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# Edge Detection of Sickle Cells in Red Blood Cells

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***Abstract*— Diseases caused by any parasite can be diagnosed using the shape of RBCs and WBCs. The blood sample consists of different cells like RBCs, WBCs, and Platelets from which manual shape analysis may not be accurate. So there is a need in designing an automated system that can identify the shape of RBCs. This paper presents an approach to detect the shape of Sickle cells present in RBCs by finding the highest, lowest and mean radius of each type of cell by comparing it with standard cell size and mark the cells by a red circle for identification. The proposed approach is tested on a collected SEM blood sample images and experimental results are encouraging.**

***Keywords*—: Image Processing, Edge detection, Shape detection.**

## I. Introduction

Sickle cell disease (SCD) is a blood disorder characterized by sickle haemoglobin (HbS)[1]. Over 3,00,000 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 anaemia, cardiac, pulmonary, renal and brain complications [2]. SCD management hence entails frequent hospitalizations and care, especially during sickle cell crisis. 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. Edge detection is one among them.

Edge detection is a primary function in image processing. It is the name for a set of mathematical methods which aim at identifying points in a digital image at which the image brightness changes sharply, or more formally, has discontinuities. Edge detection is one of the fundamental steps in image processing, image analysis, image pattern recognition, and computer vision techniques [3].

This paper deals with designing an automated system for detecting the shape of deformed cells within seconds with higher accuracy. The originality of this paper lies to compute the highest, lowest and mean radius of each type of cell[4] and comparing different types of edge detection methods like Canny, Sobel, Roberts, Prewitt, Zero Cross and Laplacian of Gaussian (LoG) [5,6,7,8,9]. A sample image of microscopic blood smear is shown in Fig 1. We have considered the gray level image as input shown in Fig 2. The highest, lowest and mean distance from centre of mass of the cell to its perimeter is calculated[11]. These parameters confirm whether the cell is circular or sickle shaped. The effectiveness of an automatic image processing method to detect normal red blood cells (RBCs) by peripheral blood smear microscope image was discussed in [10]. When single RBCs were extracted from sickle RBCs and white blood cells (WBCs) component, its images were analysed.

## II. Definitions

The proposed image processing system consists of following steps a) Filtering b) Enhancement and c) Detection.

a. Filtering: Images are corrupted by noise such as salt and pepper noise, impulse noise and Gaussian noise. As there is a trade-off between edge strength and noise reduction, filtering is done.
b. Enhancement: It emphasizes pixels where there is a significant change in local intensity values and is usually performed by computing the gradient magnitude.
c. Detection: Many points in an image have a nonzero value for the gradient, and not all of these points are edges for a particular application. Thresholding is used for the detection of edge points [12]. This paper mainly deals with the Edge Detection of Sickle cells present in RBCs.

### *A. EDGE DETECTION*

Edge detection is a type of image segmentation techniques which determines the presence of an edge or line in an image and outlines them in an appropriate way. The main purpose of edge detection is to simplify the image data in order to minimize the amount of data to be processed. An edge is defined as the boundary pixels that connect two separate regions with changing image amplitude attributes such as different constant luminance and tristimulus values in an image. The detection operation begins with the examination of the local discontinuity at each pixel element in an image. Amplitude, orientation, and location of a particular subarea in the image that is of interest are essentially important characteristics of possible edges. Based on these characteristics, the detector has to decide whether each of the examined pixels is an edge or not.

Different Edge Detector operators used for the comparison study of SEM blood sample are explained below:-

*1. Canny Edge Detection*

It is a method to find edges by isolating noise from the image without affecting the features of the edges in the image and then applying the tendency to find the edges and the critical value for threshold. Canny method is a better method without disturbing the features of the edges in the image afterwards it applying the tendency to find the edges and the serious value for threshold.

The algorithmic steps are as follows:

• Convolve image f(r, c) with a Gaussian function to get smooth image f^(r, c).
f^(r, c)=f(r,c)*G(r,c,6)

• Apply first difference gradient operator to compute edge strength then edge magnitude and direction are obtained.

• Apply non-maximal or critical suppression to the gradient magnitude.

• Apply threshold to the non-maximal suppression image.

*2. Sobel Operator*

It performs 2-D spatial gradient measurement on an image and so emphasizes regions of high spatial frequency that correspond to edges. The convolution mask of Sobel operator which are used to obtain the gradient magnitude of the image from the original as shown below

| | | |
|---|---|---|
| 1 | 2 | 1 |
| 0 | 0 | 0 |
| -1 | -2 | -1 |

| | | |
|---|---|---|
| -1 | 0 | 1 |
| -2 | 0 | 2 |
| -1 | 0 | 1 |

*3. Roberts Operator*

It performs 2-D spatial gradient measurement on an image. It highlights regions of high spatial frequency which often correspond to edges. The cross convolution mask as shown

| | |
|---|---|
| -1 | 0 |
| 0 | -1 |

| | |
|---|---|
| 0 | 1 |
| -1 | 0 |

*4. Prewitt Operator*

To estimate the magnitude and orientation of an edge, Prewitt is a correct way. Even though different gradient edge detection wants a quite time consuming calculation to estimate the direction from the magnitudes in the x and y-directions, the compass edge detection obtains the direction directly from the kernel with the highest response. It is limited to 8 possible directions; however knowledge shows that most direct direction estimates are not much more perfect. This gradient based edge detector is estimated in the 3x3 neighborhood for eight directions. All the eight convolution masks are calculated. One complication mask is then selected, namely with the purpose of the largest module. Prewitt detection is slightly simpler to implement computationally than the Sobel detection, but it tends to produce somewhat noisier results.

| | | |
|---|---|---|
| -1 | -1 | -1 |
| 0 | 0 | 0 |
| +1 | +1 | +1 |

| | | |
|---|---|---|
| -1 | 0 | +1 |
| -1 | 0 | +1 |
| -1 | 0 | +1 |

*5. The Laplacian of Gaussian (LoG)*

LoG was proposed by Marr (1982). The LoG of an image f(x,y) is a second order derivative defined as,

$$\nabla^2 f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2}$$

It has two effects, it smoothes the image and it computes the Laplacian, whch yields a double edge image. Locating edges then consists of finding the zero crossings between the double edges. The digital implementation of the Laplacian function is usually made through the mask below,

| | | |
|---|---|---|
| 0 | -1 | 0 |
| -1 | 4 | -1 |
| 0 | -1 | 0 |

| | | |
|---|---|---|
| -1 | -1 | -1 |
| -1 | 8 | -1 |
| -1 | -1 | -1 |

The Laplacian is generally used to found whether a pixel is on the dark or light side of an edge.

## III. OBJECTIVE

The objective of this work is to develop an automated image processing system to identify the shape of infected blood cells. The proposed work will be helpful in the rural areas where the expert in microscopic analysis may not be available.

### A. *Proposed Work*

1. *Image Acquisition:*
The image is first acquired from a live video feed or an existing image can be loaded from the memory. We shall consider that the acquired image is in RGB format which is a true color format for an image. In MATLAB, the captured or imported RGB image is three dimensional and each pixel is represented by an element of a matrix whose size corresponds to the size of the image.

Fig. 1 RGB image of Blood Smear

2. *Preprocessing*:
In order to process the image in an efficient manner the test image Fig. is converted from RGB to Gray scale. A set of processes is used in data preparation and filtering to remove the noise. An intelligent implementation is used to make it ready for later analysis later with the aim to automate cognition of the image and its content without human help. The techniques used at this phase are different according to the nature of information needed to be extracted from the image. The image of blood smear had been collected dataset of SEM which is colored, but in some of the coming next phases for the system is handled with 2-dimension images (that only includes gray scale), so the image should be converted to gray scale which is shown in Fig 2.

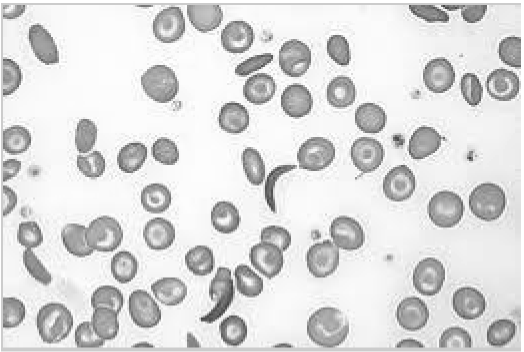

Fig. 2 Gray scale of RGB image

3. *Image Enhancement*:
Processing an image so that the result is more suitable for a particular application i.e. (sharpening or de-blurring an out of focus image, highlighting edges, improving image contrast, or brightening an image, removing noise) to increase the contrast of the image and to Enhance color difference between background and objects that will be useful in extracting the objects boundary.

4. *Edge Detection*:
Edge detection is then carried out to mark the border of each cell body using Matlab toolbox [13,14,15]. Fig 3 shows the RBCs and Sickle Cell Preset in a small segment of Edge detected image.

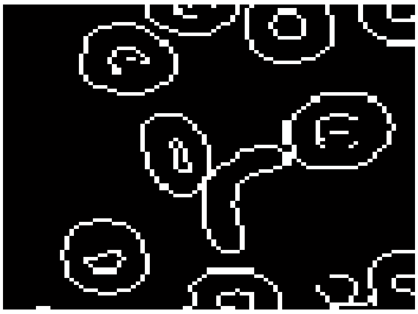

Fig. 3 RBCs and a Sickle Cell by Edge Detection

5. *Shape Detection*:
The shape of Sickle cell is marked in the image by a red circle and hence can identify the number of sickle cell present in the image. Also the mean radius of each cell is calculated. Generally when parasite attacks the RBC, they deform the structure of the cell which no longer remains circular. The distance of each pixel from the centre of mass of the each cell body is calculated and the range of radii value is noted. If the radius fluctuation is above a certain threshold value then it is confirmed that the cell body is not circular.

## B. *Experimental Results*

The Experimental results of different Edge operators are shown below

### *1. Canny Edge Detection Operator*

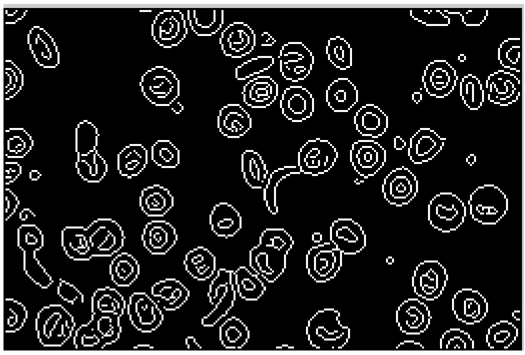

Fig. 4 Canny Edge Detection

Fig. 5 Detection of Sickle using Canny Edge Operator by red circles

*2. Sobel Egde Detection Operator*

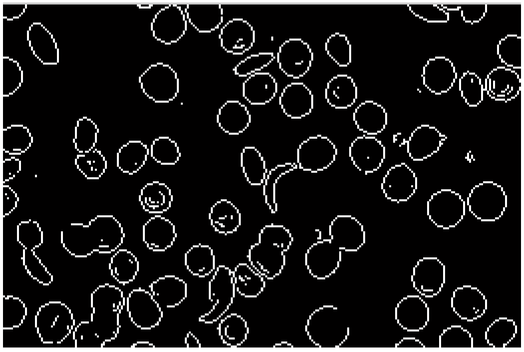

Fig. .6 Sobel Edge Detector

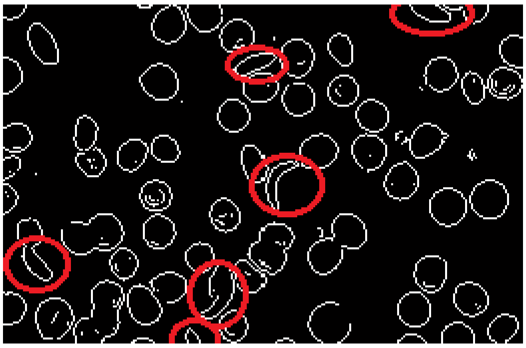

Fig. 7 Detection of Sickle using Sobel Edge Operator by red circles

*3. Roberts Operator*

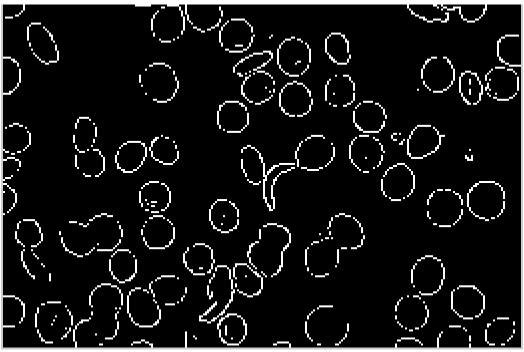

Fig. 8 Robert Edge Detector

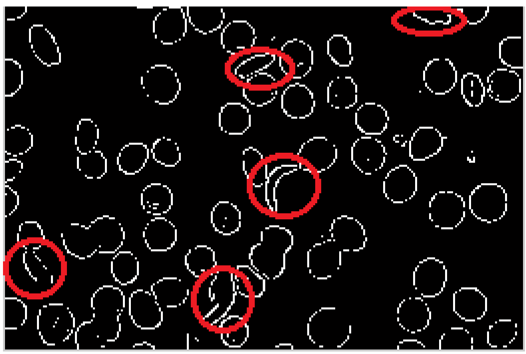

Fig. 9 Detection of Sickle using Roberts Edge Operator by red circles

*4. Prewitt Operator*

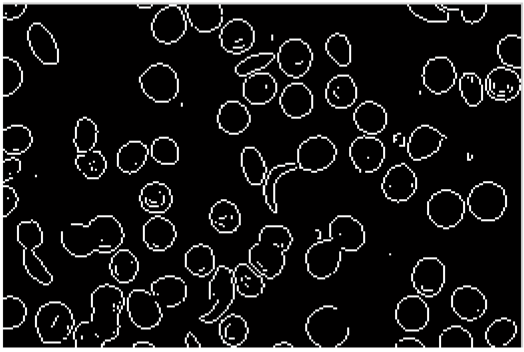

Fig. .10 Prweitt Edge Detector

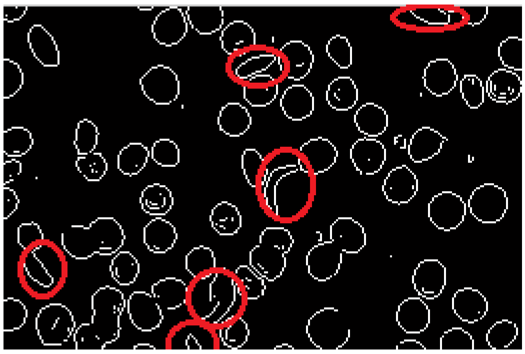

Fig. 11 Detection of Sickle using Prewitt Edge Operator by red circles

*5. The Laplacian of Gaussian (LoG) Operator*

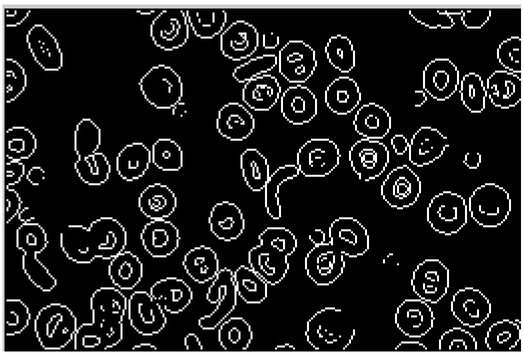

Fig. .12 LoG Edge Detector

Fig. 13 Detection of Sickle using LoG Operator by red circles

### C. Results and Discussion

Segmentation results showed better performance in comparison to the conventional methods. Different Edge detectors like Canny, Sobel, Roberts, Prewitt and LoG detectors are used for comparison and to know the best detector for automatic diagnosis system. Roberts operator was unable to identify the sickle cells properly. The highest, lowest and average radii were noted for the cell bodies and the highest, lowest radii were both divided by the average radii. For a collected dataset of infected blood samples, the (highest radii)/(average radii) ratio had a minimum value of 1.71 whereas that of the (lowest radii)/(average radii) ratio had a maximum value of 0.12. So we propose that any cell structure whose

$h/a = 1.71$ and $l/a = 0.12$

where h=highest radius, l=lowest radius, a=average radius,

is an infected cell whose normal circular shape is deformed. For a collected dataset, the size and shape of the infected blood cells were marked. From the different detection methods it is found that Canny Edge Detection method is more preferable for the diagnosis as it gives more details of the original image.

## IV. CONCLUSION AND FUTURE WORK

The blood is primarily composed of three formed blood elements; red blood cells, white blood cells, and platelets. Numerous computerized systems have been developed in order to recognize these different cells. Knowing that RBCs compose the majority of blood cells, gathering as much information as possible about them can provide very appealing outcomes. Several previous papers have tackled the process of blood film analysis each with its pros and cons, but an ideal automated image processing has not yet been developed for differential recognition of blood cells and sickle cells.

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