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# Identification of Cup-Disk Ratio for Glaucoma Prone Eyes

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**ABSTRACT**: In the framework of completely computer assisted diagnosis of glaucoma, an advanced algorithm that identifies the optic cup and optic disk, determines the radius by segmenting out the optic cup and disk and calculates the ratio of the optic cup to disk radius in fundus images of the macula is presented and discussed in this paper. The parameters of thecup to disk ratio in the optic disk region of retina are hallmark of glaucoma detection and allow itsdetection with a high sensitivity. Since detection of the ratio of optic cup to disk radius is asignificant diagnostic task, a major role is being handled by the computer assistance. The optic disk has been found by using red color space image as the optic disk is brighter considering to the other macula region and the contours are identified by means of morphological reconstruction techniques. The detection of optic cup has been done by using the green color space image. The optic disc and the optic cup have been detected by means of thresholding and morphological reconstruction technique.

**KEYWORDS***:* R-G-B color space, optic disk detection, optic cup detection, segmentation, Thresholding, cup and disk radius calculation.

## I. INTRODUCTION

Glaucoma is a chronic eye disease in which the optic nerve is gradually damaged. It is the one of the most effective reason of blindness and is predicted to affect around 60-80 million people by 2020 [1]. Glaucoma, which causes irreversible loss of vision, mainly is a disorder related to eye in population above 60 years. In this case, optic nerve fibers present in retina dies and if it's healing is not possible then it leads to blindness. The main risk factors of glaucoma are elevated intraocular pressure (IOP) exerted by aqueous humor, family history of glaucoma (hereditary) and Diabetes. It causes damage to the eye, whether intraocular pressure is either high, normal or below normal level. It causes the marginal vision loss. There are different categories of Glaucoma. Some of the glaucoma disease occurs so suddenly that the detection of glaucoma is very essential for minimizing that vision loss. It has been called the "**silent thief of sight**"[2-5] because the loss of vision often occurs gradually over a long period, and the symptoms only occur when the disease is in quite advance level. Once lost, vision cannot be recovered easily, so treatment is aimed at preventing further loss.

Glaucoma cannot be cured, but its progression can be slowed down by treatment. Therefore, the detection of glaucoma now a days is very critical. However, many of the glaucoma patients are completely unaware of this disease until it has reached the advanced stage. In some countries, more than 90% of the patients are unconscious that they have glaucoma [6]. Since glaucoma progresses with few signs or symptoms and the vision loss from glaucoma is permanent, screening of people at high risk for the disease is vital. Early detection is thus essential for early treatment to prevent the deterioration of this disease. Furthermore, current glaucoma detection requires patient examination by glaucoma specialists (ophthalmologists with specialized glaucoma training) and requires expensive specialized equipment. There are no cost-effective glaucoma screening programs available currently. It is therefore critical and challenging to detect/diagnose glaucoma early using non-specialized equipment, particularly with minimal involvement from glaucoma specialists

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## II. VISION OF THE PRESENT STUDY

Now for detecting the glaucoma the cup and disk ratio (CDR) of the eye is most important factor. So the Optic Disk detection of the eye is must for this purpose. In this disease the intraocular pressure (IOP) becomes pathologically high, sometimes rising severely to 60-70 mm Hg, the Pressures will also be greater than 25-30 mm Hg which can cause vision loss when sustained for a long time. In most cases of glaucoma [7], the abnormally high pressure results from increased resistance to fluid outflow through eye's drainage system. In normal healthy eyes there is a balance between fluids produced within eye and one that outflow. This balance keeps Inter Ocular Pressure (IOP) within the eye constant but in case of glaucoma, this balance is not maintained which in turn causes an increase in IOP, consequently damaging the optic nerve. Because of increase in IOP, the cup size begins to rise which accordingly increases the CDR. For normal disk the CDR is considered to be less than 0.4 but in case of glaucoma, it is greater than 0.4 [8-10]. As the cup size increases it also influences the Neuroretinal Rim (NRR) [11]. NRR is the region located between the edge of the optic disc and the optic cup. In the presence of glaucoma, area ratio covered by NRR in nasal and temporal region becomes thick as compared to area covered by NRR in inferior and superior region. The depression inside the optic disc where the fibers leave the retina via the optic nerve head (ONH) is known as the optic cup. The boundaries of the cup and disc structures need to be identified as it facilitates evaluation of glaucoma cues such as cup and disc asymmetry and large cup-to-disc ratio (CDR), defined as the ratio of the vertical cup diameter to the vertical disc diameter. The fundus images of normal human eye and glaucoma affected human eye are shown in figure (1).

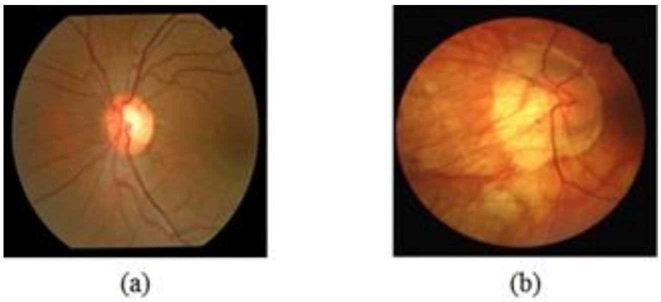


Figure 1: Fundus Image of Human Eye; (a) Normal, (b) Glaucoma Affected

Typically, the CDR value in the Optical Disk of the eye is determined from a manually outlined optic disc and cup. But since manual annotation is labor intensive, researchers have found automatic methods for disc and cup segmentation. The figure of interest of this paper is shown in figure (2).

In previous works, the researchers have mainly focused on automated segmentation of the optic disc using various techniques such as intensity gradient analysis, Hough transforms, template matching, pixel feature classification etc. In this research the use of morphological techniques for detecting the optical disk and optic cup automatically.

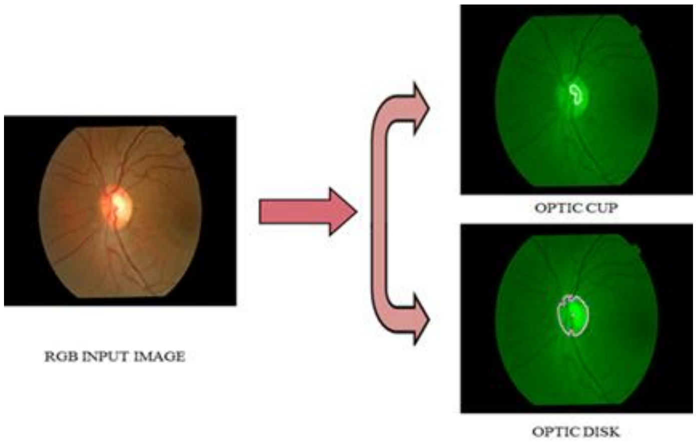


Figure 2: Distinguish image of optic cup and disk from the RGB input image.

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## III. METHODOLOGY

This paper proposes a methodology for Optic Cup (OC) and Optic Disk (OD) location in fundus images and the calculation of cup-disk ratio. The general flow chart for the methodology mentioned is shown in figure (3). The several steps for measurement of cup – disk ratio is explained below.

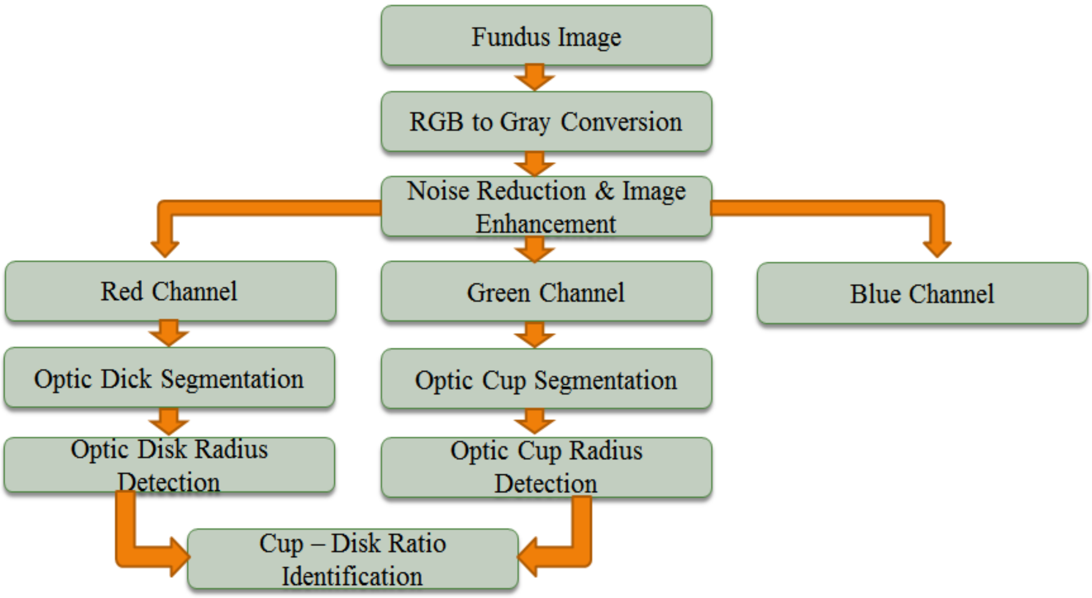


Figure 3: The flow chart for identification of cup-disk ratio

A. Preprocessing

There are several steps of pre-processing of Optical Disk detection which are briefly explained below,

1. Original Image to R, G and B color space Conversion

Initially the original retinal color image is taken as the input and the three color components (R, G, and B) are extracted separately. In the following, we work on the green channel of the RGB color space to identify the optic cup, because blood containing features appear most contrasted in this channel. Generally green channel images are very advantageous for the analysis of the retina, particularly for the visualization and analysis of blood containing elements. Another advantage of the use of the green channel image is that the choroid vessels do not appear at all, whereas they do appear in the luminance channel for instance, for it is a combination of the three channels *R*, *G* and *B*. This is why; we work mainly on the green channel image for optic cup detection. The red channel image is taken and preprocessed for the purposes of Optical Disk.

2. Noise Reduction

After transformation of original image to red and green channel, some noise is created in that image. And then median filtering technique is used to reduce the effect of noise. After using filtering technique, noise such as salt and pepper noise can be removed from the image. Noise can cause trouble in the detection of optic cup and optic disk. The median filter, which is a non-linear filter, can reduce the effect of noise without blurring the shape edge. The operation of this Median filter is first arranging the pixel values in either the ascending or descending order or then computing the median value of the neighborhood pixels. The median filtered image for applying 3×3 median filter to the red and green channel image is given in equation (1).

$$Z(n1, n1) = Median_{3\times 3}\{X(n1, n2)\} \quad (1)$$

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Where $Z(n1, n2)$ is filtered output image and $X(n1, n2)$ is input image.

3. Image Enhancement

Image enhancement techniques are used to improve the intensity of an image. Intensity adjustment is an image enhancement technique that maps the image intensity values to a new range. The output image of the median filter is enhanced by using the histogram equalization technique. The histogram equalization technique is used to overcome the uneven-illumination case. There are two methods to enhance the image: Histogram Equalization and Adaptive Histogram Equalization.

- Histogram Equalization:

It enhances the contrast of the images by transforming the values in an intensity image. The procedures of the histogram equalization are-

i. Find the running sum of the pixel values
ii. Normalize the values by dividing the total number of pixels
iii. Multiply by the maximum gray-level value and round the value

- Adaptive Histogram Equalization:

Unlike histogram, it operates on small data regions (tiles) rather than the entire image. And also contrast enhancement can be limited in order to avoid amplifying the noise which might be presented in the image. So, Adaptive histogram equalization technique works significantly better than regular histogram equalization for most images for image enhancement technique.

B. Optic Cup and Disk Segmentation

1. Image Segmentation by Morphology

Image segmentation is the process of partitioning an image into multiple segments, as to change the representation of an image which is more meaningful and easier to analyze. Blood vessels introduce errors in Optical Disk segmentation, so they must first be removed from the image. Segmentation of Optic Disk and Optic Cup are done using various morphological operations to detect their boundaries and filling of holes.

For the removal of the blood vessels in a retinal image, mathematical morphology can be used since the vessels were the patterns that exhibit morphological properties such as connectivity, linearity and curvature of vessels varying smoothly along the crystalline.

By using the correct combination of mathematical morphology operations, it is possible to improve the contrast between vessels and other structures of the image of optical disk.Morphological closing operation is used to remove dark details from the image of eye. When the size of the structuring element corresponds to the vesselwidth in optic disk, vessels are removed from the image, leaving a lighter background in the region previously occupied by them.

Morphological Closing operation is a merger between erosion and dilation operations. Dilation operation is done first. Then it is followed by a process of erosion. Dilation operation serves to expand the area of optic disk by removing the small interfering blood vessels of eye while the erosion function is done to restore the boundaries to their former position.

Morphological closing operation is performed on ROI (Region of Interest) to calculate the magnitude gradient of edge detection and fill the vessels according to equation (2).

$$f \bullet B = (f \oplus B) \Theta B \quad (2)$$

In order to remove the large intensity peaks and make the optic disk region homogenous after morphological closing operation, we can apply morphological opening operation by reconstruction with a disc structural element. For removing any peaks, morphological opening operation is applied according to the equation 3.

$$f \circ B = (f \Theta B) \oplus B \quad (3)$$

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Where f is the grayscale image, $B$ is binary structuring element, $\oplus$ is dilation operator, and $\Theta$ is erosion operator.

2. Optic Disk Radius Calculation

The determination of the radius optic cup and optic disk by 2d geometry as shown in figure 4.

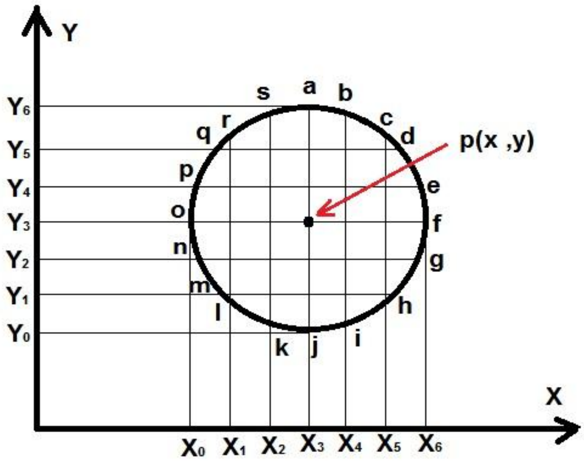


Figure 4: Two dimensional geometry to calculate the center of circular shape

At first the circular shape image of optic cup or optic disk is taken in 2-D plane. Then like figure 4 the distance of X (X1, X2, from Y plane and X plane respectively. Let that distances are (y1, y2, y3...) and (x1, x2, x3…).

Now averaging that distances from Y plane and X plane the location of the center of that optic cup P(x, y) is determined in the figure. Then from that center the distance of other points of the optic cup can easily be obtained. Let the distances are – r1, r2, r3, r4, and by averaging the distances radius of the optic can be found.

So, radius= (r1+r2+r3+…..+r8)/8.

Here the 8 points on that optic cup will help more points to get better result also.

Similarly the radius of the optic disk can be measured by using same above procedure also.

Now the ratio of optic disk radius and optic cup radius can be easily measured, which is known as Cup Disk Ratio (CDR). Now comparing the CDR ratio the information about the Glaucoma symptoms can be found.

## IV. RESULT

The Figure (5) shows an example of the segmentation of optic cup and disk from the fundus image of the normal human eye and an improvement in calculating the cup-disk ratio based on a new algorithm mentioned in this paper. The ratio of optic cup-disk radius is 0.353.The normal cup-disk ratio of a human eye is within the range 0.3 to 0.4.Table 1 shows the respective radius of optic cup and disk of 20 fundus images and the corresponding cup-disk ratio.

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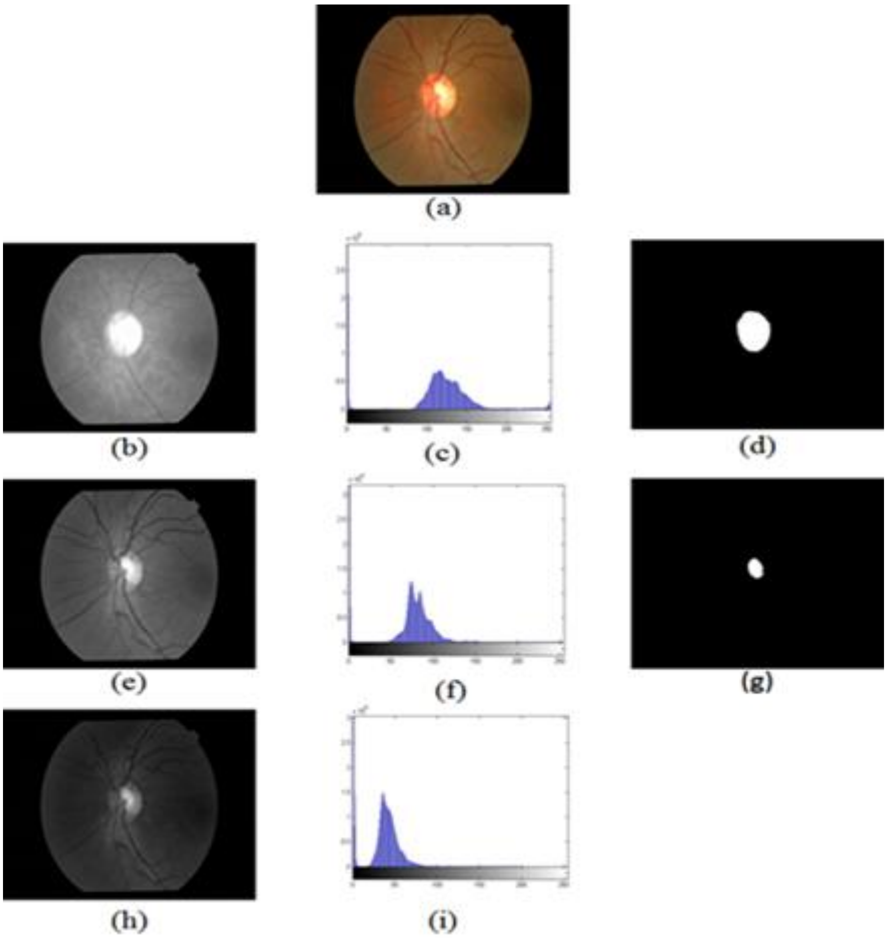


Figure 5: Results, (a) input image, (b) red component of input image, (c) histogram of the red component, (d) segmented optic disk, (e) green component of input image, (f) histogram of green component, (g) segmented optic cup, (h) blue component of input image, (i) histogram of the blue component.

A. Algorithm for Optic Disk Extraction

**STEP 1**: The colored fundus image have been captured by fundus camera.

**STEP 2:** The color image is then converted to the R, G and B color space.

**STEP3:** Then the median filtering is applied over red and green color space image for removing of noise.

**STEP4:** The histogram calculation of the different color spaced image has been done.

**STEP 5:** The segmentation process has been performed on the images to identify the optic disk easily.

**STEP6:** The optic disc area and its radius have been calculated by counting the number of pixels present in the Optic disc.

B. Algorithm for Optic Disk Extraction

**STEP 1:** The median filtering applied on the image for smoothening and removing of impulse noise.

**STEP 2:** Image enhancement and segmentation have been done on the image similarly as the calculation of optic disk.

**STEP 3:** The morphological operation has been done on the input image to identify the optic cup.

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**STEP 4:** The optic cup area and its radius have been calculated by counting the number of pixels present in the optic cup

**STEP 5:** Finally the cup-disk ratios have been calculated by dividing the number of pixels in the optic cup by number of pixels in the optic disc.

Using the above steps stated, the CDR have been calculated and tabulated in Table 1 (below). Table 1 contains the values of optic cup (in pixels), optic disk (in pixels) and also the cup-disk radius ratio (CDR). These results can be very essential for correlation of the calculated values with some standard medical data.

Table 1. The Cup Disk ratio over 20 specimen fundus images

| Sl. No. | Optic Cup (Pixels) | Optic Disk (Pixels) | Cup-Disk Ratio (CDR) |
|---|---|---|---|
| 1 | 53 | 135 | 0.393 |
| 2 | 23 | 65 | 0.35 |
| 3 | 27 | 69 | 0.391 |
| 4 | 32 | 80 | 0.40 |
| 5 | 21 | 66 | 0.318 |
| 6 | 31 | 84 | 0.369 |
| 7 | 20 | 61 | 0.328 |
| 8 | 33 | 98 | 0.336 |
| 9 | 40 | 115 | 0.348 |
| 10 | 36 | 85 | 0.423 |
| 11 | 43 | 111 | 0.387 |
| 12 | 59 | 124 | 0.476 |
| 13 | 46 | 136 | 0.338 |
| 14 | 51 | 127 | 0.402 |
| 15 | 63 | 139 | 0.453 |
| 16 | 26 | 68 | 0.382 |
| 17 | 29 | 81 | 0.358 |
| 18 | 33 | 79 | 0.418 |
| 19 | 41 | 118 | 0.347 |
| 20 | 23 | 71 | 0.324 |

## V. CONCLUSION

For cup disk ratio CDR measurement in glaucoma diagnosis, we proposed a morphological approach based on retinal structure. Tested on a large number of fundus images which produce a satisfactory result which is also appreciably similar to the results found in previous literatures. On the other hand the accuracy of the proposed process is significantly good and it also consume a very less run time for producing such results.

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