Locating Center of Optic Disc in Retinal Images

M. Suganya, S. Bramanayaki, S. Sri Nandhini and P. Subbulakshmi

Abstract--- *This paper presents a new approach for locating the center of the optic disc in color fundus images. The fundus image is first segmented into seven clusters in which only high intensity regions are retained using Fuzzy C means. The boundaries of these exudates are then identified using edge detection. Then automatic threshold value is chosen using Otsu Thresholding which produces edge image. Based on the edge image with varying intensity optic disc is detected. The Optic Disc is then removed to improve the detection rate of exudates.*

Keywords--- *Diabetic Retinopathy, Optic Disc, Optic Disc Mask, Fuzzy-C means, High Variance Image*

I. INTRODUCTION

IN the developed world, most of them are facing high range of work stress in their industrialized environment. Now-a-days, the number of people affected by diabetes is increasing drastically. The most common effect of diabetes is vision defect. Among working people visual impairment is an intimidating problem. Patient's get complicated by cataracts, glaucoma, and damage to blood vessels due to diabetes.

For example, millions of Americans are affected by Type I (juvenile onset) or Type II (adult onset) diabetes. The major complication of diabetes that has developed so far is eye diseases affecting vision. Most of the cases who registered for blindness in Singapore are affected only by retinal diseases. More than 70% patients with diabetes are affected by Diabetic Retinopathy (DR).

DR is a critical eye disease that is considered as manifestation of diabetes on the retina. The severity of the disease increases due to other abnormalities such as micro aneurysms, hemorrhages, and cotton wool spots. At the back of the eye, new blood vessels will be formed as a part of PDR which bleed and cause blurred vision. It may not be severe at the initial stage. A few specks of blood or spots will be left which tend to float in visual field. The spots may often go after few hours. However within a week, a greater leakage of blood follows the spots which further blur the vision. The blood may clear in months or years or it may not clear at all.

Fig. 1: Normal Vision

Fig. 2: Same view by Diabetic Retinopathy Patients(Image Courtesy Wikipedia)

Figure 1 is the view of a normal person whereas figure 2 is the view of a Diabetic Retinopathy affected person. The leakage of proteins and lipids from the blood stream into the retina via damaged blood vessels is the cause for the formation of exudates. It has high content of protein and is yellowish or white in color. Hard Exudates (HE) appears as lesions which are bright yellowish in nature. The small, white lesions which appear with blurry edges are known as Soft Exudates (SE). SE tends to be less visible than HE.

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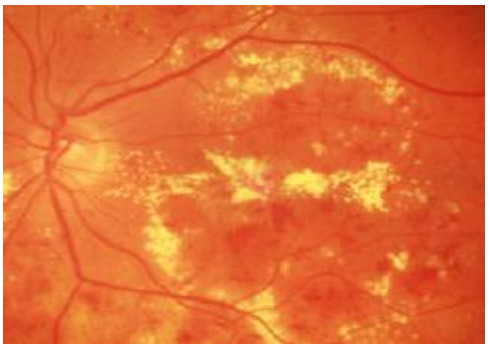


Fig .3:Hard Exudates

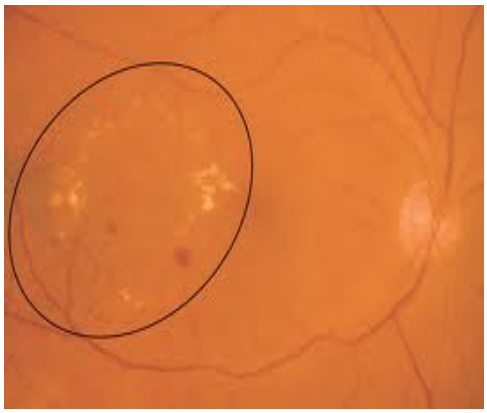


Fig. 4:Soft Exudates

Figure3 shows a color fundus image where multiple HE appear as bright lesions. Figure 4 shows a color fundus image where SE lesion is marked with a round. The OD appears to be similar in color and brightness as exudates. Hence eliminating optic disc is very essential for accurate detection of exudates.

II. BACKGROUND

Doaa Youssef et al.,[2] proposed to utilize blood vessels for detection of exudates. The main issue with this method is that when it is automatically applied to the retinal image, it detects some normal bright regions as being exudates. Akara Sopharak et al.,[4] identified OD and exudates using mathematical morphological operations like closing and dilation.The main issue with this method is that it depends on other tasks such as blood vessel removal.

In the work of Clara I. Sanchez et al.,[7] Hough Transform was employed to detect OD and the exudates are classified using a classifier algorithm called Fisher's Linear Discriminator which classifies the data into two sets as exudates and non exudates. The main limitation with this method is appropriate training set is required. Clara I. et al.,[8] used hough transform for the detection of OD and exudates are classified using a special approach called mixture model, which classifies the data into two sets exudates and non exudates. The main issue is that when there are only a few very faint HE in the retina the method may fail in the identification task.

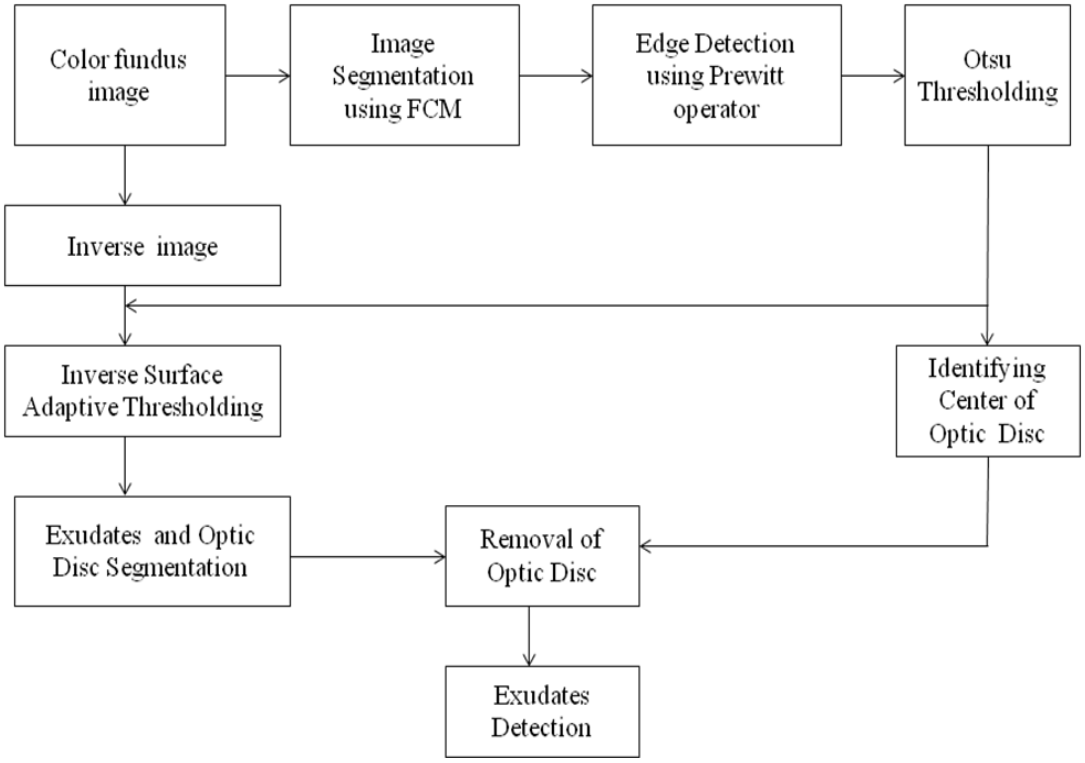


Fig. 5: The Flow Chart of the Proposed Method

III. PROPOSED METHOD

The flow chart of the proposed method is shown in figure5.The edge pixels of the exudates are detached from the background using FCM,edge detection,Otsu method.The variance intensity in adjacent pixels are used for detecting the center of disc.

The color fundus image contains three channels namely red, green and blue channel. However we focus only on green channel since it contains lot of useful information. Let us consider the initial image as K(I,j).

A. *Fuzzy-c means Clustering*

Data clustering is used to divide data elements into various classes where similar data item is grouped into a single class.Traditionally,the clustering assigned the data item to only one cluster whereas now in fuzzy clustering,a single datum is assigned to several clusters.The process of specifying membership levels and then using those levels to assign data elements to one or more clusters is called fuzzy clustering.A collection of n elements is partitioned into fuzzy clusters based on some conditions.

The color fundus images is segmented into seven clusters.It groups similar data into clusters. The membership grade is used to specify a degree of membership during each assignment of data to a cluster.Let us consider that we have a collection of N data to be segmented into 7 classes or groups.It contains a membership matrix m of size 7 x N.The matrix element m_{ij} represents membership of the jth data Y_j to class i.The procedure to be followed is illustrated below.

First,the input image K(i,j) is divided into 3 x 3 non-overlapping areas.Then the average intensity of this area is calculated.The average of these is considered as data and thus N is the total number of 3 x 3 areas in the image.Then the matrix m is initialized randomly with values between 0 and 1.

$$\sum_{i=1}^{a} m_{ij} = 1 \forall j = 1, \dots, n \qquad (1)$$

The data is partitioned into seven groups and the center for each cluster is identified iteratively while minimizing the cost function of dissimilarity.The dissimilarity function used is

$$D = \sum_{i=1}^{a}\sum_{j=1}^{b} (m_{ij})^d b_{ij}^{\ 2} \qquad (2)$$

where m_{ij} is the entries of m; b_{ij} is the Euclidean distance between ith cluster a_i ,j is the data point and n is the weighting exponent.

The center of the cluster and the entries of m are updated as follows

$$a_i = \frac{\sum_{j=1}^{m} (m_{ij})^d Y_j}{\sum_{j=1}^{n} (m_{ij})^d} \forall i = 1, \dots, C \qquad (3)$$

$$m_{ij} = \frac{1}{\sum_{k=1}^{C} \left(\frac{d_{ij}}{d_{kj}}\right)^{\frac{2}{d-1}}} \qquad (4)$$

The output of FCM is seven non-overlapping regions representing the seven clusters. Two regions with the highest intensity will be selected for further processing and together termed as I(i,j).

B. *Edge Detection*

The image brightness tends to change sharply at some points or has discontinuities at other points.The process of identifying those points is known as edge detection.The edge detection is done using many techniques.

Prewitt operator is being used to detect the edges. It is a discrete differentiation operator which is used to approximately calculate the gradient of the image intensity function. The direction of the edge in horizontal, vertical, diagonal and anti-diagonal orientations is captured by convoluting the Prewitt operator with the image.

The Prewitt operator is illustrated below:

Horizontal :	1	1	1	Vertical :	1 0 -1
	0	0	0		1 0 -1
	-1	-1	-1		1 0 -1
Diagonal :	1	1	0	Anti-diagonal :	0 1 1
	1	1	-1		-1 0 1
	0	-1	-1		-1 -1 0

The highest value is chosen from the convoluted value from four directions and this value is used to represent the edge information at the pixel. The edge values of all pixels in I(i,j) is denoted as E(i,j).

C. *Otsu Thresholding*

Automatic thresholding based on clustering can be performed using Otsu's method.In this algorithm,the image which is to be thresholded is assumed with two classes.Then the optimum thresholding is used to separate these two classes so that their intra class variance is minimal.In our paper,we expect the edge values E(i,j) of pixels at the middle or outside to be lower than the border of the exudates which is used to separate the pixels at the border from others using Otsu's method.To avoid manual selection which produces uneven illumination,automatic thresholding is employed in Otsu method which chooses a threshold value automatically.The threshold is splitted into the edge and non-edge pixels where the non-edge pixels are set to zero.

D. *OD Detection*

The OD is the brightest part in the color fundus retinal image and appear as yellow region.The one seventh of the entire image is approximately occupied by OD.It is located using the variance intensity of adjacent pixels. Consider a sub image S(i,j) of dimension N x N centered at (i,j).Then the mean intensity is calculated as follows:

$$\langle f \rangle_{S_{ij}} = \frac{1}{N^2} \sum_{k,l \in S(i,j)} f(k,l) \qquad (5)$$

The variance image is calculated as follows:

$$v(i,j) = \langle f^2 \rangle_S - (\langle f \rangle_S)^2 \quad (6)$$

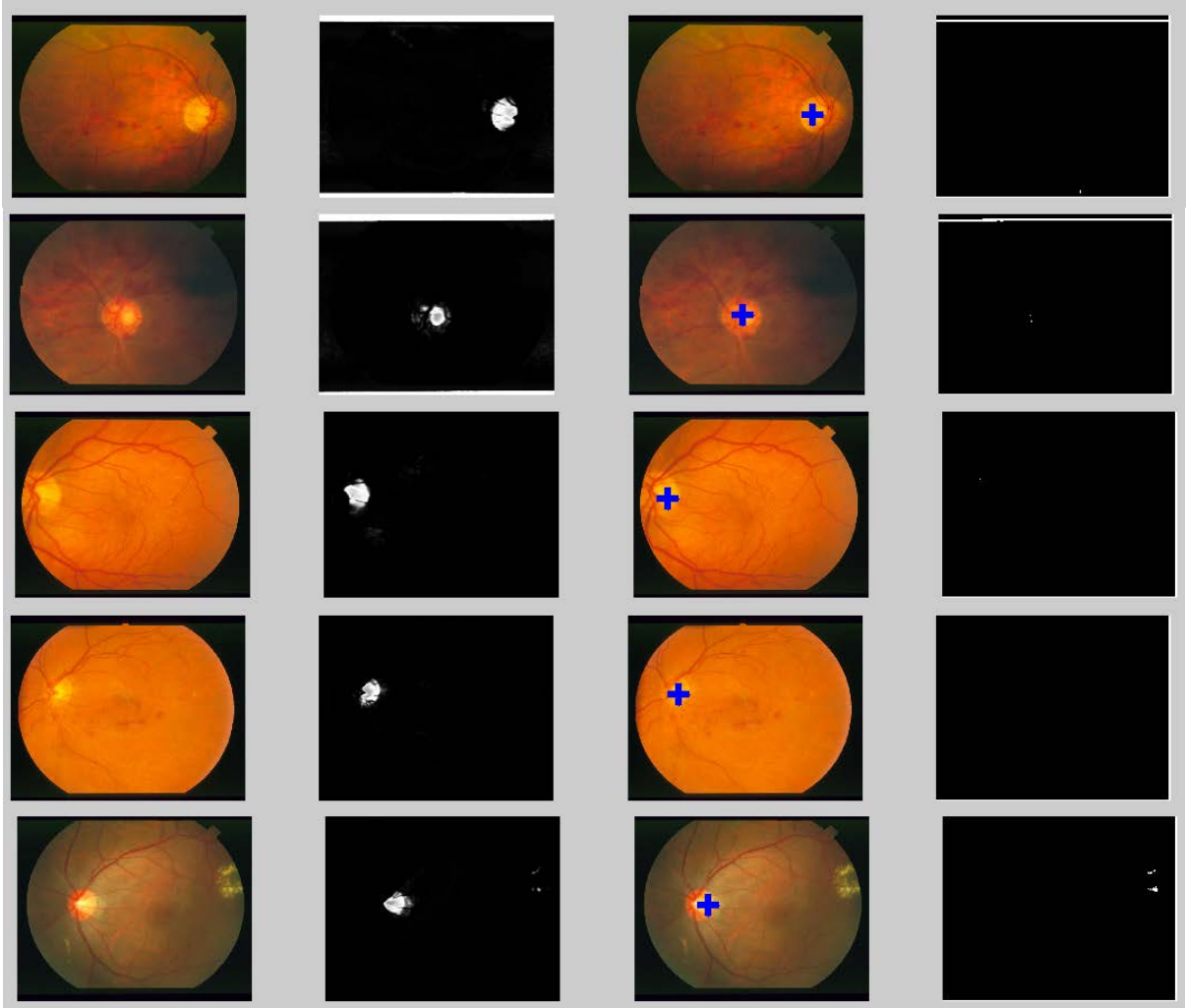
The average variance within S(i,j) is obtained as

$$w(i,j) = \langle v \rangle_{S_{ij}} \quad (7)$$

The location of maximum of this image is considered to be the center of the OD.

IV. Results

ORIGINAL IMAGE	ROI	OD DETECTION	OD MASK



V. Conclusion

The proposed method had been experimented in STARE retinal image database to locate the centre of optic disc.The proposed algorithm were applied to the images without any preprocessing technique to detect OD centre and to remove OD.This algorithm can work properly with low quality retinal images and images containing cotton woll spots and exudates together. In future,we intend to extend our proposed method to improve the detection of exudates, cotton wool spots and build an integrated screening and diagonstic system. An automated process for early diagonstics and interventions can hence be of great help to patient and specialist alike in the timely management of this widespread disease.

VI. Future Work

Future work will concentrate on detecting SE and HE and distinguishing HE from SE.We also try to detect other type of lesions associated with DR(MA,HA,IRMA)inorder to separate healthy subjects from those who suffer from DR more precisely and grade the evolution of the disease.

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