Comparative Studies on Cell Segmentation by Fuzzy Logic and Canny Edge

CH. Nooka Raju[1], Dr.G.S.N. Raju[2], Dr.V.K. Varma Gottumukkala[3]
[1] Department of Biomedical Engineering, G.V.P. College of Engineering For Women, Visakhapatnam, India,
[2]Honorary Distinguished Professor, Department of ECE, Andhra University, Visakhapatnam, India,
[3]Senior Engineer, Qualcomm, USA.

***Abstract* - It is well known that digital imaging has become a common feature. In particular medical imaging has become essential in the diagnosis. In this connection image processing is an important area as it leads to medical diagnosis. The best processing techniques improve accuracy in the diagnosis as well as surgical operations. Segmentation of blood cells has been reported by few researchers. However, the accuracy in identification of blood cells is not adequate. In the present work, segmentation of red blood cells is optimised using Fuzzy logic and Canny algorithm. The simulated results are presented in this paper.**

***Key words* – Canny edge detection, Fuzzy logic, Segmentation, Threshold**

I. INTRODUCTION

Modern time is an era of technology in which it is now believe in the vision based intelligence. Penetration of computers into each area of the market and living has forced the designers to add the capability to see and analyze and to innovate more and more into the area of electronic vision or image processing [1]. At the level of computational intelligence for electronic vision, many of the algorithms have been developed to extract different types of features from the image such as edges, segments and lot many other types of image features.

Edge detection is a terminology in image processing, particularly in the areas of feature extraction, to refer to algorithms which aim at identifying points in a digital image at which the image brightness changes sharply or more formally has discontinuities. The goal of edge detection is to locate the pixels in the image that correspond to the edges of the objects seen in the image.

Segments in an image are processed by segmentation algorithms, based on one of two basic properties of intensity values discontinuity and similarity. First category is to partition an image based on abrupt changes in intensity, such as edges in an image. Second category is based on partitioning an image into regions that are similar according to predefined criteria. The prime objective of segmenting a digital image is to change its representation so that it looks more expressive for image analysis. During the course of action in image segmentation, each and every pixel of the image segmentation is assigned a label or value. The pixels that share the same value also share homogeneous traits [2].

Almost all proposed techniques combine at least two image processing methods. In this paper the relevant/critical image processing method which makes the difference to other approaches and considerably improved the segmentation quality. The methods which use the thresholding and/or the watershed are presented. The watershed algorithm is run on the inverse distance transform of the morphological gradient.

The watershed segmentation is also used to detect individual cells in the special problem of complex clusters [3] for efficient count. A probabilistic algorithm counts the number of cells in a cluster. The separation or merging (after applying the watershed) is presented in a more complex approach in [4]. The adaptive thresholding and watershed is also used in [5] for cellular segmentation. In addition, to improve the cell identification accuracy a set of features and the context information are used. Since the thresholding method is a powerful tool, a novel method to automatically determine threshold levels (the stable count thresholding, SCT) is proposed in [6] for cell segmentation.

II. METHODS

In this, edges of objects in an image are identified that are assumed to be the object boundaries. These boundaries are used for segmentation. The result in a binary image contains only the detected edge pixels. The purpose of detecting sharp changes in image brightness is to capture important events and changes in properties of the image. The drawback of this technique is that the edges do not guarantee to form closed boundaries. To avoid this after the first step when the object boundaries are detected, these edges are processed so that only closed boundaries remain. Then these object boundaries are filled to produce segmented image. Example is Canny Edge detection and fuzzy logic edge algorithm.

A segmentation technique is based on extracting the region of interest from a larger image around threshold cell nuclei was proposed by Katz [7]. The process of segmentation into cell or non-cell regions was carried out using canny edge detection followed by a circle identification algorithm. In [8] a shape based approach is proposed to extract thin structures like lines and sheets from 3D biomedical images. These thin structures are modelled using ellipsoidal model. The existing filters which incorporate Gaussian filters are simplified and applied for getting segmentation results.

A. Canny edge detection technique with Distance transform (DT)

Among all the edge detection methods developed so far, canny edge detection algorithm is one of the most strictly defined methods that provide good and reliable detection. Canny develop an edge detector, satisfy three criteria - A low error rate, edge points be well localized, shows one response to a single edge. Owing to its optimality to meet with the three criteria for edge detection and the simplicity of process for implementation, it becomes one of the most popular algorithms for edge detection. Canny is a technique to extract useful structural information from different vision objects and dramatically reduce the amount of data to be processed.

Process of Canny edge detection algorithm

The Process of Canny edge detection, basic procedure [2] can be summarized in the following steps:

(1) The image is first smoothed using a Gaussian kernel: Gradient operators are sensitive to noise and this preliminary step is taken to reduce the image noise. The greater the width of the kernel, the more smoothing (i.e. noise reduction) is achieved.

(2) Finding the edge strength, achieved by taking the gradient of the image with horizontal and vertical directions and then adding the magnitude of these components as a measure of the 'edge strength'. Thus

$$G(x,y) = |G_x(x,y) + G_y(x,y)|$$

(3) Calculating the edge direction, easily calculated as

$$\theta = tan^{-1}\frac{G_y(x,y)}{G_x(x,y)}$$

(4) Digitize the edge direction, once the edge direction is known, approximation of an edge direction can be traced in a digital image. Considering an arbitrary pixel, the direction of an edge through this pixel can take one of only four possible values - 0_(neighbours to east and west), 90_ (neighbours to north and south), 45_ (neighbours to north-east and south-west) and 135_ (neighbours to north-west and south-east).

(5) Nonmaximum suppression, after the edge directions are known, works by tracing along the edge direction and suppressing any pixel value (i.e. set it equal to zero) that is not considered to be an edge. This will give a thin line in the output image.

(6) Hysteresis, after the first five steps have been completed, the final step is to track along the remaining pixels that have not been suppressed and threshold the image to identify the edge pixels. Critical to the Canny method, however, is the use of two distinct thresholds – a higher value T2 and a lower value T1. The fate of each pixel is then determined according to the following criteria:

If $|E(x, y)| < T1$, then the pixel is rejected and is not an edge pixel;

If $|E(x, y)| > T2$, then the pixel is accepted and is an edge pixel;

If $T1 < |E(x, y)| < T2$, the pixel is rejected except where a path consisting of edge pixels connects it to an unconditional edge pixel with $|E(x, y)| > T2$.

B. Fuzzy Logic Image Processing

Fuzzy logic tool box software useful for image processing to detect edges in the image. An edge is a boundary between two uniform regions. Edge can be detected by comparing the intensity of neighbouring pixels. However, because uniform regions are not crisply defined, small intensity differences between two neighbouring pixels do not always represent an edge. Instead, the intensity difference might represent a shading effect. The fuzzy logic approach for image processing allows using membership functions to define the degree to which a pixel belongs to an edge or uniform region. Fuzzy logic edge detection algorithm relies on the image gradient to locate breaks in uniform regions.

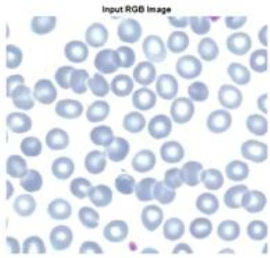
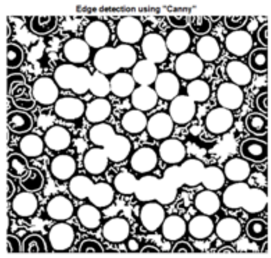
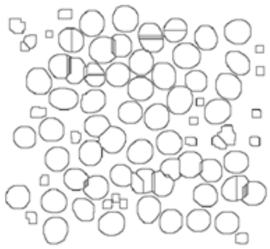
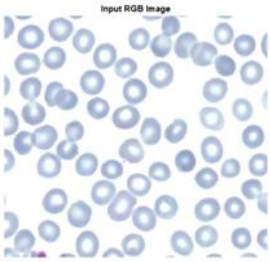
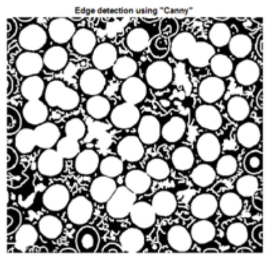
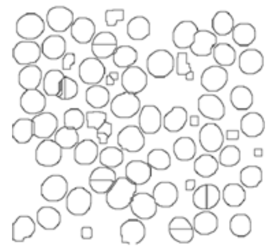
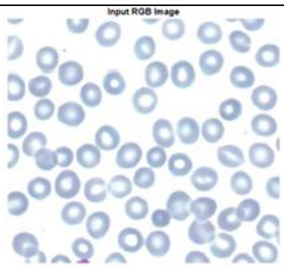
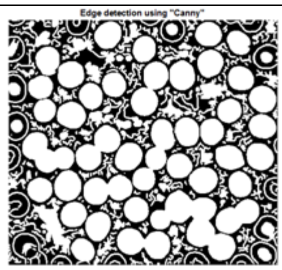
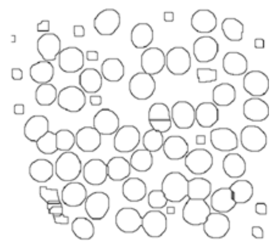
Fuzzy Inference System (FIS) for Edge Detection

In this, edge in the image is detected using a FIS, comparing the gradient of every pixel in the X and Y directions. If the gradient for a pixel is not zero, then the pixel belongs to an edge (black). It is defined the gradient as zero using Gaussian membership functions for FIS inputs.

III. RESULTS AND DISCUSSION

In this paper, Fuzzy logic edge detection and Canny Edge operator are implemented on different blood cell samples. Table 1 & 2 Shows sample blood cell images and its segmentation using Fuzzy logic and Canny Edge operator. Results shows, edge of image using Fuzzy logic gives strong contours than other methods like Canny operator and morphological technique [9]. It is observed both Canny Edge operator and morphological technique are executed

Table 1: Shows the input, Canny edged, resultant images respectively for Samples 1-3.

Image ID	Input Image	Canny edge Image	Canny edge with Euclidean DT
Sample-1			
Sample-2			
Sample-3			

by fixing the threshold value and it may vary from one image to another.

In Fuzzy logic technique, the segmentation of the image is by using two rules and without setting the threshold value. The no. of blood cells for a given sample image is counted using different distance transforms such as Euclidean, City block, Chess board, Quasi-euclidean. Table 3 shows number of cells and corresponding errors for various algorithms.

It is observed, Canny Edge with Euclidean distance transform produce good cell count and minimum error among other distance transforms. But its performance is less accurate when compared with other segmentation methods. Fuzzy technique with city block distance gives better cell Count and least error than canny edge and morphological techniques. For sample images, Fuzzy Technique produces cell count as 68, 64, 58 and its error is -1.45%, 1.58% and 0% respectively. Whereas other techniques are showing less efficient in count and produce high error.

IV. CONCLUSION

In this paper, work has been done in the area of image processing for image segmentation by Canny Edge and Fuzzy logic algorithm. Different researchers used varied segmentation algorithms. But no single algorithm is optimum. However, it is

ISSN: 2278 – 909X
International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE)
Volume 5, Issue 5, May 2016

found from the work, that Fuzzy logic is yielding improved results on the segmentation of cells. It is superior than Canny Edge detection. The results shown that Fuzzy logic gives strong/ thick edge segmentation of cells than Canny Edge detection. Fuzzy reduces false edge detection and marked pixel is near to the true edge [10]. Fuzzy inference system gives accurate edge detection using automatic process, the Fuzzy rule based system over the other segmentation processes.

Table 2: Shows the input, Fuzzy edged, resultant images respectively for Samples 1-3.

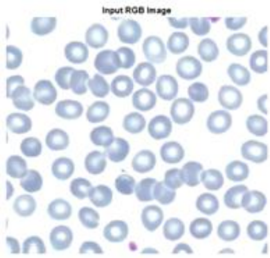
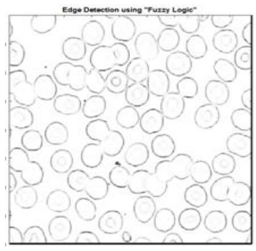
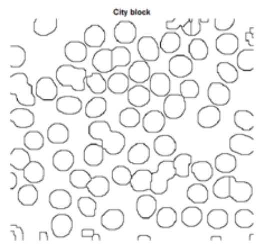
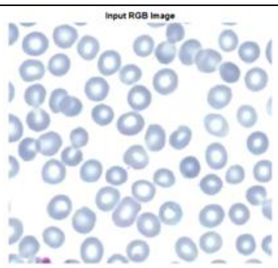
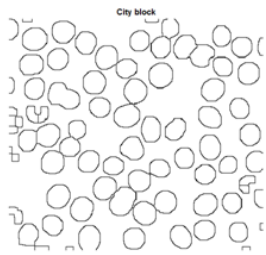
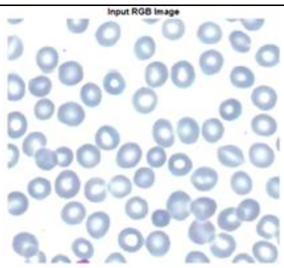
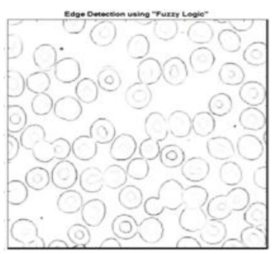
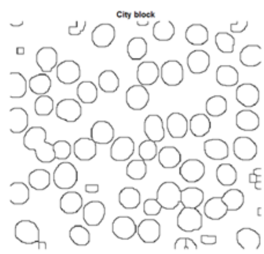
Image ID	Input Image	Fuzzy edge Image	Fuzzy edge with City block DT
Sample-1			
Sample-2			
Sample-3			

Table 3: Number of cells (NOC) and errors produced by different edge detection techniques with different distance transforms

Image ID	Manual count	Morphological with Chessboard DT	Canny with Euclidean DT	Fuzzy with Cityblock DT
Sample – 1	69	70 Error : +1%	65 Error : -5.8%	68 Error : -1.45%
Sample – 2	63	64 Error : +1.5%	67 Error : +6.3%	64 Error : +1.58%
Sample – 3	58	57 Error : -1.7%	56 Error : -3.4%	58 Error : 0%

REFERENCES

[1] J Canny. A computational approach to edge detection. IEEE PAMI, pages 679–98, November 1986.

[2] Rafael C.Gonzalez & Richard ,E Woods "Digital Image Processing" Third Edition, 2009.

[3] Angulo J., Nucleus Modelling and Segmentation in Cell Clusters. Progress in Industrial Mathematics at ECMI'2008, 217−222.

[4] Cheng J., Rajapakse J.C., Segmentation of Clustered Nuclei With Shape Markers and Marking Function, IEEE Transactions on Biomedical Engineering, Vol. 56(3), 741−748, 2009.

[5] Zhou X., Li F., Yan J., Wong S.T., A Novel Cell Segmentation Method and Cell Phase Identification Using Markov Model. IEEE Trans. Info. Tech. Biomed., Vol. 13(2), 152–157, 2009.

[6] Russell R.A., Adams N.M., Stephens D.A., Batty E., Jensen K., Freemont P.S., Segmentation of Fluorescence Microscopy Images for Quantitative Analysis of Cell Nuclear Architecture. Biophysical Journal, Vol. 96 (8), 3379−3389, 2009.

[7] A. R. J. Katz, "Image Analysis and Supervised Learning in the Automated Differentiation of White Blood Cells from Microscopic Images", Master's thesis, Department of Computer Science, RMIT, Feb. 2000.

[8] Adam Huang, Gregory M. Nielson, Anshuman Razdan, Gerald E. Farin, D. Page Baluch, David G.Capco, "Thin Structure Segmentation and Visualization in Three Dimensional Biomedical Images: A Shape Based Approach", IEEE Transaction On Visualization and Computer Graphics, Vol.12(1), January/February 2006.

[9] CH. Nooka Raju, G.S.N. Raju, V.K. Varma Gottumukkala, "Studies on Watershed Segmentation for Blood Cell Images Using Different Distance Transforms", IOSR Journal of VLSI and Signal Processing, Vol. 6, Issue.2, Ver. I Mar-Aprl 2016.

[10] Mohammed Y. Kamil, "Hybrid Alogorithm for Edge detection using Fuzzy Inference System", International Journal of Computer Applications, Vol. 102(5), September 2014.