Primary Open Angle Glaucoma Diagnosis using Neuro Retinal Rim Ratio

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ABSTRACT
Glaucoma harms the optic nerve cells that transmit graphic information to the brain. Though IOP is the most considerable reason to extend glaucoma, optic disc parameters are mainly used to find out early stage of glaucoma damage.Glaucoma is nick name as “silent thief of eyesight”, as the nickname suggests there are no previous symptoms,but due to this, Glaucoma patient can blind without any previous intimation. For glaucoma diagnosis there are multiplemethods are available like CDR, i.e. optic cup to disc ratio calculation,NRR i.e. Neuro Retinal Rim Ratio. Here we are using NRR to diagnose the glaucoma. For that we use our proposed algorithm on 300 colored retinal fundus images. These are MESSIDORE 100 images, and RIM-One 100 of Glaucomatous and 100 of Normal. Over all we got 68% result from MESSIDORE fundus image dataset. And 100% result from Rim-One normal images and 66% result from Rim-One Glaucomatous dataset.

Keywords
CDR (Cup to Disc Ratio); NRR (Neuro Retinal Rim);RDR (Rim to Disc Ratio); Multithresholding; IOP(Intra Occular Pressure).

1. INTRODUCTION
Glaucoma is an eye disease in which the optic nerve damages by the promotion in the intraocular pressure inside the eye triggered by a build-up of excess fluid. This pressure can impair vision by causing irreversible damage to the optic nerve and to the retina. It can go towards the blindness if it is not detected and treated in right time. Glaucoma result in tangential vision loss, and is an especially dangerous eye condition because it frequently progresses without noticeable symptoms.Glaucoma is defined as ‘multi factorial optic neuropathy’which is a potentially blinding disease which affects 66.8million citizens worldwide. It is the second primary cause ofblindness. Risk evaluation of the disease goes a long wayin analysis and organization of the disease. Although theincreased intra ocular pressure (IOP) is a considerable riskfactor for growing glaucoma, there is no set thresholdfor IOP that causes glaucoma. This can result in decreasedtangential vision and eventually leads to blindness. Earlyglaucomatous injure can be complicated to detect, requiringsuspiciousexamination of the optic nerve and RNFL. Thedetection of glaucoma through Optical CoherenceTomography (OCT) and Heidelberg Retinal Tomography(HRT) are very costly [1, 2] compared to digitalfundus images. With the help of image processing, thefeatures of the fundus images such as optic disc and cupcould be localized to suspect the glaucoma [3, 4, 5].From the progression of this diesis it is classified into two categories one is Primary open angle glaucoma and another is secondary glaucoma. In very early stage whenever it diagnose as glaucoma, that stage we can called as primary open angle glaucoma.

2. DATASET INFORMATION
2.1 Rim-One Dataset
Rim-I is our fundus image data base we have used healthy 100 and Glaucomatous 100 images from this database. RIM-ONE, specifically designed for glaucoma diagnosis,not only for medical educational purposes, but also as an evaluation tool for designers of segmentation algorithms. RIM-ONE allows the free download of different fundus images (healthy eyes and eyes with different glaucoma levels), contains gold standards for each image and proposes a common methodology for comparing segmentation results with the gold standard. This reference image database for glaucoma is part of a research project developed in collaboration with three Spanish hospitals: Hospital Universitario de Canarias, Hospital Clínico San Carlos and Hospital Universitario Miguel Servet.The creation of this reference image database in collaboration with domain experts of all these hospitals [6].

2.2 Messidore
The Messidore database, kindly make available by the Messidore program partners, fromlink-(seehttp://messidor.crihan.fr) The database consists of retinal fundus images obtained using a color video 3CCD camera on a Topcon TRC NW6 non-mydriatic retinograph with a 45 degree field of view. The database was separated into two sets. 40% images were used in dataset 1 for training purpose and 60 % images were used in dataset 2 for testing reason. The OC boundary for the images in dataset was drawn by professionals in ophthalmology [7].

3. METHODOLOGY
In this research paper to get CDR and RDR we are going through the several methods, From preprocessing to Feature extraction, and statistical analysis of results. In following flow diagram of proposed algorithm for CDR and RDR, we can see it with more details.

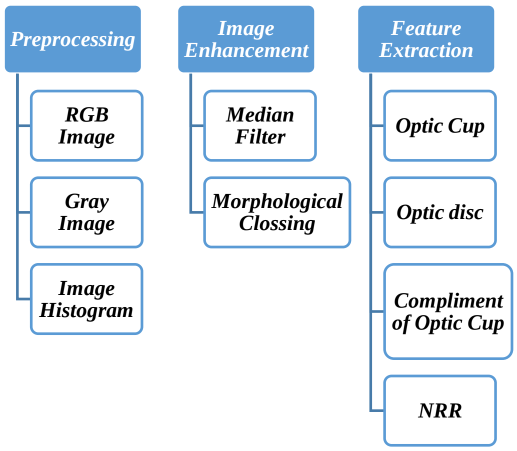


Figure 1.Flow diagram of methods used for CDR and RDR

3.1 Preprocessing

RGB Image:

Images used from the Rim-one and Messidore database areofRGB type. RGB images sometimes referred as a true color image [8]. In our experiment we have worked on Gray channel images. We are used gray channel images because feature extraction is easier than red and blue channel.

Gray Image:

In preprocessing we have acquire RGB image and translate it in to gray image for the performing of advance feature extraction methods.

Histogram of Image:

In preprocessing we have get histogram of gray image for observation of statistical view of the 2D gray image.

Image Enhancement

2D Median Filter:

After performing Histogram equalization operation, then we have applying 2D Median filter on enhance image. For the purpose of removing the noise from the image.

y= [m, n] =median{x [i, j], (I, j) Ɛ ω}………………….(1)

Here correspond to a neighborhood centered on position (m, n) in the image [9].

Morphological Closing:

After applying 2D median filter we have used the Morphological structuring element for stress on the Optic cup and disc from the retina [10].

$I_{dilated(i,j)} = max_{f(n.m)=true} I(i+n, j+m)$………(2)

$I_{eroded(i,j)} = min_{f(n,m)=true} I(i+n, j+m)$………(3)

After applying the Morphological structuring element, we have applied the Morphological closing function for lessening the retinal fiber layers. And then we have uninvolved the Optical nerve fiber from the retinal image.

4. FEATURE EXTRACTION

4.1 Muti-Thresholding Method:

This image segmentation method is based on thresholding. Its basic standard is to find out a worth as a threshold, generally in a gray image that is within the range of tones used in the image. For example, in an image with an 8 bit pixel resolution, the threshold may be among 0 and 255.After establishing the threshold of all the section in the image, it is possible to label every pixel, associating it to the value posserenowned in each region. When there are just two regions for classification, one of these receives the label 0 and the other 1, and in this case the method is called binarization. More than one threshold can be trustworthy in the same image; this technique is called multi-Thresholding. This technique subdivides the image in more than two categorization, establishing the lower and theupper limits of each ROI (region of interest). Since the optical disc in protected image is corresponding to maximum brightness regions. Thus in order to segment the optical disc the proper threshold is selected as;

Th = f (x, y)…………………………… (4)

245 < f(x, y) < 255...……………………(5)

Where, f(x, y) is the gray level value of the protected image. The threshold is set to 75 in this paper for Rim-one database. And 0.6 is selected for Messidore database [7], thereason for that two separate Threshold is FOV (Field of view) and Image resolutions are different for both the data set. Now the segmentation is performed based on the selected threshold and the segmented image is given as;

G (x, y) = {255 if a(x, y) > TH2

= {0 otherwise ………….……..(6)

Where, g(x, y) is a logical segmented image [10].

- *Optic Cup and Disc boundary setting:*

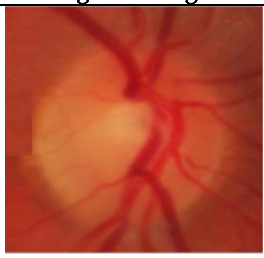
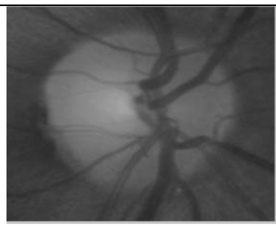
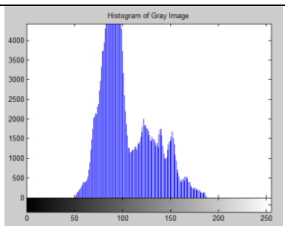
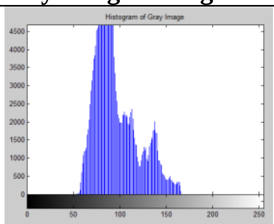
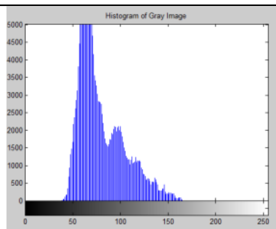
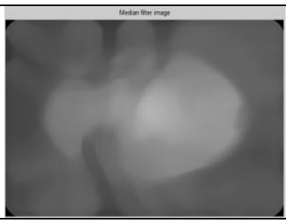
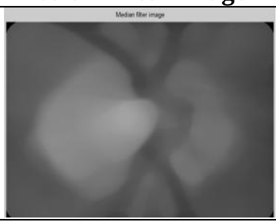
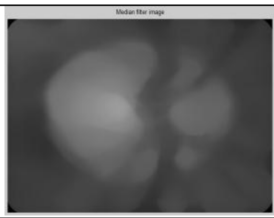
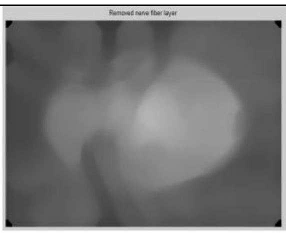
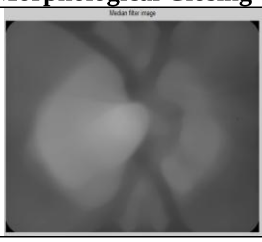
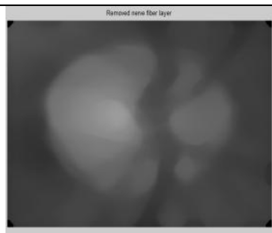
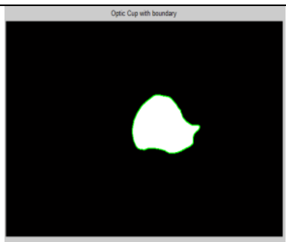
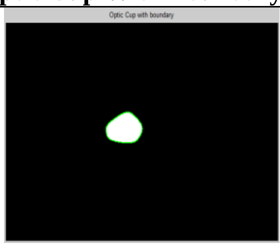
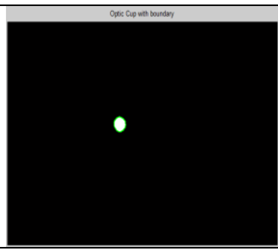
After extracting optic cup and disc from the retinal fundus image by using multi-thresholding method then, set the boundary to each one for more accurate results, or it is used for calculating exact area in between the boundary. The following resultant table shows resultant boundary fitting to optic cup and disc.

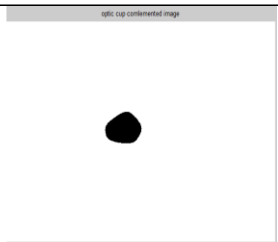
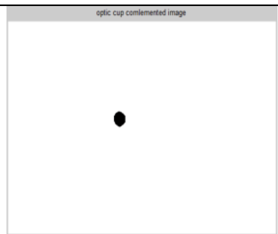
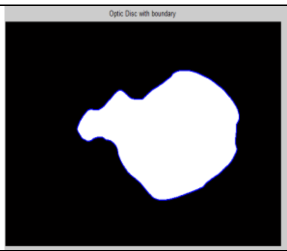
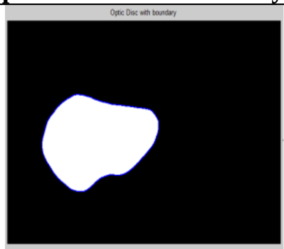
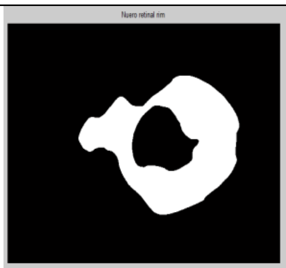
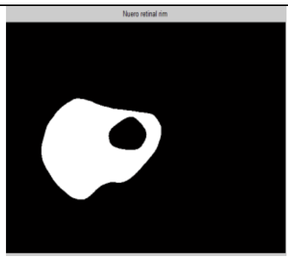
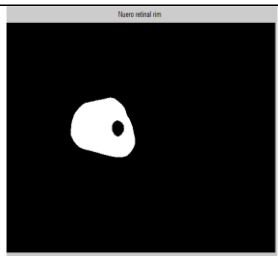
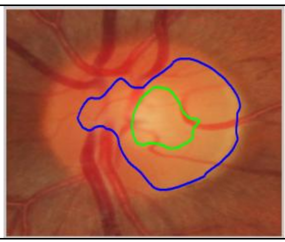
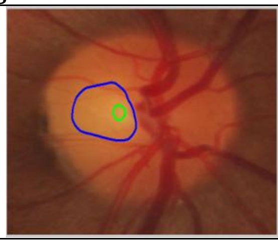
Compliment of optic Cup image:After getting the higher intensity part of fundus image i.e. optic cup, is represent as binary image white part as a cup and black as a background, we have just alter it by using compliment method background as a white color and black as a cup region. This complimented image we have use in to locate neuro retinal rim.

NRR (Neuro Retinal Rim):

The analysis criteria for glaucoma include (IOP) intraocular pressure measurement, (ONH) optic nerve head evaluation, Optic nerve head assessment in fundus images is more capable and advanced. The examination of optic nerve head, (CDR)cup to disc ratio and neural rim relationship are important for early detecting of glaucoma in scientific practice. Due to increase in Intra Ocular Pressure, the cup size begins to enlarge which accordingly increases the CDR. As the cup size increases it also influences the Neuroretinal Rim (NRR) [11]. NRR is the area located between the boundary of the disc and the physiological cup. For localization of Neuro retinal rim we have applied addition of two images one is optic disc binary image and another is complimented optic cup image.Whenever both are added as a one image, the inner black part of image assigns as a cup and white part as disc region. Neuro retinal rim location is in-betweens the cup and disc region.

Table 1. All the methods applied on retinal fundus images

Sr.No.	Operations Performed on Retinal Fundus Images		
1	Original Image		
			
2	Gray Image		
			
3	Gray Image Histogram		
			
4	Median Filter Image		
			
5	Morphological Closing		
			
6	Optic Cup With Boundary		
			
7	Complimented Optic Cup Image		

			
8	**Optic Disc With Boundary**		
			
9	**Neuro Retinal Rim**		
			
10	**Neuro retinal rim on original image**		
			

3.2 Statastical analysis of CDR and RDR

Calculating Cup to Disc Ratio:

After calculating area of optic cup and disc. We have calculated optic cup to disc ratio by using the following formula.

CDR=h1/h2………………………….(7)

Since, CDR = Cup to Disc ratio
h1 = (Area of cup), h2 = (Area of disc)
The ordinary individual have the CDR value is in between 0.2 to 0.3 and the value is larger than 0.6 or 0.7 that individual having Glaucoma and supplementary treatment is needed [12].

- *Calculating RDR (Rim to Disc Ratio):*

For calculating Rim to Disc ratio, first we have calculated the area of Neuroretinal rim, by using optic cup and disc area, We have just subtract the area of optic cup from area of optic disc for getting area of neuroretinal rim by using following formula.

NRR Area= Optic Disc Area – Optic Cup Area …… (8)

After calculating Neuroretinal Area we have calculated Neuroretinal rim ratio or Rim to disc ratio from the following formula.

RDR = D1/D2………………………. (9)

Where, RDR is Rim to disc ratio,

D1 is Neuroretinal area,D2 is Disc area.

When we have compare the results getting from equation number (7) and equation number (9) both are opposite, whenever CDR is increased at that time RDR is decreased. Because in Glaucomatous person the area of optic cup is increased so in parallels its CDR is also increased. And if CDR is increased, at that time the area of Neuro retinal rim is decreased so RDR is also decreased.

5. RESULTS

Statistical calculations are shown in following table 2:

Table 2. Statistical Results

Sr.No.	Image Name	Cup Area	Disc Area	Rim Area	CDR	RDR
1	img001	16992.00	65037.00	48045.00	0.2613	0.7387
2	img002	22732.00	70820.00	48088.00	0.321	0.6790
3	img003	34266.00	102930.00	68662.00	0.3329	0.6671
4	img004	3208.00	63315.00	60107.00	0.0507	0.9493
5	img005	9417.30	58530.00	49112.70	0.1609	0.8391
6	img006	11609.00	104000.00	92391.00	0.1116	0.8884
7	img007	10632.00	105346.00	94714.00	0.1009	0.8991
8	img008	15558.00	160930.00	145372.00	0.0967	0.9033
9	img009	65416.00	179920.00	114504.00	0.3636	0.6364
10	img010	5101.80	33458.00	28356.20	0.1525	0.8475
11	img011	17529.00	74493.00	56964.00	0.2353	0.7647
12	img012	94649.00	207380.00	112731.00	0.4564	0.5436
13	img013	16613.00	91454.00	74841.00	0.1817	0.8183
14	img014	35783.00	135180.00	99397.00	0.2647	0.7353
15	img015	83940.00	165110.00	81170.00	0.5084	0.4916

Following table number 3 shows Overall results from the entire database for Neuro retinal rim ratio.

Table No.3.Neuroretinal Rim ratio Results for all database

Sr. no.	Data base Name	Number of Images	Normal Images	Abnormal Images
1	Rim-One Normal	100	100%	00%
2	Rim-One Glaucomatous	100	33%	67%
3	Messidore	100	32%	68%

6. CONCLUSIONS

After calculating area of optic cup, area of optic disc, area of neuro retinal rim, and CDR and RDR from all retinal images we got 100%result from Rim-one normal images, 67%result from Rim-one glaucomatous images, and 68% result from MESSIDORE dataset images.Glaucomatous person the area of optic cup is increased so in parallels its CDR is also increased. And if CDR is increased, at that time the area of Neuro retinal rim is decreased so RDR is also decreased. So here we have it is concluded that like CDR, RDR is also a important factor for glaucoma diagnosis.

7. ACKNOWLEDGMENT

I would like to acknowledge both the database Rim-One [13], and Messidore [14] which are freely available for the research study.

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