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An Efficient Approach for Image Filtering by Directional Neighborhood with wavelets

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Abstract: ***Image Processing refers to the use of algorithm to perform processing on digital image. Microscopic images like some microorganism images contain different type of noises which reduce the quality of the images. Removing noise is a difficult task. Noise removal is an issue of image processing. Images containing noise degrade the quality of the images. Removing noise is an important processing task. After removing noise from the images, the visual effect will not be proper. This paper presents an approach to de-noise based on averaging of pixels in 5X5 window and wavelets is proposed.***

Keywords: Salt & Pepper Noise; Wavelets; PSNR; MSE**.**

1. Introduction

Microscopes have been used to observe, capture, measure and analyze the images of various living organisms and structures at scales far below normal human visual perceptions.

Microscopic imaging and image processing for this kind of images are of increasing interest to the scientific and engineering communities. All lives on the earth depend on organisms that are too tiny to see without a microscope. These microorganisms are much accountable for generating oxygen, releasing nutrients and minerals from dead plants and animals and helping as food source at the base of many food chains and many more things it does. Microscopic images take us to the hidden micro world within. There are many smaller objects other than organisms, which human being has to see to know about the environment.

By using microscopes, scientists are able to discover the existence of microorganisms and see the smallest parts of plants and animals. These days Electrons, X-rays and infrared rays are used for more microscopes to find even smaller structures. There are number of algorithms for noise removal [1]-[5].

In this paper, a simple method of removal of impulse noise for gray scale image is presented. The proposed method includes two level of Filtering of noisy pixels.
The proposed approach discusses the filtering method by multiresolution. It is combination of frequency domain and spatial domain. Here first directional neighborhood pixel algorithm is applied. Wavelet transform is used for decomposition of images and wavelet coefficient has been collected. Processing threshold based on wavelet detail coefficients has been calculated. New wavelet coefficient based on threshold has been found. Finally, inverse wavelet transforms using new wavelet coefficients is processed to get the image. Experimental result is shown here in this section. Assessment is done by using assessment parameter PSNR, MSE.

Here optical microscope (400X) image of Cyanobacteria with a size of 583 X 345 has been taken for analysis.
The rest of the paper is organized as follows:-
In the second section the impulse noise is described. In the third section detection algorithm and reduction algorithm is described and in fourth section assessment parameter is discussed. Experimental result and discussion is presented in section 5. Section 6 contains the conclusion.
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2. Microscopic Image Noise

Noise that disturbs microscopic images can be divided into different categories. First film grain noise, also called as Gaussian white noise, comes in an image recorded on photographic film. Second, photo electronic noise is due statistical nature of light and of the photo electronic conversion process that takes place in image sensor. At low light levels, photo electronic noise is often modeled as random with a Poisson density function. At high levels, the Poisson distribution reaches the Gaussian. Finally, electronic noise due to the thermal motion of electrons in resistive circuits is modeled as white Gaussian noise with zero mean value [6].

3. Proposed Algorithm

3.1 Directional Neighborhood

Random valued noisy microscopic image is considered. For processing, 5X5 window is taken. Minimum and maximum intensity under this widow is calculated. If processing pixel is in this range then it is noisy otherwise undetermined pixel. Four directions of 5x5 window is set. Average of the absolute difference between two closest pixels from the center pixel is calculated. Average of absolute difference between two far pixels from the center pixel is calculated. Average of absolute difference between two corner pixels from the center pixel is calculated. Get the mean of these three. If mean is in between 230 and 255.It is noise free otherwise noisy. Noisy pixels are corrected by adaptive median.

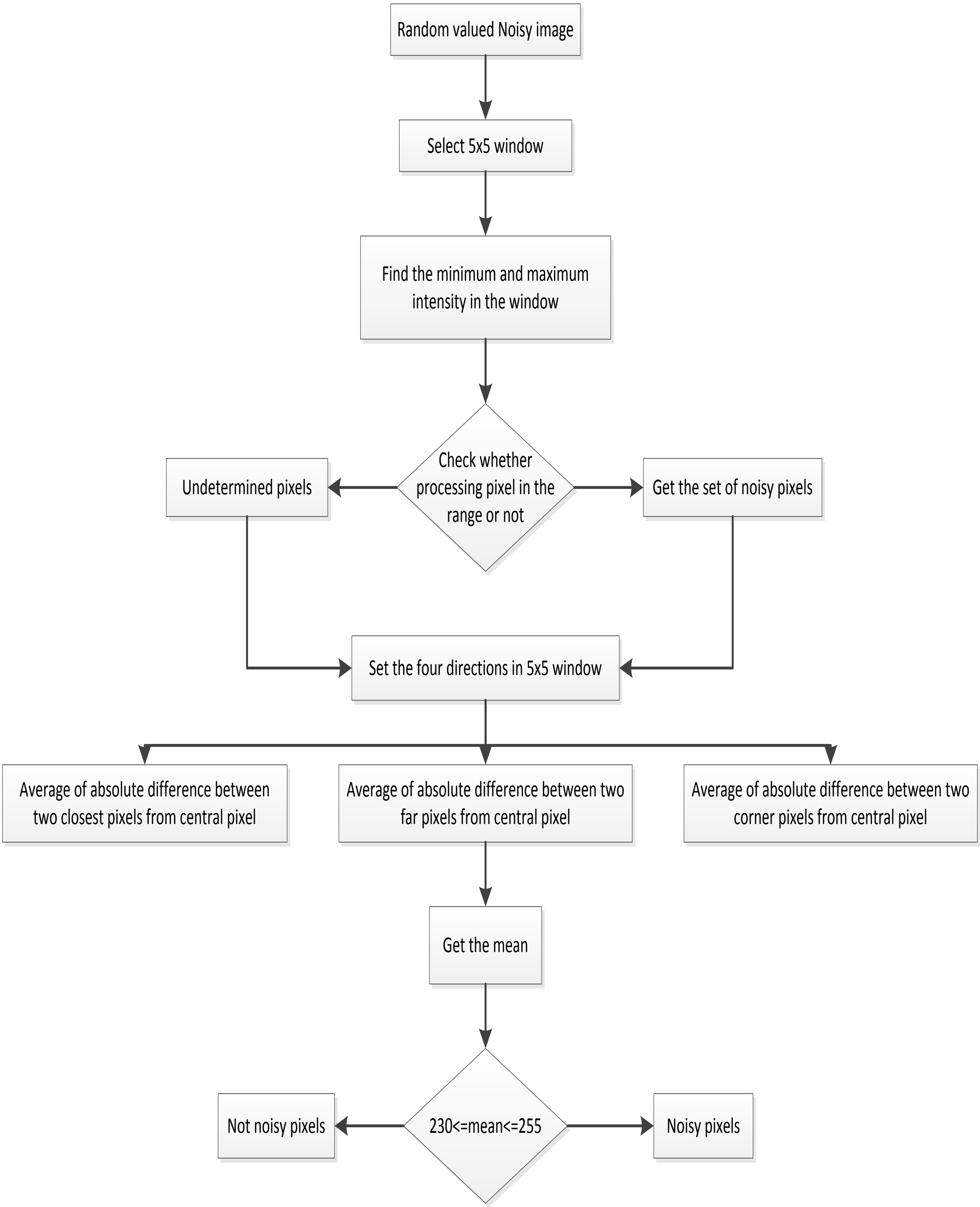

Figure 1: Directional Neighborhood

3.2 Directional Neighborhood with wavelets

Step 1

Image with noise X(i,j)

Step 2

Apply Directional Neighborhood to get the new image as f(x,y)

Step 3

F'(x,y)=Wavelet transform(f(x,y))

Step 4

Calculate the median estimation of the wavelet coefficients

If(k=odd)

m= $w^j((k+1)/2)$

else (1)

m= $w^j(k/2)+w^j(k/2+1))/2$

$$m=\begin{cases} w^j((k+1)/2) & k=odd \\ (w^j(k/2)+w^j(k/2+1))/2 & k=even \end{cases} \quad (2)$$

Where m is median estimation, wj represents wavelet transform coefficient. K is the total number of wavelet coefficients.

Step 5

Standard deviation of the noise at level j

$$\sigma_j=\frac{median(w_j-m)}{0.6745} \quad (3)$$

Step 6

Calculate the denoising thresholding

$$T_j=\sigma_j\sqrt{2\log(N)} \quad (4)$$

Where N= no of points in the signal

Step 7

Calculate the new wavelet coefficients by using soft Thresholding

If(coef[i]<=Tj

coef[i]=0.0;

else

coef[i]= coef[i]-Tj; (5)

Step 8

Make the inverse wavelet transform and output the image.

4. Assessment Parameter for Analyzing The Output Of The Algorithm

There are number of parameters such as Noise Standard Deviation (NSD), Mean Square Error (MSE), Equivalent Numbers of Looks (ENL), and Peak Signal to Noise the algorithm.

4.1 Mean Square Error(MSE)

The Mean Square Error is used to find the total amount of difference between two images. It indicates average difference average difference of the pixels of throughout the image where K is the de noised image and I is the original image with noise. A lower MSE indicates that there is small difference between the original image with noise and de noised image. The formula is

$$MSE=1/mn\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}\left(I(i,j)-K(i,j)\right)^2 \quad (6)$$

4.2 Peak Signal to Noise Ratio

To assess the performance of the noise removal method, PSNR is used. The formula is

$$PSNR=10\log_{10}\left(255^2/MSE\right) \quad (7)$$

5. Results and Discussion

For the performance analysis, a microscopic image of Cyanobacteria with a size of 583 X 345 has been. Here microscopic image is corrupted by salt and pepper noise and Gaussian noise at different density. In this section result are presented to illustrate the performance of algorithm. in terms of PSNR and MSE.

An original noise free image shown in figure 4 is given as reference. A quantitative comparison is performed between different techniques in terms of PSNR. Figure 5 shows the result of Cyanobacteria corrupted by noise (Salt and Pepper Noise and Gaussian Noise) at different density. Noise of different densities ranging from 20% to 90%. The proposed method has been compared with simple median, Adaptive median and Low pass with Homomorphic filter. Noisy image is filtered using different algorithm and result is shown in the figure 6,7,8,9. Figure 6 is filtered image of Cyanobacteria on which simple median filter is implemented. Figure 7 is filtered image of Cyanobacteria by Adaptive median filter. Figure 8 is filtered image of Cyanobacteria by Low pass with Homomorphic algorithm. Figure 9 is filtered image of Cyanobacteria by proposed algorithm. It can be seen that result using the proposed method are significantly better than other

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three methods when noise density is more than 30%. The results are measured quantitatively using PSNR. Table 1 and Table 2 shows the comparison table of PSNR and MSE of different techniques. Figure 1 and Figure 2 show the comparison graph of PSNR and MSE of different techniques for Cyanobacteria.

6. Conclusion

Here an efficient approach for Salt and pepper noise and Gaussian noise removal is proposed. The algorithm goes in three stages. Stage one identifies noisy and noise free pixels. This stage separates those two sets of pixels. Again, in these stage noisy pixels is considered as undetected pixels and goes for second level detection. Second stage does filtering to restore the image. The noisy pixels are replaced by adaptive median which is calculated recursively by increasing the size of the window up to limited size of window. With this salt and pepper noise will be removed. In the third stage, noise free image from second stage will be passed. Gaussian noise will be removed. It shows that the method proposed in the paper is effective for microbiologist in digital image processing. With experimental result. It is seen that proposed algorithm gives good result for noise removal. The peak signal to noise ratio also shows improvement as compared to other methods.

Table 1: Comparison of PSNR of Different Techniques for Cyanobacteria

Noise Density	*Median*	*Adaptive Median*	*Proposed Algorithm*	*Low Pass with Homomorphic*
20	12.3054	21.92414	53.922285	22.359355
60	7.42288	17.38097	50.455515	17.992555
90	5.05986	15.6713	46.636205	15.79727

Table 2: Comparison of MSE of Different Techniques for Cyanobacteria

Noise Density	*Median*	*Adaptive Median*	*Proposed Algorithm*	*Low Pass with Homomorphic*
20	0.2938	0.112715	0.004585	0.10762
60	0.47771	0.177105	0.006495	0.16701
90	0.60391	0.209995	0.00953	0.21296

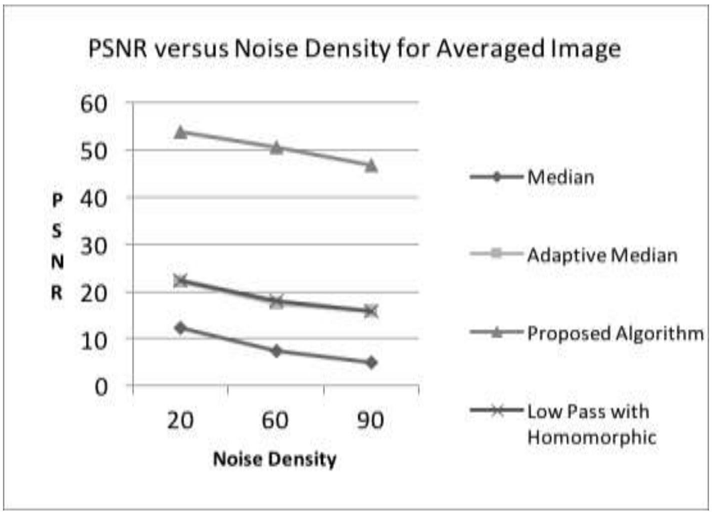

Figure 2: Comparison of PSNR of Different Techniques for Cyanobacteria

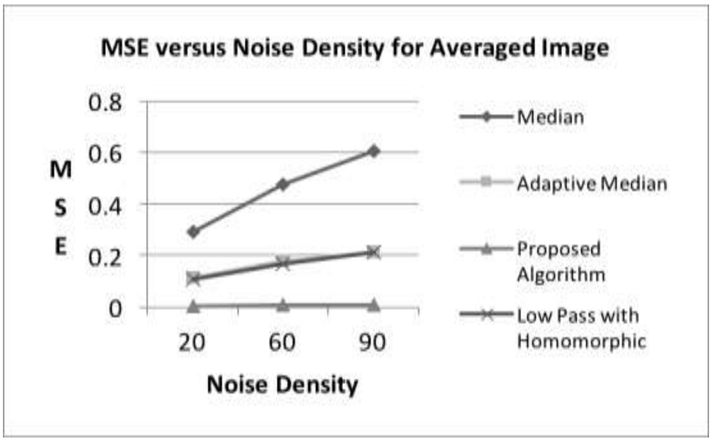

Figure 3: Comparison of MSE of Different Techniques for Cyanobacteria

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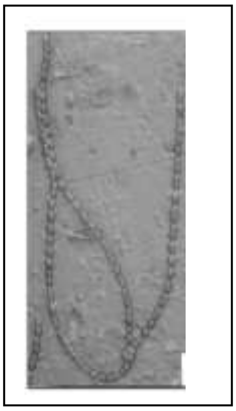
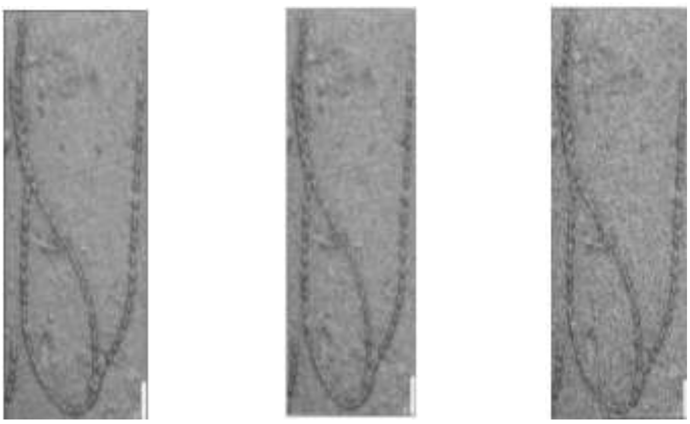


Figure 4: Original microscopic image of Cyanobacteria.

(a) (b) (c)

Figure 5: Image Cyanobacteria corrupted by salt & pepper noise and Gaussian noise. (a) Noise Density 20%, (b) Noise Density 60%, (c) Noise Density 90%, (d) Noise Density 90%



(a) (b) (c)

Figure 6: De-noising by Simple Median filter (a) De-noising image of figure 5(a),(b) De-noising image of figure 5(b),(c) De-noising image of figure 5(c)

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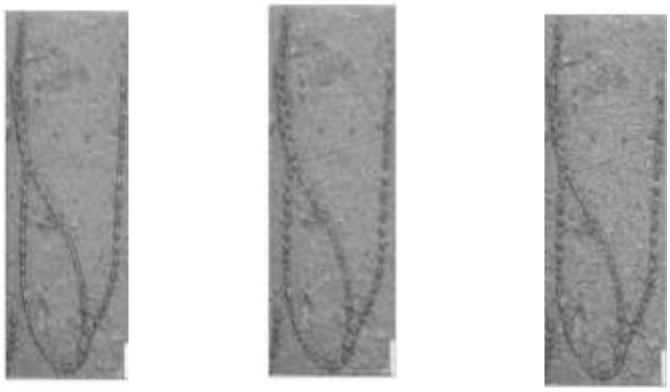
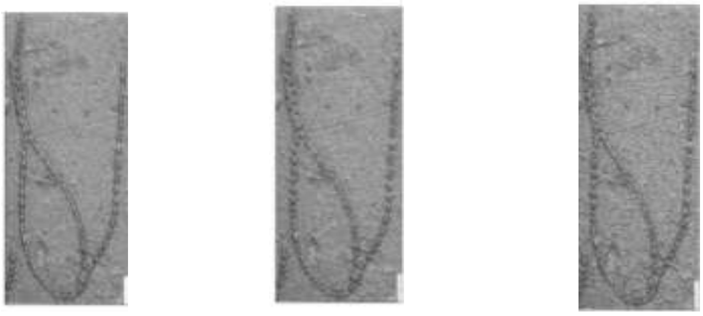


(a) (b) (c)

Figure 7: De-noising by Adaptive median (a)De-noising image of figure 5(a),(b)De-noising image of figure 5(b),(c)De-noising image of figure 5(c)



(a) (b) (c)

Figure 8: De-noising by Lowpass with Homomorphic (a)De-noising image of figure 5(a),(b) De-noising image of figure 5(b),(c) De-noising image of figure 5(c)

(a) (b) (c)

Figure 8. De-noising by Lowpass with Homomorphic (a) De-noising image of figure 5(a) ,(b) De-noising image of figure 5(b) ,(c) De-noising image of figure 5(c)

Figure 9: De-noising by Proposed Algorithm (a) De-noising image of figure 5(a),(b) De-noising image of figure 5(b),(c) De-noising image of figure 5(c)

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