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Research Article

Determination of Glaucoma Grade with Cup to Disc Ratio

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Abstract

Assurance of the vertical cup/plate proportion (CDR) chooses glaucoma suspect. For ordinary eye, the even C/D proportion is generally bigger than the vertical C/D proportion, yet considers have demonstrated that the vertical proportion progress quicker in ahead of schedule and transitional phases of glaucoma. In our exploration we have measure real size of the cup and optic plate. This examination is chip away at optic plate restriction/location. At that point by optic plate division and by Optic cup division, we discover little circles as having vertical widths under 1.5 mm and enormous circles as having vertical distances across more prominent than 2.2 mm. we choose grade like on the off chance that C/D proportion is $0 \le CDR \le 0.4$ at that point eye is ordinary. On the off chance that C/D proportion is 0.4 < CDR < 0.55 then glaucoma malady condition is moderate and on the off chance that it is CDR ≥ 0.55 , at that point eye is in serious phase of glaucoma infection.

Keywords: Glaucoma; Cup/Disc Ratio (CDR); Segmentation

Introduction

Glaucoma is serious eye disease which is responsible for increase in intraocular pressure on retina (IOP). Because of increase in IOP, it directly affects on other retinal internal structure.



Figure 1: Glaucoma disease.

Figure 1 shows human eye image, having glaucoma disease. In these images we can clearly observe damages in optic disc due to intraocular pressure on retina (IOP) on retina. Intraocular pressure on retina (IOP) is responsible for increase in pressure starts damages in retinal nerve fibres, small vessel, Thus we can observe change in pattern of retina which leads diabetic patients to blindness [1,2]. In some patients there may be other symptoms like endovascular eye disease. This means new tiny blood vessels may grow on iris. After few years these buddle of vessels may damage and unwanted fluid may flow through these vessels. Sometimes these blood vessels may have blockage or blood clotting which may be the big hurdle in blood flow in eye or sometimes becomes reason for increase in pressure. This increase in eye pressure further leads to increase in or change in size and shape of cup and disc are causes blur vision [5,6]. Figure 2 clearly shows what will the effect on patients vision if not treated early or severity level of human eye vision.



Preprocessing Standard Dimension: Vertical Diameter= 1.8 mm **Retinal Fundas** Horizontal Diameter = 1.5 Image Optic Optic Depth=1 mm Disc Cup Cup: Disc ratio-Ratio of vertical diameter of optic Neuroretinal cup to that of optic disc Rim(NRR) May vary from 0.1-0.9 CDR Glaucoma Normal

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Figure 4: Workflow.

Primary glaucoma and related conditions Primary angle-closure glaucoma

Latent glaucoma, Intermittent glaucoma, Acute congestive glaucoma, Post congestive angle- closure glaucoma, Chronic closed angle glaucoma, Absolute glaucoma.



a) carry stage

b) Moderate stage c)

Figure 3: Glaucoma patient Images.

In figure 3 we can see a) early stage, b) Moderate stage, c) sever stage glaucoma patient Images [3].

Glaucoma detection - work flow

Figure 4 shows workflow difference of normal eye image and glaucoma image cup to disc ratio. According to ophthalmologist for normal condition of human eye for vertical and horizontal diameter of eye size is 1 mm. So when eye has pressure its cup/disc ratio may vary from 0.1 to 0.9. But if cup to disc ratio size is more than >0.5 mm then this is called case of glaucoma. If cup to disc ratio size < 0.5 mm then its normal eye condition. Therefore is important to

keep regular follow of eye examination [7].

The eye continually produces some fluid. This fluid flows between iris and membrane. Fluid generated by eye determines internal pressure of eye. Sometimes due to physical exertion or due to aging this pressure may increase or decrease in human body. This increase in fluid ultimately results in to increase in cup and disc size [4].

Type of glaucoma



Figure 5: Stages of Glaucoma.

Figure 5 shows the disease stages of glaucoma a) Normal, b) mild, c) Severe.

With increase in intraocular pressure (IOP), size of the Cup and Disk may increase or it may damage. This action is responsible for



change in internal pattern structure of retina, ultimately vision may change. Thus patient's diagnostic priorities can be blow.

Figure 6: Spectrum of disease (optic disc size difference).

Figure 6 shows the effect of increase in pressure on Optic disc and cup size. In figure 6 a) glaucoma image has increase in size of cup and disc, which gives bluer vision. In figure 6 b) normal image having normal cup and disc size, which gives good vision.

Primary open angle glaucoma (POAG): Primary open angle glaucoma severity increases with increase in pressure IOP (>21 mm of Hg).

IOP (>21 mm of Hg) this value is depend on change in cup and disk size and their effect on vision.

Ocular hypertension or glaucoma suspect: When intraocular pressure IOP on eye persistently more than 21 mm of Hg but if still there is no effect on shape and size of optic disc or vision.

Traditional tension eye disease (NTG) or low tension eye disease (LTG)

It is diagnosed once typical glaucomatous disc bloodletting with or while not sight view changes is related to associate degree pressure perpetually below twenty one metric linear unit of Hg. Glaucoma is associate degree insidious un wellness as a result of it seldom causes symptoms. Detection and interference area unit solely potential with routine eye examinations. However, bound varieties, like angle closure and inherent, do cause symptoms [8].

Angle Closure (emergency),Sudden decrease of vision, Extreme eye pain, Headache Nausea and instinctive reflex, Glare and light-weight sensitivity, Congenital, Tearing, Light sensitivity, Enlargement of the tissue layer. Because eye disease doesn't cause symptoms in most cases, those that area unit forty or older ought to have associate degree annual examination together with an activity of the pressure. Thus area unit eye disease suspects may have extra testing [8,9].

Ophthalmologist uses ophthalmoscope for the measurement of extra pressure in retina. For the vision test they use gonioscopy. The doctor evaluates the nervous optics and grades its health by noting the cup to disc quantitative relation. This is often merely a comparison of the cup (the depressed space within the center of the nerve) to the whole diameter of the nervous optics. As eye disease progresses, the world of bloodletting or depression, increases. Therefore, a patient with a better quantitative relation has a lot of harm.

Methodology Module 1 RGB to gray conversion

It is required to convert picture in grayscale from rgb because, in grayscale image information can be Cleary observe. Cup to disc calculations becomes easier using grayscale conversion.

Module 2

Preprocessing

Histogram Equalization was updated technique. Histogram leveling could be popular in medicinal claim to fame picture process, since it's horribly powerful in making the occasionally eye catching notable segments a great deal of evident.

Module 3

Optic disk localization/detection

To get cup to disc ratio CDR, difficult job is to find and fragment the plate. The plate restriction centers on discovering partner rough area of the circle, frequently the circle focus.

In figure 7 we portion the circle utilizing oneself surveyed plate division techniques are combinations of methodologies like Edge

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Detection and Circular Hough Transform. Thus Edge Detection technique is mostly used for the detection of eye diseases.



Figure 7: Optic disk and cup view.

Module 4

Optic disk segmentation

We basically applied Otsu's method to detect optic plate. Thus it is necessary to know exact level of thresholding level. Thresholding level shows grayscale tissue layer of retinal image. Thus only optic plate seen in white shade and consequently the foundation are of dark shading can be observe.

Module 5

Optic cup segmentation

The cup is situated to inner side of the plate region. We utilize morphological activities for segmentation. Morphological operations like opening, closing, dilation and erosion. Dilation- technique used to expand the pixel area in the image Erosion-used to erode/ reduce the pixel area.

Module 6

Cup to disk ratio (CDR)

Based on the world occupied by the divided disk and therefore the cup, CDR is computed. The optic disc and eyecup divided image is given because the input. The CDR ratio is obtained at the output. Then eye condition consider as normal, Moderate or extreme

Results and Discussion Primary glaucoma

For glaucoma detection we tested all kind of images from standard database. We taken normal stage, mild stage and sever stage condition patient's image. Then we tested our program of processing of image.

Thus ophthalmologist has decided their slandered ratio; according to this ratio visibility of patients can be decided. CDR=Area of cup/Area of Disk.

- Depending on the CDR fluctuate persistent condition is known as customary, Moderate or Severe.
- Expected yield is that the state of the patient.
- Normal, Moderate or extreme

Condition	CDR range	
GRADE 1(NORMAL)	0≤CDR≤0.4	
GRADE 2(MODERATE)	0.4 <cdr<0.55< td=""></cdr<0.55<>	
GRADE 3(SEVERE)	CDR≥0.55	

Table 1: Grade condition.

Table 1 shows standard grade decided by ophthalmologist. According to ophthalmologist for normal condition of human eye for vertical and horizontal diameter of eye size is 1 mm. So when eye has pressure its cup/disc ratio may vary from 0.1 to 0.9.

- If cup to disc ratio size is more than >0.5 mm then this is called case of glaucoma.
- If cup to disc ratio size is more than .04 and less than 0.55 then its moderate glaucoma.
- If cup to disc ratio size < 0.5 mm then its normal eye condition. Therefore is important to keep regular follow of eye examination [11].

Normal condition

Figure 8 shows the normal eye condition, these images have normal size of cup and disc.

Now because of proper cup and disc size human vision is clear. Cup to disc ratio size < 0.5 mm then its normal eye condition



Figure 8: Processed on normal image showing normal cup and disk size.

Cup to disk ratio (CDR)

In study of Ophthalmology, they have decided some slandered values of Cup size and disk size. Also if pressure inside the eye increases due to diseases like glaucoma then both cup size and disk size may change. The eye continually produces some fluid. This fluid flows between iris and membrane. Fluid generated by eye determines internal pressure of eye. Sometimes due to physical exertion or due to aging this pressure may increase or decrease in human body. This increase in fluid ultimately results in to increase in cup and disc size.



Figure 9

In figure 9 shows stages of glaucoma disease a) Normal optic nerve, b) Mild cupping, c) Severe cupping.

According to ophthalmologist for normal condition of human eye for vertical and horizontal diameter of eye size is 1 mm. So when eye has pressure its cup/disc ratio may vary from 0.1 to 0.9. But if cup to disc ratio size is more than >0.5 mm then this is called case of glaucoma. If cup to disc ratio size is more than .04 and less than 0.55 then its moderate glaucoma.

If cup to disc ratio size < 0.5 mm then its normal eye condition. Therefore is important to keep regular follow of eye examination [11].



Figure 10: Image is process to get cup to disc ratio.

Figure 10 a) Severe, b) Moderate, c) Normal shows stages of glaucoma. In figure 10 a) severe we can clearly observe that, patient have glaucoma symptom because cup and disc size is large than

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regular size of cup and disc. Here cup to disc ratio size is more than >0.5 mm therefor this is called case of glaucoma condition of eye. So patients will have blur or blind vision.

In figure 10 b) Moderate condition we can see that images has cup to ratio 0.4<CDR<0.55, so this condition is suppose to be moderate condition. So patients will have blur vision. Figure 10 c) shows the normal eye condition, these images have normal size of cup and disc. Now because of proper cup and disc size human vision is clear.

Our method	Severe	Moderate	Normal
Area (mm)of Optic cup	2793	1975	869
Area (mm)of Optic Disc	4396	4470	4864
Cup to Disc Ratio (mm)	0.6354	0.4418	0.1787



Table 2 clearly shows comparison between Cup/Disc ratio normal, moderate and sever condition. Here we can easily decide if patient glaucoma disease severity level.

Optic cup segmented image

The cup is present inside the disk region. It was segmented by using morphological operations such as morphological opening, closing, dilation and erosion.



Figure 11: Determination of optic Cup.

Optic disk segmented image

- The optic disk is segmented by using Otsu thresholding algorithm.
- Based on the thresholding level, the grayscale retina image was converted to black and white image in which, the centre portion, i.e. the optic disk alone will be in white color and the background will be in black color.



Figure 12: Determination of optic Disc.

Figure 12 we have find out area of optic Disc of retina which is 2346.

In above figure 11 and 12 we can observe all steps of glaucoma image processing. After processing on image we can see cup extracted image and disk extracted image. In above figure we can Cleary see increase in size of cup and disk. This is symptom of severe glaucoma. In above figure we calculated cup to disk ration which is 0.3393.

According to our condition if cup/disk < 0.4 then it is earlier stage glaucoma. Above figure cup to disk ratio is 0.3393 so above image is Normal eye image. In this patients image no Gluacoma symptom is found.

Figure 13 shows MATLAB window showing results of abnormal cup and Disk size.

In figure 11 a) we have find optic cup area size of retina is $796\,$ mm.

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Figure 13: Window showing results of abnormal cup and Disk size.



Figure 15: Severe stage Glaucoma with increase in cup size.

Severe stage



Figure 14: Showing severe stage Glaucoma.



Figure 16: Showing severe stage Glaucoma with cup/ratio 0.5840.

In above figure 14 we can observe all steps of glaucoma image processing. After processing on image we can see cup extracted image and disk extracted image. In above figure we can Cleary see increase in size of cup and disk. That is symptom of severe glaucoma. In above figure 14 we calculated cup to disk ration which is 0.5920.

According to condition if cup/disk > 0.55 then it is severe condition of glaucoma. In this patients image we find gluacoma symptom.

In above figure 15 and 16 we can observe all steps of glaucoma image processing. After processing on image we can see cup extracted image and disk extracted image. In above figure we can Cleary see increase in size of cup and disk. This is symptom of severe glaucoma. In above figure we calculated cup to disk ration which is 0.5840.According to our condition, if cup/disk > 0.55 then it is severe condition of glaucoma. In this paitients image we find glaucoma symptom.

In table 3 we have taken database, we have taken number of images for study and detection. Our system tries to find out level of disease if it is normal, mild or severs. In table 3 below we can Cleary see disease condition, area of cup and disk is given and its ratio is calculated.

Graph 1 and 2 shows whole database images cup to disc size and ratio for comparison.

Determination of Glaucoma Grade with Cup to Disc Ratio

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Image no.	Images	Disease condition	Area of optic cup	Area of optic disc	Cup to disc ratio
Gimg1		NORMAL CONDITION 0≤CDR≤0.4	796	2346	0.3393
Gimg2		MODERATE GLAUCOM A 0.4 <cdr<0. 55</cdr<0. 	2376	4349	0.5463
Gimg3		MODERATE GLAUCOM A 0.4 <cdr<0. 55</cdr<0. 	1975	4470	0.4418
Gimg4		SEVERE GLAUCOM A CDR≥0.55	2521	4158	0.6063
Gimg5		SEVERE GLAUCOM A CDR≥0.55	2793	4396	0.6354
Gimg6		MODERATE GLAUCOM A 0.4 <cdr<0. 55</cdr<0. 	3984	6993	0.5697
Gimg7		MODERATE GLAUCOM A 0.4 <cdr<0. 55</cdr<0. 	3269	6210	0.5264

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Gimg8	MODERATE GLAUCOM A 0.4 <cdr<0. 55</cdr<0. 	0.2193	0.4565	0.4804
Gimg9	MODERATE GLAUCOM A 0.4 <cdr<0. 55</cdr<0. 	0.3204	0.6417	0.4993
Gimg10	NORMAL CONDITION 0≤CDR≤0.4	869	0.4864	0.1787

Table 3: Cup to disk ratio evaluation.



Graph 1: Area showing Cup and Disk size.



Graph 2: Area showing Cup and Disk Ratio.

Conclusion

- 93.49% accuracy rate is detecting optic disk and cup area.
- As per ophthalmologist slandered we can give our results.
- Glaucoma severity level can be easily detected.

The Sensitivity and specificity of detection achieved 92.68% and 98.20%, respectively This research work is on Optic disk localization/detection, then by optic disk segmentation and by Optic cup segmentation. We find small discs as having vertical diameters less than 1.5 mm and large discs as having vertical diameters greater than 2.2 mm. we decide grade like if C/D ratio is 0≤CDR≤0.4 then eye is normal. If C/D ratio is 0.4<CDR<0.55 then glaucoma disease condition id moderate and if it is CDR≥0.55 then eye is in severe stage of glaucoma disease. We have taken 10 patients eye images for study, out of this we find, 2 Normal, 6 moderate stages of images.

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