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Automatic Diagnosis of Glaucoma using Image Processing Technique

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Abstract*: Glaucoma is a human eye condition which will affect the optic nerve present in the retina. This condition occurs due to the abnormal ocular pressure in human eye. If it is not diagnosed and treated well in advance, it may lead to blindness. This is the major problem of elderly people all over the world. The best way to avoid vision loss due to glaucoma is to detect the disease at the early stage and treat it as soon as possible. These are the keys to prevent blindness. As vision is an important organ in human body it is advisable to keep it healthy. The optic cup in the retina will be pulled in towards the optic nerve away from the optic disc. At one point, the cup will be detached from the retina, causing blindness. So if one can monitor by measuring the optic disc to cup ratio, the progression of glaucoma can be diagnosed earlier. The proposed method detects the optic disc and cup using thresholding method. Direct least square fitting algorithm is used here to fit the ellipse in order to calculate the cup height and disc height. Then the ratio is calculated. If the calculated ratio is above the threshold value, it is considered as glaucoma affected eye otherwise not. The CDR is calculated using the formula VDH/VCH (Vertical Disc Height to the Vertical Cup Height). Thus, the proposed method helps to automatically detect the glaucoma disease with better sensitivity and specificity.

***Keywords*: Glaucoma, Retinal Image Processing, CDR, Segmentation.**

I. INTRODUCTION

Glaucoma is a major cause of blindness because it affects the optical nerve. When the optical nerve is detached from the retina, due to intra ocular pressure, optical signal cannot pass to brain, causing total blindness. As stated by Mohammadi, Anari and Cyrus et al[1], person with glaucoma disease will not feel any symptom until the advanced stages all over the world. The elderly people are mostly affected by glaucoma. To keep the intraocular pressure balanced, the production of aqueous humor and drainage in the eye should be balanced. If there is any block present in the drainage system then the balance of the ocular pressure will be affected, causing glaucoma.

Different methods are used to detect the glaucoma disease for suspected patient such as tonometry, gonioscopy, optical coherence tomography and fundus imaging. In the proposed method, fundus image is taken for the analysis and diagnosis of the glaucoma.

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The blood vessels enter into the retina from optic disc. So the retinal image will have the blood vessels near the optic disc. The objective here is to locate the optic disc and remove the blood vessels near the disc and then segment the OD (optic disc) and OC (optic cup).

The figure 1 shows the retinal image with optic disc and cup. It is also called as neuro retinal rim.

To find out the Cup to Disc ratio, elliptical fitting algorithm is used to fit the ellipse on the optic disc and optic cup. Once it has been successfully done, the ratio is taken.

Normally the vertical ratio is larger than the horizontal ratio but if the fundus image has glaucoma, the horizontal ratio grows very fast.

The Cup to Disc ratio is calculated using the following formula.

CDR= Area of cup/ Area of Disc

If CDR is greater than 0.6, the image is considered to be glaucomatous image otherwise it is not.

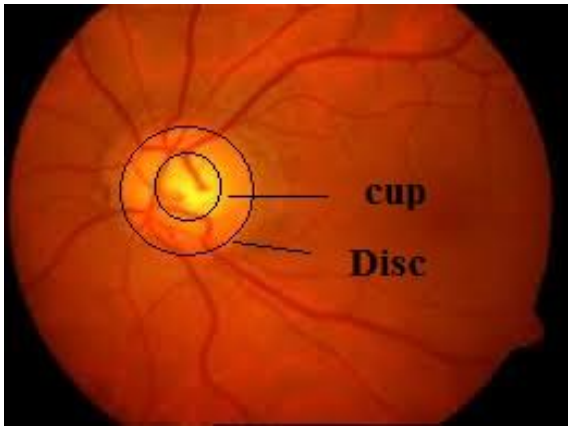

Fig. 1. Retinal Image with Optic cup and disc marked.

Different image processing techniques were used to detect glaucoma automatically. But the accurate measurement of the CDR is difficult in those techniques[1].

Anusorn et al [2] proposes edge detection algorithm to segment the disc. The problem in using edge detection is that, if the patient is having peripapillary atrophy, a disease which causes the edge of the disc. So this algorithm is not suitable for images having this kind of fundus diseases. During early stages of the disease, it is hard to detect the edge of the cup.

Dhumane and Patil [3] uses a segmentation method called super pixel segmentation to detect the cup and disc. The accuracy achieved is almost 91 percentages.

Here it uses clustering algorithm for segmentation. But the drawback here is that, the presence of blood vessels in the cup region is more dense so clustering algorithm has change of clustering it wrongly.

Ayub et al [4] uses k-mean clustering algorithm to segment optic cup and optic disc. Here, the blood vascular structure is not taken into account which is present all over the disc. K-mean clustering algorithm used here finds difficulty in clustering the pixels present inside the disc.

II. PROPOSED WORK

The block diagram of the proposed system is shown in the figure 2. The retinal image is taken from Drive database. Optic disc and cup is the area of interest. So the disc and cup are located and localized. The Disc and cup are segmented using thresholding technique. Elliptical fitting is achieved through Least Square criterion algorithm to fit the ellipse on the disc to measure the vertical height. Once the height of the disc and cup are measured, it is applied to the formula to get the cup to disc ratio. If the obtained value is above 0.6 then it is considered to be abnormal eye. If it is less than 0.6, it will be considered as normal eye. This automatic method will assist ophthalmologist to diagnose the eye disease more quickly without going for multiple opinions. But to achieve the correct CDR, the segmentation of the cup and disc should be accurate. Thresholding technique used here has high percentage of accuracy in segmenting the cup and disc region.

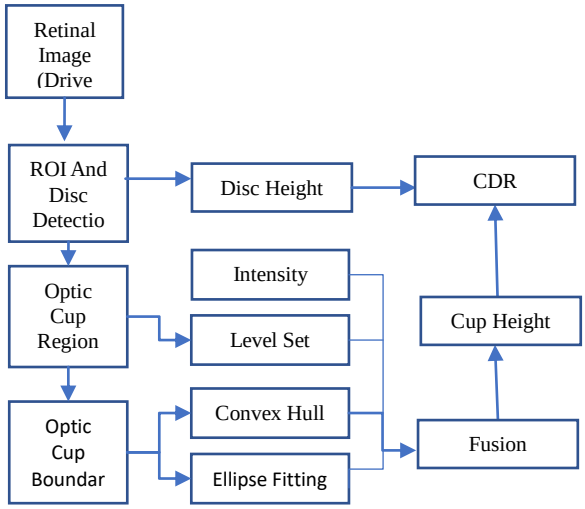

Fig. 2. Block Diagram of the Proposed System.

The following are the steps involved in the proposed system to diagnose the retinal disease such as Glaucoma.

A. Region of Interest

The sub region of the image for which the image processing is needed is referred as region of interest. In the proposed method, the image taken is the fundus image. The fundus Image has all the retinal information such as blood vessels, macula, fovea, arteries, optic disc and optic cup. Here the optic disc and cup are the area of interest. The disc region is localised using edge detection algorithm. Usually a binary mask is created to get the region of interest. Here the aim is to get the optic disc using a filter or mask. The mask is of the same size of the image but the region of interest is set to 1 in the mask and rest of the pictorial elements are set zero. The disc region may be specified using any of the mathematical primitives, such as point, line, circle, polygon ect.

Here the circular mask is used since the area of interest is of circular shape.

Using single algorithm for extracting the region of interest is difficult in medical imaging. So can use multiple segmentation algorithm to extract the same. In thresholding method, the difficulty in exact segmentation lies in the blood vessels present in the cup region. The blood vessels enter in to the retina through the optic cup. So it is difficult to extract the disc correctly.

B. Optic Disc and Cup Segmentation

Optic Disc detection is an important and common step in automatic segmentation method in many fundus screening procedures. [5]. The optic disc is in the shape of ellipse in vertical position. This disc has two parts, inner part called as cup and the outer part is called as peripheral region. To detect glaucoma, observation should be on the color and shape changes of the OD [6]. So the optic disc and cup measurements play an important role in diagnosing ophthalmologic disease such as glaucoma [7,8]. The object of interest is given the threshold value of 1 and the back ground is given the value of 0. Using color planes, the disc boundary is localized.

C. Disc and Cup edge smoothing

After segmentation of the optic disc, the edges will not be accurate. The boundary obtained may be
not be accurate. So smoothening of the edge is required. For optic disc smoothening, average filtering is one of the methods used in image processing technique. The proposed method uses elliptical fitting algorithm. Circular fitting algorithm is used in previous analysis. In this method, elliptical fitting algorithm is used. Elliptical fitting is normally uses least square fitting algorithm. Least squares method is a mathematical regression analysis method which is used to find the best fit line for set of data. The data point represents the relationship between known independent and unknown dependent variable.

D. Ellipse Fitting

To smooth the segmented edges, circular fitting may be used but the retina is similar to ellipse, the proposed method uses ellipse fitting algorithm to smoothen the optic disc and cup. Least square fitting algorithm is the base for ellipse fitting . This algorithm assumes that the best fit curve of a given type is the curve that has the minimal sum of the deviations squared from. This algorithm is chosen because the effect of noise around the disc area can be minimized during the formation of the ellipse. By using Eigen vector it can also be solved.

In Fitting algorithm, a quadratic constraint is set on the features to avoid unwanted and unexpected solutions. The goal is to search for a vector parameter which contains the six coefficients of the standard form of a conic. An ellipse is a simply a conic equation and can be represented as second order polynomial.

F(x,y) = ax+ bxy +cy+dx +ey+f=0 -----(1)

With an ellipse-specific constraint

b2–4ac<0 -----(2)
Where a, b, c, d, e, f are coefficients of the ellipse and(x, y) are coordinates of points lying on it. By introducing vectors

A=[a, b, c, d, e, f] T

x= [x2, xy, y2, x, y, 1] -----(3)

It can be rewritten to the vector form
F a(x) = x.a = 0
The fitting of a general conic to a set of points (xi,yi),i–1...N may be approached by
minimizing the sum of squared algebraic distances of the points to the conic coefficient a.

E. Cup To Disc Ratio Calculation

The developed methodology is tested on 30 different fundus images obtained from the database. The Optic Cup to Optic Disc ratio (CDR) value is obtained using the following formula,

CDR = Vertical Cup Diameter(VCD)/ Vertical Disc Diameter VDD. The CDR values for all the 30 images have been calculated.

III. SIMULATION AND RESULTS

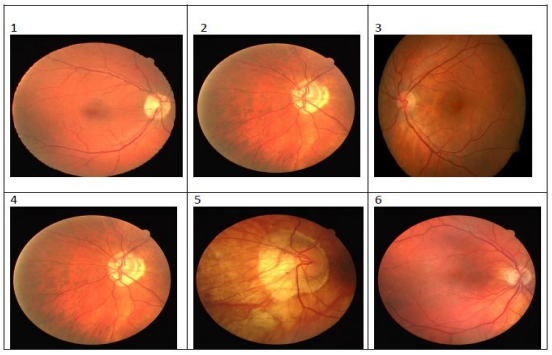

Fig. 3. Sample Fundus Images

The figure 3,4,5,6,7 shows the processed image of the retinal image taken from database. After the segmentation of optic disc and cup, the obtained boundary is not closely related to the desired one. To get the proper boundary, the ellipse fitting algorithm is used. It is shown in figure 8.

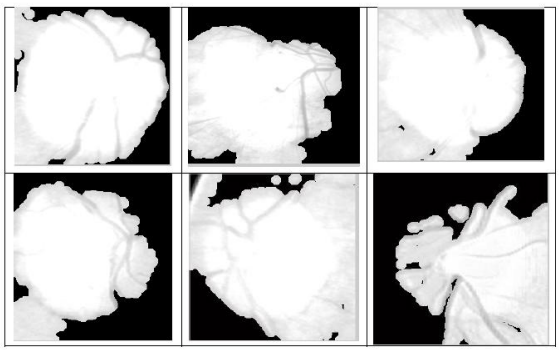

Fig. 4. OD Localisation

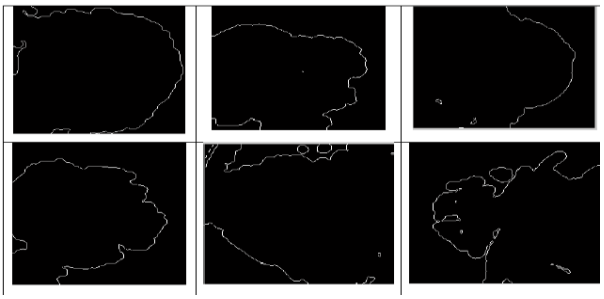

Fig. 5. Disc Segmentation

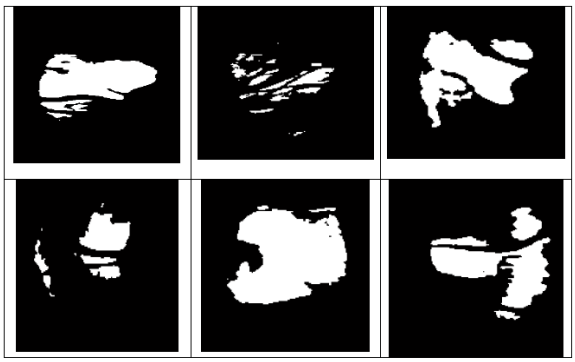

Fig. 6. Cup Localisation

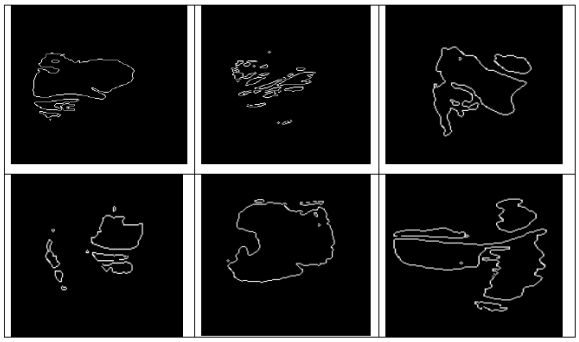

Fig. 7. Cup Segmentation

Similarly, for the cup segmentation, the proposed system localized the optic cup boundary. After the cup boundary localization, again the ellipse fitting algorithms is used to get smooth desired boundary. The CDR is eventually obtained based on the height of detected cup and disc.

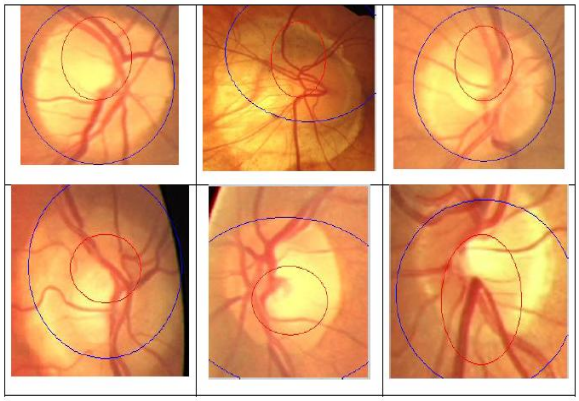

Fig. 8. Ellipse Fitting

IV. CONCLUSION

A. CONCLUSION

Proposed method aids automatic detection of glaucoma and it will assist the ophthalmologist not to go with multiple opinions. The CDR method is best compared to other non invasive method because the accuracy obtained is more than the existing methods. By using thresholding algorithm for segmentation and also Least Square Criterion algorithm for ellipse fitting, the processing time is less and achieved better accuracy. The Sensitivity achieved is 88.00 and accuracy achieved is 90.90%.

B. FUTURE ENHANCEMENT

The proposed method faces difficulty in using the threshold value since wrong choice may result into over or under segmentation. Neglects spatial information of an image, cannot guarantee that the segmented regions are contiguous. Hence, these are the areas to be taken care of or made better in future.

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