Detection and Removal of Noise from Images using Improved Median Filter

[1]Sathya Jose S. L,
[1]Research Scholar,
Univesrity of Kerala, Trivandrum
Kerala, India.
Email: [1]sathyajose@yahoo.com

[2]Dr. K. Sivaraman,
Research Guide,
Univesrity of Kerala, Trivandrum
Kerala, India

***Abstract*—** Noise is any unwanted component in an image. It is important to eliminate noise in the images before some subsequent processing, such as edge detection, image segmentation and object recognition. This work mainly concentrates on automatic detection and efficient removal of impulse (salt and pepper) noise. For automatic detection of impulse noise, a method based on probability density function is proposed. The basic idea of automatic detection is that the difference between the probabilities of black and white pixels will be small. After detecting the presence of impulse noise in an image, we have to remove that noise. For the removal of impulse noise a new efficient impulse noise removal method (Modified SDROM filter) is proposed. The Modified SDROM consists of two parts 1) Impulse detector and 2) Filter. The results show that this method has higher performance than other methods in terms of PSNR values and SSIM-Index values.

***Keywords*-:** *impulse noise, probability density function, PSM Filter, SDROM Filter, PWMAD Filter, Modified SDROM, PSNR, SSIM Index*

*****

I. INTRODUCTION

Noise is unwanted component in an image [5 pp.325]. Noise can occur during image capture, transmission, or processing, and may be dependent on or independent of, image content. Familiar one is Gaussian noise. Example is white noise on weak television station is modeled as Gaussian noise. Since image sensors must count no. of photons, images often have photon counting noise. The grain noise in photographic film is sometimes modeled as Gaussian and sometimes as Poisson. The black and white dots in image are due to salt and pepper noise. Other noises are quantization noise and speckle in coherent light situation. The performance of imaging sensors is affected by variety of factors such as environmental conditions during image acquisition and the quality of sensing elements themselves. For example in acquiring image with CCD camera, light levels and sensor temperature are major factors affecting the amount of noise in resulting image. Images are corrupted during transmission principally due to interference of channel used for transmission.

Salt and pepper noise [5] refers to a wide variety of processes that result in the same basic image degradation: only a few pixels are noisy, but they are *very* noisy. The effect is similar to sprinkling white and black dots - salt and pepper - on the image. One example where salt and pepper noise arises is in transmitting images over noisy digital links.

Salt and pepper noise is an example of (very) heavy-tailed noise.

II. IMPULSIVE NOISE MODEL

Impulsive noises are often caused by errors during the image acquisition or transmission of digital images through communication channels. The noisy image P (i, j) (1 <= i <= X: 1 <= j <= Y) is defined by [1]

$$P(i,j)=\begin{cases} P_0(i,j) \text{ with probability } 1-p_1-p_2 \\ h_1 \quad \text{with probability} \quad p_1 \\ h_2 \quad \text{with probability} \quad p_2 \end{cases} \tag{1}$$

Where P_0 (i, j) is the original image; h_1 is equal to or near the maximum intensity as a positive impulse; and h_2 is equal to or near the minimum intensity as a negative impulse.

III. IMPULSE NOISE DETECTION

The Probability Density Function (pdf) of noisy image is same as that of the pdf of noise present in it [6]. For this the image strip (e.g. 150X20) with highest number of midgray value is taken and the corresponding pdf is plotted. If the black and white pixels have highest value of probability than other pixels then by theoretically it can be assured that it contain impulse noise. But as the noise content decreases the image details dominates Therefore by using several experiments a new algorithm for the detection of impulse noise is developed. The algorithm is given below.

Impulse noise detection algorithm:

```
    g1=min (p (0), p (255));
  if ((0.9*(abs(p(0)-p(255)))<=g1)
              & ((p(0)&p(255))~=0))
 disp ('There is impulse noise in the given figure')
   else
disp('There is no impulse noise in the given figure')
             end
```

Where p(0) and p(255) are probabilities of black and white pixels respectively. This algorithm is tested with several images with Gaussian and impulse and it is found that in almost all cases it recognizes the image contains impulse noise or not. But there are some exceptional cases with image containing extraordinary features. But in practical case these types of images are rare.

IV. IMPULSE NOISE REMOVAL (MODIFIED SDROM FILTER)

In order to improve the capability of detection the noise in highly corruption rate, a new algorithm is proposed, to address this problem. The detection scheme is like Signal Dependant Rank Ordered Mean (SDROM) [3] scheme, preserving the details of the image. Recently, several filters to remove impulse noise in highly corrupted images has been proposed, such as progressive switching median filter (PSM)[2], soft switching median filter. Although these two filters can remove impulse noise effectively, some disadvantages of which is that they will need more computational time and just can solve the only the salt and pepper type impulse nose. To overcome this problem, a new detection scheme is proposed to detect the impulse noise both in highly and lightly corruption rate and for the impulse noise,"salt and pepper" type.

A new method for the removal of impulse noise is proposed. It has higher performance than existing methods. The components of the proposed filter are 1) The detection mechanism 2) The switching median filter or the recursive switching median filter. Here for detection, instead of four thresholds in SDROM [3] twelve thresholds are used. Implementation shows that this detection algorithm detects impulses (salt & pepper) in efficient way. The removal part is similar to PSM filter [2] with some modification. The algorithm is described below.

IV.1 Impulse Detection

Using a 5X5 window 24 pixels outside the current pixel X (i,j) are selected as given below,

$S = (s1, s2,\ldots\ldots s24)$

$S = (X(i-2, j-2), X(i-2, j-1),\ldots, X(i+2, j+2))$ (2)

Then these are arranged using rank order criteria

$r_k = (r1,r2,\ldots\ldots,r24)$ (3)

Where rk represents the elements of 'S' arranged in ascending order. Then the rank ordered mean is ROM, ME = (r12+r13)/2; the rank ordered differences

$d_k = (d1,d2,d3,\ldots\ldots,d12)$ (4)

$d_k = r_k - X(i,j); \text{if} X(i,j) <= ME$ (5)

$d_k = X(i,j) - r_{(24-k)} \text{if} X(i,j) > ME$ (6)

where k=1,2,…,12

Set f=zeros (m, n), where m, n are the number of rows and columns of X.The impulsive pixel is detected if any one of the differences dk

$d_k > T_k, \quad k=1,2,\ldots\ldots,12$ (7)

where $T_k < T_{k+1}$ represents thresholds and set f(i,j)=1;

IV.2 Impulse Noise Removal

Use a 3X3 window for taking median of current pixel at (i,j). X1=X; For each pixel perform the following operations.

```
If f (i,j)==1
E=median[X1(i-1,j-1),X1(i-1,j1),……,X1(i,j-1),
   { X1(i,j+1), … X1(i+1,j+1)  with  f(i,j)=0 }]
     X1 (i,j)=E;
 end
```

i.e. E is the median of processed pixels and remaining good pixels in the 3X 3 window centered at current pixel (i,j).
'X1' is the denoised image.

IV.3. Selection of Parameters:

Compute the noise ratio R. Set the values TD1=40,N1=0 where TD1 is the threshold and N1 is the number of impulses detected. If X is original
image and M is the median image using 3X3 window, then for each pixel (i,j) calculate,

If (X (i,j)-M (i,j)) >= TD1
N1=N1+1; (8)

After performing this operation on all the pixels calculate the noise ratio as

R=N1/N;

Where N is the total number of pixels.
Select the number of iterations ND for impulse detection. If R < 0.25 then the number of iterations ND=1 otherwise ND=5.For large size images (E.g. image size greater than 200X200 number of pixels) the noise ratio value for ND is lowered from 0.25 to 0.15.The Threshold values are selected as which give good removal of impulse noise. From several experiments the threshold values are set as given below,

T_1=8,T_2=15,T_3=25,T_4=35,T_5=50,T_6=60,T_7=65,T_8=70,T_9=75, T_{10}=80,T_{11}=85, T_{12}=90.

This algorithm is tested with several images and found that it has higher performance over other existing methods. This method gives good results in salt & pepper type noise. The works are going to generalize this method for random valued impulses.

V. ANALYSIS AND RESULTS

For automatic impulse noise detection the noisy image is divided into four equal parts; if its size is less than 300X300 & sixteen equal parts if its size is greater than 300X300 for getting flat area. Then a part of this image containing maximum number of midgray values (i.e. number of pixels with values greater than 80 and less than 175) is selected, which is the flat area. For this part, if the difference between probabilities of black and white pixels is less than the minimum of these probabilities, then there is impulse noise in the noisy image.

For automatic detection of impulse noise with small impulse noise ratio, the image 'peppers' without noise (Figure 1.a), 5% impulse noise added image (Figure 1.b), its flat area i.e. 1/4rth of image with largest no. of midgray values (1064,first quadrant, Figure 1.c) 70% impulse noise added image (Figure 1.d), its flat area i.e. 1/4rth of image with largest no. of midgray values (358,first quadrant, Figure 1.e), the pdf of flat area © (Figure 1.f), and the pdf of flat area (e) (Figure 1.g) are shown above. In the pdf plot, x-axis represents gray levels and y-axis represents probabilities. In Figure 1.f, the probability of black pixel is 0.3362 and the probability of white pixel is 0.3463.The 90% magnitude difference between the probabilities of black and white pixels is 0.0091,which is less than the minimum of probabilities of black and white pixels(0.3362).The probability of black or white pixel is not equal to zero. These two conditions detect the presence of impulse noise in Figure 1.b. In Figure 1.g, the probability of black pixel is 0.0231 and the probability of white pixel is 0.0256.The 90% magnitude difference between the
probabilities of black and white pixels is 0.0025, which is less than the minimum of probabilities of black and white pixels (0.0231).The probability of black or white pixel is not equal to also zero. These two conditions detect the presence

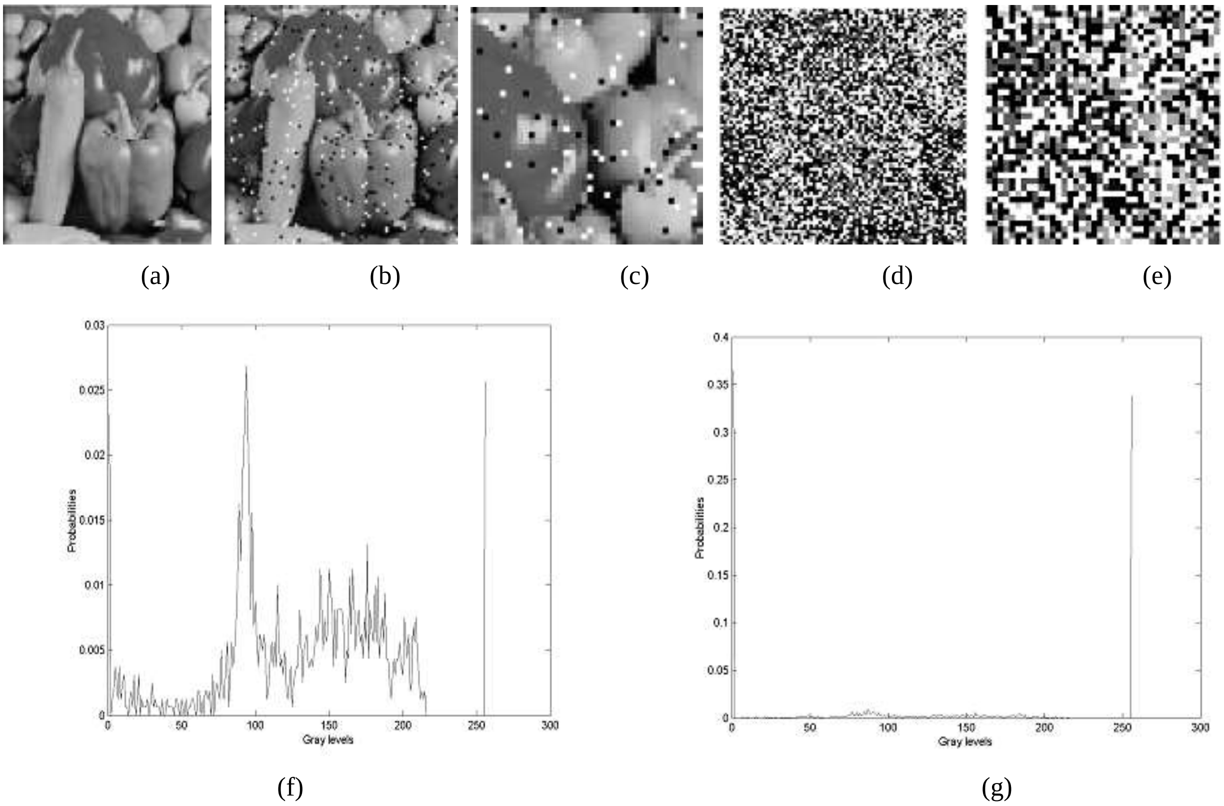

Figure 1. Impulse Noise Detection for the image Peppers with 5% and 70% of impulse noise. a) Original image(80X80),b) 5% impulse noise added image ,c) 1/4rth of image (b) with largest no. of midgray values(1064,first quadrant), d) 70% impulse noise added image, e) 1/4rth of image (d) with largest no. of midgray values (358), f) pdf plot of (c),g) pdf plot of (e).

 ISSN: 2321-8169
309 – 313

of impulse noise in Figure 1.d.

The proposed Modified SDROM filter is compared other impulse noise removal methods for 10% to 70% values of noise ratios, with extremely different noisy test images. The results are plotted and are given below. The parameters are selected are, for PSM Filter [2] $N_D=3,W_F=3,T_R=25,a=65,b=-50,T1=40$,for Modified PSM Filter[1] $W_{E1}=5,W_{E2}=7$, $T_{E1}=10$, $W_{D1}=7,W_{D2}=9$, $T_{N'}=10,T_R=0.8$,for SDROM Filter[3] T1=8, T2=25,T3=40,T4=50,for PWMAD Filter[4]$T_d=5$ and for Modified SDROM(Proposed) $TD1=40,T_1=8,T_2=15,T_3=25,T_4=35,T_5=50,T_6=60,T_7=65,T_8=70,T_9=75$, $T_{10}=80,T_{11}=85$, $T_{12}=90$.

The proposed Modified SDROM filter is compared other impulse noise removal methods Figure 2 shows the standard test images 'lena','peppers','bridge' and 'camera man' for comparison of median filtering, iterative median filtering, PSM filtering[2], Modified PSM filtering[1], SDROM filtering[3], PWMAD filtering[4] and proposed Modified SDROM filtering techniques. To prove the efficiency of proposed algorithm (Modified SDROM) an average plot among these images are required. It is given in Figure 3.Here we can see that the proposed filter has higher performance than other methods like median filter, iterative median filter, PSM filter, Modified PSM filter, SDROM filter and PWMAD filter.

From Figure 3 some inferences using PSNR values are given below,

1. Proposed filter (Modified SDROM filter) has higher performance than other methods.
2. The PSM filter shows higher performance at low noise ratios and lower performance at high noise ratios.
3. The SDROM filter has just reverse performance as that of PSM filter.
4. The performance of PWMAD filter is lower than even median filter.
5. The performance of Modified PSM filter is lower than even median filter at lower noise ratios and is having challenging performance than SDROM filter at higher noise ratios.
6. From the noise ratio 0.2 onwards iterative median has higher performance than median filter.

VI. CONCLUSION AND FUTURE WORK

For automatic detection of impulse noise, a method based on probability density function is proposed. The basic idea of automatic detection is that the difference between the probabilities of black and white pixels will be small. The automatic detection algorithm is verified by using impulse noise, Gaussian noise and speckle noise added images. In all cases this algorithm correctly detects whether the image contain impulse noise or not.

After detecting the presence of impulse noise in an image, we have to remove that noise. For the removal of impulse noise several existing methods like Median filter, PSM filter, Modified PSM filter, SDROM filter, and PWMAD filter are implemented. From the idea obtained from these methods a new efficient impulse noise removal method (Modified SDROM filter) is proposed. The results show that this method has higher performance than other methods in terms of PSNR values and SSIM-Index values[10].

Gaussian noise is an additive noise. The Gaussian noise is introduced on the image by adding random values to pixel values to produce a Gaussian distribution. As the SDROM filter uses twelve rank ordered differences and twelve thresholds, it can efficiently detect the presence of Gaussian noise pixel also. The removal of which can be done by using Gaussian masks. Thus we can introduce a switched filter concept in Gaussian noise removal. The random valued impulse noise take any values between '0' and '255'.The Modified SDROM filter itself can be applied to remove random valued impulse noise also.

(a) (b) (c) (d)

Figure 2 Standard test images for comparison of different filtering techniques. a)'Lena' b)'Peppers' c) 'Bridge' d) 'Cameraman'

ISSN: 2321-8169
309 – 313

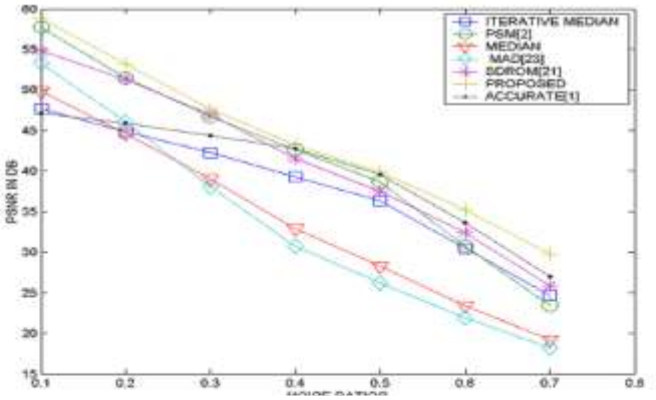

Figure 3 Average plot of comparison of different noise removal methods on different test images.

REFERENCES

[1] Keiko Kondo, Miki Haseyama and Hideo Kitajima"An Accurate Noise Detector for Image Restoration", Proc. of 2002 IEEE International Conference On Image Processing, , Vol.1, pp.321-324, 2002.

[2] Z.Wang and D.Zhang,"Progressive switching median filter for the removal of impulsenoise from highly corrupted images", IEEE Trans. Circuits and Syst.II, Analog and Digital Signal Processing,vol.46,pp.78-80,January 1999.

[3] E. Ahreu and S. K. Mitra, "A signal-dependent rank ordered mean (SDROM) filter-A new approach for removal of impulses from highly corrupted images," in *Proc. Int. Conf Acoust. Speech Signal Processing,* Detroit, MI, vol. 4, May 1995, pp. 2371-2374.

[4] Vladimir Crnojevic´, Vojin ˇSenk , Željen Trpovski*,,"*Advanced impulse detection based on Pixel-Wise MAD (PWMAD)", *IEEE Signal Processing Letters, Vol. 11, No. 7, July 2004,pp.589-592.*

[5] Handbook of Image & Video Processing, Academic Press Series in Communications, Networking, and Multimedia, Editor AL Bovik.

[6] [6] Digital Image Processing, Second Edition, Rafael .C. Gonzalez, Richard .E. Woods, Pearson Education, inc., 2002.

[7] Fundamentals of Digital Image Processing, A.K.Jain, Prentice Hall of India Private Limited, New Delhi, 2002.

[8] Digital Image Processing, Third Edition, William .K. Pratt, John Wiley & Sons (Asia), INC 2004.