RESEARCH ARTICLE OPEN ACCESS

Automated Screening of Glaucoma in Fundus Imagery by Morphological Operations

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Abstract:

Glaucoma is a chronic disease and if not detected at an early stage it may cause permanent blindness. Funduscopic examination of the Retina enables ophthalmologists to examine the Optic Disc. Our Proposed method consists of two stages detection and screening. The detection stage comprises the detection of Optic Disc and Optic Cup. The Screening stage comprises the screening of fundus images for glaucoma based on the measured value of CDR (Cup-Disc Ratio).CDR is the ratio of cup area to disc area and it is one of the noticeable structural change that occurs if glaucoma progresses. CDR value is used to classify normal eyes and glaucomatous eyes. Cup size increases in glaucomatous eyes, resulting in increase of CDR. Our proposed method achieves a success rate of about 95.7%.

Keywords **—Fundus images, Optic disk, Cup to Disc Ratio (CDR), Glaucoma.**

I. INTRODUCTION

Glaucoma is an eye disease that kills the retina cells and causes vision loss. It is symptomless in the early stages and since the loss cannot be restored its early detection and treatment is essential to prevent damage to the vision. It is the second main cause of blindness. As the symptoms only occur when the disease is quite advanced, glaucoma is called the silent thief of sight. Glaucoma cannot be cured, but its progression can be slowed down by treatment. The images captured from fundus camera suffer from different problems like improper positioning, improper illumination, out-of focus, field mis-labeling etc. These problems degrade the quality of a fundus image making them unsuitable for diagnosis. This requires repeat acquisition of images which increases the burden to patients as well as clinics. Poor Image quality can lead to misclassification of features in retinal images[1]. Thus Quality grading whether images are gradable or ungradable is crucial for medical Imagery Applications.

The Optic Disc (OD) is a circular bright component of the fundus image most seriously the OD may be completely changed by retinopathy [2]. In the red channel, the Optic Disc appears most contrasted against the background and has least vessel distractions. Therefore the red channel of the original RGB image is extracted. The glaucoma screening is usually based on the value of the CDR. The value of the CDR for a normal eyes lies in the value range between 0.1-0.65. If the CDR value increases above 0.65, then it indicates Glaucomatous eyes. For patients with Glaucoma the CDR value may lie between 0.65-0.9.Based on these values the Input Images are screened either as Normal/Glaucoma Image. The database used for our proposed method for screening of Glaucoma is MESSIDOR.The values of Normalized Absolute Error NAE>0.15 and Structural Similarity Index Measurement SSIM<=0.5 were classified as

ungradable and NAE>=0.15and SSIM>0.5 were classified as gradable Images.

II. PROPOSED METHOD

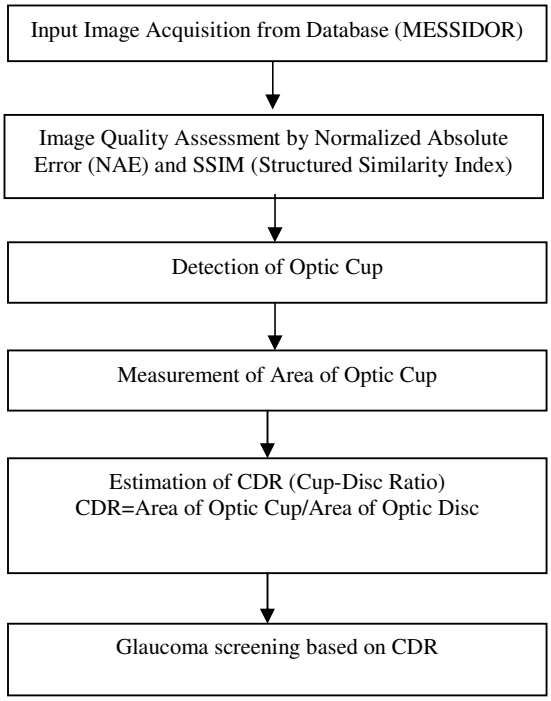

Fig 1 : Flow diagram of the Proposed Methodology

The Proposed method consists of two stages detection and screening. The detection stage comprises the detection of Optic Disc and Optic Cup. The Screening stage comprises the screening of fundus images for glaucoma based on the measured value of CDR (Cup-Disc Ratio).

Fig 2 : Input Image from the MESSIDOR

The Input Retinal fundus Image is obtained from MESSIDOR Database. The proposed method is written and executed in MATLAB R2014.

Fig 3 : Image Quality Grading-Gradable Image

The Input Images are classified as either Gradable or Un-Gradable Image. The above figure shows a gradable Image classified by the proposed method depending on value of NAE and SSIM. NAE value <0.15 and SSIM value>0.5 are classified as gradable Images.

The above Image shows a NAE Value= 0.1021 and SSIM Value=0.8984

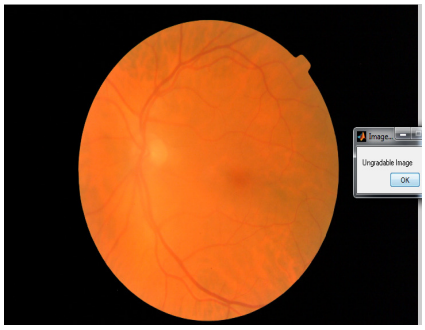

Fig 4 : Image Quality Grading- Un-gradable Image

The Input Images are classified as either Gradable or Un-Gradable Image. The above figure shows an Un-gradable Image classified by the proposed method depending on value of NAE and SSIM. NAE value >0.15 and SSIM value< 0.5 are classified as Un-gradable Images.

The above Image shows a NAE value=0.3286 and SSIM Value=0.4090

Fig 5:Extracted Red channel from the Input Fundus Image

The optic disc is a brightest component of the fundus image. In the red channel the Optic Disc (OD) appears most contrasted against the background and has least vessel distractions. Therefore the red channel of the original RGB image is extracted

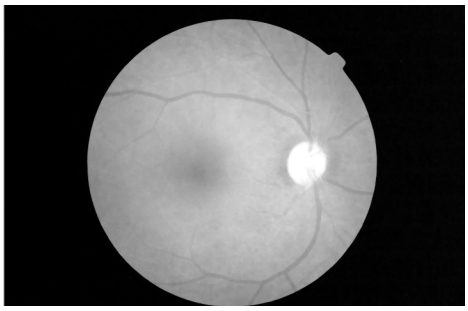

Fig 6: Closing Operation to eliminate Blood vessels from the Optic Disc Region

Blood vessels in the Fundus Image are removed by applying closing operation using octagon shape structuring element of size 3 to create fairly uniform region. This operation contributes towards the better segmentation of OD where the vicinity of the blood vessels is more in the OD region.

Fig7 : Image Negative Transformation-OD region appears black with respect to the other background Pixels

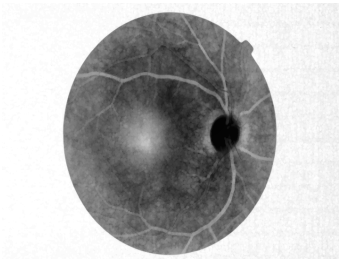

Fig 8: Image Enhancement by Histogram Equalization to highlight the Optic Disc Region

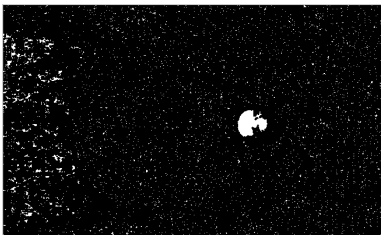

Fig 9: Extended Minima Transform for segmentation of Optic Disc Region

The extended minima transform can identify the optic disc region with minimum Intensity value in the Image. The extended-minima transform is a thresholding technique that brings most of the valleys to zero. The extended minima transform suppresses all the minima in the intensity image whose depth is less than or equal to a predefined threshold. The threshold value used for the detection of optic disc by proposed method is set equal to 3.

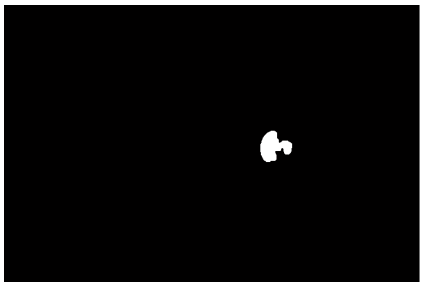

Fig10 : Opening Operation performed to remove the regions other than Optic Disc

Opening operation is defined as erosion followed by a dilation using the same structuring element for both operations. Opening removes small objects from the foreground of an image, placing them in the background. For the detection of Optic Disc a disc shaped structuring element of size 10 is used. Opening operation detects the Optic disc region in the Image.

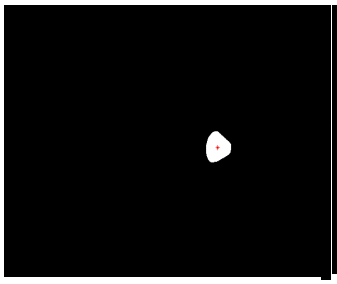

Fig11: Detection of the Centroid of the Optic Disc Region in Binary Image format

Fig12: Detected Optic Disc highlighted in red circle in the Input Fundus Image

After the Detection of Optic disc for the process of estimation of CDR it is necessary to determine the area of the Optic disc. So the value of the Centroid, radii and diameter of the disc are computed and Area of the Optic disc is determined.

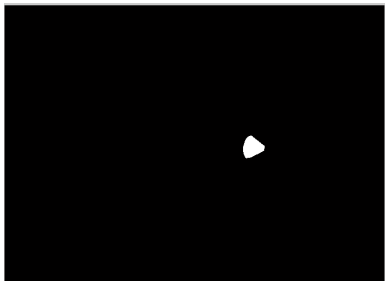

Fig13: Detected Optic Cup represented in Binary Image

The value of the Optic Disc size (Vertical Optic Disc Diameter) of non-glaucomatous eyes typically lies in the range of 1.77-1.88 mm and the Vertical optic cup diameter of non-glaucomatous discs lies in the range of 0.09–1.88 mm. Therefore the diameter of the optic cup is about one-third of the size of the optic disc. The Optic cup is localized with a diameter of one-thirds of that of the optic disc. For the extraction of optic cup similar spherical shaped structuring element of size 5 is used. Similarly the Centroid, diameter, Radii are computed and the value of the area is computed separately for the Optic cup.

Fig 14 : Localization of Optic Cup on the Input Retinal Fundus Image

The CDR (Cup-Disc Ratio) is defined as the ratio between the areas of the Optic Cup to the Area of the Optic Disc. The Optic disc appears to be normal in size for patients without Glaucoma. The size of the Optic disc usually enlarges or diminishes for patients with Glaucoma thus causing change in value of CDR.

Fig 15 : Glaucoma screening based on the measured value of CDR

The glaucoma screening is usually based on the value of the CDR. The value of the CDR for a normal eyes lies in the value range between 0.1-0.65. If the CDR value increases above 0.65, then it indicates Glaucomatous eyes. For patients with Glaucoma the CDR value may lie between 0.65-0.9.Based on these values the Input Images are screened either as Normal/Glaucoma Image.

TABLE I
MEASURED VALUES OF QUALITY MEASURES AND GLAUCOMA SCREENING

Image	NAE	SSIM	CDR	Gradablity	Screening
01	0.1021	0.9045	0.1968	Gradable	No-Glaucoma
02	Nil	Nil	Nil	Un-gradable	Nil
03	0.1056	0.8984	0.4945	Gradable	No-Glaucoma
05	0.1021	0.9019	0.4844	Gradable	No-Glaucoma
07	Nil	Nil	Nil	Un-Gradable	Nil
08	Nil	Nil	Nil	Un-Gradable	Nil
18	0.1181	0.8910	0.6853	Gradable	Glaucoma
63	0.0907	0.9039	0.5299	Gradable	No-Glaucoma
68	0.0930	0.8141	0.4844	Gradable	No-Glaucoma
70	0.1302	0.8982	0.6519	Gradable	Glaucoma

From the table , depending on value of NAE and SSIM the input images are classified as either Gradable or Un-Gradable Images. NAE value <0.15 and SSIM value>0.5 are classified as gradable Images. Blood vessels in the Fundus Image are removed by applying closing operation using octagon shape structuring element of size 3 to create fairly uniform region. This operation contributes towards the better segmentation of OD

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III. CONCLUSIONS

A novel approach for Optic Disc and Optic Cup segmentation by means of morphology operations is designed by this proposed method. In addition to this, an OD location methodology for obtaining the OD position needed by the segmentation algorithm as initial information is also proposed. The results obtained by the proposed method show that it offers a reliable and robust solution for Optic Disc and Optic Cup segmentation.

The proposed method of OD detection is simple and efficient, thus reducing the computational time. The method successfully detects OD boundary and Optic Cup boundary depending on the Vertical Diameter of the Optic Disc and Optic cup. It can detect the positions of optic disc and optic cup in fundus images that are irregular, varying sizes and is independent of locations of OD. The proposed method yielded encouraging results for both normal and DR fundus images. Out of 70 images tested on the MESSIDOR Database, the proposed method achieved successful OD detection in about 67 images. The proposed method achieves a success rate of about 95.7%.

The success rate of OD Detection can be further improved by considering the effects of myelinated nerve fibers, blurred OD and blood vessels. The proposed method produces accurate segmentation of Optic disc and Optic cup to obtain a reliable value of CDR that is used in the screening of Glaucoma.

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