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Performance Evaluation of Selected Noise Removal Algorithms in Sickle Cell Images

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Abstract
The impact of digital image processing is increasing by the day for its use in the medical and research areas. Proper identification of diseases is very crucial step for curing disease. In many cases microscopic analysis of peripheral blood samples by medical practitioner is an important test in the procedures for the diagnosis of any blood related disease and accurate diagnosis of disease is crucial for curing and controlling that disease. Some of the developed expert systems diagnosing various diseases using digital images of blood samples were prone to a variety of types of noise which affect image acquisition process that result in pixel values that do not reflect the true intensities of the real scene. The presence of noise in an image could result into wrong and incorrect information which could have possible consequence on the given image. Hence there is need for proper and adequate removal of noise during processing of images so as to obtain valuable and important information necessary for classification and diagnosis. In this paper, a comparison of performance of three selected noise removal algorithms (Median filter Ordinary filter and Weiner filter) was carried out on sickle cell images. The results revealed that the median filter showed high performance accuracy than the other filter types.

Keyword:- Image processing, Sickle Cell, Median filter, Ordinary filter, Weiner filter

1. Introduction
Sickle cell disease (SCD) is a blood disorder characterized by sickle hemoglobin (Hariharan and Aruna, 2014). Over 3,000,000 babies worldwide are born each year with these disorders. Patients suffering from this disease experience acute pain episodes and infections in addition to other chronic conditions like anemia, cardiac, pulmonary, renal and brain complications. Normal red blood cells are disc-shaped and look like doughnuts without holes in the center. They move easily through your blood vessels. Red blood cells contain an iron-rich protein called hemoglobin (HEE-muh-glow-bin). This protein carries oxygen from the lungs to the rest of the body. Sickle cells contain abnormal hemoglobin called sickle hemoglobin or hemoglobin S. Sickle hemoglobin causes the cells to develop a sickle, or crescent, shape. Sickle cells are stiff and sticky. They tend to block blood flow in the blood vessels of the limbs and organs. Blocked blood flow can cause pain and organ damage. It can also raise the risk for infection. The disease is inherited in an autosomal recessive pattern. This means that a child will not inherit the disease unless both parents pass down a defective copy of the gene. People who inherit one good copy of the gene and one mutated copy are carriers. They are clinically normal, but can still pass the defective gene to their children. (www.nhlbi.nih.gov/health/health-topics/topics/sca/) Sickle Cell Diseases management hence entails frequent hospitalizations and care, especially during sickle cell crisis. The widespread of computers and the emergence of new information systems have played a leading role in the development of modern software. The use of such software has widely spread, especially in the fields of Biomedical Science, where new information systems have been created to represent creative and pioneering capabilities as far as application and usages are concerned. The medical field has made great advances in reducing mortality from SCD, but much work remains to be done in improving quality of life for patients. The mechanical properties of individual RBCs in SCD have not been fully assessed, largely due to the limitations of the measurement techniques. Digital Image Processing provides different techniques for the identification of shape and size of cells present in blood. Identification of the disease is very crucial step for curing disease. In many cases microscopic analysis of peripheral blood samples by medical practitioner is an important test in the procedures for the diagnosis of any blood related disease. Accurate diagnosis of disease is crucial for curing and controlling that disease. Computer vision and image processing has been very useful in classification, and processing of medical image, which helps medical experts in making quick and accurate diagnosis. Due to the complexity of these images, several pre-processing steps has to be done, so as to get adequate information from these images which could serve as an eye opener or a very useful tool in computer aided diagnosis, classification, and processing.

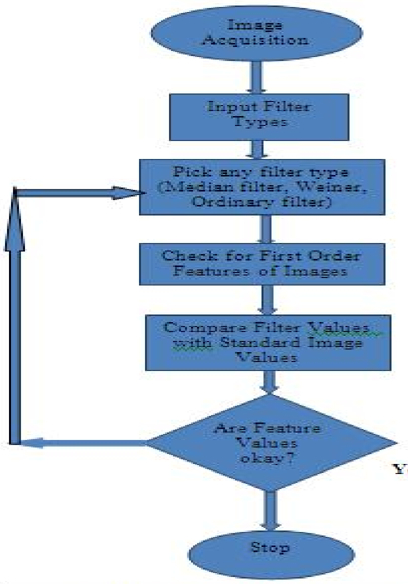
For proper diagnosis and information extraction using image processing, the images undergo a pre-processing stage which involved the removal of noise. Images are corrupted by noise such as salt and pepper noise, impulse noise and Gaussian noise (Aruna and Hariharan, 2014). The aim of de-noising technique is removal of noises from an image and thus becomes the first step in image processing. The technology for removal of noise should be applied carefully; otherwise noise removal introduces artifacts which cause blurring of the image(Thamotharan et al, 2012) In image processing application, image analysis methods may be used to help determine the type of processing required and the specific parameters needed for that processing. For example, to determine the degradation function pre-processing is carried out which is used to remove noise and eliminate irrelevant, visually unnecessary information. Noise is unwanted information that can result from the image acquisition process. Proper and adequate removal of noise during processing of images is necessary so as to obtain valuable and important information necessary for classification and diagnosis. The presence of noise in an image could result into wrong and incorrect information which could have possible consequence on the given image. In this paper, different filter types were evaluated on a named sickle cell image, these filters were used to remove noise in the images. The performance of these filter types were then evaluated and compared with the standard image.

2. Related Work

In general, any kind of magnetic resonance image analysis starts with an image enhancement process. The choice of enhancement technique has a direct impact on the final result, since the image quality has great impact on subsequent analysis. In the literature, however, relatively little attention has been given to this pre-processing step. Neha and Karaulia (2014) provided a quantitative evaluation of the performance of different de-noising techniques for MRI images using the median filter, Gaussian filter, Max filter, Min filter and Arithmetic Mean filter. Niraj, Gerald and Arcangelo (2012) worked on evaluation of image enhancement techniques for Capillary Imaging. Youlian and Cheng (2012) proposed an Improved Median Filtering Algorithm for Image Noise Reduction. In this paper, a comparison of performance of three selected noise removal algorithms (Median filter Ordinary filter and Weiner filter) was carried out on sickle cell images.

3. Materials and Method

The steps used to achieve the aim of this work are as shown in the flowchart in figure 3.1 below



The Flowchart of the Proposed System

3.1 Image (Data) Acquisition

The image used for this paper was obtained from an online database of brain MRI Images. The database provides a repository of these images which can be downloaded and regenerated in the Matlab environment. Some of these images are stored for research purposes, and for other image processing analysis. After the images were gotten from an online source, a database that contains the images was created in the Matlab environment. The images were called from the database using Matlab algorithm. A typical sickle cell image is shown in figure 3.2

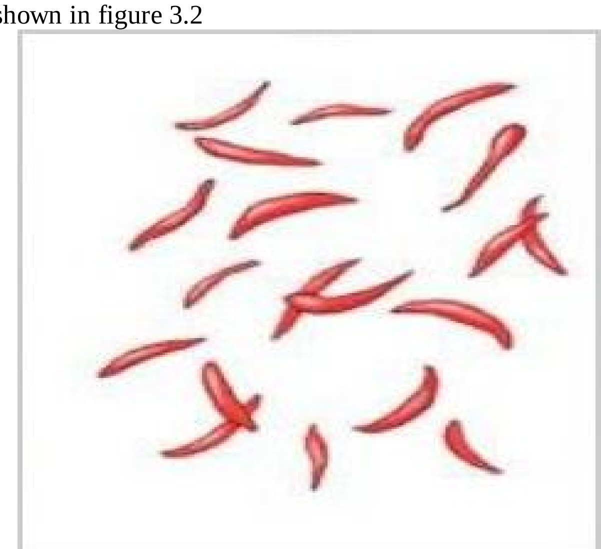


Figure 3.2: A Typical sickle cell image (Jambhekar, 2011)

3.2 Image Pre-processing

Pre-processing of image is necessary before any image analysis can be carried out. It involves filtering, selecting, randomizing, conversion to gray-scale, resizing and removal of objects that could affect the proper processing of the images. Before a computer vision method can be applied to image data in order to extract some specific piece of information, it is usually necessary to process the data in order to ensure that it satisfies certain assumptions implied by the method. The image filtering or pre-processing depends mainly on the quality of the image acquired from image acquisition system. The main aim of image preprocessing is to suppress unwanted noise and to enhance image features important from further analysis point of view, and is most of the time specific in nature depending upon the type of noise present in the image. (For example, in case of image with poor 'brightness and contrast,' histogram equalization can be used to improve the brightness and contrast of an image). In analysis of medical images, we try to avoid image pre-processing unless and until it is very much necessary as image preprocessing typically decreases image information content.

3.2.1 Pre-processing to gray scale

A major pre-processing used in this paper is conversion to grayscale. Most images obtained are always in colored form, and the only way to process such image is by conversion to gray scale. An RGB image is a 3 by 3 image matrix consisting of rows, columns, and index type. The value of an image is also identified by its class, such as uint8, uint16, double. For a grayscale image, it is made to be 2 by 2 matrix, depending on the image size, and also retain its class.

3.3 Noise Removal Algorithms

Different types of algorithm exist for noise suppression and reduction, depending on which of the algorithm suits the particular purpose. This purposes are specific to the individual or on what is needed to be done, as well as what ought to differentiate it from a given or a particular process. In this paper, three of the noise removal algorithms (1) Median filtering, (2) Ordinary filtering and (3) Weiner filtering were evaluated.

3.3.1 Median filtering

The median filter is a nonlinear signal processing technology based on statistics. The noisy value of the digital image or the sequence is replaced by the median value of the neighborhood (mask). The pixels of the mask are ranked in the order of their gray levels, and the median value of the group is stored to replace the noisy value. The median filtering output is given as

$$g(x, y) = med\{ f(x - i, y - j), i, j - W\} \quad (1)$$

where $f(x, y)$, $g(x, y)$ are the original image and the output image respectively, W is the two-dimensional mask: the mask size is n x n(where n is commonly odd) such as 3 x 3, 5 x 5, and etc.; the mask shape may be linear, square, circular, cross, etc (Zhu and Huang, 2012).

Median filtering Algorithm

The Median Filtering Algorithm used in this paper consists of the following steps:

Step 1: Read Image into Matlab

Step 1: The mask slides over the image, overlaps the center of the mask with the pixel on the image to search the center element $f(i, j)$

Step 2: Read the values of the corresponding pixels of the mask;

Step 3: Compute the average value (*average*) of the mask;

Step 4: Compare the value of each pixel with *average*, if the value of each pixel is greater than *average*, then searching the median value and let $f(i, j) = med$; otherwise, retaining the original value of the pixel unchanged;

Step (5) Repeating the step (4), until $i = j = n$.

3.3.2 Ordinary Filtering

Ordinary filtering replaces each element in A by the order-th element in the sorted set of neighbors specified by the nonzero elements in domain. B = ordfilt2 (A, order, domain, S) where S is the same size as domain, uses the values of S corresponding to the nonzero values of domain as additive offsets. B = ordfilt2 (..., p adopt) controls how the matrix boundaries are padded. Set p adopt to 'zeros' (the default) or 'symmetric'. If p adopt is 'zeros', A is padded with 0's at the boundaries. If p adopt is 'symmetric', A is symmetrically extended at the boundaries. Domain is equivalent to the structuring element used for binary image operations. It is a matrix containing only 1's and 0's; the 1's define the neighborhood for the filtering operation. For example, B = ordfilt2(A,5,ones(3,3)) implements a 3-by-3 median filter; B = ordfilt2(A,1,ones(3,3)) implements a 3-by-3 minimum filter; and B = ordfilt2(A,9,ones(3,3)) implements a 3-by-3 maximum filter. B = ordfilt2 (A, 1, [0 1 0; 1 0 1; 0 1 0]) replaces each element in A by the minimum of its north, east, south, and west neighbors. The syntax that includes S (the matrix of additive offsets) can be used to implement grayscale morphological operations, including grayscale dilation and erosion. (www.mathworks.com/ordfilt2)

Algorithm for Ordinary filter

Step 1: Read image into Matlab

Step 2: Identify pixels in the images

Step 3: Replace each element in the image by the sorted sets

Step 4: Set the value of the 'p adopt' to either symmetric or zeros.

Step 5: If 'p adopt is zeros', A is padded with zeros, if 'p adopt is symmetric', A is padded with ones.

3.3.3 Weiner filtering

Wiener2 low pass-filters a grayscale image that has been degraded by constant power additive noise. wiener2 uses a pixel-wise adaptive Wiener method based on statistics estimated from a local neighborhood of each pixel J = wiener2(I, [m n], noise) filters the image I using pixel-wise adaptive Wiener filtering, using neighborhoods of size m-by-n to estimate the local image mean and standard deviation. If you omit the [m n] argument, m and n default to 3. The additive noise (Gaussian white noise) power is assumed to be noise.[J, noise] =wiener2(I, [m n]) also estimates the additive noise power before doing the filtering. wiener2returns this estimate in noise.

Mathematical Algorithm for Weiner filtering.

Step 1: Read Image into Matlab

Step 2: Identify pixels in image

Step 3: Calculate the local mean around pixel using the formula in equation (2)

$$\mu = \frac{1}{NM} \sum_{n1, n2, \epsilon n} \sigma(n1, n2) \text{and}$$

$$\mu = \frac{1}{NM} \sum_{n1, n2, \epsilon n} \sigma(n1, n2) \text{and} \sigma^2 = \frac{1}{NM} \sum \sigma^2(n1, n2) - \mu^2 \quad (2)$$

where n is the N by M local neighborhood of each pixel located in each image A.

Step 4: Create a pixel-wise filter using the equation below:

$$b(n1, n2) = \mu + \frac{\sigma^2 - v^2}{\sigma^2}(\sigma(n1, n2) - \mu) \quad (3)$$

Where v^2 is the noise variance if the noise is not given

Step 5: Use local mean to create new image.

4. System Implementation

This involves loading the image anywhere in the computer to get the image. The first stage of any image processing is getting the image. After the image has been gotten, the various tasks which involve processing the image, analyzing the image can now be performed. It is also important to note that if image has not been gotten the processing cannot take place, therefore rendering the work useless. An interactive interface in figure 4.1 was developed which was used to carry out the process.

4.1 Matlab Implementation

Any image which comes into the Matlab environment has a definite value, which is identified by Matlab. In image processing Matlab enhances the image and generates its value using the im-read function. This enables further processing. Image components are also gotten in the work environment, after its value has been gotten. This is very important because it helps to enhance image processing. These components are identifiable and are attached to each image; this implies that for every image coming into the Matlab environment it has a definite component, which makes it very useful in analysis.

Fig 4.1 System User Interface for Design and Implementation

4.2 Parameters for Evaluation

This paper checked and evaluated the performance of the three filtering types: Median filtering, Ordinary filtering and Wiener filtering. After different filters have been used on the images, various filters are then compared and the image with close parameters with the original image is then chosen. These parameters are: (1) Area (2) Mean (3) Correlation and (4) Standard Deviation. The Area of Pixels: The area of pixels of the original sickle cell disease image has the value of 57318 pixel bytes which is specific and consistent for the other filter types. The Mean: The values of the mean are also consistent with each other and also identifiable and measurable for all of the filter types. The mean is the average values of the pixel in bytes calculate as the sum of 1 to n divide by n. There is a relationship between the area, and the mean. For the Median filter, Ordinary filter and Weiner filter, their values remain the same and still correspond with the original sickle cell image. The Correlation: From the values of the correlation, the Median filter and Weiner filter have closer value to that of the original image but, the values of the Weiner filter is high meaning some elements have been introduced to the image, this leaves us with the median filter as the best option The Standard Deviation: The values of their standard deviation differs with a slight value from the original one, except for the Ordinary filter whose value seems outrageous, at this stage, the ordinary filter might not be considered an effective tool for filtering.

5. Results and Discussion

In image processing, filtering of image is necessary before any process can take place. For medical image, filtering is done but when done we do much processing so as not to lose some vital information in the images, so as much as the image to be processed is filter, checks are placed on the resulting values arising from the different filter types. These checks are done to see if some closely features of the original image are still retained. If the features (first order features) gotten are close or similar to the features of the original image, then such filter type is picked and selected to be the best. The results presented for the different filter types are shown in table 5.1. These results show the corresponding output of the different parameters for Area, Mean, Correlation and Standard Deviation in terms of pixel values.

Table 5.1: The Statistical Results for the different Filter types.

Parameters	Sickle Cell Original Image Value	Median Filter	Ordinary Filter	Weiner Filter
Area	57.318	57.3145	57.318	57.318
Mean	23.93604	23.93604	23.93604	23.93604
Standard Deviation	38.3385	37.2409	14.926	32.2544
Correlation	99.433	99.904	97.651	99.986

As seen in the table 5.1, it is evidently clear that Median filter is the most acceptable filter type in terms of Area, Mean , Standard Deviation and Correlation. Its values seem to be closer to the original image than any other filter type hence making it qualitative for image filtering.

6.Conclusion and Recommendation

In this work, different filter types were evaluated on a named sickle cell image, these filters were used to remove noise in the images. The performance of these filter types were then evaluated and compared with the standard image. The median filter tends to show high performance accuracy than the other filter types. Future work can be tailored toward the following:

i. Evaluation of the different filters and their performances could be carried out on other images of the Lung and Liver.
ii. A new filter type could be developed by merging the Median filter with the Weiner filter and applied to filtering of noise in the images.
iii. The weakness of the ordinary filter type could be improved upon.
iv. Syntactical (Structural) features could also be evaluated after filtering of images.

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