | 6.4684 | 13.8772 | 5.3265 |
| 30 | 23.7201 | 9.1319 | 8.4948 | 16.3682 | 8.4742 |
| 40 | 25.1341 | 11.5351 | 12.0403 | 18.2402 | 11.3957 |
| 50 | 26.4404 | 15.3874 | 16.2737 | 21.7089 | 14.5539 |
| 60 | 27.0546 | 17.4696 | 18.1610 | 27.2132 | 18.5855 |
| 70 | 29.9294 | 25.2296 | 22.9535 | 30.5294 | 21.5089 |
| 80 | 33.5667 | 29.5116 | 22.7060 | 34.3305 | 24.9425 |
| 90 | 35.1055 | 38.2801 | 26.5101 | 37.4545 | 32.3642 |
| 95 | 36.0501 | 34.3604 | 28.1224 | 40.9841 | 28.2753 |

Table 2: PSNR Values for various algorithms for Lena Image

| Noise Density% | Simple Median | CBDA | DTDA | STDA | Proposed Algorithm |
|---|---|---|---|---|---|
| 10 | 35.0659 | 44.0295 | 40.2619 | 37.1542 | 44.2894 |
| 30 | 34.3796 | 38.5252 | 38.6393 | 35.9908 | 38.8498 |
| 40 | 34.1282 | 37.5106 | 36.1133 | 35.5205 | 37.5634 |
| 50 | 33.9081 | 36.2592 | 35.9009 | 34.7644 | 36.5010 |
| 60 | 33.8084 | 35.1080 | 34.0461 | 33.7830 | 35.4391 |
| 70 | 33.3698 | 34.1117 | 33.3539 | 33.2836 | 34.8046 |
| 80 | 32.8717 | 33.4309 | 33.2694 | 32.7740 | 34.1614 |
| 90 | 32.6771 | 32.3011 | 32.8967 | 32.0958 | 33.0302 |
| 95 | 32.5617 | 32.7702 | 31.6403 | 32.0047 | 33.6167 |

Table 3: SSIM values for various algorithms Lena Image

| Noise Density% | CBDA | DTDA | STDA | Proposed Algorithm |
|---|---|---|---|---|
| 10 | 0.8983 | 0.8245 | 0.8145 | 0.9818 |
| 20 | 0.8733 | 0.7982 | 0.7263 | 0.9414 |
| 30 | 0.7364 | 0.6732 | 0.6244 | 0.8620 |
| 40 | 0.6452 | 0.5930 | 0.5329 | 0.7570 |
| 50 | 0.5982 | 0.4829 | 0.4420 | 0.6562 |
| 60 | 0.4922 | 0.3292 | 0.3127 | 0.5391 |
| 70 | 0.3902 | 0.2893 | 0.2967 | 0.4388 |
| 80 | 0.2453 | 0.1923 | 0.1182 | 0.3217 |
| 90 | 0.2224 | 0.1567 | 0.1123 | 0.2765 |
| 95 | 0.1934 | 0.1354 | 0.1084 | 0.1012 |

$$\text{detected} - \text{propsed} = \begin{matrix} 1 & 1 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 0 \\ 0 & 1 & 0 & 1 & 0 \\ 1 & 0 & 1 & 0 & 1 \\ 1 & 0 & 1 & 0 & 0 \end{matrix}$$

From the detected output, its seen that In single threshold case , pixels 82 , 86 are misdetected as noisy pixels and are replaced as '1'. In dual threshold case , pixels 82, 86, 88 are misdetected as noisy pixels and are replaced as '1'.Whereas , in proposed case, only noisy pixels are replaced with '1' . There occurs no misdetection of noise free pixels as noisy pixels and hence misdetection is eliminated. In Proposed algorithm, misdetection can be eliminated till 90% noise density and 20% error occurs when noise density is above 90%.

From the simulation results, it is concluded that misdetection is eliminated completely till 90% noise density. 20% error occurs in case of noise density above 90%. Table 1 shows the MSE values for the algorithms discussed. Table 2 shows the PSNR values and Table 3


Fig. 2: Restored images: a) Original image; b) 50% noisy image; c) Simple median filter; d) Single threshold algorithm; e) Dual threshold algorithm; f) Condition based algorithm and g) Proposed algorithm


Fig. 3: Restored images: a) Original image; b) 90% noisy image; c) Simple median filter; d) Single threshold algorithm; e) Dual threshold algorithm; f) Condition based algorithm and g) Proposed algorithm

shows the SSIM values. From the Tables it is inferred that Proposed algorithm gives better results compared to all other algorithms.

From the simulation results it is concluded that Proposed algorithm outperforms the other discussed algorithms in terms of PSNR,MSE and SSIM values for Lena image of size 256×256. Figure 2 and 3 displays the simulation results of Lena image with 256×256 with 50 and 90% noise density using Matlab R2012, respectively. The restored output image for the proposed algorithm is found to be better than the other discussed algorithms.

## CONCLUSION

The proposed algorithm effectively eliminate 'Misdetection of noise free pixels' (as noisy pixels) till 90% of noise density. PSNR, MSE and SSIM values for the proposed algorithm is found to be better than the other discussed algorithms. Simple threshold calculations results in lesser computation time. The restored images with the proposed algorithm is satisfactory till 50% noise density. Beyond 50% noise density when the filtering window size is increased, it results in image blurring.

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