International Journal of Electronics Communication and Computer Engineering
Volume 5, Issue (4) July, Technovision-2014, ISSN 2249–071X

Technovision-2014: 1st International Conference at SITS, Narhe, Pune on April 5-6, 2014

Optic Disk Segmentation and Localization

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Abstract **– Optic Disk (OD) detection is a main step in the detection of eye disease. Optic Disk boundary and centre localization are the two features of retina were necessary for the detection. The diameter of optic Disk in a standard retinal image, and iterative thresholding was used to locate optic Disk. The fovea was localized based on its distance and position with respect to the optic Disk as it remained relatively constant. Fovea is considered to be one of the darkest regions without vessels in a retinal image. The conversion of colour to gray image using rgb2gray code conversion. Then vessels extraction using opening & closing function. Using threshold value the centre of optic disk is localized. Among 17 images considered for evaluating the methods optic disc and fovea were localized with sensitivity of 99.32% and 96.6% respectively.**

Keywords – **rgb2gray Image Conversion, Vessel Extraction, Closing and Opening Operation, Optic Disk Center Detection.**

I. Introduction

One of the first requirements for automatic eye screening system is the localization of anatomical landmark such as the optic Disk (OD), fovea and retinal vasculature seen in figure below.

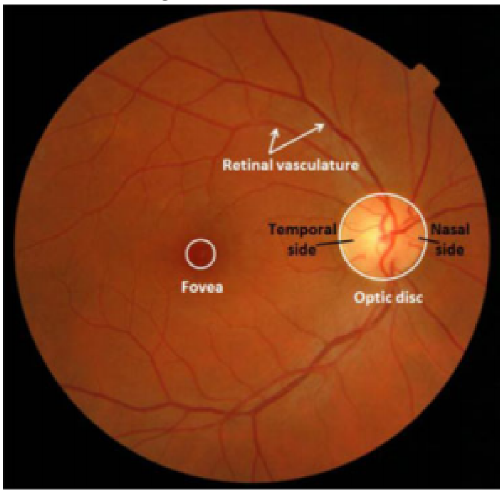

Fig.1. Retinal image landmarks

An efficient detection of optic Disk in colour retinal images is a significant task in an automated retinal image analysis system. Its detection is prerequisite for the segmentation of other normal and pathological features. For this, the measurement of optic Disk to cup diameter ratio is used in the detection sight threatening disease called glaucoma. The position of optic Disk can be used as a reference length for measuring distances in retinal images. In case of blood vessel tracking algorithms the location of optic Disk becomes the starting point for vessel tracking. Finally, diabetic maculopathy lesions identification, masking the false positive optic Disk region leads to improvement in the performance of lesion detection [1].

The attributes of optic Disk is similar to attributes of hard exudates in terms of colour and brightness. Therefore it is located and removed during the hard exudates detection process, thereby avoiding false positives [6]. It can be seen that optic nerves and vessels emerge in to the retina through optic Disk. It is situated on the nasal side of the macula and it does not contain any photoreceptor. Therefore it is also called the blind spot. The size of optic Disk varies from patient to patient, but its diameter always lies between 80 and 100 pixels in a standard fundus images. In most of the images the Disk boundaries are not clearly visible. And also, several parts of Disk will be obscured by the crossing blood vessels [1]. In the current work, the segmentation of optic Disk boundary is performed in two steps. First the Disk is spatially localized and its approximate center is determined using iterative thresholding. This provides a baseline for finding of its exact boundaries. Then, the geometric model based implicit active contour is employed to obtain accurate optic Disk boundary. The method was tested on images and qualitatively evaluated by comparing the automatically segmented Disk boundaries with manual ones drawn by an experienced ophthalmologist.

II. Methodology

A. Detection of optic disk

The optic disk appears in color fundus images as a bright yellowish or white region. Its shape is circular, interrupted by outgoing vessels, although sometimes due to the nature of the photographic projection it has the form of an ellipse.

Mathematical morphology in image processing is particularly suitable for analyzing shapes in images. The two main processes are those of dilation and erosion. These processes involve a special mechanism of combining two sets of pixels. In that, one set consists of the image being processed and the other a smaller set of

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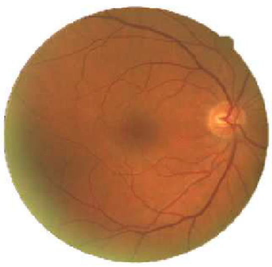
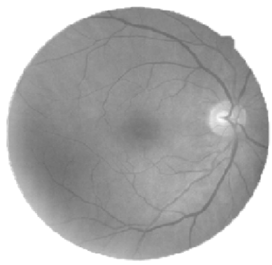
pixels known as a structuring element or kernel. Two very important transformations are opening and closing. Opening performs erosion followed by dilation whereas Closing performs dilation followed by erosion. Intuitively, dilation expands an image object and erosion shrinks it. Opening generally tends to smooth the contour in an image, breaking narrow isthmuses and eliminating thin protrusions. Closing tends to narrow smooth sections of contours, eliminating small holes, and filling gaps in contours.

The red, green and blue channels of the image are combined as illustrated in Figure 2(b) and it shows a good variation between the optic disk and the background. As in [2], the local intensity variation of the image is used to find the locus of the optic disk. As the optic disk is a bright pattern, and as the vessels appear dark, the gray level variation in this region is higher than in any other part of the image.

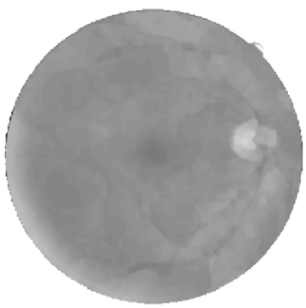
Unfortunately, this is only true if there are no exudates on a dark background. So that, a shade correction operator is used in order to remove slow background variations. This has been calculated by subtracting the approximated background from the gray-tone image and has the effect of a low pass filter.



(a)



(b)



(c)

Fig.2. Results of a healthy retinal image: (a) Original fundus image (b) Gray tone image (c) After background removal and filtering of blood vessels.

Further morphological opening and closing has the effect of filtering out the blood vessels and small exudates. The binary image which contains the brightest and the biggest part from the shade corrected image shown in Figure 2(c) is computed by the area thresholding method. The initial boundary of the optic disk is traced from that binary image as in Figure 2(a). A circular region of interest (ROI), 3 times the equivalent diameter of the initially traced blob boundary as in Figure 2(b) is used to find the contours of the optic disk. The magnitude gradient of the image for the ROI is calculated with the use of morphological operations. Initially morphological closing is performed on the ROI to fill the vessels, and then to remove large peaks morphological opening is performed. Then the image is reconstructed using morphological reconstruction.

B. Detection of the fovea

Detection of the position of anatomical structures is essential in an automatic diabetic retinopathy screening system. Using these locations, a frame of reference can be set up in the fundus image. This is essential for two reasons. 1) To find abnormalities in a fundus image, it is essential to mask out the normal anatomical structures from the analysis; and 2) The distribution of the abnormalities associated with diabetic retinopathy is not uniform over the retina[3]. The position of an abnormality relative to the anatomical structures will be useful as a feature for later analysis. This chapter deals with the detection of vascular arcade, macula and fovea. Macula is located at the centre of retina. It is temporal to the optic disk between the main superior and inferior vascular arcades. Fovea is a small depression in the macula and is indicated by a deep-red or red-brown color in color fundus images. It is the darkest part in the retinal images. Accurate localization of the fovea region is important to any diagnosis method that is based on the statistical categorization of vision threatening lesions in the retina. In this chapter, a novel approach for detecting vascular arcade, macula and fovea is proposed and also a polar fundus coordinate system is established based on the locations of the major anatomical structures of the retina. The proposed approach consists of five steps. Firstly, the blood vessels are segmented based on HMLRE method[7]. Next, the optic disk is localized by finding the vessel branch having highest vessel connections. Using the segmented vasculature as input, horizontal raphe of the retina is localized using a model based method. Then the centre of macula (fovea) is determined from the horizontal raphe. Finally, a fundus coordinate system is placed.

III. Algorithm

1. The images are read from the database.
2. Conversion of all colour images to the gray images using rgb2gray function.
3. After conversion, the vessels are suppressed using closing function.
4. Using max function, the threshold value is decided.
5. Then using X & Y direction value the centroid is located.

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IV. Block Diagram

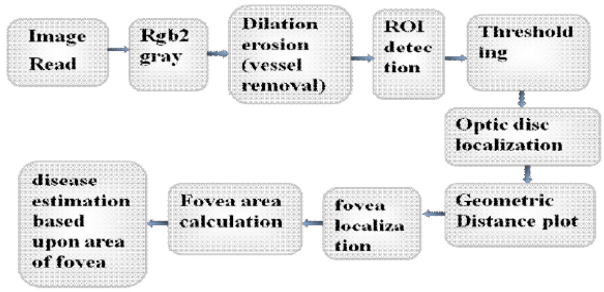

Fig.3. Flow of work

V. Location of Optic Disk

The localization of optic Disk is important for two purposes. First, it serves as the baseline for finding the exact boundary of the Disk. Secondly, optic Disk center and diameter are used to locate the macula in the image. In a colour retinal image the optic Disk belongs to the brighter parts along with some lesions. The central portion of Disk is the brightest region called optic cup, where the blood vessels are absent. Using a threshold will separate part of the optic Disk and some other unconnected bright regions from the background.

A. Selection of Initial Threshold

Optimal thresholding method based on approximation of the histogram of an image using a weighted sum of two or more probability densities with normal distribution is used for initial thresholding of the retinal image. Histogram information derived from the source image is used to partition the brightest regions from background. [3] It is observed that Disk appears most contrasted in the green channel compared to red and blue channels in the RGB image. So that, only the green channel image is used for calculating the optimal threshold. Figure shows the input green channel image and its histogram. It can be seen that the pixels corresponding to the optic Disk and the optic cup belong to the higher intensity bars in the histogram. [1] The diameter of the optic Disk is in the range of 1.8 to 2mm. Based on the visual inference in a standard retinal image with 768 × 576 size with 20micron/pixel resolution, this prior information is used to calculate the threshold.

To obtain an optimal threshold, histogram derived from the source image *I* is scanned from highest intensity value *l*2 to lower intensity value. The scanning stops at the intensity level *l1* which has at least a thousand pixels with the same intensity. The initial threshold *Tk* for step *k*=1 is taken as the mean of *t*2 and *t1* resulting in subset of histograms. Formulation for the calculation of optimal threshold is given by the following pseudo code.

1. Initial estimate of Tk is calculated at step *k* as

2. At step *k,* apply the threshold. This will produce two groups of pixels: *G*o consisting of all pixels belonging to object region and *G*b consisting of all pixels belonging to background region.

3. Compute the average intensity values and for the pixels in *G*o and *G*b respectively.

4. Update the threshold as follows:

5. Repeat steps 2 through 4 differences in *T* in successive iterations are smaller than a predefined value.

Optimal threshold thus calculated results in maximization of gray level variance between object and background. Figure shows the result of thresholding on one of the test image resulting in number of isolated connected regions.

B. Estimation of the Optic Disk Center

Thresholding of an image results in number of connected components such as part of optic Disk, some noise and other bright features. The entire image is scanned to count the number of connected components. Each of the connected components in the thresholded image is labelled, total number of pixels and mean spatial coordinates of each connected component is calculated. The component having the maximum number of pixels is assumed to be having the optic cup part of Disk and it is considered to be the primary region of interest. The maximum diameter of optic Disk can be of 2mm. [5]Therefore, in an image, if any of the components whose mean spatial coordinates are within 50 pixels distance from the mean spatial coordinates of the largest component, then they are merged with it and new mean spatial coordinate is calculated.

VI. Application

1. Digital image processing algorithms when added with it, can lend it to biomedical fields.
2. Data analysis and image modification can be effectively used in research domain.
3. It can also be an effective tool for ophthalmologist ability to detect and diagnose the eye patient

VII. Result

A. Command window output

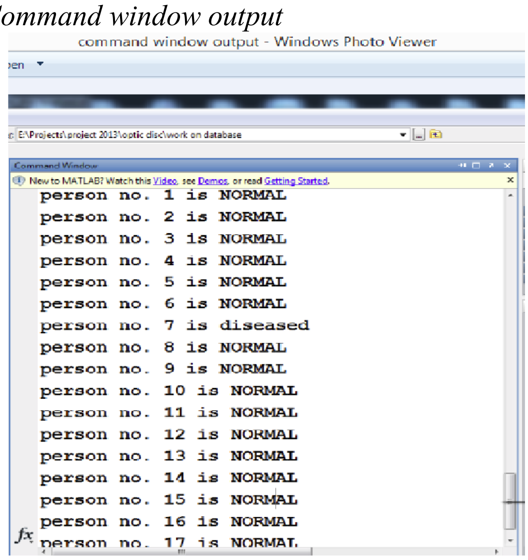

Fig.4. Sorted output

B. Result of optic disk localization

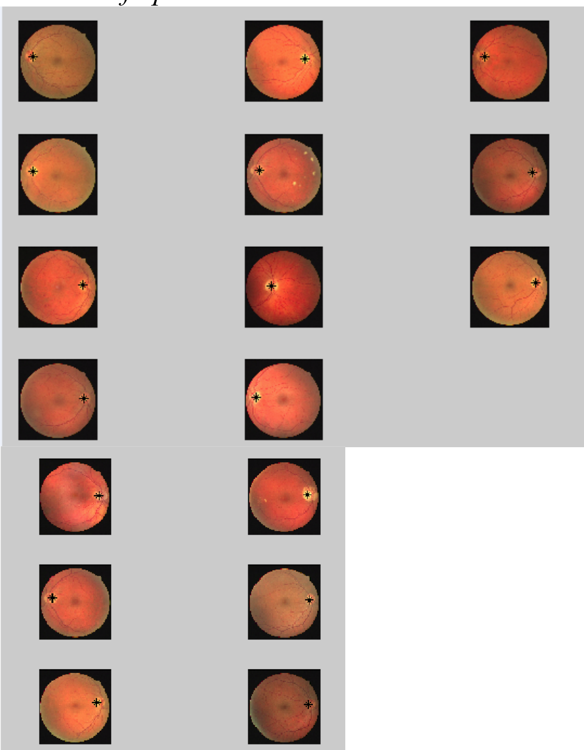

Fig.5. Final output

ACKNOWLEDGMENT

I would like to thank Prof. Joshi V.M. Assistant professor of Electronics & Telecommunication Department of PVPIT, Bavdhan & also other staff members who helped in this paper writing.

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