Segmenting Optic Disk Cup in Retinal Fundus Images

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ABSTRACT

The optic disk (OD) center and margin are typically requisite landmarks in establishing a frame of reference for classifying retinal and optic nerve pathology. Reliable and efficient OD localization and segmentation are important tasks in automatic eye disease screening. OD Cup is segmented using Gradient method, Adaptive Threshold and Connected Component. They utilize BBB method hang on the Tint Discrepancy in the retinal images for fast and fully automatic OD localization and segmentation. Its robustness make the OD and OD Cup segmentation useful for automatic retinal disease screening in a variety of clinical settings and eye diseases such as diabetic retinopathy(DR), Glaucoma, other common retinal diseases such as age related macular degeneration including myopic crescents, per papillary atrophy (PPA), and myelinated nerve fibers.

Keywords

Optic Disk, Optic nerve pathology, Diabetic retinopathy, Per papillary atrophy.

1. INTRODUCTION

1.1. Optic Disc

OD is slightly oval shape in the back of the eye about 3 to 4 millimeters (0.14 to 0.18 inch) nasal to the center.

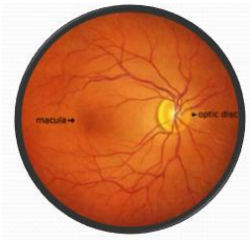

Fig 1: Optic Disc

The OD is the brightest feature of the normal fundus image appears as a bright yellowish region. The absence of the pigmented epithelium in this zone is responsible for the yellowish color of the OD in the digital fundus image. It is made up of the nerve fibers of nerve cells, called ganglion cells.The 1.0 to 1.2 million ganglion cell nerve fibers or axons or called as vasculature network. They leave the eye at the disc and form the optic nerve, which carries visual information to the brain.

1.2. Optic Disc Cup

The optic disc has a center portion called the "cup" which is normally quite small in comparison to the entire optic disc. Fig 2 shows the cup area inside the Optic Disc

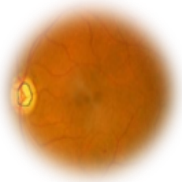

Fig 2: Optic Disc Cup

One of the necessary step for automatic eye screening system is the localization of anatomical landmarks such as the optic disk, fovea, and retinal vasculature. OD detection is the first requirements for automated eye disease screening.

1.3. Why Optic Disc Cup Segmentation?

In Glaucomatous the OD Cup enlarges shown in Fig. 4. OD Cup may also enlarge vertically called Notching exposed in Fig. 5

Fig 3: Normal Eye

Fig 4: Cup Enlarges

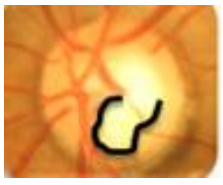

Fig 5: Notching

Glaucoma is a silent thief of sight because they leads to complete eye vision loss. They can be controlled not cured.

65 million peoples in India are affected by Glaucoma. Early detection of Glaucoma can prevent eye loss. So, automatic detection of OD Cup will be a boon for medical field in curing Glaucoma.

2. LITERATURE SURVEY

2.1. Optic Disk and Cup Segmentation from Monocular Color Retinal Images for Glaucoma Assessment

OD Cup is segmented by Contour model method which is based on anatomical evidence such as vessel bends at the cup boundary.

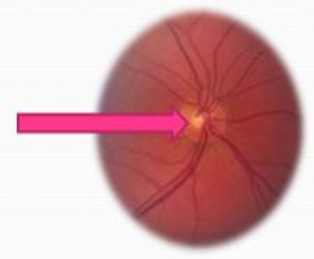

Fig 6: Normal retina with Vessel bends inside OD

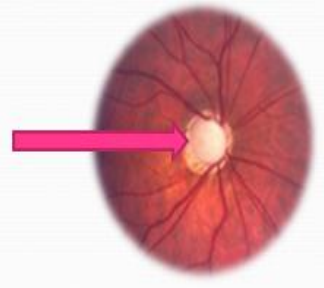

Fig 7: Abnormal retina with no vessel bends inside OD

This method is not suitable with abnormal retina because they don't have proper vessel bends in the retina shown in Fig 6 Most Glaucomatous OD Cup will have anomalous blood vessels.[5]

2.2. Ultrafast localization of the optic disc using dimensionality reduction of the search space

For segmenting the OD, Macula is detected initially then OD's position is found out. For this purpose we must know about the distance between the macula and OD.

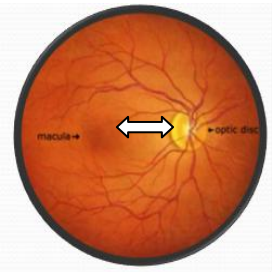

Fig 8: Distance between Macula and OD

This is shown in Fig. 8 White arrow is the distance between Macula and OD. But the distance between them may vary in some cases. For instance, swollen optic nerve, where the circular shape and size are distorted hence leading to misdetection of OD. Another issue is it is unnecessary to detect Macula's position to detect OD position [1].

2.3. Segmentation of the optic disc, macula and vascular arch in fundus photographs

An automatic system is presented to find the location of optic disc, macula, and vascular arch in the major anatomical structures in color fundus photographs. The Segmentation of OD is done by observing the vasculature network inside the retina

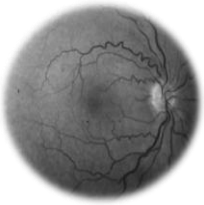

Fig 9: Vascular Network in the Retina – Grey Scale image.

There are millions of gangalion cels so called as vascular network available inside the retina. Fig 9 shows the vasculature network in a grey scale image of retina. Though Vasculature network can improve the OD localization's reliability, it is so complex and time-consuming task to validatre the whole vascular network [2].

3. SYSTEM ARCHITECTURE

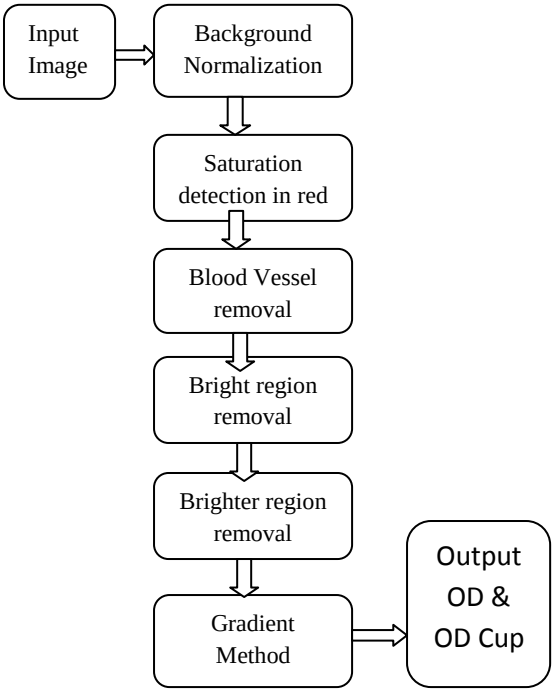

Fig 10: System Architecture for the proposed

For automatic OD segmentation, the BBB method is helpful, which hang on the Tint Discrepancy besides, act as the back bone of this project. The proposed approach

shifts focus on segmenting OD Cup firmed from cues such as Gradient method, Connected component and Adaptive Thresholding.

4. OPTIC DISC SEGMENTATION

4.1. Background Normalization

In image processing, normalization is a process that changes the range of pixel intensity values. Applications include photographs with poor contrast due to glare, for example. Normalization is sometimes called contrast stretching. In more general fields of data processing, such as digital signal processing, it is referred to as dynamic range expansion. The purpose of dynamic range expansion in the various applications is usually to bring the image, or other type of signal, into a range that is more familiar or normal to the senses, hence the term normalization. Often, the motivation is to achieve consistency in dynamic range for a set of data, signals, or images to avoid mental distraction or fatigue. For example, a newspaper will strive to make all of the images in an issue share a similar range of grayscale.

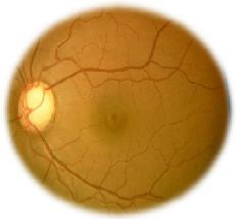

Fig 11: Normal Image

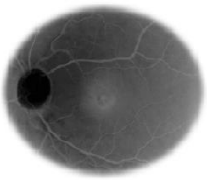

Fig 12: Normalized Image

4.2. Saturation in red channel

A new pre-processing method for colour fundus images with adaptive contribution of the red channel is proposed. This method can be used to correct non-uniform illumination in colour fundus images or as a pre-processing step in the automatic analysis of retinal images. In the digital realm, there can be any number of conventional primary colors making up an image, a channel in this case is extended to be the grayscale image based on any such conventional primary color. An RGB image has three channels: red, green, and blue. RGB channels roughly follow the color receptors in the human eye, and are used in computer displays and image scanners.

4.3. Blood vessel detection

Optic Disc is a part in the retinal image. There are many blood vessels in the retina Blood vessels which introduce errors in OD segmentation So these Blood vessels network need to be extracted. Zoomed photo of the blood vessels structure and nerve fibres are shown in Fig 13 Blood Vessel inside the retina

$g(x, y)=\gamma(Bn)\text{opn}\{(Bn)\text{clo}[\ldots\gamma(B1)\text{opn}((B1)\text{clo})f(x, y)))]\}n = 3$ (1)

where $(Bi)\text{clo} = f(x, y) \_ (Bi)$ is a closing with structural element

Bi , and $\gamma(B\ i)\text{opn} = f(x, y) \_ (Bi)$ is an opening with structural element Bi .

Fig 13: Blood Vessel inside the retina

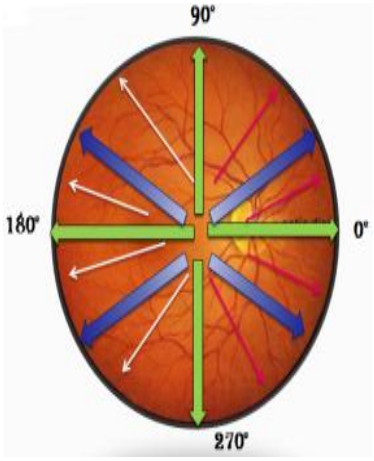

Fig 14: Directional Filter applied on Retina

We have to find the nerves inside the retina. This can be achieved by Direction Filter. The variations can be observed by evaluating the image pixels in direction wise. The angle of direction is shown in the Fig 14. In this way direction varies inside. The pixels which are uniform in structure will be uniformly distributed so they can be taken separately. Fig 14 depicts how Blood Vessels are found out by Directional Filtering inside the retina Thousands of angles will be made by directional filter to find out the vessels only some of the directions are shown.

Fig 15: After blood vessel removal

4.4. Bright and brighter region removal

The bright region and brighter region are the area except Optic Disk. The OD is the brightest feature of the normal fundus image appears as a bright yellowish region.

$$fmk(x, y)= \begin{cases} f(x, y), \text{ if pixel } (x, y) \text{is on border} \\ 0, \text{ otherwise.} \end{cases}$$

Morphological reconstruction is the repeated dilation of the

marker image until the contour of the marker image fits under

the mask image. The single reconstruction step can be defined

as

$\delta(B)i\ (f\text{mk}|f) = (f\text{mk} \oplus B) \cap f.$

where B is a structural element defined by connectivity. If 8-

connectivity is used, the structural element is a 3 × 3 matrix of1 s.The reconstruction of $f(x, y)$ from marker $f\text{mk}(x, y)$ is definedas

$f(x, y) = Rf\ (f\text{mk}) = \delta(B)n \cdot \cdot \cdot \delta(B)1\ (f\text{mk}|f).$

So according to the colour variation we threshold the pixel values to segment the OD.

4.5. Region get segmented by threshold

The blood vessels are removed and shown in the Figure . Now we have to remove the OD which is the brightest region. Remaining region namely bright region and brighter region are removed as shown in Fig 17 and Fig 18.

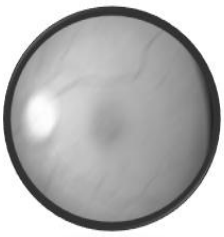

Fig 16: Blood Vessel Removed

Fig 17: Bright region removed

Fig 18: Brighter region removed

4.6. Proof for Threshold value– Grey Scale Chart

Threshold value is taken as 200 and 225 revealed in Fig 19

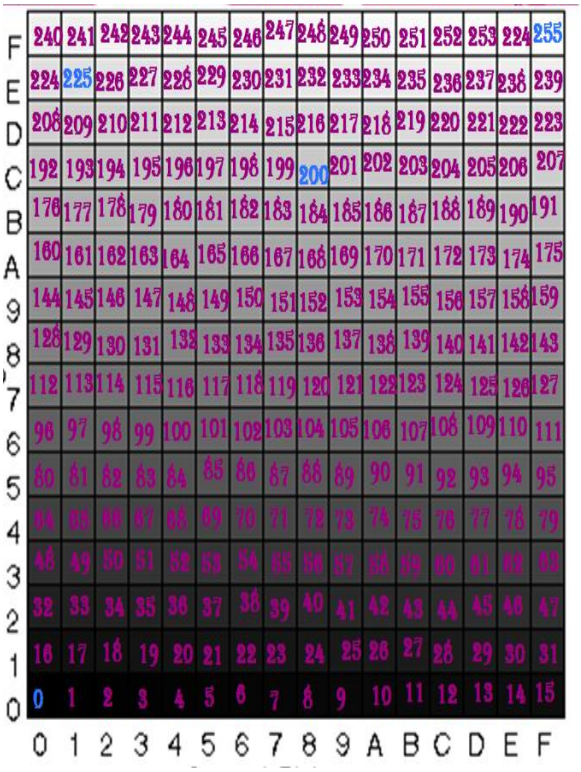

Fig 19: The colour range from 0 – 225 in Grey Scale Chart

4.7. Secret in threshold

The region which is lesser than the value 200 is the bright region. The region between the value 200 and 225 is brighter region. The region greater than 225 is Optic Disk area

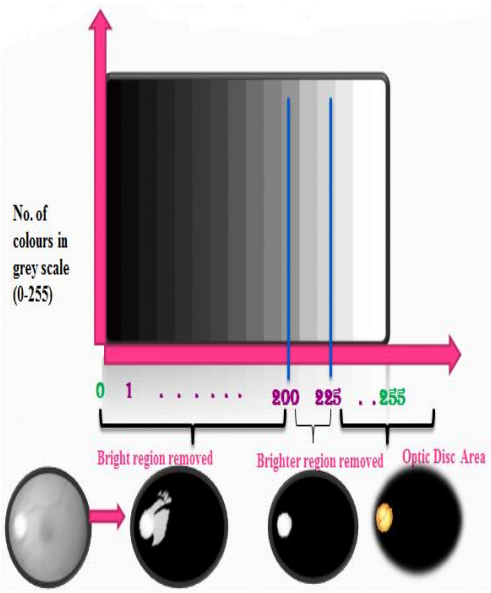

Fig 20 Threshold Value to segment OD

Fig 20 is the grey scale chart ranges from 1 to 255 colours. Threshold point is shown as Blue stripes in Figure 3.20. The first blue stripe threshold value is 200, the bright region falls beside it. The next blue stripe threshold value is 225, the brighter region falls close to it. Remaining area is our target area, i.e. Optic Disk. If any exudates, lesions occurs during the segmentation they will be removed in the second threshold which give more robust OD segmentation.

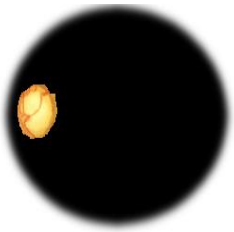

Fig 21 Segmented OD

5. OPTIC DISC CUP SEGMENTATION

Optic Disc Cup can be segmented by Gradient Method, Adaptive Thresholding and Connected Component.

5.1. Gradient Method

1. In vector calculus, the gradient of a scalar field is a vector field that points in the direction of the greatest rate of increase of the scalar field, and whose magnitude is that rate of increase. In simple terms, the variation in space of any quantity can be represented (e.g. graphically) by a slope. The gradient represents the steepness and direction of that slope
2. In Figure 4.1, the scalar field is in black and white, black representing higher values, and its corresponding gradient is represented by blue arrows.

The Gradient is applied to Fig 22 as a result we get the output graphically as shown in Fig 23 So the lower magnitude will be plotted at the bottom and they get increases gradually as we go above**.**

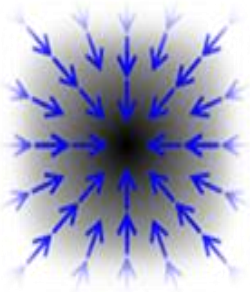

Fig 22: Variation in Magnitude

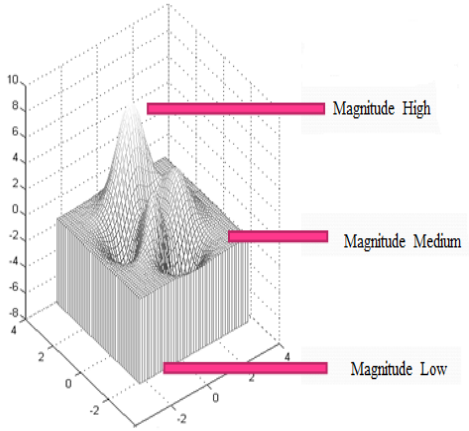

Fig 23: Represented Graphically

In the graph the portion where the OD Cup reside is at the higher magnitude area. In general, the peaks in the graph represent the different regions of an image.

5.2. Adaptive Thresholding

Thresholding is the simplest way to segment objects from a background. If that background is relatively uniform, then you can use a global threshold value to binarize the image by pixel-intensity. If there's large variation in the background intensity, however, adaptive thresholding may produce better results. Adaptive thresholding methods are those that do not use the same threshold throughout the whole image. So, the output got in the previous step is given as input hence Adaptive Thresholding is made on it to get the accurate area of Cup area. Probably at this juncture the value of Adaptive Threshold will be between 0.5 to 0.9 which is dynamic and varies accordingly for each different image (retinas). The range of Adaptive Threshold stuck between 0.5 to 0.9 as the pixel in an image varies among 0 to 1.

5.3. Connected Component

Connected components labeling scans an image and groups its pixels into components based on pixel connectivity, i.e. all pixels in a connected component share

similar pixel intensity values and are in some way connected with each other. Once all groups have been determined, each pixel is labeled with a graylevel or a color (color labeling) according to the component it was assigned to.

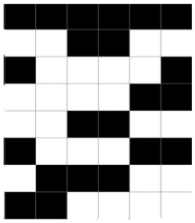

Fig 24: Connected Component

Connected Component when applied to the previous result they gives Cup area very accurately. As Figure4.3 Depicts, the similar variation will be grouped therefore Cup area diverges equally as a result they will be segmented.

Fig 25 Segmented OD Fig 26 OD Cup

6. EXPERIMENTAL RESULTS

In MatLab the process has been done. File System are used as the database. The database containes nearely 100 images of the posterior pole acquired by fundus camera. Following is thwe result obtained during the progress.

No. of Images	Disc Area	Bright area	Blood Vessel Area
1	0.1452	0.129	17.8255
2	0.1355	0.1205	6.561
3	0.1536	0.1231	5.2562
4	0.1444	0.1247	7.0873
5	0.1314	0.0759	4.7987
6	0.1413	0.1423	17.2751
7	0.1446	0.1163	8.4128
8	0.1465	0.1123	5.8363
9	0.1632	0.1186	5.8276
10	0.1383	0.0761	5.0095

TABLE 1: OBTAINED RESULT

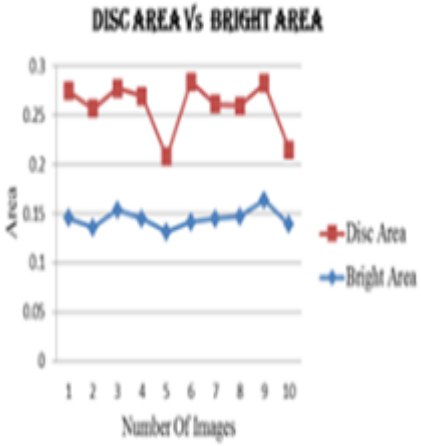

FIG 27 DISC AREA VS BRIGHT AREA FOR 10 IMAGES

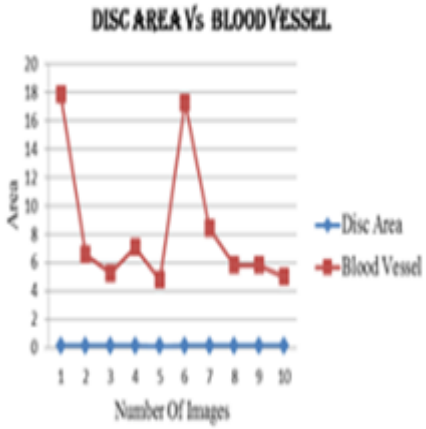

FIG 28: DISC AREA VS BLOOD VESSEL FOR 10 IMAGES

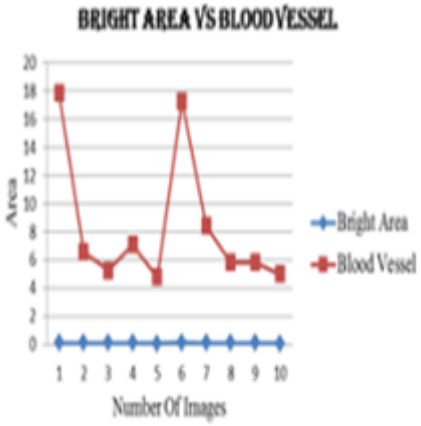

FIG 29: BRIGHT AREA VS BLOOD VESSEL FOR 10 IMAGES

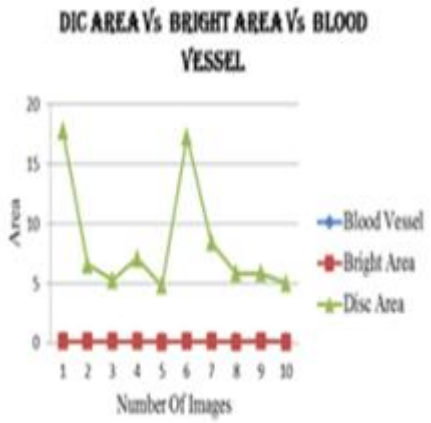

Fig 30: Disc Area Vs Bright Area Vs Blood Vessel for 10 images.

7. CONCLUSSION

A new, fast, and robust OD localization and segmentation methodology for retinal image screening has been developed. The future automatic eye disease screening system will have to be robust, fast, and provide high accuracy rates in order to support high workloads and near-real-time operation. The methodology developed herein has been designed to satisfy these requirements. The robustness and efficiency makes this methodology suitable for assisting automatic screening for early signs of eye diseases.

8. ACKNOWLEDGMENTS

"There is no one holy as the LORD; there is none like him; no protector like our JESUS Christ; happy are the people whose God is the LORD JESUS CHRIST, Amen!"

I remember my family members who were always with me in all my sorrows, happiness and provided moral support. I take this opportunity to express my deep sense of gratitude to my beloved parents Dr. A. Selvakumar, Mrs. F. Graceline Julia Selvakumar. It is also the time to say thanks to my dear sister Miss. S. Ida Blessy. I owe gratitude to my grandparents for their kindness and care on me, Mr. D. Ayyapillai, Mrs. C. Mariammal Ayyapillai, Mr. N. Francis and Mrs. S. Leela Francis. I convey profound sense of gratitude to Pastor A. Joseph and Mrs. A. Arockia Mary Joseph for their invaluable prayers for my family are memorable.

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