Optic Disc Boundary Detection and Cup Segmentation for Prediction of Glaucoma

R. Preethi Rajaiah[1], R. John Britto[2]

***Abstract*— Optic disc is considered as one of the main features of a retinal fundus image. The optic disc has two distinct zones namely a central bright zone called the cup and a peripheral region called the neuroretinal rim. Finding the cup region helps to measure the Cup to Disc Ratio which is an important property for identifying the glaucoma. Here a new method is proposed to predict the glaucoma. The overall method has two process namely optic disc boundary detection and cup segmentation. The proposed method for optic disc boundary detection is based on operations such as linear discriminant analysis, contrast limited adaptive histogram equalization, inpainting and morphological operations. Linear discriminant analysis involves in feature extraction. Contrast limited adaptive histogram equalization is used to enhance the image. After the extraction of vessel from retinal fundus image, they are removed by inpainting technique. Finally morphological operations are applied to the resulted image to detect the optic disc boundary. The cup segmentation is performed in the green channel which is extracted from the input image. Watershed transformation is used for cup segmentation. Cup to Disc Ratio is calculated after determining the optic disc and cup boundary. The Normal cup to disc ratio range is from 0.1 to 0.3. If the cup to disc ratio exceeds 0.3 then it indicates the abnormal condition that is the presence of glaucoma. The robust process provides automated results without any user intervention. The proposed method is tested with collected database images which contain 50 images. This methodology successfully found the diseased samples in 48 cases out of 50 images with the success rate of 96%.**

Index Terms—Cup to disc ratio, Glaucoma, Histogram equalization and Optic disc.

I. INTRODUCTION

The eye is an organ that reacts to light and has several purposes. It is nearly a sphere, with an average diameter of 20mm.

A. Anatomy of eye

Three membranes enclose the eye. Fig. 1 shows the cross section of the eye.

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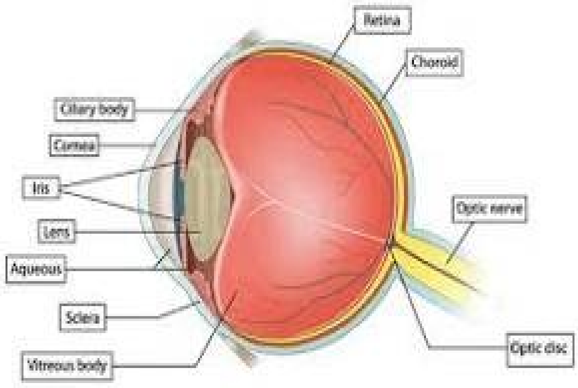

Fig. 1 Cross-section of eye

The cornea and sclera outer cover. Cornea covers the anterior surface of the eye and remaining optic globe covered by sclera. The choroid lies directly below the sclera. It has the network of blood vessels that serve as the major source of nutrition to the eye. The retina is the innermost membrane of the eye, which lines the inside of the wall's entire posterior portion. The light from an object outside the eye is imaged on the retina. The central portion of the retina is called fovea.

B. Retinal Fundus Image

The macula, the optic disc, and the blood vessels are the main anatomical features of the retina. A macula in the eye is a small spot where vision is keenest in the retina. The macula of the retina is the light-sensitive layer of tissue at the back of the eye. Blood vessels are the elastic tube or passage in the body through which blood circulates. Fig. 2 shows the color fundus image showing main retinal features.

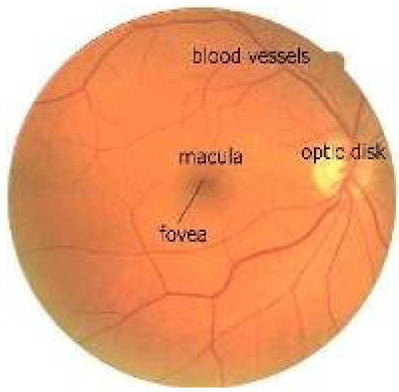

Fig. 2 Color Fundus image showing main retinal features

Optic disc (OD) is one of the main components on retina. It is the location where ganglion cell axons exit the

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eye to form the optic nerve through which visual information of the photo receptors is transmitted to the brain. It is the small blind spot on the surface of the retina located about 3 mm to the nasal side of the macula. It is only part of the retina that is insensitive to light. It is an indicator of various ophthalmic pathologies.

Now a day's lots of disease can occur in the eye. Diabetic retinopathy and glaucoma are some of the diseases which cause the loss of vision. These diseases can be examined by ophthalmologists. Early diagnosis and proper treatment of these diseases can prevent visual loss. Due to population growth and aging this process requires more number of ophthalmologists. So, there is a need of automatic recognition system for optic disc detection to identify these diseases in early stage. Optic Disc detection is an important step to examine severity of some diseases such as glaucoma and diabetic retinopathy.

C. Optic Cup

The OD can be divided into two distinct zones, namely, a central bright zone called the cup and a peripheral region called the neuroretinal rim where the nerve fibres bend into the cup region. The loss in optic nerve fibres leads to a change in the structural appearance of the OD, namely, the cup region enlargement and thinning of neuroretinal rim called cupping. Fig. 3 shows the optic disc and cup image.

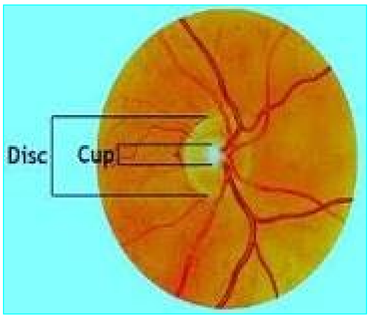

Fig. 3 Optic disc and Optic cup image

Cupping is the hallmark of glaucoma which is the visible manifestation of optic nerve head structure. It is an important structural indicator for accessing the presence and progression of glaucoma. The vision of the normal and glaucoma affected eye are shown in Fig. 4.

Fig. 4 Normal and glaucoma eye vision

Glaucoma is one of the main causes for blindness in recent times. Deformation of optic disc and the cup is an important parameter for glaucoma detection. Glaucoma is an eye disease in which the optic nerve is damaged in a characteristic pattern. This can permanently damage vision in the affected eye and lead to blindness if left untreated. It is normally associated with increased fluid pressure in the eye.

Visual loss due to glaucoma can only be halted, not reversed. The ratio of the optic cup to disc (CDR) in retinal fundus images is one of the principal physiological characteristics in the diagnosis of glaucoma. Early diagnosis and treatment is the key to prevent sight in people with glaucoma.

The cup region is not necessarily to be in circular, its shape can vary depending upon the shape of eye along with the glaucoma. Finding the cup region helps to detect the Cup-to-Disc Ratio (CDR) which is also an important property for identifying the disease.

II. Previous work based on literature survey

Optic disc in retinal images varies in appearance, size and location. Its detection is very important for blood vessel tracking and it works as a landmark to measure distance and identifying anatomical parts in the retina. The literature describes some approaches for the determination of optic disc and optic cup.

Marc Lalonde, Mario Beaulieu, and Langis Gagnon [2] proposed "Fast and Robust Optic Disc Detection Using Pyramidal Decomposition and Hausdorff-Based Template Matching". They used two procedures for optic disc localization. They are Hausdorff-Based Template Matching technique on edge map, guided by a pyramidal decomposition for large scale object tracking. They start with some assumptions. First some information about the retina and its structures are guessed and exploited. This is used to guide the searching process of the OD in an image. Second, the bright region represents the optic disc. But it is not always true in practice. Then the process is decomposed into two stages. First Pyramidal Decomposition works on the gray scale representation of the input color image. The decomposition is used to find which area contains the optic disc based on assumptions. However, the position found is sometimes quite far from the true optic disc center and the pyramidal approach is no help in identifying the optic disc contour. Second, by using Hausdorff Based approach edge detection and thresholding process are achieved. It is fast and reliable, but it fails on images where optic disc contour is very diffuse and it is necessary to select proper threshold for create an edge map. If it selects improper threshold it will break the edge map.

Thomas Walter and Jean-Claude Klein [8] proposed "Segmentation of Color fundus images of the Human Retina: Detection of the Optic Disc and the Vascular Tree Using Morphological Techniques". They presented an algorithms based on mathematical morphology for the detection of the

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optic disc and the vascular tree in noisy low contrast color fundus photographs. For the detection of the optic disc, the position is found out approximately. Then the exact contours are detected by means of the watershed transformation. In order to detect the location of the optic disc approximately, a simple area threshold is applied to obtain a binary image. The centroid of the biggest particle of the binary image can be considered as an approximation for the locus of the optic disc. To detect the contours of the optic disc, classical watershed transformation is applied to the gradient of the filtered image. In this method, if there are a lot of hemorrhages and micro aneurysms, particularly if they are close to the vascular tree, another preprocessing step must be performed. If the images have too low contrast the algorithm was failed and the result was not acceptable.

Akara Sopharak, Khine Thet Nwe, Yin Aye Moe, Matthew N. Dailey and Bunyarit Uyyanonvara [6] proposed "Automatic Exudates Detection with a Naive Bayes Classifier". They gave an idea for detecting the optic disc by entropy filtering. First the original RGB image is transformed into HSI color space, median filtering is applied to remove possible noise and for contrast enhancement Contrast Limited Adaptive Histogram Equalization (CLAHE) is done. After preprocessing, optic disc detection is performed by probability filtering and then binarization is done with Otsu's algorithm to separate the complex regions from the smooth ones, and the largest connected region with an approximately circular shape is marked as a candidate for the optic disc. This method gives good performance. They considered optic disc is a bright region but this assumption is not always true in practical.

D. W. K. Wong, J. Liu, J.H. Lim, X. Jia, F. Yin H. Li, and T. Y. Wong [3] proposed "Optic Cup and Disk Extraction from Retinal Fundus Images for Determination of Cup to Disc Ratio". They proposed a method for automatic Cup to Disc Ratio (CDR) determination. First the optic disc is extracted by variational level-set method. Then they compared the performance of a Threshold based Level Set (TLS) method against a Color Intensity Threshold (CIT) based approach towards the extraction of the optic cup. In this approach, after determination of ROI a variational level-set algorithm is applied to the fundus image to detect the disc boundary. Next step is cup segmentation. In CIT method they first identify a point in the optic disc that contains the cup. Using the color intensity information from the chosen point, the cup region is obtained when the pixels corresponding to the cup have been selected. In TLS method the cup boundary is determined by threshold and then applying the level-set method to optimize the detected cup contour. The obtained contours are smoothened using direct ellipse fitting to reduce the noise in the detected boundary. Thereafter, the CDR is calculated using the extracted cup and disc. CDR is the measurement of diagnosis of glaucoma. In this approach the TLS performs well in both normal and diseased retina but the CIT method fails on diseased retina.

D. W. K. Wong, J. Liu, J.H. Lim, X. Jia, F. Yin H. Li, and T. Y. Wong [4] proposed "Level set based automatic Cup to Disc Ratio determination using retinal fundus images in ARGALI". They proposed automatic CDR determination method using a variational level-set approach to segment the optic disc and cup from retinal fundus images. Threshold analysis is used in preprocessing to eliminate the initial contour. To detect the disc location using intensity information, a histogram of the fundus image is first obtained. In this approach, 0.5% of all pixels in the grayscale fundus image with the highest intensity are selected as the disc region is typically of higher intensity. The image is then divided into 64 8x8 pixel regions and the region corresponding to the largest number of selected pixels is marked as the disc center. A circle with a radius of twice the typical normal optic disc radius value and centered at the disc center is used to determine the ROI, with the circle used as the initial contour for segmentation using variational level-set in the next step. The variational level-set algorithm is applied to the fundus image to detect the disc boundary using the red channel. Due to the presence of retinal vasculature traversing the disc and cup boundaries which can cause inaccuracies in the detected contours, an ellipse-fitting post-processing step is also introduced. Utilization of a curvature constraint in the level set method is complicated.

III.PROPOSED METHOD

The overall process has two stages.

- Optic disc detection
- Optic cup segmentation

After detection of optic disc and optic cup the Cup to Disc Ratio (CDR) measurement is obtained. The CDR is used for glaucoma assessment.

Fig. 5 shows the glaucoma assessment process.

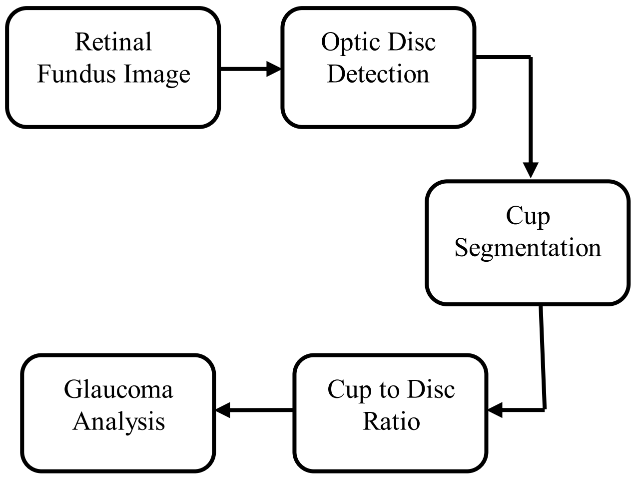

Fig. 5 Block Diagram of Glaucoma Assessment Process

A. Optic disc detection

The identification of the position and the shape of the optic disc in the retinal fundus images are very important for the diagnosis of retinal diseases such as diabetic

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retinopathy, glaucoma and macular degeneration. Early diagnosis for these diseases in retina can prevent the vision loss.

The processes involved in the optic disc detection are shown in Fig. 6.

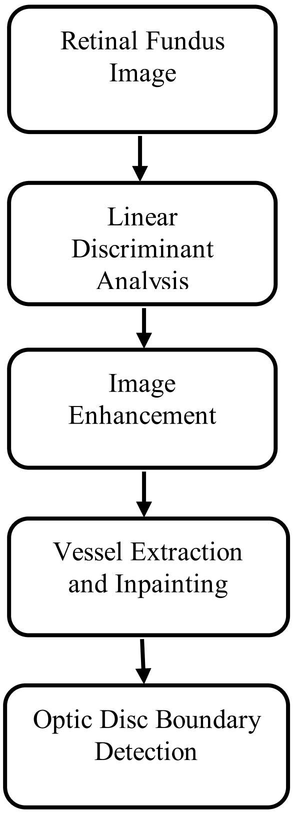

Fig. 6 Optic disc detection process

1) Linear Discriminant Analysis (LDA)

LDA is the first step in the optic disc detection. It involves feature extraction and selection. It plays an important role in dimensionality reduction. It aims at finding a feature representation by which the within-class distance is minimized and the between-class distance is maximized.

In pattern recognition and in image processing, feature extraction is a special form of dimensionality reduction. When the input data to an algorithm is too large to be processed and it is suspected to be notoriously redundant then the input data will be transformed into a reduced representation set of features also named features vector. Transforming the input data into the set of features is called feature extraction. If the features extracted are carefully chosen it is expected that the features set will extract the relevant information from the input data in order to perform the desired task using this reduced representation instead of the full size input. Feature extraction involve in simplifying the amount of resources required to describe a large set of data accurately.

LDA involves both within class variability and between class variability. So there is no loss of information and it combines the all features of the image.

❖ Within-class scatter matrix:

Within-class variability is defined as for each data value the difference between that value and the mean of its group.

$$S_W = \sum_{i=1}^{c} \sum_{j=1}^{M_i} (y_j - \mu_i)(y_j - \mu_i)^T \qquad (1)$$

❖ Between-class scatter matrix:

Between-class variability is defined as for each data value the difference between its group mean and the overall mean.

$$S_b = \sum_{i=1}^{c} (\mu_i - \mu)(\mu_i - \mu)^T \qquad (2)$$

$$\mu = \tfrac{1}{c} \sum_{i=1}^{c} \mu_i \qquad (3)$$

Where c = Class

μ_i = Mean vector class i, i = 1, 2… c

μ = Mean of entire data set

S_W = Within -class scatter matrix

S_b = Between- class scatter matrix

LDA computes a transformation that maximizes the between-class scatter while minimizing the within-class scatter. Fig. 7 and Fig. 8 show the retinal fundus image which is given as an input for optic disc detection and LDA output respectively.

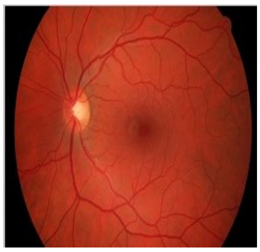

Fig. 7 Input image

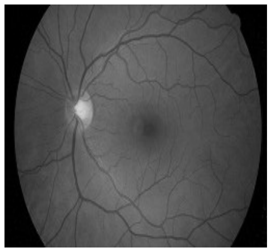

Fig. 8 LDA output

2) Image enhancement

Image enhancement is used to improve the image quality. Here the LDA output is enhanced by means of Adaptive Histogram Equalization (AHE). Histogram is a graphical representation of the tonal distribution in a digital image. The horizontal axis of the graph represents the tonal variations, while the vertical axis represents the number of pixels in that particular tone.

In adaptive histogram equalization technique the image is divided into a limited number of regions and the histogram equalization technique is applied to pixels in each

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region. A variant of adaptive histogram equalization called Contrast Limited Adaptive Histogram Equalization (CLAHE). The contrast limiting procedure has to be applied for each neighborhood from which a transformation function is derived. CLAHE is used to prevent the over amplification of noise in the image. CLAHE operates on small regions in the image, called tiles, rather than the entire image. Each tile's contrast is enhanced, so that the histogram of the output region approximately matches the histogram specified by the 'Distribution' parameter. First the LDA output is enhanced by histogram equalization and then contrast limited adaptive histogram equalization is applied to reduce the noise in an image. Fig. 9 shows the enhanced image and Fig. 10 shows the corresponding histogram diagram of the enhanced image.

Fig. 9 Enhanced image

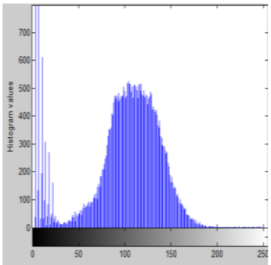

Fig. 10 Histogram output

3) *Vessel Extraction and Inpainting*

Retinal vessels are originated from the optic disc therefore there are numerous vessels crossing its border which makes its detection process difficult. So, vessel removal of the enhanced image is important process to make the segmentation process easier. Its aim is to extract the optic disc boundary more precisely and to reduce the existing borders within the optic disc.

In vessel extraction process the vessels are identified. Two processes are involved in vessel extraction process. First the spatial filtering is applied to the enhanced image to remove the noise component present in an image. Then a threshold is applied to extract the vessels from the background region.

In the thresholding process, individual pixels in an image are marked as "object" pixels if their value is greater than some threshold value and as "background" pixels if their value is less than threshold value.

- Typically, an object pixel is given a value of "1" while a background pixel is given a value of "0".
- At any point *(x, y)* in the image at which *f(x, y)* > T is called vessels otherwise the point is called a background point.

$$g(x,y)=\begin{cases}1 & if \quad f(x,y)>T \\ 0 & if \quad f(x,y)\le T\end{cases} \tag{4}$$

Where $g(x,y)$ = Vessel extracted image

After vessel extraction process the vessels are removed through inpainting technique. Inpainting is the process of removal/replacement of selected objects [5]. In vessel extraction process the vessels are identified. From this the vessels are considered as black and remaining region is considered as white in the inpainting process.

Fig. 11 shows the vessel extracted image and Fig. 12 shows the inpainted image.

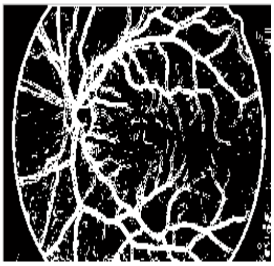

Fig. 11 Vessel extracted image

Fig. 12 Inpainted image

4) *Optic disc Boundary Detection*

First the centroid of an image is obtained in boundary detection process. It gives the area of the optic disc. The k-means clustering is applied to detect the centroid of an image. Then morphological operation is involved in shape analysis.

K means algorithm

It is an algorithm to classify or to group your objects based on attributes or features into K number of group. K is positive integer number.

The k-means algorithm has following steps.

1. Initially take any k objects as centroids.
2. Find distance of all objects from those k centroids, less the distance the object is in that centre of centroids.
3. Now find the centroids from the objects which are in that clusters.
4. Repeat step 2 and step 3 until the value of centroids is same.

Morphological Operations

Mathematical morphology (MM) in image processing is particularly suitable for analyzing shapes in images. The two main processes are those of dilation and erosion. These processes involve a special mechanism of combining two sets of pixels. Usually, one set consists of the image being processed and the other a smaller set of pixels known as a structuring element or kernel.

In dilation, every point in the image is superimposed onto by the kernel, with its surrounding pixels.

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The resultant effect of dilation is of increasing the size of the original object. Erosion is an inverse procedure in which an image is thinned through subtraction via a structuring element or kernel.

The algorithms of opening and closing are based upon these processes. Opening consists of erosion followed by dilation, and tends to smooth an image and breaking narrow joints. Closing consists of dilation followed by erosion and also smoothes images, but by fusing narrow breaks and gulfs and eliminating small holes [5].

Let f be a grayscale image which is defined as f(x): E→T, where x is the pixel position. In the case of discrete valued images, $T = \{t_{\min}, t_{\min}+1, \ldots, t_{\max}\}$ is an ordered set of gray - levels. Typically, in digital 8-bit images $t_{\min}$=0 and $t_{\max}$=255. Furthermore, let B(x) be a subset of Z^2 called structuring element centered at point x, whose shape is usually chosen according to some prior knowledge about the geometry of the relevant and irrelevant image structures. The two basic morphological operators are

Dilation: $$[\delta_B(f)](x) = \max_{b \varepsilon B(x)} f(x+b) \qquad (5)$$

Erosion: $$[\varepsilon_B(f)](x) = \min_{b \varepsilon B(x)} f(x+b) \qquad (6)$$

After determination of centroid of an image the boundary of the disc is detected based on morphological operations. Morphological operations give the shape of the optic disc. The optic disc is approximately a circular region. Based on this a circle is fit into the region to get the circular boundary of the optic disc.

Fig. 13 shows the centroid image and Fig. 14 shows the dilation process image and the boundary of the optic disc is shown in Fig. 15.

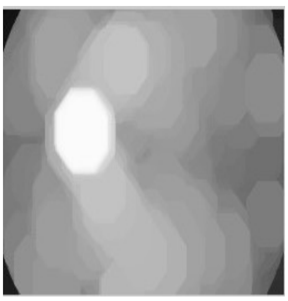

Fig. 13 Centroid image Fig. 14 Dilation image

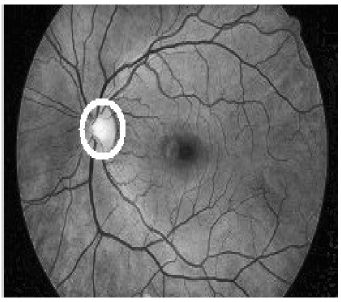

Fig. 15 Optic disc boundary

B) Cup Segmentation

The optic disc can be divided into two distinct zones, namely, a central bright zone called the cup and a peripheral region called the neuro retinal rim where the nerve fibers bend into the cup region.

Finding the cup region helps to measure the Cup to Disc Ratio (CDR) which is also an important property for identifying the glaucoma. An automatic CDR measurement system is a fast, reliable and efficient method for diagnosis of glaucoma. Several processes are involved in the cup segmentation. The steps are shown in Fig. 16.

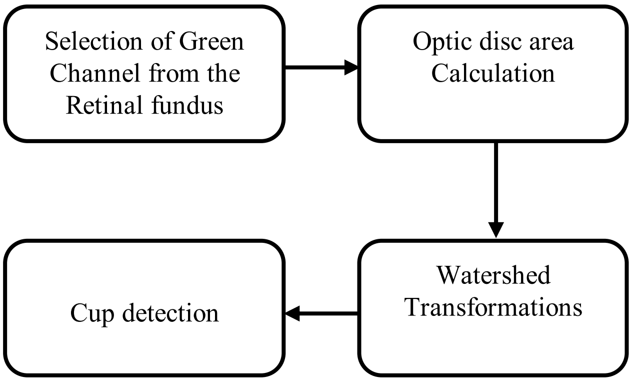

Fig. 16 Cup segmentation

1) Optic disc area calculation

The Cup to Disc Ratio (CDR) is measured in the green channel. It is extracted from the input image. The optic cup is more easily discriminated in the green image because the visibility and contrast of the optic cup is superior and its pixels are of higher intensities, while the neuroretinal rim and the retinal vessels are often of lower intensities.

Following steps are involved in the optic disc detection in green channel.

- First the green channel image is filtered to remove the noise component present in the image.
- Based on centroid of an image the optic disc area is determined.

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- Then the shape of the optic disc is determined by reconstruction by dilation process.

Fig. 17 shows the green channel of the input image and Fig. 18 and Fig. 19 shows the optic disc area which is extracted from the green channel of the input image and reconstruction by dilation process image respectively.

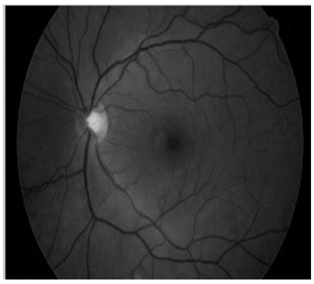

Fig. 17 Green channel Image

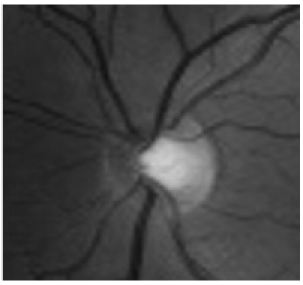

Fig. 18 Optic disc region

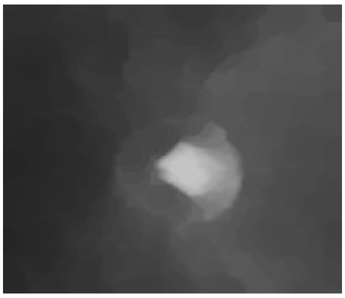

Fig. 19 Reconstruction by dilation image

2) Watershed Transformation

After reconstruction by dilation process a gradient image is obtained. It is applied to the input of the watershed transformation. Watershed transformation is a segmentation technique [8] for gray-scale images. This algorithm is a powerful segmentation tool whenever the minima of the image represent the objects of interest and the maxima are the separation boundaries between objects [5]. Due to this fact, the input image of this method is usually a gradient image. In mathematical morphology, the gradient $\rho(f)$ (x) of an image f(x) is obtained as the point wise difference between a unitary dilation and unitary erosion, i.e.

$$\rho(f)\ (\mathrm{x}) = \delta_B(f)(\mathrm{x}) - \varepsilon_B(f)\ (\mathrm{x}) \tag{7}$$

If the gradient image is considered as input image, the watershed transformation produces a segmentation which can be viewed as a set of closed contours of segmented regions. The segmentation method uses markers to build a contour of cup region. Both internal and external markers are used. The internal marker is drawn based on centroid of an image. The external marker will be a circle centered on the centroid of the image, specifically; the size of this circle is related to the image size, so that it is approximated by a 15% of the size of the fundus image. In this method an internal and external markers are defined and it is imposed on the image. f_{int} will be internal marker based on centroid and f_{ext} will be external marker. Then the logical OR of both internal and external markers is applied into the optic disc region. After logical OR operation watershed transformation is applied to get a cup region.

$$f_m = f_{\mathrm{int}} \vee f_{ext} \tag{8}$$

Fig. 20 shows the gradient image and Fig. 21 shows the optic cup boundary.

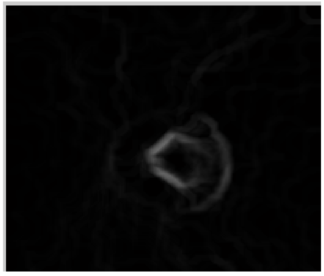

Fig. 20 Gradient Image

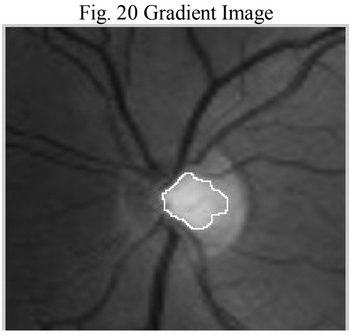

Fig. 21 Optic cup boundary

IV. CONCLUSION

An automatic CDR measurement system is a fast, reliable and an efficient method for the diagnosis of glaucoma. Glaucoma is a chronic and irreversible neurodegenerative disease in which the neuro retinal nerve that connects the eye to the brain is progressively damaged and patients suffer from vision loss and blindness. The diagnosis of Glaucoma can be done through measurement of CDR, defined as the ratio of the vertical height of the optic cup to the vertical height of the optic disc. The normal cup to disc ratio range is from 0.1 to 0.3. If the cup to disc ratio exceeds 0.3 then it indicates the abnormal condition that is the presence of glaucoma. Based on this the experimental results shows the input image is considered as glaucoma affected fundus. The proposed method has been evaluated in a database of 50 images. This methodology successfully found the diseased samples in 48 cases out of 50 images and producing the success rate of 96%.

This work can be extended for other disease detection, such as diabetic retinopathy, macular edema and retinal hemorrhage. Also algorithms can be implemented to identify the severity of the diseases.

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REFERENCES

[1]. Foracchia M., Grisan E., and Ruggeri A. "Detection of optic disc in retinal images by means of a geometrical model of vessel structure," IEEE Transactions on Medical Imaging,Vol. 23 No 10. pp. 1189-1195.2004.

[2]. M. Lalonde, M. Beaulieu, and L. Gagnon, "Fast and robust optic disc detection using pyramidal decomposition and Hausdorff-based template matching," *IEEE Trans. Med. Imag.*, Nov. 2001.

[3]. J. Liu, D. W. K. Wong, J.H. Lim, X. Jia, F. Yin, H. Li, W. Xiong and T. Y. Wong, "Optic Cup and Disk Extraction from Retinal Fundus Images for Determination of Cup-to-Disc Ratio, *IEEE Trans. Med. Imag.,* 2008.

[4]. J. Liu, D. W. K. Wong, J.H. Lim, X. Jia, F. Yin, H. Li, W. Xiong and T. Y. Wong, "Level set based automatic cup to disc ratio determination using retinal fundus images in ARGALI", *IEEE EMBS conference,* August 2008.

[5]. Sandra Morales, Valery Naranjo, Jesus Angulo, and Mariano Alcaniz, "Automatic Detection of Optic Disc based on PCA and Mathematical Morphology," *IEEE Trans. Med. Imag*., vol. 32, no.4, April 2013.

[6]. Sopharak, A., Thet New, K., Aye Moe, Y., N. Dailey, M., Uyyanonvara, B., "Automatic Exudate Detection with a Naïve Bayes Classifier", International Conference on Embedded Systems and Intelligent Technology, Grand Mercure Fortune Hotel, Bangkok, Thailand, pp. 139–142, 2008.

[7]. Rupesh Ingle, and Pradeep Mishra, "Cup Segmentation by Gradient Method for the Assessment of Glaucoma from Retinal Image, International Journal of Engineering Trends and Technology (IJETT), June 2013.

[8]. T. Walter and J. C. Klein, "Segmentation of color fundus images of the human retina: Detection of the optic disc and the vascular tree using morphological techniques," in Proc. 2nd Int. Symp. Med. Data Anal., 2001.

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