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Pre-Processing of Sickle Cell Anemia Images

Dr. Hariharan S.[1], Aruna N.S.[2]

Professor, Dept. of Electrical and Electronics, College of Engineering, Trivandrum, Kerala, India[1]

Research Scholar, Dept. of Electrical and Electronics, College of Engineering, Trivandrum, Kerala, India[2]

ABSTRACT: Digital images that we get from modern imaging modalities such as computed tomography (CT), Magnetic resonance imaging (MRI), Ultrasonographyetcnot only consist of tremendous amount of information but also various types of noises which reduces the image quality. These noises are mainly due to sensor defects, lens distortion, software, artefacts, image compression, blur, distortion due to transmission over communication channel etc. In order to get good quality images from these captured images we have to remove the impulse noises. However, this work has to be carried out carefully without losing any information content of the original image. Several methods are now available for filtering the cell images, but our aim is to find a simple and most suitable method for removing noises from blood cell images of sickle cell disease(SCD) without losing the information present in the image.

KEYWORDS: Sickle cell anemia, cell image analysis, image denoising, filtering, computer processing of blood cell images.

I. INTRODUCTION

Getting good quality medical images for visualization and interpretation is the dream of every medical professional. This is possible by the implementation of filters. There are various types of filters available in the literature used for image processing applications. All these types of filters are equally useful for producing good quality images, but filters used in one application may not give good result in other images. Another disadvantage of most of the works found in literature is that, inorder to prove the efficiency of the method, they artificially added noise to the image (for eg. Salt and pepper noise or Gaussian noise etc.) and then filtered the image with their own filters or the existing filters. The aim of the present work is the enhancement of quality of image by filtering without disturbing the characteristics of the original images. Unlike other image processing techniques we are not adding any kind of noises, but removes the naturally occurring noises by using very simple filters which are easy for implementing in clinical environment.

II. RELATED WORK

Researchers designed and implemented several types of filters which are now available in the literature [1-6]. In the present work, an effort is made to find a suitable filtering method for preprocessing the sickle cell anemia images. There are several developments that took place in this direction, but all the efforts always falls under a common title 'case studies'. We are well aware that, this work also will shrink as a case study alone but we try to put sincere efforts in improving the quality of images of red blood cells which are the key factors of sickle cell anemia.
Image denoising has been found to be an interesting area for biomedical image processing researchers in recent times. Researchers continuously, cautiously and clearly studied about the reasons for the introduction of noises due to belonging factors and implemented various filters for removing noises. They also demonstrated that their algorithms are computationally scalable and contribute excellent denoising performance. As a result there are several image denoising surveys [7-13] appeared in the literature.
In biomedical engineering we need filters for removing noise and extracting the signals. Noise is what we do not require. Signals are required as it contains information, while acquiring a signal or image for processing or measurement. The noise will occur due to physiological variability, electronic noise and environmental interference or transducer artefacts. All the above noises can be eliminated usingsuitable filters.

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III. THEORY OF FILTERS

Filters are important in every aspects of human life. If we want to drink a cup of tea, before using it, the tea dust has to be filtered out. Drinking water has to be filtered and treated before making it potable. Likewise, water has to be filtered before using it in medical application such as dialysis, cleaning utensils which come in contact with body fluids like blood. Application of filters in a civil engineering construction site, we use a filter for removing small stones and other impurities present in the sand. Similarly in the field of digital signal processing and digital image processing, we use filters for removing various types of noises. Filtering enhances the image by removing the noise. In image processing two types of enhancement techniques are commonly used. They are spatial domain and frequency domain techniques. After applying the filters we get a good quality image or signal which is easy for further processing or interpretations.

Different filters used in this paper are mentioned below:

1. **Low pass filters**

Low pass filters can smooth out sudden changes in the pixel value. It accomplishes this by removing noise but introduce some blurring in the images. The classical 3x3 template for a LPF is given as $\begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$. Use of LPF is mainly for removing noise from snowy pictures such as the one captured from television with poor antenna.

2. **High pass filter**

The high pass filter will remove gradual changes but enhance the sudden changes. The template of high pass filter is

$\begin{bmatrix} 0 & -1 & 0 \\ -1 & 4 & -1 \\ 0 & -1 & 0 \end{bmatrix}$. Use of HPF is that it enhances the edges and removes background from poorly illuminated images.

3. **Mean Filter:**

This filter is also called as a spatial averaging filter. Its template is also a 3x3 matrix with the central element being replaced by average of eight neighborhood elements.Mean filtering is a simple, intuitive and easy to implement method of smoothing images. The idea of mean filtering is simply to replace each pixel value in an image with the mean value of its neighbors, including itself. It is usually thought of as a convolution filter. It is based around a kernel, which represents the shape and size of the neighborhood to be sampled when calculating the mean.

4. **Median Filter**

Median filter is mainly used for removing noises while preserving edges. In this type of filters the value of pixels in the window are sorted and the median (middle) value is the one plotted into the output image. The median filter is normally used to reduce noise in an image, somewhat like the mean filter. However, it often does a better job than the mean filter of preserving useful detail in the image. Median filter considers each pixel in the image in turn and looks at its nearby neighbors to decide whether or not it is representative of its surroundings. Instead of simply replacing the pixel value with the mean of neighboring pixel values; replace it with the median. The kernel value is $\begin{bmatrix} 0.1111 & 0.1111 & 0.1111 \\ 0.1111 & 0.1111 & 0.1111 \\ 0.1111 & 0.1111 & 0.1111 \end{bmatrix}$.

Different measures used in this paper for the performance evaluation are mentioned below:

1. **MSE (Mean Square Error)**

The MSE incorporates degradation function and statistical characteristics of noise in the edge detected image. It measures the average squared difference between the estimator and the parameter. MSE specifies the average difference of the pixels throughout the original ground truth image with edge detected image. The higher MSE

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indicates a greater difference between the original and processed image. The objective of MSE is to find out the edge detected image withI input image.

$$MSE = \frac{1}{mn} \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} [I(i,j) - K(i,j)]^2 \quad (1)$$

where, I is original image, K is edge detected image, m and n are height and width of the image respectively. The MSE should be less, when processing with image restoration, reconstruction and compression. But, in terms of image edge detection, the Mean Squared Error could be higher to ensure it found more edge points on the image and also it is capable of detecting weak edge points.

2. SNR (Signal to Noise Ratio)

SNR is defined as Signal Power to Noise Power. A higher value of SNR is always preferred since it signifies larger amount of signal content than the noise content in the signal, resulting in proper reconstruction.

$$SNR = \frac{P_{signal}}{P_{noise}} \quad (2)$$

3. PSNR(Peak Signal to Noise Ratio)

Peak signal-to-noise ratio, is ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. The PSNR usually expressed in terms of the decibel (dB) scale. PSNR is a rough estimation to human perception of reconstruction quality. Although a higher PSNR generally indicates that the reconstruction is of higher quality in image compression. But in some cases like edge detection PSNR should lesser to achieve proper results. The PSNR calculated based on the MSE by,

$$PSNR = 10.\log_{10}\left(\frac{MAX_1^2}{MSE}\right) \quad (3)$$

MAX_1 is the maximal variation in the input image data. If it has an 8-bit unsigned integer data type,MAX_1 is 255.

IV. PROPOSED METHOD

The proposed method differentiates the difference between different filtering methods and can analyse the appropriate filter that can be used for microscopic blood cell images. In this paper we are trying to evaluate the performances of different filters in the analysis of blood cell images namely mean, median, low pass and high pass filter.The images are pre-processed using the following filters as in block shown in figure 1. The output images are taken for analysis.

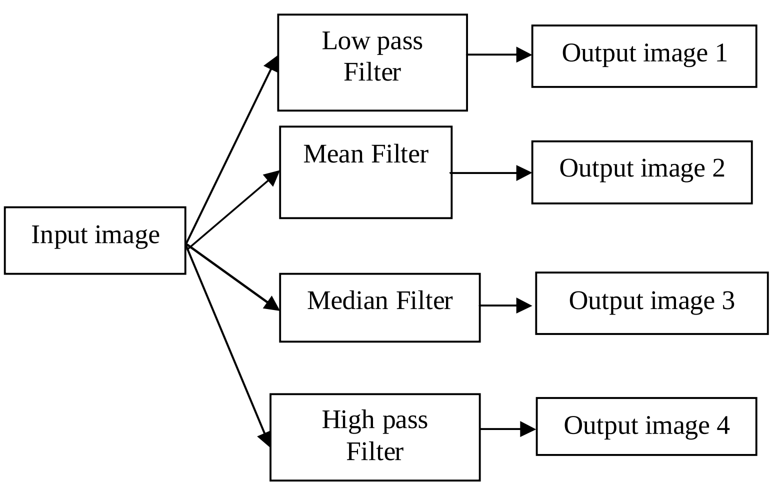

Fig.1. Block Schematic of the proposed method

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Table 1. Comparison of different filtering methods

	Low pass Filter	Mean Filter	Median Filter	High pass Filter
Advantage	It passes only low frequency components	1. It is easy to implement and removes impulse noise. 2. It highlights the edges	1. It is easy to implement and used for de-noising different types of noises. 2. Median filtering is a non-linear method. 3. It has less blurring ability compared to other filters.	It passes only high frequency components
Disadvantage	It blocks high frequency components	1.Some information in the image is also removed. 2. It reduces the intensity of image between the pixels. 3. Images get blurred.	Tends to remove image details such as thin lines and corners. It is not suitable for signal dependent noises	It blocks low frequency components

The above figure 1 is the block schematic diagram of proposed method done in this paper. Each microscopic image is filtered with low pass, high pass, mean and median filter and the output of these is taken for proving the difference of the methods used.

V. RESULTS AND DISCUSSIONS

A. GENERAL DISCUSSION

The primary focus of digital image processing is to enhance pictorial image for better human interpretations. Noises in image are available because of bit errors during transmissions or affected during capturing stage. Noise hides the important details of image and degrades it. Removing the noise from the degraded image is one of the major and preliminary tasks involved in image processing. This can easily be done with the help of image filters. Filtering helps to enhance the image by removing noise. There are different types of filters which are classified under linear and non linear filters. In linear filtering denoising procedure is directly applied to the image without checking accessibility of noisy pixels. Thus it will affect the non noisy pixels in the image. Non linear filters,on the other hand detects the noisy pixel and then filter the image. The median filter is one of the most popular non linearfilters because of its good denoising power and computational efficiency. Median filter algorithm works on highly corrupted image. Noisy pixels are classified into various classes and they are low density, moderate density and high density noises. Weighted 8 neighborhood function filter is used to remove low density noises. Median filter is applied to remove moderate density noises and 4 neighborhood mean filter is applied to remove high density noises. Low pass filters and high pass filters are also a classification of filters. High pass filters preserves the edge details and low pass filters denoise the image by preserving details.

B. EXPERIMENTAL RESULT

The images are acquired from different sources available. Original and synthetic images are used for differentiating the difference of using different filters mentioned in this paper. The processing of images is done with the help of MatlabR2014a. Matlab code was specially written for these microscopic images to generate the output.

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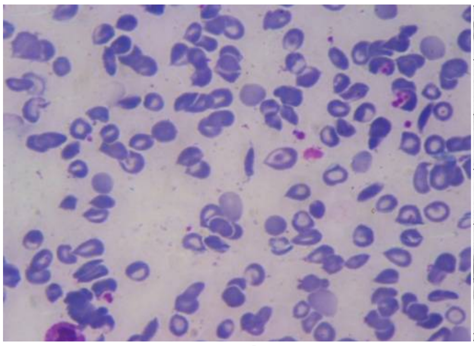

Fig 2(a). Original image

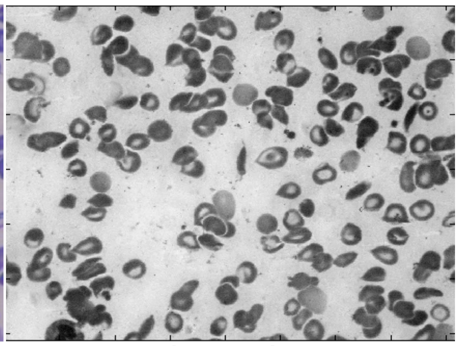

Fig 2(b). Grayscale image

Images used in this work are from the data base of the sickle cell anemia affected blood smears. The original image is first converted to 32 bit gary scal imageand is shown in fig2(b).

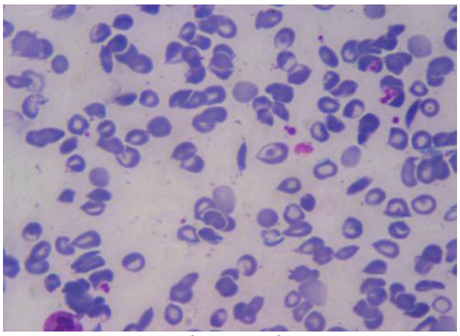

Fig 2(c).Image after mean filtering

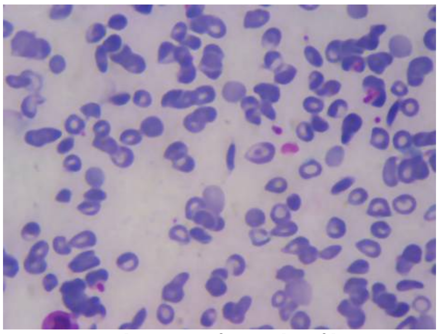

Fig 2(d). Image after median filtering

All the above mentioned filters are applied to the images and the results are obtained. The fig 2(c) is the result of original image after mean filtering and fig 2(d) is the result after median filtering. Low pass and high pass filters are applied to the original image and the results are shown in fig 2(e) and 2(f).

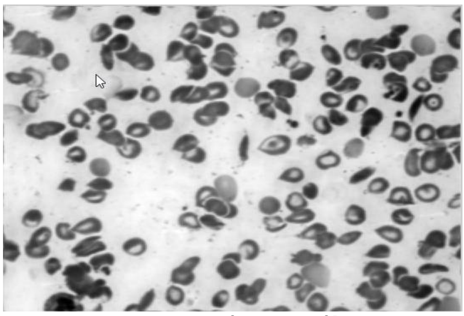

Fig 2(e). Output of Lowpass filter

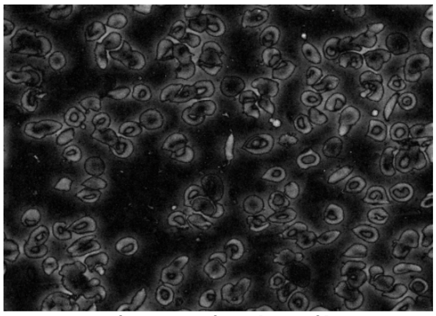

Fig 2(f).Output of Highpass filter

The figure 3(a) is a synthetic image which is a 3 dimentional image of sickle cell anemia affected blood smear. This image is converted to gray scale as some of the operations can be done with grayscale image only. Figure 3(b) is the grayscale image. 3(c) and 3(d) are the output result of mean and median filters.


Fig3(a). Original image Fig 3(b). Grayscale image


Fig 3(c). Image after meanfilteringFig 3(d). Image after median filtering

Figures 3(e) and 3(f) are the output result of low pass and high pass filters. The low pass filters from the output image, it clear that they it smoothens the image and preserves the details in the image. The high pass filters from the figure 3(f) makes it clear that it preserves edge details.

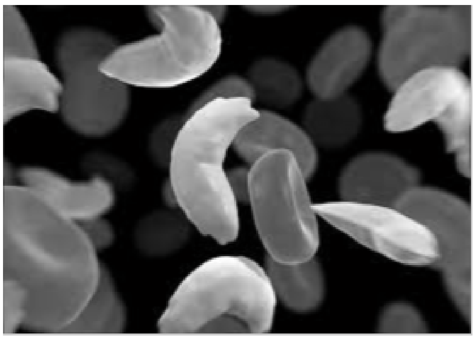
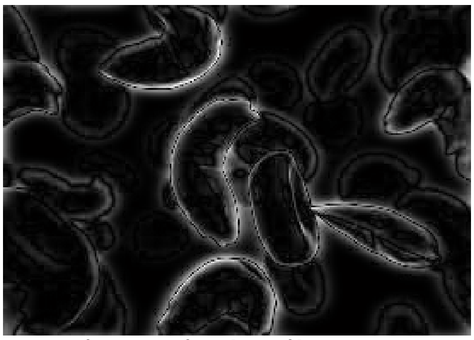

Fig 3(e). Out put of Lowpass filter Fig 3(f). Output of Highpass filter.

The same process is continued with more than 300 images. The images are evaluated using their noise ratio values. SNR and PSNR values of all images are taken and results of 10 images is taken for evaluation purpose of this paper. The table 2 shown below mentions the evaluated values of noise ratio of different images. These images consists of original images and synthetic images. The filters are applied to both type of images to find the difference. A little more effort is taken in writing the matlab code to apply the filters to the original microscopic image. Low pass and high pass filters are applied to grayscale image.

Table 2. Comparison of Noise ratio of Different Filters

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Image serial no.	Low pass Filter			Mean Filter			Median Filter			High pass Filter		
	MSE	SNR	PSNR	MSE	SNR	PSNR	MSE	SNR	PSNR	MSE	SNR	PSNR
1	23538.89	0.038	-43.71	7.47	29.56	33.53	6.38	31.85	36.21	227.62	0.23	-23.57
2	8340.96	0.036	-39.21	15.19	22.15	29.23	10.95	24.16	33.10	225.97	0.11	-23.54
3	25965.54	0.031	-44.14	3.50	34.14	37.78	5.52	33.66	37.60	123.84	0.31	-20.93
4	26199.10	0.030	-44.18	3.30	34.23	37.99	5.13	34.02	37.93	85.46	0.36	-19.32
5	25868.14	0.035	-44.13	3.44	34.07	37.85	5.41	33.74	37.70	100.77	0.34	-20.03
6	23979.67	0.035	-43.80	3.41	33.91	38.03	5.40	33.42	37.71	127.34	0.31	-21.05
7	24580.94	0.032	-43.91	3.33	34.22	38.23	5.25	33.66	37.84	122.55	0.30	-20.88
8	23663.43	0.036	-43.74	3.60	33.80	37.74	5.76	33.06	37.40	224.20	0.23	-23.51
9	24069.05	0.039	-43.81	3.56	33.87	37.79	5.65	33.23	37.49	210.59	0.24	-23.23
10	23549.71	0.037	-43.72	3.54	33.86	37.91	5.60	33.17	37.53	281.26	0.21	-24.49

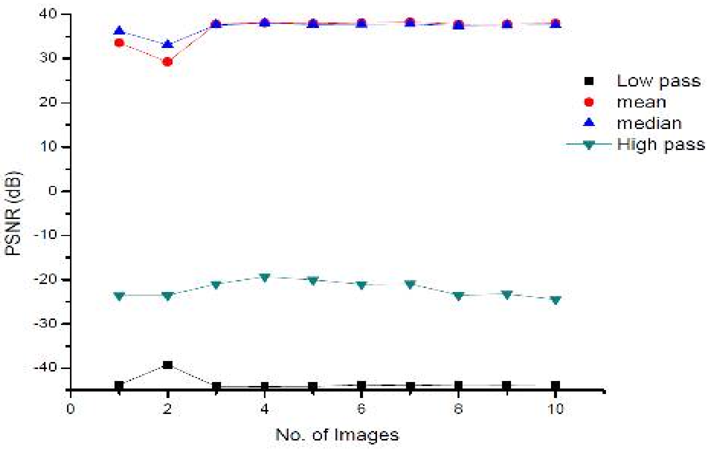

Fig 4.Plot of PSNR valueof different filters with sample images.

Figure 4 is the plot of Peak signal to noise ratio with the sample images. This plot is drawn taken to conduct a study of how the values differ with different filters. The mean and median filters are applied to the original image and hence the values of PSNR are positive values. Low pass filters and high pass filters are applied to grayscale image and hence the PSNR values are having negative values.

VI. CONCLUSION

Image filtering is one of the most important operations in digital image processing. Noises are present in the image due to various reasons. They have to be removed before further processing operations or giving to visual interpretation for human beings. For the purpose of performance evaluation we use the parameters like MSE, SNR and PSNR. Different values of the parameters obtained while applying the four discussed filters such as low pass filter, high pass filter, mean and median filters are summarised in table 2. A comparison of different image filtering methods is done. This helps to understand how these filtering applied to the images make difference without affecting the information in the image. This also helped to improve the visual quality of the image for further image processing. This can also be used to reverse the effect of blurring on a particular image.

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