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Studies on the Application of Edge Detection Techniques to the Blood Cells

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ABSTRACT: Efficient location of an object in an image is required to measure the performance in image analysis. Segmentation by edge detection is the most fundamental tool used in separation of component region or objects in an image. Edge detection techniques, used to detect boundaries between Red blood cells (RBC) and the background and also between overlapping Red blood cells. In this paper, an attempt is made to study the performance of Canny edge detection and other conventional operators like – Sobel, Prewitt, Roberts and Laplacian of Gaussian (LoG). Canny and LoG edge operators are found to be suitable for RBCs segmentation. Further, Canny is showing better results of segmentation with reference to parameters like edge strength and entropy values.

Keywords: Edge detection, Edge strength, Entropy, Red blood cell, Segmentation.

I. INTRODUCTION

Most of the segmentation algorithms are based on one of two basic properties of intensity values: discontinuity and similarity [1]. In the first category, the approach is to partition an image based on abrupt changes in intensity, such as edges. The second category is based on partitioning an image into regions that are similar according to a set of predefined criteria. Edge based segmentation is the principal approach used in this paper.

Edges define the boundaries between regions in an image, with segmentation and object recognition. Many operators have been introduced to perform edge detection in different fields of images. However, not every operator give a good performance, it depends on images quality such as lighting conditions, the presence of objects of similar intensities, density of edges in the scene. Furthermore, choosing the appropriate edge detection techniques, it is important to improve the efficiency of image by pre-processing [2], comprises a number of methods, like gray-level transformation, image sharpening, image smoothing etc [1]. Therefore, the main objective of this work was to compare among several edge detection operators and to find out the appropriate operator to detect blood cells in a blood smear image.

To extract the edges from the images, derivative edge detection operators [3], such as Sobel, Prewitt, Roberts, and Laplacian (LoG), Canny operators are used. Edge detection is an important in image processing and plays a major role in image analysis. It is widely used in contour extraction, feature detection and texture analysis.

II. DIFFERENT EDGE DETECTIONS USED FOR IMAGE SEGMENTATION

Edge detection is used for image segmentation based on abrupt changes in intensity. Edge detection refers to the process of identifying and locating sharp discontinuities in an image. Edge detection helps in extracting information about the image - location of objects present in the image, their shape, size, image sharpening and enhancement etc.

2.1 Sobel Edge : Sobel is an operator of a pair of 3×3 convolution kernels [4]. One kernel is for horizontal changes and the other rotated by 90° for vertical changes as follows:

$$G_x = \begin{bmatrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{bmatrix} \qquad G_y = \begin{bmatrix} +1 & +2 & +1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix}$$

The Sobel masks are designed to maximally respond to edges running vertically and horizontally relative to the pixel grid and these directional edges are finally combined to determine the absolute magnitude and direction of the gradient. Sobel operator uses only integer values for the coefficients to weight and determine the gradient approximation of images.

2.2 Robert Edge: Robert is an operator which performs a simple and quick approach to determine 2-D spatial gradient measurement on an image [5]. The operator consists of a pair of 2×2 convolution kernels as follows:

$$G_x = \begin{bmatrix} +1 & 0 \\ 0 & -1 \end{bmatrix} \qquad G_y = \begin{bmatrix} 0 & +1 \\ -1 & 0 \end{bmatrix}$$

The Robert operator is assigned to maximally respond to edges running at 45^o relative to the pixel grid. The absolute magnitude and direction of the gradient are determined by combining these kernels as similar to Sobel.

2.3 Prewitt Edge: Prewitt is an operator which produces an image where higher gray scale value indicated the presence of an edge between two objects [6]. This operator is similar to the Sobel operator and is used to detect the vertical and horizontal edges in images. The operator consists of a pair of 3×3 convolution kernels as follows:

$$G_x = \begin{bmatrix} -1 & 0 & +1 \\ -1 & 0 & +1 \\ -1 & 0 & +1 \end{bmatrix} \qquad G_y = \begin{bmatrix} +1 & +1 & +1 \\ 0 & 0 & 0 \\ -1 & -1 & -1 \end{bmatrix}$$

2.4 Canny Edge : Canny is an operator which is generally known as the optimal edge detector [7]. It has a low error rate and is robust. Canny operator converts an input image into a gray scale image and then performs a noise reduction by smoothing with Gaussian filter as follows:

$$G''(x) = -\left(\frac{x}{\sigma^2}\right) e^{-\left(\frac{x^2}{2\sigma^2}\right)}$$

The algorithm runs in following separate steps: Smoothing - the image to remove noise, Finding gradients - marked where the gradients of the image has magnitudes, Direction calculation - direction of edge be calculated, Non maximum suppression - Only local maxima be marked as edges, Double thresholding - Potential edges are determined by thresholding, Edge tracking by hysteresis - Edges are determined by suppressing all Edges not connected to very certain (strong) edge.

2.5 LoG: The Laplacian of Gaussian (LoG) filter operate on images to find the place that the value of Laplacian passes through zero[1] [8]. Isotropic digital LoG kernels are used to convolve with an image to compute the Laplacian value at each pixel. LoG operator kernel is described as

$$LoG(x,y) = -\frac{1}{\pi\sigma^4}\left[1 - \frac{x^2+y^2}{2\sigma^2}\right] e^{-\left(\frac{x^2+y^2}{2\sigma^2}\right)}$$

III. COMPARISON OF EDGE DETECTION METHODS

The performance of the edge detector is compared to commonly used or comparable algorithms such as the Canny, Sobel, Prewitt, Robert and LoG edge detection algorithms. To evaluate edge detection results produced by various edge detectors is a challenging problem. As it is still difficult to assess whether one algorithm produces more accurate segmentations than another, whether it be for a particular image or set of images, or more generally, for a whole class of images. Extensive research has been done in creating many different approaches and algorithms for image segmentation. In this paper, different edge detection techniques like Canny, Sobel, Prewitt, Roberts and LoG operators are implemented to segment the blood smear sample images and compared for better segmentation of blood cells.
Further, the resultant edged images of all the samples are calculated and compared for edge strength and entropy.

3.1 Image Edge Strength: The edges at least have three characteristics as shown in Fig. 1.
A. The local regularity/smoothness/continuity along certain direction.
B**.** The local irregularity/oscillation/discontinuity along the orthogonal direction.
C. There exists anisotropic structures in the image and the edges always stretch out in multiple directions.

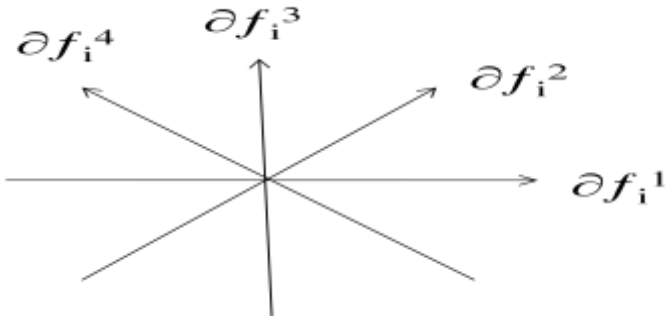


Fig1: The directional derivatives considered and the definition of the edge- strength

The edge strength in the diagonal directions is defined as

$$E_i^{2,4}(f) = \left| \partial f_i^2 - \partial f_i^4 \right|^p$$

Where p is introduced to nonlinearly rescale the edge-strength to fit the human perception. Similarly, the edge-strength in the vertical or horizontal direction is defined as

$$E_i^{1,3}(f) = \left| \partial f_i^1 - \partial f_i^3 \right|^p$$

The total edge-strength around the i th pixel is defined as

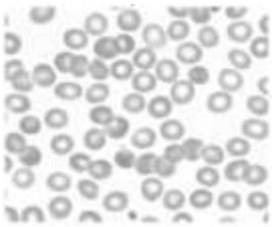
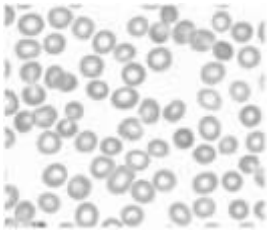
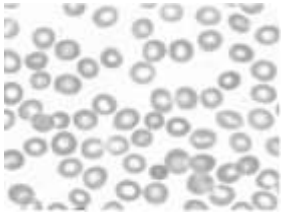
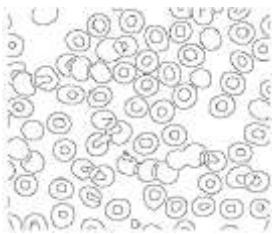
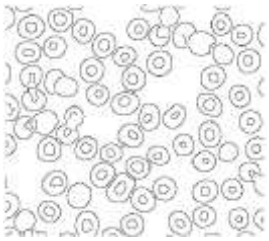
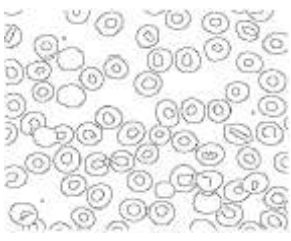
$$E(f,i) = max\,(E_i^{1,3}(f), E_i^{2,4}(f))$$

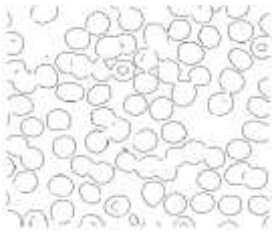
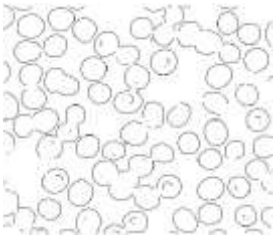
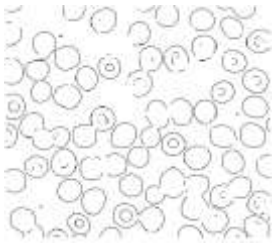
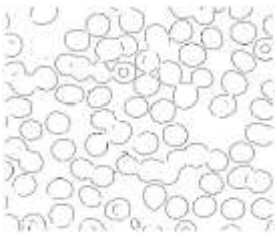
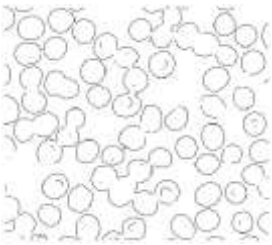
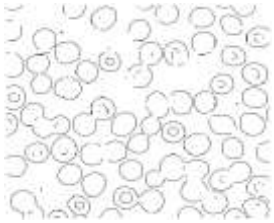
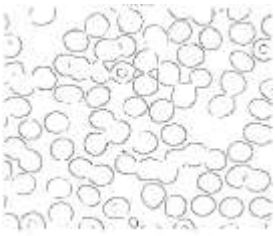
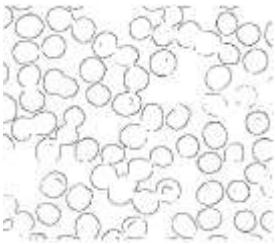
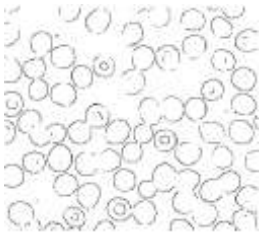
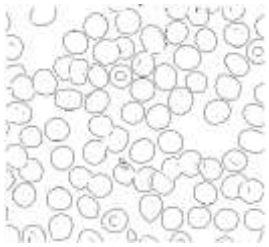
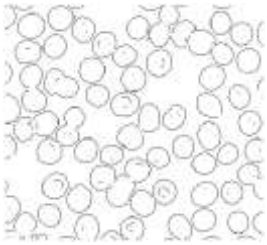
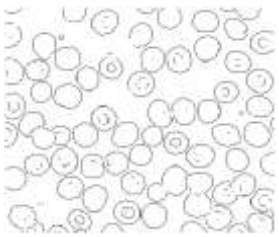
3.2 Image Entropy: Image entropy is a quality which is used to describe the 'amount of information' of the image, which must be coded for by a compression algorithm. Image entropy is calculated by

$$\text{Entropy} = -\sum_i p_{i\,Log_2} p_i$$

p_i – Probability that the difference between 2 adjacent pixels equal to i
Log_2 - The base 2 logarithm

Table 1 : Shows results of different edge detection techniques on blood smear image samples

Type of Image↓	Sample-1	Sample-2	Sample-3
Input image			
Canny Edge			

Sobel Edge			
Prewitt Edge			
Roberts			
LoG			

IV. RESULTS AND DISCUSSION

The resultant edged images for three blood smear samples are tabulated in the Table 1 against their respective edge detection technique. Among all the resultant images after segmentation by different edge operators, Canny and LoG operators are showing better results in segmentation of cells and proper edge formation. Whereas other operators like Sobel, Prewitt, Roberts are showing poor edge formation as well as segmentation of the blood cells are seen. For further clarification of better segmentation and proper edge formation of the objects in the image, other parameters like edge strength and entropy values are tabulated in the **Table 2.** Canny operator shows the better results with edge strength and entropy values than other conventional methods.

Table 2: Parameters like Edge strength and Entropy for Sample 1 – 3 using different Edge detection methods

Method	Sample-1		Sample-2		Sample-3	
	Edge strength	Entropy	Edge strength	Entropy	Edge strength	Entropy
Canny	23249	0.3835	24182	0.3705	22422	0.3729
Sobel	17451	0.2521	17045	0.2463	17317	0.2475
Prewitt	17473	0.2521	17060	0.2460	17315	0.2472
Robert	19419	0.2831	19031	0.2812	18724	0.2751
LoG	19097	0.2680	18665	0.2615	18872	0.2630

V. CONCLUSION

Segmentation of Red blood cell images using different edge detection techniques is showing a clear isolation of cell boundaries from its surrounding background. It is observed that image segmentation using

Canny operator, optimal edge performance is producing than other conventional methods. Canny edge image is producing smooth and strong edge objects. In Canny edge image, some cells contain internal rings may be removed by application of proper thresholding or using morphological operations.

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