

Segmentation of Optic Disc using Bit Plane Technique for Glaucoma Screening

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Abstract - It is known that glaucoma, a group of eye disease is the second leading cause of permanent vision impairment. Glaucoma is caused due to neuro-degeneration of the optic nerve, which leads to the loss of vision if left untreated. In the early stages of glaucoma no perceptible symptoms appear and hence the disease onset is often left unnoticed. As the disease progresses, vision start to become hazy and eventually leads to the loss of vision. An approach to automatically segment out the optic disc and removal of blood vessel from the fundus image has been presented. The screening system presented processes and analyses the acquired fundus images. Optic Disc (OD) segmentation along Optic Cup (OC) fundus image is used to calculate cup-to-disc-ratio (CDR) which acts one of the vital indicators of the disease. The retinal fundus image is acquired by fundus camera and the proposed system is validated on public database DRIONS-DB and local dataset.

Key Words: Glaucoma, Fundus images, optic disc and cup, optic nerve, CDR.

1. INTRODUCTION

Glaucoma is a diseased condition of the retina in which the optic nerve is damaged and gets into a worse condition as time progresses. The condition is much often related to the Intraocular Pressure (IOP) of the eye. The disease may be due to genetic factor i.e, inherited. Glaucoma originates from increase in intraocular pressure caused by aqueous humor, a fluid produced by the eye. In a normal eye, a balance is maintained as the amount of liquid produced is equal to the amount of liquid discharged by the eye. However, in glaucoma the liquid do not flow out of the eye and increases stress on the eye resulting in the damage of optic nerve which is responsible for brain and eye communication. This results more IOP in the eye which damages the highly sensitive optic nerve causing vision impairment. It mainly affects the portion inside the optic disk where the size of the optic cup increases resulting in a high cup-to-disk ratio. It causes the successive narrowing of the field of view of affected patients. Therefore diagnosing glaucoma at initial stage is acutely important for an proper management of the first-line medical treatment of the disease. Figure 1 shows a sample retinal image depicting the important structures in the eye like blood vessels, fovea, macula and disk.

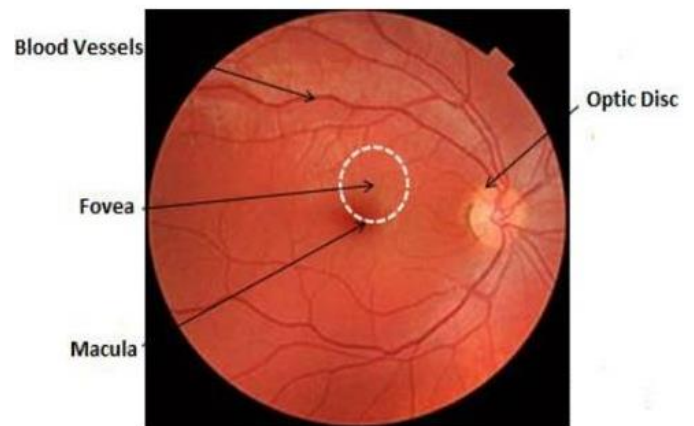


Fig 1- Retinal fundus image

One of the most important things to be noticed in glaucoma is that, one cannot immediately experience the onset of the disease. By the time the patient starts to experience the disease, the damage to the retina would already have been done. Hence it is the required to detect the disease at an early stage to control the progression of the disease. Glaucoma has several types, out of which the two main types open angle and close angle glaucoma are of serious concern and threat. Both the types have high intraocular pressure inside the eye. Glaucoma can be acquired from birth even.

Wide or Open-angle glaucoma: It is the most common type, also referred as chronic glaucoma. It occurs due to partial blockage of drainage canal in which pressure increases slowly, as fluid does not drain properly. Symptoms arise from peripheral vision loss and may not be noticed until central vision is affected.

Angle-closure glaucoma: It is also called acute glaucoma. Acute angle closure is an uncommon type. It is caused by a sudden increase in intraocular pressure (IOP) in the eye. This happens when the drainage canals get blocked, with a sink smoothing covering the drain. The pressure rises rapidly leading to loss of vision quickly. In some cases, complete loss of vision may occur within a day of attack. It requires immediate medical care.

2. RELATED WORK

Many works in computer vision and image processing related to glaucoma detection has been proposed in the literature. Few works are mentioned here. To identity

symptoms of glaucoma segmentation of optic disc is presented [1] which uses the local image information around some point of interest in multi-dimensional feature space and seems to provide robustness against some variants around the optic disc.

Segmentation of optic disc and optic cup from color fundus image is presented [2] where a circular Hough transform is used. Cup to disc calculation method is presented [3] where double threshold based approach is used for blood vessel and background extraction and second threshold for segmenting the super intensity pixels contained by optic disc and optic cup. K-means clustering technique to extract OD and OC was proposed in [4] and elliptical fitting technique is used to calculate the CDR. A super-pixel classification based optic disc and optic cup segmentation[5] was done based on histograms and center surround statistics method.

A novel OD localization technique [6]horizontal localization was obtained using scatter degree, by using brightness and edge gradient vertical location was determined, a preprocessing step is used to determine the region of interest in fundus image. Regressive based method [8] and texture descriptors are used to identify the circle which fits the OD boundary which is used to detect the OD.

Histogram matching for localizing the OD [7] and average filter is applied to reduce the noise. OD is extracted by using a window and threshold was applied on the correlation function to localize the center of the OD.

3. PROPOSED METHODOLOGY

The optic disc is the primary area where the glaucoma symptoms occur. The proposed method of Optic Disc segmentation involves optic disc detection, segmentation and removal of blood vessel from the retinal fundus image. The input image will be automatically processed and the following steps will be made without any manual intervention as shown in Figure 2.

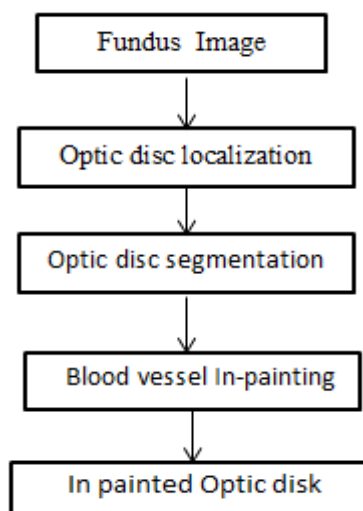


Fig 2- Flow Diagram of Proposed OD segmentation

The proposed method of glaucoma detection is broadly classified into four different stages

- i) Image Acquisition
- ii) Optic disc detection and localization.
- iii) Optic disc segmentation.
- iv) Blood vessel removal.

a) Digital Fundus image database

The fundus images used in this work were collected from the DRIONS-DB [8] and local database. In this work total of 110 images were used. The inbuilt imaging software of the fundus camera is used to take pictures of the eye. The images are in JPEG format and had a resolution of 600x 400 of 8 bits/pixel. Fig 3 shows the two samples of the digital fundus image of normal and glaucoma affected eye.

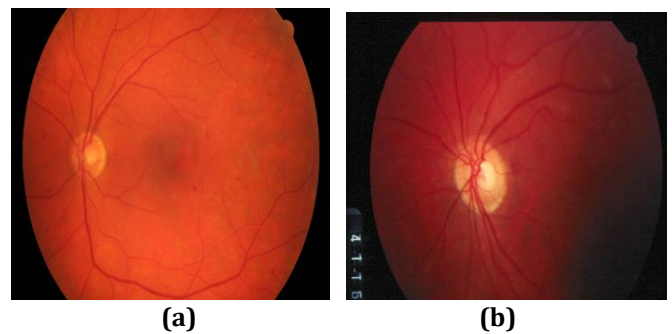


Fig 3 Fundus Image (a) Normal (b) Glaucoma

b) Optic Disc Localization

It is known that optic disc is the brightest intensity part in the fundus image. Optic disc is the slightly elliptical shaped in nature and it serves as the exit point of the optic nerves. The strategy adopted here is to detect the bright intensity object in the fundus image. Optic disc center detection involves extraction of green channel from the fundus image because green channel has the maximum intensity feature needed for optic disc detection [9,10]. Kaiser window and hat shaped Kaiser Window is passed to run through each of the rows and columns of the fundus image respectively to detect the optic disc center with exact co-ordinates.

c) Optic Disk Segmentation

Segmentation of optic disk can be carried out by the way of locating the disk. Various literatures have shown that the optic disk can be easily segregated from the red channel of the fundus RGB image components [11-13]. Optic disc is segmented from the fundus image using bit plane technique. A digital fundus image is segregated into its bit planes. This is quite useful for analyzing the importance or role played by every bit of the image and it calculates the sufficiency of numbers of bits needed in quantizing each pixel. The database image used has 8 bit representation, hence 6th, 7thand 8th bit plane of the fundus image are considered for

the optic disc segmentation. After obtaining the red channel of the input image, a circular sub image is extracted depending on the number of rows and columns in the image. It is meant to completely cover the optic disc area. Using logical operators, it is possible to combine the bit planes to obtain a common area. The accuracy of this step depends on locating the bright spot. There will not be any bright pixel in the OD; if the above process is done correctly else another common area has to be checked for. If the above passes the check point correctly, then the final segmentation is completed, else using another bit plane, common area has to be segmented. Similarly using the logical operator, this common area and the previous common area can be combined to get the new area. Commonly logical "AND" can be used. From this newly segmented common area, noisy pixels have to be removed. Labeling of the objects removes noise pixels and the objects are selected having the largest area and roundness. The selected object is nothing but optic disc. Fig 4 shows the fundus image, circular sub image and segmented optic disc.

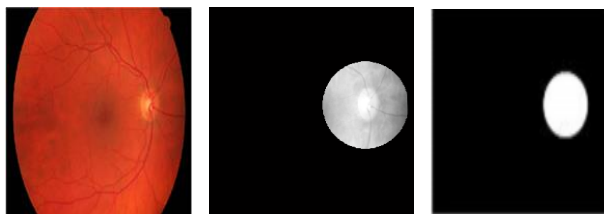


Fig 4 - (a) (b) (c)

(a) Fundus image (b) Circular sub image
(c) Segmented OD

d) Blood Vessel Removal

Blood vessels are considered as noisy pixels in the fundus image and have to be eliminated to obtain the accuracy of OD detection. To remove the noisy pixels from the segmented optic disc, image in-painting is adopted [14]. The pixel intensity is considered as a function of distance from the optic disk center. It is to be noted that as the distance increases outwards from the OD, the gray pixel values tend to decrease. Similar intensity levels are observed for all the pixels that are at equidistant from the center of the optic disk. Presence of blood vessel is detected, if there is any deviation from the above. In this process, the disk pixels are not disturbed. Fig 5 represents the OD sub-image, segmented OD, OD image after blood vessel in-painted.

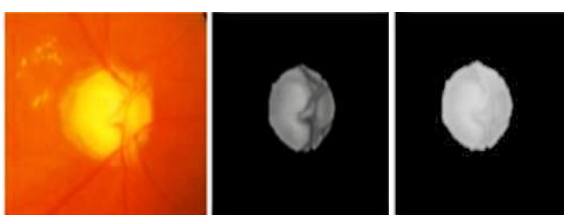


Fig 5 - (a) (b) (c)

(a) OD Sub-image (b) Segmented OD Image
(c) OD image after blood vessel in-painted

4. SEGMENTATION METRICS

Dice metric is quite commonly used to evaluate the segmentation. It is given by

$$DM = 2 * \frac{A \cap B}{A + B} \quad (1)$$

A is the segmented image and B is the ground truth image. A perfect match between the segmented result and the ground truth one is indicated by a dice mean value of 1 and no overlap case is indicated by 0 [15]. Another metric that shows whether the segmented is over segmented or under segmented is the Relative Area Difference (RAD) mean. It is given by

$$RAD \text{ mean} = \frac{A+B}{B} * 100 \quad (2)$$

The sign of the RAD mean indicated the metric such that over segmentation is indicated by positive values and vice-versa. The proposed system of OD segmentation is tested on DRIONS-DB and local dataset. The average Dice coefficient and RAD Mean for the OD segmentation was 0.94 and 96.9%, respectively on the local dataset, while obtaining 0.93 and 95% for DRIONS-DB image set.

5. CONCLUSION

The automatic optic disc segmentation technique has been proposed by using double windowing method. The noisy blood vessels are removed from segmented optic disc by using image in-painting technique. The efficiency of the segmentation results were tested on the DRIONS-DB and local dataset and their performance is evaluated using two metrics. As OD segmentation plays a vital role in the detection of glaucoma, this method can aid in the early detection or screening of the disease, glaucoma can only be treated and cannot be prevented.

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