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Automated Detection of Optic Disc in Retinal FundusImages Using PCA

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Abstract: *An automatic system is presented to find the locationof optic disc andit is a major landmark for the detection of other anatomic features and the macula. These localizationare found by principal component analysis to the image,that contains each structure.The detection of optic disc in colour retinal photograph is a significant task in an automated retinal image analysis system. It is a challenging task to detect optic disc in the normal as well as abnormal, that is, images affected due to disease. This paper presents an automated system to detect an optic disc and its center in normal and abnormal retinal images. The proposed algorithm gives excellent results of optic disc detection. The proposed technique is developed standard databases provided of online Diaretdb0 130 images and Diaretdb1 89 images the images size of 1500 × 1152. The results achieved by after tested images different algorithms can be compared when algorithms are applied on same standard databases. This paper result comparison with another paper result and in which shows that the proposed algorithm is well efficient.*

Keywords: *Retinal image, normal image; abnormal image; optic disc.*

I. Introduction

Detection of normal and abnormal features in retinal images is important and helpful for automatic detection of ophthalmologist. The normal features are the anatomical structures of fundus images that include optic disk, macula, and fovea. It allows recording the diagnostic data and enabling the ophthalmology discussion afterwards. For a particularly long time, automatic diagnosis of retinal diseases from digital fundus images has been an active research topic in the medical image processing.Optic disk is a bright yellowish disk where the blood vessels and the optic nerves occur. The dimensions of the optic disk are often studied for signs of some diseases. To identify the contour of the optic disk a method based on pca contours with new variationalpreparation is proposed.Fig. 1 shows main anatomical structures the retinal fundus image. The retina is an interior part of eye which acts as the film of eye. It converts light rays into electrical signals and sends them to the brain through the optic nerve. Optic nerve is the cable connecting the eye to the brain[1]. Optic disc is the bright region within the retinal image. It is the spot on the retina where the optic nerve and blood vessels enter the eye. Macula is responsible for our central vision. The fovea is an indentation in the centre of the macula. This small part of our retina is responsible for our highest visual acuity. The vascular network is a network of vessels that supply nutrients and blood to the retina.

An important criterion for automation is the accurate localization of the main anatomical features in the image. An accurate and efficient detection of optic disc in an automated retinal image analysis system.

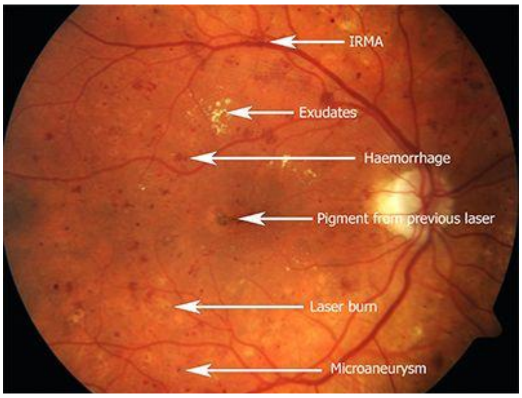


Fig. 1.ColourRetinal Fundus Image

The optic disc localization is important for many reasons. The automatic and efficient detection of the location of the optic disc in colour retinal images is an important and fundamental step in the automated retinal image analysis system [1], [2].To successfully find abnormal structures in a retinal image An example of this is the optic disc, an anatomical structure with a bright appearance, which should be ignored when detecting bright lesions. The attributes of optic disc are similar to hard exudates in terms of colour and brightness. Therefore it is located and removed during hard exudates detection process, thereby elapse false positives.

Optic disc detection is the main step to automated screening systemsdevloping for diabetic retinopathy and glaucoma. Optic disc boundary and localization of macula are the two features of retina necessary for the detection of exudates and also knowing the severity of the diabetic maculopathy [3]. In case of diabetic maculopathy lesions identification, masking the false positive optic disc region leads to improvement in the performance of lesion detection. The distribution of the abnormalities associated with some retinal diseases (e.g. diabetic retinopathy) over the retina is not uniform; certain types of abnormalities more often occur in specific areas of the retina [7]. The position of a lesion relative to the major anatomy could thus be useful as a feature for later analysis. It is used as prerequisite for the segmentation of other normal and pathological features by many researchers. The position of optic disc can be used as a reference length for measuring distances in retinal images, especially for the location of macula. In case of blood vessel tracking algorithms, the location of optic disc becomes the starting point for vessel tracking.

The optic disc, fovea, blood vessel bifurcations and crosses can be used as control points for registering retinal images [8]. The registration of retinal images is an important step for superresolution and image change detection. Unique feature points within image are used as control points for registration. Optic disc is a unique anatomic structure within retinal image. These methods play major role in automatic clinical evaluation system. When feature based registration algorithms are used, the accuracy of the features themselves must be considered in addition to the accuracy of the registration algorithms [9]. Optic disc acts as landmark feature in registration of multimopticdiscal or temporal images.

Location of the retinal optic disc has been attempted by several researchers recently. According to S. Sekhar et al., the optic disc is usually the brightest component on the fundus, and therefore a cluster of high intensity pixels will identify the optic disc location [10].

Sinthanayothin et al. [11] presented a method to detect the location of the optic disc by detecting the area in the image which has the highest variation in brightness. As the optic disc often appears as a bright disc covered in darker vessels, the variance in pixel brightness is the highest there. They also presented method for the detection of the macular centre. They used a template matching approach in which the template was a gaussian blob. The search area was constricted by the fact that the macular centre was assumed to be in the darkest part of the image approximately 2.5 times the optic disc diameter from the optic disc [12]. In macula localization the approximate distance between optic disc and macula is used as a priori knowledge for locating the macula [13]. A method based on pyramidal decomposition and Handoff-distance based template matching was proposed by Lalonde et al. [14]. The green plane of the original image was sub-sampled and the brightest pixels in this sub-sampled image were selected as candidate regions. An edge detector was used on the candidate regions in the original image. Next, multiple circular templates were fit to each of the regions using the Hausdorff-distance as a distance measure. The centre of the fitted circular template was taken as the optic disc centre.

Sopharak et al. [15] presented the idea of detecting the optic disc by entropy filtering. After pre-processing, optic disc detection is performed by probability filtering. Binarization is done with otsu's algorithm [16] and the largest connected region with an approximately circular shape is marked as a candidate for the optic disc. Hoover et al. [17] described a method based on a fuzzy voting mechanism to find the optic disc location. In this method the vasculature was segmented and the vessel centrelines were obtained through thinning. After removal of the vessel branches, each vessel segment was extended at both ends by a fuzzy element. The location in the image where most elements overlap was considered to be the optic disc.

Ravishankar et al. [18] tried to track the optic disc by combining the convergence of the only thicker blood vessels initiating from it and high disk density properties in a cost function. A cost function is defined to obtain the optimal location of the optic disc that is a point which maximizes the cost function.

Niemeijer et al. [19] defines a set of features based on vessel map and image intensity, like number of vessels, average width of vessels, standard deviation, orientation, maximum width, density, average image intensity etc. The binary vessel map obtained [20] is thinned until only the centerlines of the vessels remain and all the centerline pixels that have two or more neighbors are removed. Next, the orientation of the vessels is measured by applying principal component analysis on each centerline pixel on both sides. Using the circular template of radius 40 pixels having manually selected optic disc center within the radius, all features are extracted for each sample location of the template including distance d to the true centre. To locate optic disc, a sample grid is overlaid on top of the complete field of view and features vector are extracted and location of optic disc is found containing pixels having lowest value of d.

Improved results on the same dataset were reported by Foracchia et al. [21]. They described a method based on the global orientation of the vasculature. A simple geometrical mopticdiscel of the average vessel orientation on the retina with respect to the optic disc location was fitted to the image.

In most of the papers researchers considered the optic disc as the brightest region within retinal image. However, this criterion may not be applicable for retinal images those include other bright regions because of diseases such as exudates due to diabetic retinopathy. Some considered the optic disc as the area with highest variation in intensity of adjacent pixels. Both the criteria considered by many researchers are applicable for normal, healthy retinal images. M.D. Abramoff and M. Niemeijer clearly mentioned in the paper [2] that the approach in this paper has the potential to detect the location of the optic disc in retinal images with few or no abnormalities.

This paper presents a novel algorithm for optic disc localization. The proposed algorithm groups the steps based on different principles and propticdiscuces more accurate results. First we estimated threshold using green channel histogram and average number of pixels occupied by optic disc. Applying this threshold, all bright regions within image called clusters are detected. Then we applied two different criteria on these clusters, a: area criterion and b: density criterion. The details about this are discussed in further sections. Once the candidate cluster for optic disc is identified, the brightest oculus criterion is applied to locate the centreof optic disc.

The propose an automatic system to locate an optic disc not only in normal, healthy images but also in images affected because of diseases such as diabetic retinopathy and images of poorer quality. There are more chances of false optic disc detection in images affected due to diseases and images of poor quality than desirable. The problem with retinal images is that the quality of the acquired images is usually not gooptic disc. As the eye-specialist does not have complete control over the patient’s eye which forms a part of the imaging optical system, retinal images often contain artifacts and/or are of poorer quality than desirable [24]. Despite controlled conditions, many retinal images suffer from non-uniform illumination given by several factors: the curved surfaces of the retina, pupil dilation (highly variable among patients) or presence of disease among others [25]. However, our system avoids detecting false optic disc applying different criteria based on different principles. We tested proposed system on 453 retinal images which include normal (healthy) as well as abnormal (affected) retinal images. We are able to locate optic disc in 98.45% of all tested cases. Once the optic disc is located accurately, its centre is also located accurately.

II. Material And Methods

Database used for optic disc localization is as shown in Table I.

TABLE I DATABASE USED FOR OPTIC DISC LOCALIZATION

Sr. No.	Test Database	Number of Images
1	Diaretdb0	130
2	Diaretdb1	89

Thus, a set of 219 retinal images is studied for automated localization of optic disc and its centre.

A.Proposed Algorithm for Detection of Candidate Region for optic disc

Step 1: Estimate Threshold.

Step 2: Apply Threshold and identify bright regions. Step 3: Select candidate regions which satisfy area criterion.

Step 4: Select candidate region which satisfies density criterion.

Step 5: If no candidate region is selected, reduce threshold.

Step 6: If threshold is greater than zero, apply steps 2 through 5.

Step 7: Stop.

The major steps in the algorithm are discussed in detail here.

1)Threshold estimation

In healthy retinal images, optic disc is mostly the brightest region. However, in retinal images affected due to diseases such as diabetic retinopathy, there may other bright regions in addition to optic disc. So first we detected all bright regions within retinal images. In paper by Li and Chutatape [22], they used the highest 1% gray levels in intensity image to obtain threshold value to detect candidate bright regions. However, there is risk of not detecting opticdisc as candidate region if highest 1% gray levels are occupied by other bright regions within image.

Siddalingaswamy et al. [1] used iterative threshold method to estimation threshold for optic disc detection. This criterion is also not applicable to all types of retinal images.

Green channel image shows better contrast than red channel or blue channel image. It is observed that optic disc appears most contrasted in the green channel compared to red and blue channels in RGB image.

Therefore, only the green channel image is used for the effective thresholding of the retinal image. So, we estimated threshold considering green channel histogram. Optimal thresholdingmethod divides the pixels of the image in two groups: group A and group B such that group A contains pixels at least equal to the number of pixels occupied by the optic disc. Optic disc size varies from person to person. It is a vertical oval, with average dimensions of 1.76mm horizontally by 1.92mm vertically [26]. Its width and height are 1/8 and 1/7.33 of retinal image diameter, respectively [27]. Thus, it is possible to determine the number of pixels occupied by the optic disc as :

$$\pi \frac{}{(7.33)\times(8)} \qquad (1)$$

where D is the diameter of the retinal image in pixels.

To obtain an optimal threshold, the histogram derived from the source image is scanned from highest intensity value to the lowest intensity value. The scanning stops at intensity level T when scanned pixels are greater than the estimated optic disc pixels and there is a 10% rise in pixel count between two consecutive intensity levels. Thus, the optimal threshold is calculated as follows :

Step1 : Initialize i = 255 and sum = 0

Step2: sum = sum + H[i]

Step3: i = i_ 1

Step4: if $sum \leq_{count}$ or

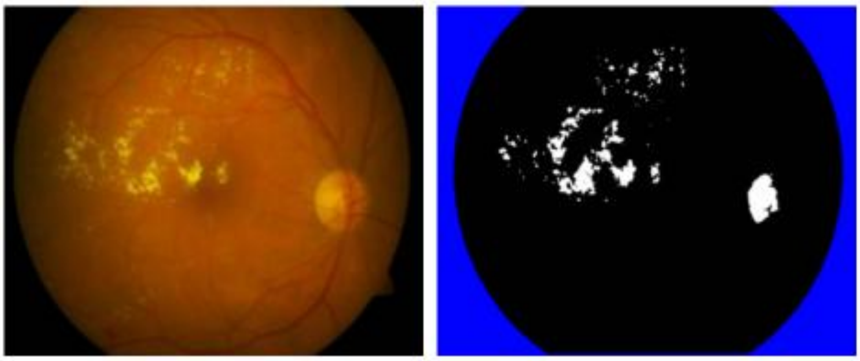
$$\frac{[i-1] - [i]}{[\,[i]} < 1$$ repeat steps 2 through 4

Step5: Threshold, T = i

where H[i] indicates the histogram of the source image and
i indicates the intensity level.

2) Area criterion

The optimal threshold when applied to the image results in one or more isolated connected regions (clusters). Each of the cluster in the thresholded image is labeled and total number of pixels in each cluster are calculated. The clusters having more than 125% or less than 10% of the optic disc area are discarded. This criterion minimizes the possibility to miss the optic disc from the selected candidate clusters.



(a) (b)

Fig. 2.(a) Original image (b)After Filtering

3) **Density criterion**

The density criterion is applied to clusters which have already satisfied the area criterion. According to the density criterion, if the ratio of number of pixels occupied by cluster to the number of pixels occupied by rectangle surrounding the cluster is less than 40%, the cluster is discarded. From the remaining clusters the cluster having highest density is considered to be the primary region of interest. Fig. 4

A.Localization of Centre of an optic disc

The cluster which occupies optic disc is located in algorithm discussed above. The centroid of this cluster is determined using calculus method. A search area is defined around this centroid such that this centroid is center of the search window. This search window is a square window with side equal to twice of optic disc diameter (optic discd).

A circular window called an oculus of radius optic discd/2 is moved across the search area. This is illustrated in Fig. 6. The maximum intensity oculus is identified using procedure given here.

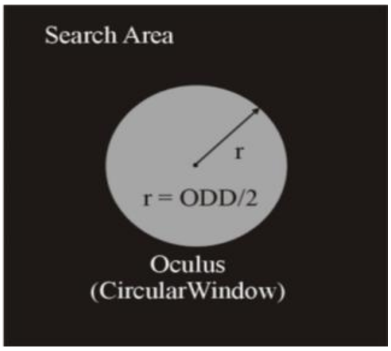


Fig. 3. Center Circular window for optic disc detection

Each pixel within the square window of side equal to optic disc is tested for its distance (d) from the centre of the window. As shown in Fig.4, if the distance, d is less than or equal to the radius r (radius of the oculus), it is considered as inside pixel. The total intensity of the oculus is calculated by adding squares of intensities of all inside pixels.

The centre of maximum intensity oculus is marked as a centre of optic disc.

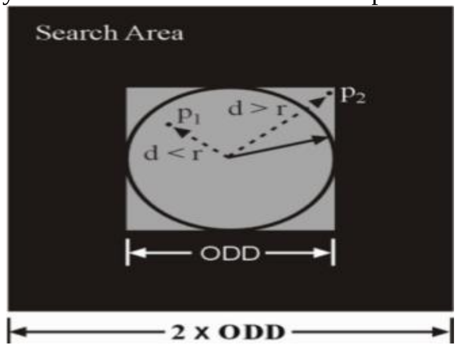
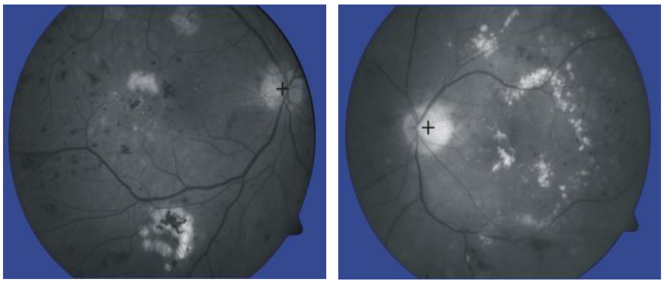


Fig. 4. Center for Pixel inside circle test

There may be more than one window of same maximum total intensity. In this case, the central window amongst the same intensity windows is the resultant window and the centre of the resultant window is considered as a centre of an optic disc.



a) b)

Fig. 5.a)andExamples of centre of optic disc Detection.

III. Results

TABLE II RESULTS OF PROPOSED OPTIC DISC LOCALIZATION METHOD

Test database	Images	optic disc Detected	% Accuracy
Diaretdb0	130	127	98.04
Diaretdb0	89	87	97.47
Total	219	214	97.75

The outcome of optic disc localization is deemed true detection if obtained centre is within the optic disc area. Table II shows the accuracy of true optic disc detected retinal images.

A.Comparison of results obtained using different methods

Rashid Jalal Qureshi et al. [28] discussed different OPTIC DISC detection algorithms and optic disc percentage detection rate in each case using standard databases. Table III summarizes the percentage accuracy achieved applying each algorithm discussed in this paper and proposed algorithm.

We can easily conclude observing Table III that proposed method gives better accuracy in localizing optic disc compared to other methods. Rashid Jalal Qureshi et al. [28] mentioned that performance of the methods listed in columns 2 through 6 of Table III is generally gooptic disc, but each method has situations, where it fails. These methods fail on a difficult data set i.e., the diseased retinas with variable appearance of optic discs in terms of intensity, colour, contour definition etc. The criteria used in the proposed algorithm are determined by considering abnormality of retinal images and hence provides better accuracy in localizing optic disc as shown in the last column of Table III.

IV. Discussion And Conclusion

This proposed automated method has been presented which is localization an optic disc in retinal images. The results show that the system is able to locate the optic disc accurately in 97.75% of all tested cases. The percentage of successful detection of optic disc is increased using method presented in this paper. Themethod of optic disc localization is tested on retinal images and qualitatively valuated by comparing the automatically segmented optic disc with center can be detected accurately. Manual ones detected by an experienced ophthalmologist or clinicians in detecting and diagnosing retinal diseases. Compared to the approaches by other researchers, our algorithm for optic disc detection has the advantage that it is applicable to all types of retinal images, healthy as well as abnormal, affected due to disease and/or acquisition process.

The work in this paper as the optic disc and its center are located accurately, macula and center of optic disc, center of macula can be used as control points for registration of retinal images. The bifurcation points within retinal images which are to be registered can be correlated by checking their distances from centerof optic disc and center of macula. The accurate registration of retinal images can be further used for retinal image.

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