Detection of Optic Disc from Retinal Images using Wavelet Transform

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***Abstract*— The people suffering from diabetic retinopathy is increasing continuously over the time. There is need for huge number of experienced ophthalmologists to identify and treat the diabetic people at early stage of retinopathy. There are many features of retina those indicate progress of diabetic retinopathy such as blood vessels, optic disc (OD) which are bright objects that changes when eye is affected by disease and it can be used as main features for detecting diabetics' presence. In our work a new method for identifying and separating out the optic disc from fundus RGB image using wavelet transform and windowing (partitioning) the image is performed. Then energy and standard deviation for each window is computed to segment out optic disc. The proposed method is evaluated by considering DRIVE and STARE datasets. It is observed that the method yields 95% of detection accuracy.**

***Keywords*— Diabetic retinopathy, Exudates, Cotton wool spot, Optic disc.**

I. Introduction

A. Motivation

Eye is the main organ of human body, which is responsible for the complete visionary. There is eye disorder called diabetic retinopathy which is contributed by diabetes disease. If the disease is not detected and treated at it's early stages there is chance of leading to blindness. In the total registered blindness cases almost half of the cases are because of diabetic retinopathy. Manual examination of retinal disorders caused by diabetes require more time and cost. Identification of optic disc and exudates location and extraction of these characteristics from retina is one of the crucial aspects of research. Optic disc is the originating point of optic nerve in retina. Optic disc is characterized by higher intensity having yellowish or white region but some hard exudates also appear like optic disc this creates difficulty in segmentation step. The optic disc look like approximately circular or spherical in shape with broken up by blood vessel going out from it's center. The size of optic disc in terms of number of pixels is around 40 to 60 pixels in 640 X 480 sized color images, but the size of optic disc varies from person to person. If accurate and automated computerized method is developed to detect diabetic retinopathy, then it can save cost and time significantly.

B. Literature review

Anup et al. [1] proposed a algorithm for bright object classification from retinal image based on features entropy and local mean of pixels. Preprocessing of input fundus retinal image is done to improve the uneven illumination in the input image. Intensity adjustment is carried out with the help of brightness transformation function on fundus retinal image. To estimate the location of optic disc in the retina image morphological operations such as closing of the image was performed on the green channel content of the image. Circular Hough transform is applied to locate approximate position of optic disc in fundus image.

Ahmed et al. [2] presented a method for isolation of optic disc and exudates features from fundus retinal image. The method includes preprocessing input image with an averaging filter with 25 X 35 size interms of number of pixels. Contrast stretching transformation is applied on filtered image to distinguish contrast between bright objects and other contents of retina image. The watershed transform was applied to determine bright object basins. It treats image as a surface which contain bright pixels having high value of intensity and low intensity pixels (pixels having very low intensity called dark pixels). Here gradient magnitude was used to preprocess before applying t he watershed transform method for segmentation. The direct use of watershed transform algorithm to the gradient images generally creates over segmentation.

Ana Salazar et al. [3] presented new algorithm for optic disc and blood vessel extraction from color fundus retinal image. This method performed first retinal vascular tree extraction by applying graph cut technique. The information of blood vessel network segmented from retina image was used to predict the approximate location of optic disc in fundus color retina image. The segmentation of optic disc is done after locating its position applying two independent methods. The first method called Markov random field (MRF) which is useful in image reconstruction segments the optic disc by eliminating blood vessel network from optic disc region.tha second method called compensation factor segments out the optic disc with the help of the prior local intensity information about blood vessels.

Amin Dehghani [4] proposed a new method of determining the location of optic disc region in fundus retina images. Finding location of optic disc region and its center is the primary step of the much blood vessel segmentation, disorder analysis and quantifying it. In this method they calculated histogram for each color component of retina and then average of these histograms is computed which was used as template for the determining the position and center of optic disc. They used certain number of retina images to develope template for identifying optic disc, as an alternative of creating an image as template. At the first step they used an average filter of 6 X 6 size to decrease effect of noise and used a window of 80 X 80 pixels to go with the size of optic disc was used to extract OD.

Fraga et al. [5] presented a method for the precise extraction of the main bright object, optic disc in retina images. Initially the image intensity and disparity are normalized so as to adjust the lighting effects. In this method the retinal images are enhanced by retinex algorithms. The location of optic disc is estimated by analyzing the convergence of blood veins segments the fundus retinal images and detected circular bright shapes. They used transform of blood vessel network in a set of connected segments of blood veins and analyzed their junctions in retina images to locate the optic disc. The second method used for optic disc localizing involves determining the highest intensity vaued circular area in an image. They used a fuzzy Hough transform and applied DOG filter to detect the section of attention Canny filter is applied. Finally fuzzy Hough transform is used to obtain only OD edge points.

Omar et al. [6] presented an automatic estimation of location and boundary detection of retina image. It consists of three measure phases that contains preprocessing, segmentation and detection of retina image features. The preprocessing contains modification of non-uniform lighting, color normalization and dissimilarity enhancement. Mainly three parts of retina image are segmented consisting of retina blood vessel, optic disc and fovea. Blood vessels segmentation is done using Kirsch's template which was originally designed as line detection algorithm. The optic disc segmentation depends on color intensity of retinal image. The image produced after segmentation is used to locate the optic disc exactly and a threshold was used to detect it. Fovea is the darkest part in the retina image. Fovea contain specific geometric distance from the optic disc and it can be detected using it's color intensity.

Rangaraj et al. [7] presented a method for detection of optic disc from retina image. The method proposed by this paper for detection of optic disc depends lying on the beginning discovery of blood vessel network with the help of Gabor filters. The Gabor filter contain kernel and a set of 180 kernels was used in this method. Every peak in the node map in declining order of its amplitude is verified to locate the midpoint of the optic disc area. The area with circular shape is extracted with radius equal to 20 pixels. The peak distance location was accepted as hub of optic disc.

Amin et al. [8] presented an algorithm for prediction the region of optic disc core in fundus retinal images based on the Harris corner detector. This method was based on the characteristics of optic disc, blood vessels originate from the center of optic disc and amount of blood vessels in the joint of optic disc is more than other regions in the fundus retinal images. Largest number of corners and bifurcation around the optic disc is observed. Using Harris corner detector, corners and bifurcations are determined from fundus retinal images. Then moving the window near the optic disc location is done to count the number of corners. The center of windows in which the highest number of corners was found is considered as optic disc.

Murugan and Korah [9] proposed a new method for detecting optic disc of retina image with the help of line filter operator. The algorithm starts with converting the fundus RGB image input into its LAB constituent. The input image is smoothed out using bilateral smoothing filter. Line operator was used for gray scale orientation and binary map orientation is approved out and with the help of the resulting maximum image distinction, the conegion taining OD is found.

C. Our contribution

In this paper a new algorithm for detection and mining of optic disc from fundus images is proposed. The proposed algorithm contains eight steps as listed here: (1) Preprocessing of input image which is essential to remove noise and uneven distribution of intensity in the image. (2) Conversion of color fundus image to gray scale image which makes the processing simple. (3) Image segmentation which is necessary to separate bright objects from remaining content of the image. (4)Windowing, to partition the segmented image, it is necessary to divide the image into the parts called windows that contain different objects. (5) Applying wavelet transform, a two level wavelet transform is applied on each of the windows (partitions). (6) Computing energy and standard deviation for each window content. Energy and standard deviation are determined for each part of the image (window). (7) A window with highest energy and standard deviation is selected that gives optic disc. (8) Merging of two windows: If there are two windows with relatively higher energy and standard deviation then these windows are merged to form optic disc area that gets separated from the image. The advantage of proposed method is that there is no need of varying threshold with respect to brightness variation in the image that is necessary for proper image segmentation. The proposed method only relies on maximum energy and standard deviation which requires fixed threshold. This method automatically separates out hard exudates and optic disc from fundus retina image. The methodology presented here provides good sensitivity of 95%.

The first part of the paper in introductory part is committed to the discussion of the way in which a computerized image processing algorithms can be used for analysis of diabetic retinopathy and as well it covers the properties and state of the art of OD, hard exudates and cotton wool spots in retina analysis. The remaining part of the paper is organized as follows; section II describes proposed method for optic disc detection. In section III experiments on two different retinal image data sets are presented. Section IV contains conclusion of the paper with future work.

II. PROPOSED METHOD

The primary processing such as reading, contrast enhancing, resizing and filtering images are known as preprocessing of images. The sizes of different database images are different hence for simplicity the input images are resized to 256 X 256. The filtering process removes the unwanted noise added. An averaging filter of 25 X 35 size in terms of pixels having weight of numerical value of one is used to the image g(x,y) for suppressing small objects with low intensity varying background content, retaining the objects of our interest relatively undisturbed. As the fundus retina image contain more data because of color, it is converted to gray scale image whose data content is less and easy to process further processing. Then the image is segmented using appropriate threshold value which becomes binary image that contain only bright objects. The binary image is partitioned into multiple partitions called windows. The size of the window is suitably selected. The two level discrete wavelet transform (DWT) is employed on each window to compute spatial density. Energy and standard deviation is computed for each window content. The window having highest energy and standard deviation contain optic disc. If two windows have relatively higher energy and standard deviation then those two windows will be merged to display optic disc. The thresholding can be presented as follows

$$Pixels\ value = 1\ ;if\ \ f(i,j) > Tr \quad (1)$$

$$= 0\ ; otherwise$$

Where Tr is threshold value of intensity.

We appliedd discrete wavelet transform (DWT) to get energy and standard deviation which are also know as spatial density over every windowed image. It's spatial density is calculated with following manner.

Let J is a retina image having dimension of AXB with $w\in$ J the window of size SXT, that can is selected so as to match the size of optic disc in fundus retina image. To each window of size w, we applied two level discrete wavelet transform for computing the DWT coefficients. The number of windows w is so selected that it should match optic disc area and is computed as k = round(B/n). The retina image J is partitioned into k windows w of size PXQ. For every window we have computed DWT coefficients and then calculate energy and standard deviation of those coefficients through equation 2 and equation 3. Let E_l and S_l are the energy and standard deviation vectors of the window W_l. The following parameters are computed to find optic disc from segmented image area

$$El = \frac{1}{S\times T}\sum_{x=1}^{S}\sum_{y=1}^{T}|\mathrm{Wl(x,y)}| \quad (2)$$

$$Sl = \left[\frac{1}{S\times T}\sum_{x=1}^{S}\sum_{x=1}^{T}(\mathrm{Wl(x,y)} - \mu\mathrm{l})^2\right]^{1/2} \quad (3)$$

The input fundus retina image is shown in fig.1 which contain exudates, optic disc, blood vessels, cotton wool spots and all parameters. Fig.2 shows the optic disc segmented image and all other parameters are removed from it.

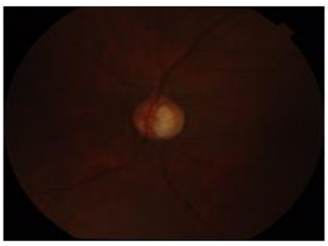

Fig.1.Original image

Fig.2.Optic Disc detected image

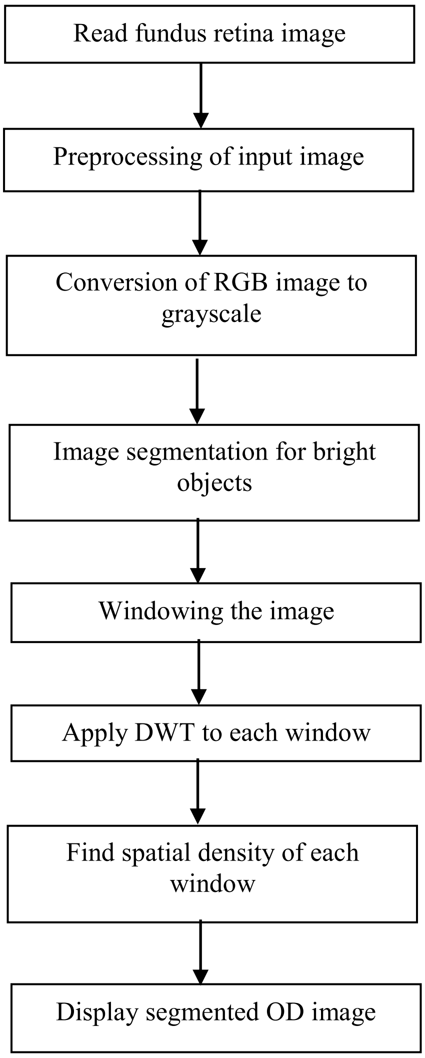

Fig.3. Flow diagram of Proposed method.

III. Experimental Results

The algorithm proposed in this method is tested using DRIVE and STARE data sets which publically available. The optic disc are in these database images clearly distinguishable from other parameters of retina which makes it easy to segmentation. In this method the segmented image for bright objects are taken and two level discrete wavelet transform is applied to calculate spatial density of each windowed image.

The performance of proposed method is measured with following parameters (1) true positive fraction (TPF), (2) true negative fraction (TNF). TPF indiactes the fraction of pixels correctly classified as OD. This measure is also known as sensitivity. TNF indicates the portion of pixels wrongly classified as OD. This measure is also known as specificity. The two parameters are calculated using following equations and tabulated.

$$TPF = \frac{TP}{TP+FN} \tag{4}$$

$$TNP = \frac{TN}{TN+FP} \tag{5}$$

Where TP, FN, TN and FP represent true positive, false negative, true negative and false positive values respectively. The results are tabulated by selecting 20 fundus images from DRIVE and STARE data sets for comparison.

TABLE I. PERFORMANCE OF SEGMENTATION TECHNIQUES ON DRIVE AND STARE DATABASE.

Method	TPF value (sensitivity)	TNF value (Specificity)
Walter [10]	92.74%	100%
Ahmed [2]	94.74%	100%
Proposed method	95%	100%

IV. CONCLUSION

The proposed method works in four levels: preprocessing RGB image, segmentation of grayscale image for bright object detection, windowing the segmented image and finally applying wavelet transform to each window to determine the spatial density (energy and standard deviation) of each windowed part of the image. The innovation or originality of the paper primarily relies on the selection of window size, so as to match the size of the optic disc in fundus retina image. This is necessary to differentiate optic disc and hard exudates in the retina image. The data sets DRIVE and STARE used for testing the proposed algorithm. Extraction of OD from retina image gives good result which is comparable with other known method. The proposed method provides detection accuracy of 95%. It is effective method for optic disc detection

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