An Improved Method for Optic Disc Localization

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ABSTRACT
An accurate approach for localization and segmentation of an optic disk (OD) in the retinal images is one of the most imperative tasks in an automated screening system. The retinal fundus images analysis is extensively used in the diagnosis and treatment of several eye diseases such as glaucoma and diabetic retinopathy. This research brings out a new algorithm that has not been used before to detect and segment the optic disk in all categories of retinal images, specifically healthy retinal images plus anomalous, or in other words fundus images affected due to diseases. The technique adopted for the separation of the optic disk is centered on histogram specification, mathematical morphological operations includes erosion as well as dilation along with proper thresholding and detection of circles using the Hough Transform technique. The proposed procedure has been tested on standard databases provided for ophthalmic image processing researches on internet, Diaretdb0, Diaretdb1 and local databases collected from the National Eye Hospital and the Vision Care (Pvt) Ltd. The proposed algorithm is able to locate the OD in 90% of all tested images.

Keywords
Optic disk, Retinal Images, Automated detection, Histogram specification, Hough transform, Morphology, Segmentation.

1. INTRODUCTION
Retina plays a valuable role in the human eye. It acts as a film in a camera. Retina converts the light signals that it receives to neural signals and send them to the brain. Damages to the retina may cause impaired vision. Image processing techniques and algorithms have played significant roles for the ophthalmic field. It has been a clinical practice to perform retinal image processing in order for early detection of diseases such as Diabetic Retinopathy and Glaucoma. The neural signals to the brain will be sent through the optic disk.

The optic disk as in the Figure 1, may appear in the same colour as in exudates. Hence, the removal of the optic disk will help the ophthalmologists in many ways. One such example is LASER treatment. It is a common treatment used by the ophthalmologist, but if accidently the optic disk gets burnt by the LASER the patient will get permanent vision loss. This paper proposes a novel method of capturing and segmenting the optic disk from a retinal image.

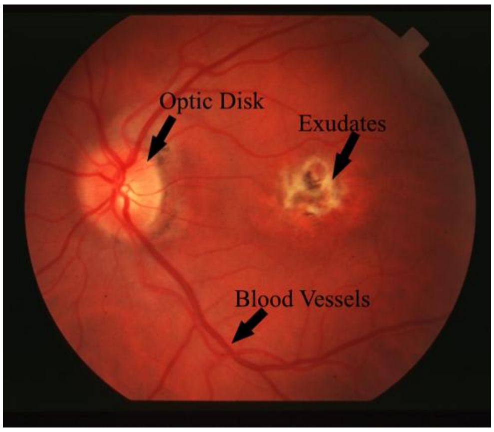


Fig.1.Retinal Fundus Image with Exudates

2. LITRITURE REVIEW
The original image has been transformed to grey scale and filtered by a median filter to cancel out the Salt and Pepper noise. Then a canny edge detector is used to detect the edges and the Hough transformation is used to segment the optic disk in the approach taken by Vijaya R.Patil , Vaishali Kumbhakarna and Seema Kawathekar [1]. An RGB image is smoothened using a bilateral smoothing filter and a line operator. Then the optic disk is segmented using a maximum image variation in the resultant binary image [2]. A morphological method is used to enhance the optic disk and from a neural network based supervised learning method segmentation of the optic disk is done in the research published by Harsha Panchariya and Sangita Bharkad [3]. In “Optic Disc Identification Methods for Retinal Images”, the optic disk is localized in two steps. Firstly, the green component of the RGB image is enhanced based on texture indicators and pixel intensity variance. Secondly, the optic disk is segmented by the Hough transform [4]. Amandeep Kaur and Reecha Sharma has processed the image by filtering and morphology operations, then the optic disc is detected using thresholding [5]. The optic disk was segmented using histogram based particle swarm optimization techniques by Thresiamma Devasia, Poulose Jacob and Tessamma Thomas [6]. A slightly different approach was taken by C. Pereira, L. Gonçalves, and M. Ferreira by using the Ant colony optimization algorithm [7] to localize the optic disk. A simple and efficient approach for segmentation of the optic disc by thresholding the morphologically connected regions and boundary extraction was done in “Segmenting the Optic Disk in Retinal Images using Bi-Histogram Equalization and Thresholding the Connected Regions” [8].

3. METHODOLOGY

The following flow chart shows the steps in the methodology of the proposed framework.

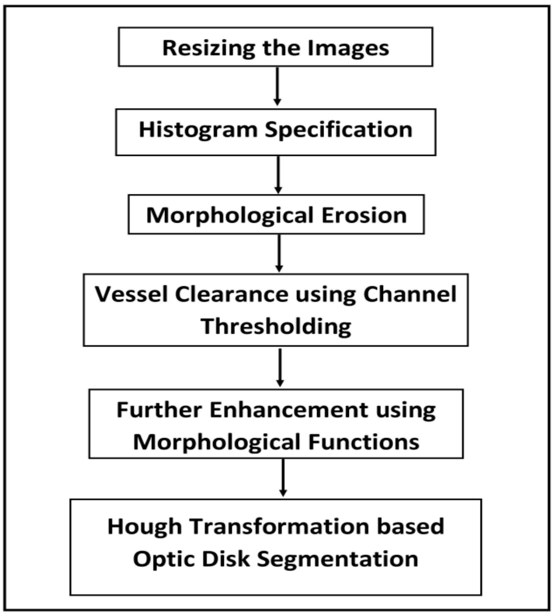


Fig.2.Steps in the methodology of the proposed framework

3.1 Resizing the Images

Various different sizes of colour retinal images are brought to one common 480x640 size in order to bring them to a common dimension(because the reference image is in 480x680 dimension). Otherwise the Histogram Specification cannot be performed.

3.2 Histogram Specification

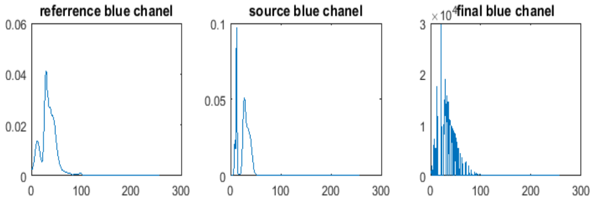


Fig.3.Histogram Specification of the blue channel

An image which has different pixel values in the vessels of the optic disk has been chosen as a template image (reference image). These pixels of the vessels inside the optic disk contain high values in the red channel, low values in green and blue channels compared to the other RGB values of the pixels in the rest of the image. Then the RGB colour histograms of the source image (image which should be segmented) is rearranged according to the RGB colour histograms of the reference image. Fig .3 is an example for the Histogram Specification of the blue channel (the other two channels will also undergo this process).

Specific steps of the histogram specification algorithm,

- Step 1: The histogram of source image h_x,could be equalized as,

$$H_x[j] = \sum_{i=0}^{j} h_x[i] \qquad (1)$$

- Step 2: The histogram of the reference image H_z,could be equalized as,

$$H_z[j] = \sum_{i=0}^{j} h_z[i] \qquad (2)$$

- Step 3: For each input level i, an output level j is found, so that $H_z[j]$ best matches $H_x[i]$.This is done in order to build up a look up table for overall mapping:

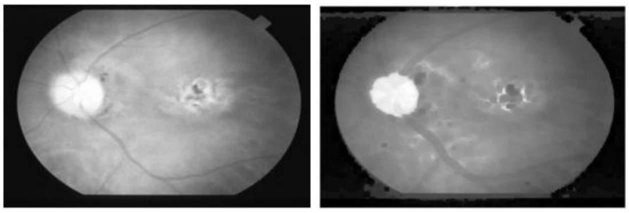
$$|H_x[i] - H_z[j]| = \min_k |H_x[i] - H_z[k]| \qquad (3)$$

- Step 4: From the look up table the following mapping will be done,

$$lookup[i] = j \qquad (4)$$

3.3 Morphological Erosion

Due to the histogram specification done in the previous steps some of the areas out of the optic disk might be having an unusual brightness which would not be expected. Hence a morphological closed function or in other words erosion is used to clear out these unwanted bright areas of the retinal image.

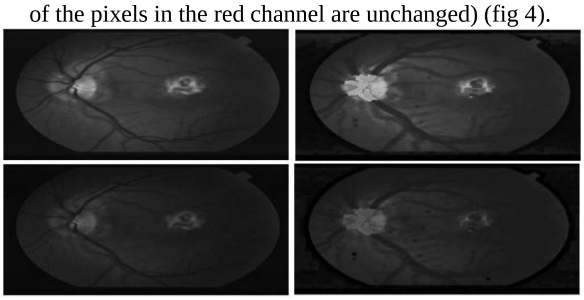


(a) **(b)**

Fig.4.Red Channel Image (a) Before Equalization (b) After Equalization and Erosion

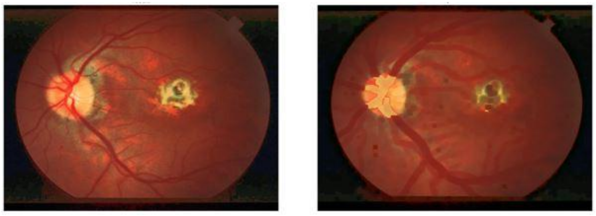
3.4 Vessel Clearness using Channel Thresholding

At this point, the highest values for red channel and the lowest values for blue and green channels would obtain by the pixels of the vessels inside the optic disk. A scan will be made to find these areas. After finding the above said vessels, the blue and green channel values of the pixels will be increased until the nerves disappear (increased up to predefined values). However, the red channel will be untouched (intensity values of the pixels in the red channel are unchanged) (fig 4).



(a) **(b)**

Fig.5.Green and Blue Channel (a) Before Equalization (b) After Equalization and Highlight the Vessels inside the OD



(a) **(b)**

Fig. 6. Vessel Clarity by Thresholding (a) Image with vessel in OD (b) Image without vessels in OD

3.5 Further Enhancement using Morphological Methods

Though the optic disk is very sharp and recognizable to the human eye, it needs to be further purified in order to make a perfect segmentation. The resultant will be dilated by using a disk shaped structural element. Then the red channel is selected. The reason for the selection is due to the brightness of the red channel compared to the other two. Now further purification will be done to the disk, adjusting image intensity values in order to highlight the optic disk from the background. Then erosions and dilation are done in order to obtain a perfect shape.

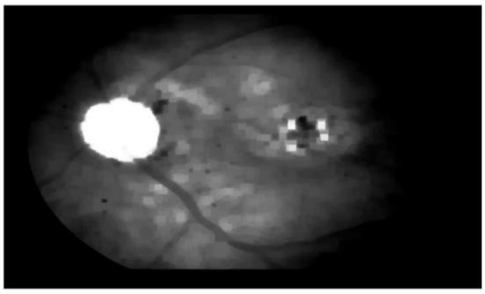
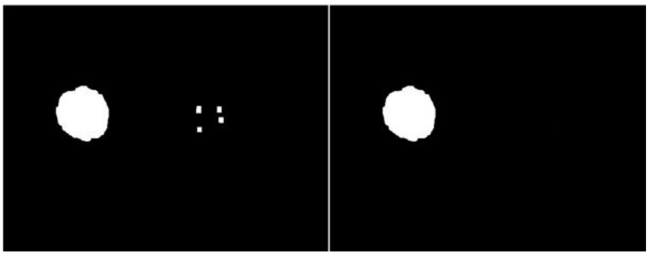


Fig.7.Intensity Adjusted Red Channel

Then the adjusted image turn into binary tone using a predefined illumination value. In order to separate the area of the optic disk, the noisy blobs that are smaller than 50 pixels has been removed.



(a) **(b)**

Fig.8.Binary Image (a) With noisy Blobs (b) Noisy Blobs Removed

3.6 Hough Transformation based Optic Disk Segmentation

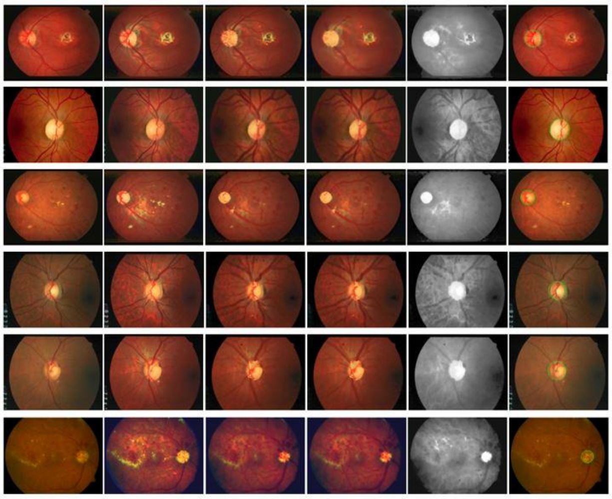
Finally, the Hough transformation is used on the result and the disk is segmented from the image (Fig 10). The diameter of the Hough circle is determined by getting the maximum distance among every two white pixels.

Fig.9.Segmented OD Area in the Binary Image

Fig.10.segmented Optic Disk

4. RESULTS AND DISCUSSION

The following images are from the various steps of the proposed algorithm. The algorithm was applied to various data sets.



(a) **(b)** **(c)** **(d)** **(e)** **(f)**

Fig.5.(a) Input Retinal Image (b) Channel Recombination Image (c) Vessel Free Image (d) Vessel Free Dilated Image (e) Red Channel of Vessel Free Dilated Image (f) Optic Disk Segmented Image

The proposed algorithm was tested with four different data sets. Diretdb0 and Diretdb1 are open source data sets. Data set 1 is taken from the National Eye Hospital Sri Lanka and data set 2 is taken from the Vision Care (Pvt) Ltd. The following results are obtained by inserting the images.

TABLE 1. Accuracy of the proposed frame work

Test Data	Images	OD detected	% Accuracy
Diretdb0	130	118	90.7
Diretdb1	89	80	89.8
Dataset1	100	100	100
Dataset2	100	100	100

The algorithm is tested and compared with three other algorithms done in other research work. Firstly based on an edge detection method [9]. Secondly based on a feature vector and a uniform sample grid [9]. Finally based on a Hough transformation [9]. The results could be given as follows.

TABLE 2. Comparison between frame works

Test Dataset	Edge Detection Method	Feature Vector Method	Hough Transformation Method	Proposed Algorithm
Diretdb 0	77.56	77.56	80.12	90.7
Diretdb 1	75.46	75.46	76.41	89.8
Dataset 1	-	-	-	100
Dataset 2	-	-	-	100

According to the table 1 for all datasets the proposed algorithm has given approximately more than 90% accuracy. Furthermore according to figures from table 2 the accuracy of the proposed algorithm is better than other algorithms (referring to row one and two).

5. CONCLUSION

A novel method based on histogram specification, morphological functions and channel thresholding is proposed. The result were tested by using four different data sets and the accuracy appeared to be more than 90%. The proposed algorithm produces more accurate results than Edge detection method, Feature vector method and the Hough Transformation method. As a future enhancement a vessel segmentation technique will be used along with the proposed method.

6. ACKNOWLEDGMENT

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7. REFERENCES

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