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RESEARCH ARTICLE

ANALYSIS OF BLOOD SMEAR IMAGES OF SICKLE CELL ANEMIA BASEDONFUZZY FILTERING.

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Abstract

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Fuzzy systems are quite famous due to their imprecise, uncertain, softness and flexibility. Fuzzy filters are now available for various images and they can be easily turned specifically for different types of images. Zadeh has repeatedly specified that one of the most important application domain of fuzzy set theory is medical image processing. Now-a-days, Fuzzy set theory is inherently used in image enhancement, segmentation such as hard and soft thresholding, filtering, smoothening, edge enhancement etc. In the present work a fuzzy filter has been designed and implemented. It has been specifically turned for the analysis of blood smear images of sickle cell anemia patients.

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Introduction:-

Fuzzy set theory, developed by Zadeh [1] has won several successful applications in almost all fields of engineering and medicine.Instead of coming to a saturation level its popularity is increasing day by day due to their special characteristics such as soft computing,uncertain and imprecise nature.Applications of fuzzy set theory in image processing and pattern recognition have contributed several research publications [2-6].One of the important image processing applications performed on digital images is filtering.Image filtering approaches are useful when image is corrupted with noise.Fuzzy filtering is one method for filtering the image. This can easily be achieved with the help of a fuzzy filter.In digital image processing filtering is used for image smoothing,edge enhancement or image manipulation operation.

In the case of sickle cell anemia,the surface of the cell becomes sticky and beads like sickle shape or half-moon shaped.The captured image on the microscope also contains various types of noise.Inorder to get good quality image these noises has to be removed. For this purpose image filtering is most commonly used. After this operation the output image will be smoothened without losing information content from original image.

Application of fuzzy set theory in cell image analysis is performed by many researchers [7-14]. Most of them concentrate their work towards the WBC or leukocyte image analysis. In many situations like leukemia detection, leukocyte pattern recognition is found to be an essential and desirable component. Among the algorithms in segmentation research thresholding is found to be one of the most important and easy to implement technique. It has got so many disadvantages and hence people started with soft thresholding techniques. Fuzzy based image analysis techniques are introduced in order to overcome the difficulties of hard thresholding approaches [15]. Several fuzzy based segmentation algorithms are also now available in the literature [16- 23]. Another most important operation which can be performed on digital images is filtering. This can also be implemented in several ways, however one of the most simple way is to make use of a fuzzy filter [24-30].

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Image processing researches observed that the two types of noises commonly found in images are the impulse noise and the random noise. Impulse noise is defined by noise density while random noise is expressed in mean and variance [2].These noises can be removed effectively by using suitable filters. As compared to an ordinary filter, fuzzy filter provides a smooth, imprecise vague and flexible type of filter. There are few limitations for conventional filtering. These conventional spatial filtering utilizes an over lagging procedure to generate the smoothened image. The weights used for the averaging are crisp or in otherwords image data invariant. Thus all regions of an image which can be brought under and arbitrary neighborhood are equally affected. In this regard it can be said that conventional spatial filtering by masking or averaging suffers from at least two limitations from the point of view of its design and implementation.These two limitations are presented as follows.

(1) It does not take into account the effect of the difference of grey levels between the central pixel and a neighboring pixel.
(2) It does not always take into account the diminishing influence of the pixels that are situated in the increasing distance from the central pixel.

In this work the above two limitations are of the conventional spatial averaging filtering are taken under consideration while designing fuzzy averaging spatial filter.

Methodology:-

Proposed fuzzy spatial averaging filter:-
In this present paper an effort is made for the analysis of Sickle Cell Anemia images by applying a fuzzy filter. This is basically employing an averaging technique which can decide the weights of a 3x3 mask based on the distance of a particular neighborhood pixel from the central pixel. The gray level difference between that pixel and the central pixel is also being considered for the purpose of smoothing the image.

These considerations come primarily from the assumption that a particular pixel is basically a prototype of its neighboring pixels. Based on this we can say that the grey value of a particular pixel in the noiseless image can be represented as a weighted average of the grey levels of its neighboring pixels. These weights will primarily depend on two factors:

- ❖ how far a particular pixel in the neighbourhood is situated from the central pixel in the physical plane.
- ❖ how far a particular pixel in the neighbourhood is situated from the central pixel in the grey level plane.

Under these assumptions based on the above it is possible to state that the contribution of a particular pixel in the neighborhood to its weight in the averaging process would decrease as it becomes more and more far situates from the central pixel as also its grey level becomes increasingly different from that of the central pixel.

This particular percept leads us to design the membership values (which eventually will save as the weights in the averaging process)of the pixels in the neighborhood. It can be noted that the weights used in this filter are not constant and depends on the neighborhood information of the central pixel.

Development of the membership function and the smoothing algorithm:-
The membership function determines the extent to which a particular pixel in the neighborhood represents the central pixel. Thus a pixel moves away from the central pixel its membership values will decrease. At the same time if it has a large difference of grey value from the central pixel its membership value would become lower than what it would have been if the difference were smaller. Taking this into account the membership function can be modeled as a double bell shaped curve. The membership function as it can be expected will be depended on two parameters, difference of grey values and distance.

Let the grey level of the pixel at the location (m,n)be given by x_{mn}. If the central pixel grey level can be given by x_c,then the membership value $\mu(x_{ij})$ of any pixel in the neighborhood of x_c is given by

$$\mu(x_{ij}) = \exp\left[\frac{-(x_c - x_{ij})}{\alpha \times \exp\left(-\frac{d^2}{\beta}\right)}\right] \quad (1)$$

where d is the distance between the central pixel x_c and the neighboring pixel x_{ij}. α and β are two scaling factors which determine the extent of flatness of the membership function. It can be noticed that the membership function returns 1 only when the neighboring pixel and the central pixel coincide. That is to say $x_c = x_{ij}$. Thus the central pixel has the maximum contribution in determining its modified value. This leads to a problem if the central pixel itself is a noise pixel, because then the effect of the noisy pixel in the output image would be most prominent. To overcome this problem the effect of the central pixel itself is neglected while determining the modified grey value of it.

In the averaging procedure the membership values themselves serve as the weights of the grey levels of the pixels in the neighborhood. In the light of the above discussions the algorithm can be presented concisely as follows.

Step 1:-For a central pixel x_c, determine a neighbourhood w of some suitable size (say 3x3).

Step 2:- For each pixel x_{ij} in the neighbourhood determine the membership value μ_{ij}as given from (1)

Step 3:-The modified grey value of the central pixel can thus be given by

$$x_c' = \frac{\sum\sum \mu_{ij}.x_{ij}}{\mu_{ij}}, \qquad i, j \in w \quad (2)$$

and $x_{ij} \neq x_c$. It can be observed that even after implementing the algorithm in some images, the filtered image is not very clear for human visual system for interpretation. In such cases a second stage of filtering is also necessary. This can be achieved with the help of a moving average window with triangular membership function. In the standard moving average filter also the value of the central pixel of the window is replaced by the mean value of the neighbourhood. An asymmetrical triangular median filter will modify and give an output which is pleasant for human interpretation.

The working of the asymmetrical triangular membership median filter is in such a way that it takes into account the deviation of the pixel value with the median values and replace the noisy pixels with the output based fuzzy triangular membership function.

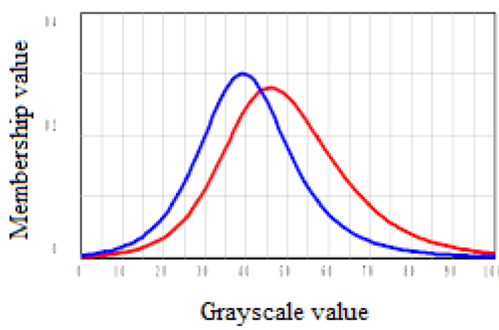

Fig 1:- Plot of Double bell shaped moving average function

The fuzzy filter with triangular function and median value within the window can be represented as

$$O(x,y)=\begin{bmatrix} 1-\left(\dfrac{I_{med}(x,y)-I(x+y,y+j)}{I_{med}(x,y)-I_{\min}(x,y)}\right) & for \quad I_{\min}(x,y)\le I(x+i,y+j)\le I_{\min}(x,y) \\ 1-\left(\dfrac{I_{med}(x,y)-I(x+y,y+j)}{I_{med}(x,y)-I_{\min}(x,y)}\right) & for \quad I_{med}(x,y)\le I(x+j,y+j)\le I_{\max}(x,y) \end{bmatrix} \quad (3)$$

For $I_{\max}(x,y)-I_{med}(x,y)=0$ or $I_{med}(x,y)-I_{\min}(x,y)=0$ where $I_{\max}(x,y)$=maximum value, $I_{\min}(x,y)$ = minimum value, $I_{med}(x,y)$= median value in the 8 neighbourhood.

Results and Discussions:-

One of the most fundamental and important operations on digital images is filtering. Filtering is required in many cases because of the presence of noise while acquiring the images. This problem can be eliminated by applying suitable filters. The selection of suitable filter and its design, implementation and evaluation are some of the tasks involved in the image analysis. Ordinary type of filters like low pass and high pass are not suitable for filtering images of sickle cell anemia. Median filtering can be used for such applications but have the disadvantage of image blurring. Fuzzy based approaches are free from such limitations and are suitable for special applications such as sickle cell anemia. However, they are also effective in case of the multiplicative noises. This can be removed by implementing a second stage of de-speckling wherever necessary.

Medical images obtained from X-ray, CT, MRI, PET etc often consist of noise while acquiring the image or transmitting the image from one place to another. For getting good quality images for visual interpretation noises from these images have to be removed. For noise removal we normally use linear filters or nonlinear filters. Examples of linear filters include low pass filters and high pass filters. Median filters are found to be one of the most efficient, commonly used filter for image processing applications.

Linear filtering techniques used for noise reduction in images have mathematical simplicity and effectively reduce noise with spectral exponents that do not overlap with those of an image. Linear filters will not reduce impulse noise and have a tendency to blur the edges of an image. In situations like this median filters, which are nonlinear filters provide an effective solution.

Filters used in image analysis applications can be classified into two based on the nature of filters used. They are hard digital filters such as low pass filters, high pass filters, median filters etc or soft fuzzy filters which are adaptive in nature. Fuzzy filters have improved characteristics such as imprecise, uncertain and unlimited bandwidth. Fuzzy filters are a promising group of filters which are suitable for cell image analysis due to their soft computing nature and computational efficiency.

Median filters have good edge preserving ability can eliminate impulse noise and have moderate noise attenuation ability in the flat regions of an image. The operation of median filter involves the application of a window to move over an image and replace the central pixel with the median of all the pixel values within the window. By doing like this a pixel with a distinct intensity as compared to those of its pre-defined neighbours can be eliminated. The implementation of a standard median filter is simple and the filter can process an image in a fast manner. The performance of a median filter is average for filtering random noise. This difficulty can be eliminated with some success by another nonlinear filtering technique called MAV filters or Moving Average filters. Moving Average filters can smooth random noise but they are not able to suppress impulse noise. They are also not able to preserve sharp edges of an image.

Fuzzy mean filter is basically a modification of a fuzzy median filter. It has been designed for reducing impulse noise. Using fuzzy rules, fuzzy median filter determines the degree that a centre pixel is not a noise pixel. The weight is assumed to be 1 when the centre pixel is not noisy. If it is not noisy the centre pixel will remain unchanged. Otherwise the centre pixel will be replaced by the sum of mean value within the window.

The processing of images is done with the help of MatlabR2014a. Figure2 is the original image and 2(a) and 2(b) are the images after mean filtering and fuzzy filtering respectively.

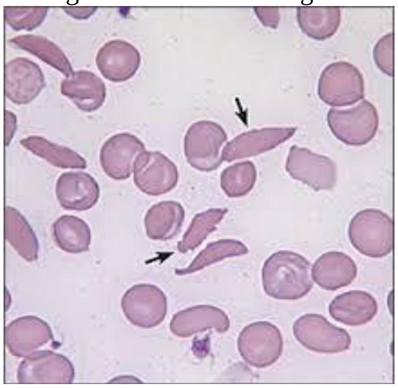
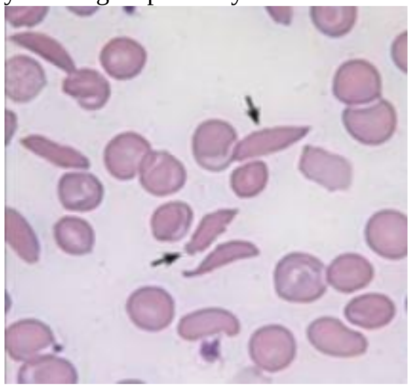


Fig 2:- Original Image **Fig 2:-** (a) Mean filter **Fig 2**:- (b). Fuzzy filter

Fig 3:- is another blood smear image containing sickle cells. Figures 3(a) and 3(b) are the images after mean filtering and fuzzy filtering respectively.

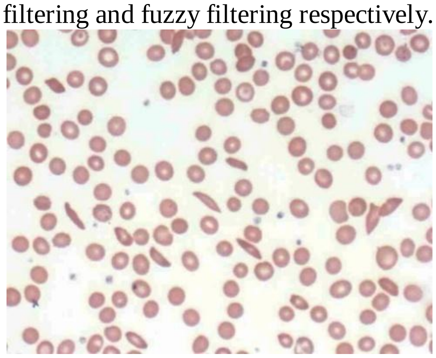
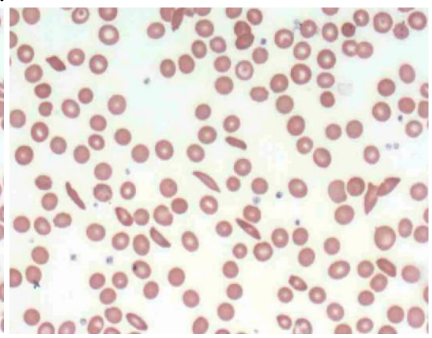
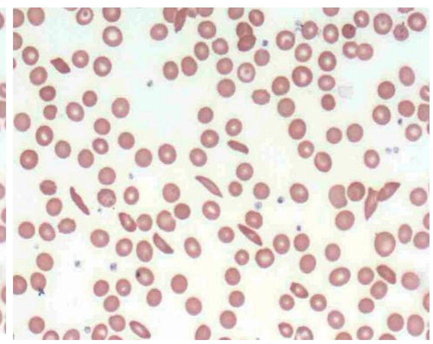

Fig 3:- Original Image **Fig 3:-** (a). Mean filter **Fig 3:-** (a). Fuzzy filter

Fig 4 is another blood smear image containing sickle cells. Figures 4(a) and 4(b) are the images after mean filtering and fuzzy filtering respectively.

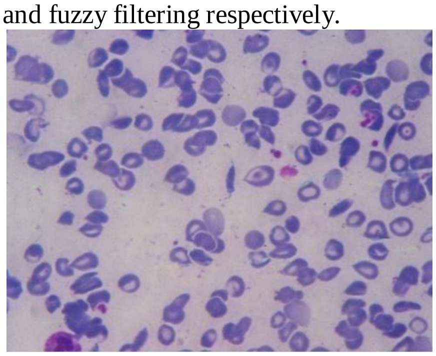
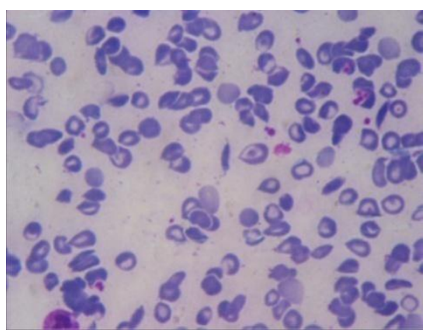
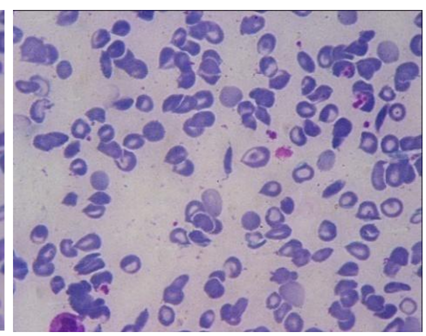

Fig 4. Original Image **Fig 4(a).** Mean filter **Fig 4(b).** Fuzzy filter

The table below shows the performance evaluation of mean and fuzzy filters that are used in this proposed work. The values of Mean square error (MSE), Signal to noise ratio (SNR) and Peak signal to noise ratio (PSNR) are evaluated.

Table 1:- Performance evaluation of proposed filters

Sl. no.	Mean Filter			Fuzzy Filter		
	MSE	SNR	PSNR	MSE	SNR	PSNR
Image 1	7.47	29.56	33.53	49.01	18.56	34.45
Image 2	15.19	22.15	29.23	8.03	35.12	36.24
Image 3	3.50	34.14	37.78	31.02	27.11	39.50
Image 4	3.30	34.23	37.99	6.83	32.95	36.59
Image 5	3.44	34.07	37.85	6.36	33.12	39.88
Image 6	3.41	33.91	38.03	6.66	32.91	40.68
Image 7	3.33	34.22	38.23	6.63	32.58	41.69
Image 8	3.60	33.80	37.74	6.46	32.81	38.81
Image 9	13.56	33.87	37.79	42.91	22.42	39.32
Image 10	10.54	33.86	37.91	7.01	32.57	38.47

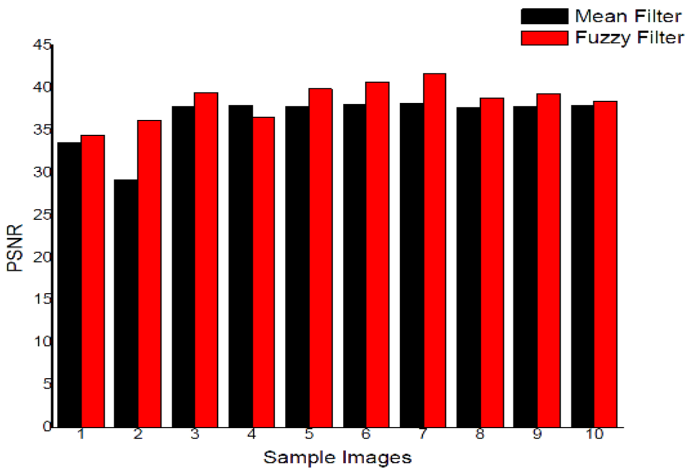

Fig 5:- Plot of PSNR value of sample images

Performance evaluation of both the filters are done and is plotted which is shown in fig 5. The bar diagram represents the PSNR value against different sample images. The fuzzy filter used has high value of PSNR which means that it has a good reconstruction of image.

Conclusions:-

Fuzzy set theory has been used for image processing applications for quite long time. It is also used for medical image processing. Medical images obtained from modern image modalities are also filled with noises which make the human interpretation and disease diagnosis a difficult task. Images are considered to be the fundamental types of data. Hence noise present in it must be removed while acquiring it or transmitting over communication channels. For this purpose we use image filters. But most of the time a single filter will not provide the best result. Under this situation we use a hybrid filter for achieving the expected result. The design and implementation of fuzzy filter is simple because it considers a local approach based on spatial averaging of a small window of 8 neighbourhoods. Here a double bell shaped membership function is considered for the development of membership function. For this purpose a simple mathematical function is used along with two scaling factors α and β. These scaling factors will determine the extent of flatness of the membership function.

It is observed that in some cases a second stage of filtering is needed for better quality images. In such cases a hybrid filter is needed. This can be achieved with the help of a moving average window with triangular membership function. It takes into account the deviation of the pixel value with the median value and replaces the noisy pixel with an output based on fuzzy triangular membership function. Thus we get a good quality image from the hybrid fuzzy filter.

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