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Image Denoising Technique Using Trimmed Based Median Bilateral Filtering Method

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Abstract: ***Most of the image processing techniques such as edge detection, segmentation, object tracking, pattern recognition etc. do not perform well in the occurrence of noise. Thus, image restoration as a preprocessing step is performed before applying the image to any of the beyond mentioned techniques. This dissertation work presents an Decision based unsymmetric trimmed median filter algorithms for the removal of impulse noise has been proposed with color images rather than gray scale images by separation red- green- blue plane of color image. This proposed algorithm shows better results than the Standard Median Filter (MF), Decision Based Algorithm (DBA),Adaptive Median Filter(AMF) , Hybrid Filter Based Algorithm (HMF), and Trimmed Median Filter (TMF). The show of the system is analyzed in terms of Mean square error (MSE), Peak signal to noise ratio (PSNR) image enhancement factor (IEF) and time required for executing the algorithms for different noise densities. Simulation results shows that proposed algorithm outperforms the existing algorithms even at high noise densities for color images. Many experiments are conducted to validate efficiency of the proposed algorithm.***

Keywords - Image Processing, Denoisng, Impulse Noise, Bilateral Filter

I. INTRODUCTION

Noise reduction in digital images, despite many years active research, still rests a challenging problem. The rapid proliferation of portable image capturing devices, combined with the miniaturization of the imaging sensors and aggregate data throughput capacity of communication channels, results in the need to create novel fast and effective denoising algorithms[5]. Color images are very often corrupted by impulsive noise, which is introduced into the image by faulty pixels in the camera sensors, transmission errors in noisy channels, poor lighting conditions and aging of the storage material **[1]** The suppression of the disturbances introduced by the impulsive noise is indispensable for the success of further steps of the image processing pipeline.. This image contains 8 bits/pixel data, which means it can have up to 256 (0-255) dissimilar brightness levels. A 0'represents black and '255' denotes white. In between values from[13] 1 to 254 represent the different gray levels. As they contain the intensity information, they are also referred to as intensity images. Colour images are considered as three band monochrome images, where each band is of a different colour. Each band offers the brightness information of the corresponding spectral band. [4]Typical colour images are red, green and blue images and are also stated to as RGB images. This is a 24 bits/pixel image.

1.1Noise in Images

During the capture, transmission, processing or acquisition of an Image it can have many kind of variations in its original[2] form, this variation is usually random and has no particular pattern.In many cases, it reduces image quality.This random variation in image is called noise. Generally noise gives an image an undesirable appearance the most significant factor that noise can cover and reduce is the visibility of certain features within the image. The noise present in image can be either in additive form or in multiplicative form. These both forms can be represented as below:

Additive noise equation - $w(x,y) = s(x,y) + n(x, y)$, Eq. (1.1)
Multiplicative noise equation - $w(x, y) = s(x, y) \times n(x, y)$ Eq. (1.2)

In the above equations s(x, y) represents the original signal, n(x, y) is the noise introduced in signal, w(x, y) is the image corrupted by noise and (x, y) is the pixel location. There are different sources of noise in a digital image, depending upon sources noise can be: Dark current noise, Shot noise [4], Amplifier noise and Quantization noise, usually following types of noises are most common in image processing:

- Gaussian Noise
- Impulse noise (Salt and Pepper Noise)
- Speckle Noise

1.1.1 Gaussian Noise
Gaussian noise is a noise which has Gaussian distribution, which has a bell shaped probability distribution function. This noise is evenly distributed over the signal. This means that in the noisy image each pixel has a cost which is the sum of the true pixel value and a random Gaussian distributed noise value. The probability distribution function of Gaussian noise is given by:

$$F(g) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-(g-m)^2/2\sigma^2} \quad \text{Eq. (1.3)}$$

In the above equation g represents the gray level, m is the mean or average,and σ is the standard deviation of the noise. The following graph shows the distribution:

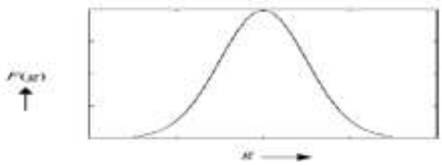

Fig.1.1Probability Density Function for Gaussian noise.

1.1.2 Impulse (Salt-and-Pepper) Noise Model

The PDF of (bipolar) impulse noise is given by

$$p(z) = \begin{cases} p_a & for\ z = a \\ p_b & for\ z = b \\ 0 & otherwise \end{cases}$$

(1)

If $b > a$, gray level b will appear as a light dot in image. Conversely, level a will look like a dark dot. If either P_a or P_b is zero, the impulse noise is called unipolar. Impulse noise is found in conditions where quick transients, such as faulty switching take place during imaging. Four impulse noise models are reported in recent papers.

1.1.3 Speckle Noise: Speckle noise is a multiplicative noise. This type of noise occurs in almost all coherent imaging systems such as laser, acoustics [12] and SAR (Synthetic Aperture Radar) images. The source of this noise is the random interference between the coherent returns. Fully developed speckle noise has the characteristic of multiplicative noise. Speckle noise follows a gamma distribution and is given as:

$$F(g) = \frac{g^{a-1}}{(a-1)!a^a} e^{\frac{-g}{a}} \quad \text{Eq. (1.5)}$$

In the above equation variance is $a^2 a$ and g is the gray level.

II. SCOPE OF RESEARCH

In my work I have done the study of various kinds of noises and denoising techniques in image processing and my main concentration is on denoising of salt and pepper noise by using Median Filter, Trimmed Filter, Adaptive Filter, Hybrid Filter Bilateral Filtering technique. Various advancements in the field of median filter, Bilateral Filtering and impulse noise removal have been studied and then a new filter for the denoising of impulse noise and edge preserving is purposed by using Bilateral Filter. The Scope of my research work will include following aspects:

Efficient Removal of Noise – The purposed filter is very efficient in removing the salt and pepper noise from images almost at any densities value especially the high density noises but the other MF, BF techniques cannot remove the impulse noise from images. The given technique provides better results than existing techniques for impulse noise removal and can be very effective in image processing applications.
Edge preserving in images – Bilateral filter is known as an edge preserving filter, because it not only removes the noise from images but also at the same time saves the important features of image. It is the most efficient technique in edge preservation. The proposed algorithm uses this property of BF and can preserve edges of image even when the high density salt and pepper noise is denoised. The other techniques of high density impulse noise removal cannot do this.
Compatibility with other methods – The proposed filter is basically a combination of two different approaches which are bilateral filter and median filter. To further improve its efficiency it can be used with other techniques also. Previously the BF[8] technique is used with many techniques in order to use for different applications. Hence our proposed technique has a good compatibility with other methods used for image denoising.
Adaptability– Performance of proposed filter can be improved by optimizing its parameters[22] like domain parameter σ_d and predefined parameter α.Hence the technique can be used more efficiently by using proper values of these parameters.

III. PROPOSED METHOD

In proposed algorithm, first we divide the three plane of color image. Then we apply Trimmed Based Bilateral Filter algorithm on every plane of color image for recognition of impulse noise. Checking is performed to determine if the

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processing pixel of each plane is noisy or noise free. It is left unmoved in case of noise free pixel for which the processing pixels of color plane lies between maximum (255) and minimum level (0). Noisy pixel is processed by Trimmed Based Bilateral Filter for color image. For noisy pixel, the giving out pixels of the plane take maximum (255 or minimum level (0).

The detailed operation of our proposed method for the removal of salt and pepper noise from images shown. The stepwise operation of proposed method is as follows:

(i) Read the noisy image which is corrupted with salt and pepper noise.

(ii) Select a 2D window of size 3 $\times$ 3. Assume that the processing pixel is $f(x, y)$.

(iii) If $0 < f(x, y) < 255$ then $f(x, y)$ is a noise free pixel and will be left unchanged.

(iv) If $f(x, y) = 0$ or 255 then $f(x, y)$ is noisy pixel. Hence two cases will be possible:

Case (i): If selected window contain all values as 0 and 255 then replace $f(x, y)$ with mean of values in selected window.

Case (ii): If selected window also contains values other than 0 and 255 then apply the TMASBF on the processing pixel.

(v) The output will be the denoised image $\tilde{f}(x, y)$.

Algorithmic Design

1. Read color noise image.
2. Separate the three jet of color of color image i.e. red-green-blue plane.
3. Select either of the planes(R/G/B).
4. Select 2-D window of size 3×3. Assume to the pixel being processed is P_{ij}.
5. If the processing pixel has values either greater than 0 and less than 255 i.e. $0<P_{ij}<255$ then P_{ij} is an unspoiled pixel and its value is left unchanged.
6. If $P_{ij}=0$ or $P_{ij}=255$ then it is a tainted pixel and further proceeding is based on following conditions
7. Case i): If the selected window contains all the elements as 0's and 255's. next replace with the mean of the element of window.
8. Case ii): If the selected window contain not all elements as 0's and 255's. Then eliminate 255 and 0's and find the median value of the remaining elements. Replace among the median value.
9. Repeat steps 4 to 6 until all the pixels in the entire plane are processed.
10. Go to step 3 and choice next plane.
11. Restored all three de noise plane.

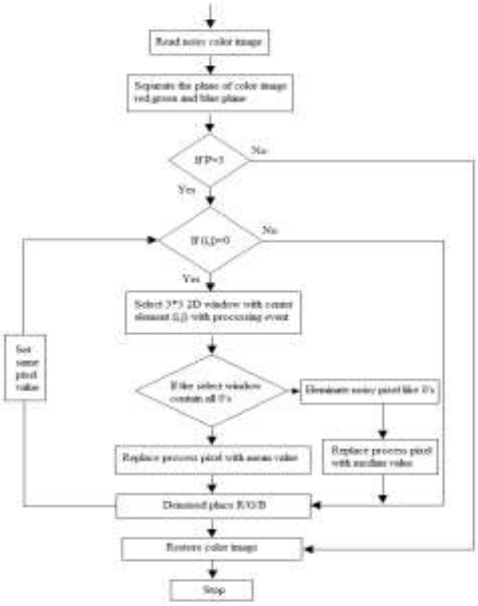

Fig.3.1 Flowchart- Proposed Novel Algorithm based for color images.

IV. SIMULATION RESULTS

The Original Color Image is Leena use Salt & Pepper noise and De-noised image using Median filter, Trimmed filter, Adaptive Filter, Hybrid Filter ,Decision based algorithm, Trimmed Mean Adaptive Switching Bilateral Filter comparisons among them with image matrices like PSNR, IEF, and MSE.

Table 4.1 Comparative analysis of Image Metric parameter (PSNR) using different filter

Density level	PSNR by Adaptive filter	PSNR by Hybrid filter	PSNR by conventional filter	PSNR by Trimmed filter	PSNR by DBA Filter	PSNR by Purposed Filter
0.9	5.2441	5.8040	7.6490	15.9578	12.6202	17.4590
0.8	5.3004	5.9001	9.1402	20.2768	19.5619	22.2818
0.7	5.3006	5.1001	11.0223	24.6545	24.2003	26.9577
0.6	5.3001	5.1201	9.0980	20.1420	28.5819	30.3712
0.3	5.2123	5.8294	23.8836	36.5829	38.1330	34.0134

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0.1	5.4223	6.0023	29.4894	42.8393	45.7571	35.1481

As shown in Table 4.1, PSNR value of different algorithms is compared with the proposed algorithm as a function of noise density for color lena, image. Table shows that the proposed algorithm (TMASBF) outperforms the existing algorithms for noise densities from 0.1 to 0.9 A plot of PSNR values has been presented in Fig.4.1

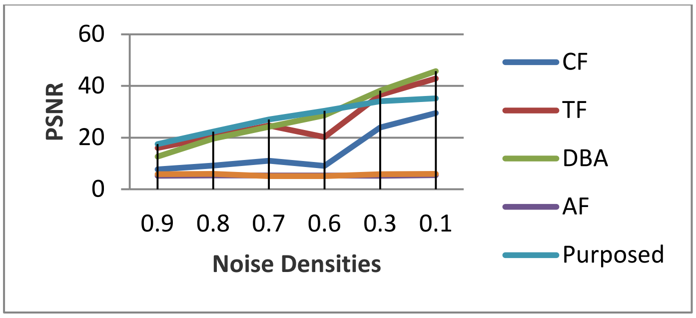

Fig.-4.1- PSNR By lena, Different Filter

Table No- 4.2 Comparative analysis of Image Metric parameter (IEF) using different filter

Density level	IEF by Adaptive filter	IEF by Hybrid filter	IEF by conventional filter	IEF by Trimmed filter	IEF by DBA Filter	IEF by Purposed Filter
0.9	0.8588	1.000	1.4984	10.0868	14.2333	14.3170
0.8	0.7625	1.004	1.8704	23.9377	28.8894	38.6670
0.7	0.2951	1.115	2.5268	58.4271	96.4340	98.4535
0.6	0.5743	1.221	3.6916	130.8048	38.6670	186.8449
0.3	0.2867	1.4532	19.8471	120.4534	140.4657	385.6745
0.1	0.0950	1.6543	25.6134	591.8261	592.3421	595.3432

Table 4.2 shows comparison of Image Enhancement factor of different algorithms for color image at different noise densities (0.1 to 0.9). In comparison with the existing algorithms, the proposed algorithms shows substantial growth in IEF values even at high noise density. From Fig. 4.2 it is clear that, at low noise density, this algorithm outperforms the existing ones having high IEF Values

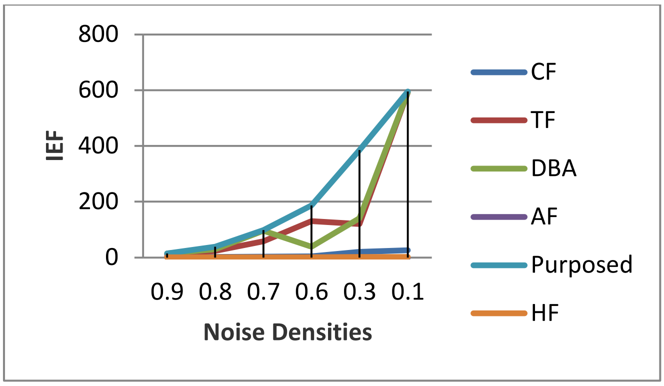

Fig.-4.2- IEF By lena, Different Filter

Table No-4.3 Comparative analysis of Image Metric parameter (MSE) using different filter

Density level	MSE by Adaptive filter	MSE by Hybrid filter	MSE by conventional filter	MSE by Trimmed filter	MSE by DBA Filter	MSE by Purposed Filter
0.9	0.2989	0.3846	0.1713	0.0255	0.0005	0.0177
0.8	0.2787	0.5672	0.1219	0.0095	0.0007	0.0058
0.7	0.6764	0.6778	0.0790	0.0034	0.0020	0.0020
0.6	0.5653	0.6882	0.0471	0.0013	8.0013	9.4417
0.3	0.2989	0.6983	0.0043	2.1928	2.2346	3.0010
0.1	0.2345	0.7054	0.0011	4.8101	4.9000	4.9012

Table 4.3 shows the mean square error comparison of different algorithms as a function of noise density for leena image. Here as the noise density varied from 0.1 to 0.9 i.e. even at high noise density the proposed algorithm shows

minimum MSE values in comparison with the existing algorithms, showing the effectiveness of proposed algorithm.

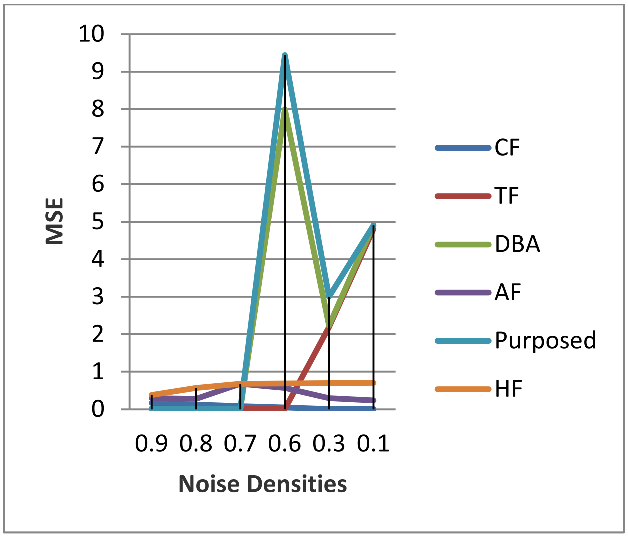

Fig.4.3 - MSE Lena, By Different Filter

V .Conclusion

The proposed algorithm gives better performance in comparison with Median Filter (MF), Decision Based Algorithm (DBA) and other existing noise removal algorithms in terms of PSNR, MSE and IEF. However the time required executing this algorithm is bit more than the existing algorithms .The performance of the algorithm is tested against colour images at low, medium and high densities, showing the effectiveness how impulse noise is removed through the colour images. It yields better results than existing methods even at very high noise densities of 80% and 90%. Both visual and quantitative results are also demonstrated

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