Eminent Identification And Segmentation Of Optic Disk In Digital Fundus Images Using Marr- Hildreth Operator

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Abstract: This paper proposes a novel method for the detection of Optic Disk (OD) using fundus image to diagnose glaucoma. Glaucoma is a terrible disease associated with human eyes. As it is a symptomless tragedy that can lead permanent vision loss if not treated in the early stage. Hence, it became the most important research topic in medical field. It is the second leading cause of blindness in the world and it has no cure. Glaucoma has different types, they are normal tension, open angle, close angle etc. Normal tension affects the vision field and damage the optic nerve as well. The term angle means distance between iris and cornea. If the distance is large then it is referred as open angle glaucoma. Similarly if the distance between iris and cornea is short, that is referred as close angle glaucoma. Close angle glaucoma is very painful and it reduces the vision field of eye very quickly. Currently there are treatments are available to prevent vision loss but the disease must be detected in the early stage. Since, OD is the main factor in detection of several eye disease. Glaucoma affects the optic nerve and leads to cupping of optic cup and disk. This paper provides a structure to develop an automatic detection method of OD in retinal images and the methodologies used are optic disc localization and segmentation using Marr-Hildreth operator and Polar Transform.

Keywords: Glaucoma, optic Disk, Optic Cup, Edge detection, Marr- Hildreth operator

1. Introduction

Glaucoma is a group of eye disorder that can cause gradual and irreversible vision loss if left untreated at the early stage [25]. There are many types of glaucoma that can be categorized into mainly two types. One is Open Angle

Glaucoma **(**OAG) and another one is Close Angle Glaucoma **(**CAG).According to World Health Organization **(**WHO) glaucoma is the second leading cause of blindness in the world wide. The growth of glaucoma usually goes undetected until the severe stage of nerve damage occurs. In case of ophthalmic disorders timily treatment is vital for preventing the vision loss. Retinal examination using fundus photographs provide better support in glaucoma diagnosis. It is common examination at general ophthalmologic centers. As mentioned earlier, some of the symptoms of glaucoma found in fundus image include retinal nerve fiber layer defect **(**RNFLD**)** and Optic Disk **(**OD) deformation [11]. The two vital characteristics of glaucoma are degeneration of optic nerve and ganglion cells. As the disease progresses, Optic Cup **(**OC**)** enlarges and increases the pressure inside of the eye called Intra Ocular Pressure **(**IOP**).** But, people with normal pressure can also have glaucoma. The ratio of vertical diameter of cup and disk is considered as a diagnostic index. Also thinning of neuro-retinal rim can suspect glaucomatous changes.

The symptoms of glaucoma can be identified through regular screening once in every two year [13]. As glaucoma is an asymptomatic disease, there are some common factors which are part of the disease such as mild headache, eye pain, visual field effect, redness in eye etc. Glaucoma can be categorized into two stages based on its severity.

i) Early glaucomatous

ii) Advanced glaucomatous

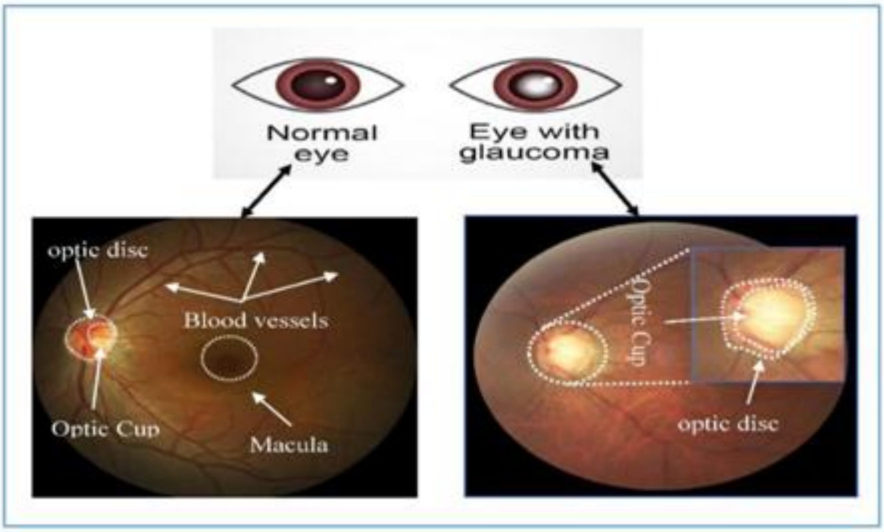

Fig 1. Normal image and Glaucomatous image

Early glaucomatous changes include large optic cup shape greater than 0.6 mm and asymmetry between two eyes would be 0.2 mm and atrophy of RNFL, Similarly, advanced glaucomatous changes include, thinning of neuro-retinal rim, nasal shifting of retinal vessels lamellar dot sign etc. Presently, computerized analysis of fundus image would help the medical professionals by providing accurate suspected condition, location and quantitative details. As, it is known that automatic detection of optic disk is a risky task. Figure 1 shows the basic differentiation of normal and advanced glaucomatous image. Because of the factor that similarity in terms of color, contrast and intensity are found and it will alter the measurement patterns. Also, blood vessel segmentation helps in detecting optic disk very accurately. The density of vessel will be higher on and dear to the optic disk.

2. Related Work

Liu et al., [1] proposed a work of Closed/ Open angle glaucoma arrangement and is significant for glaucoma analysis. RetCam is another imaging tool that catches the picture of iridocorneal plot with the end goal of grouping. Be that as it may, manual evaluating and examination of the RetCam picture is emotional and tedious. In this paper, a framework for keen examination of iridocorneal point pictures, which can separate shut edge glaucoma from open edge glaucoma naturally is proposed. Two methodologies are proposed for the grouping and their exhibitions are looked at with a total of 1866 fundus images. First gander at the exhibition is the analysis depends on a solitary picture of the eye. At that point, it take a gander at the presentation if the conclusion depends on all the pictures caught on each eye. The exploratory outcome shows great result, particularly the width based methodology. The cost and accessibility of RetCam act as one of the major downside with this work.

A methodology of programmed foremost chamber point division and estimation technique for Angular Segment- Optical coherence Tomography (AS-OCT) symbolism has proposed by the author *Fu et al.*, in 2017 [2]. The fundamental components of this work are the presentation of marker move from named models to produce starting markers, and division of the corneal limit and iris districts to acquire clinical Anterior Chamber Angle (ACA) estimation. The tests exhibit the adequacy and heartiness of proposed technique. For evaluating the performance efficiency, 4135 AS-OCT images were taken from a local hospital. One of the impediment in this technique is that AS-OCT picture may prompt contortions of the iris shape and another difficult case is low complexity, which may prompt mis-division in the corneal limit. This makes the work inefficient.

Zahoor and Fraz [3] built up a novel optic disc and division procedure for identification of glaucoma. The technique has utilized various leveled blend of morphological tasks and Circular Hough Transform (CHT) for the Optic Disc (OD) localization. The acquired outcomes shows that the system is computationally efficient and performs well even in shifting differentiation setting, brightening changes and also within the sight of pathologies in the picture. The publically available datasets named MESSIDOR, DIARETDB1, DRIONS-DB, HRF, DRIVE, and RIM-ONE are used for evaluation. OD segmentation algorithm had the option to accomplish just a normal spatial cover on the datasets utilized for test. This technique can be used as a back born for the upcoming strategy with progress in the time proficiency.

In 2018, *Sahina et al.,* [4] proposed a work in which the G-EyeNet comprises of a profound convolutional auto encoder and a conventional convolutional neural system/network (CNN) classifier sharing the encoder structure. These multi-model system is half and half for limiting both picture remaking blunder and the classification mistake. Exploratory outcomes show that G- EyeNet gives an extensive improvement with the present learning calculations.

In a work of *Fu et al.*, [6] a blend of low- position reproduction blunders technique has proposed. The methodology depends on Retinal Pigment Epithelium (RPE) shape of eye. The structural and functional change from optic disc to RPE can be identified with high exactness in contrast with the present techniques. Likewise, a geometrical requirement named separation inclination that gives the smooth state of the RPE is presented here. This can be utilized to deal with the 3D-OCT volume, for which promising outcomes are additionally accomplished. One of the constraint found in this work is that investigation with glaucoma patients were excluded, just OD recognition of retinal pictures are engaged.

From the survey it is clear that optic disk detection and segmentation is one of the main challenging factor for diagnosing retinal diseases. In this paper, an eminent detection and localization of optic disc with optimum Marr-Hildreth operator is presented.

3. Proposed Work

The block diagram of proposed work is shown below. It includes various steps like preprocessing with Contrast Limited Adaptive Histogram Equalization (CLAHE), vessel identification with morphological operations and finally detection of optic disk with Maar – Hildreth operator.

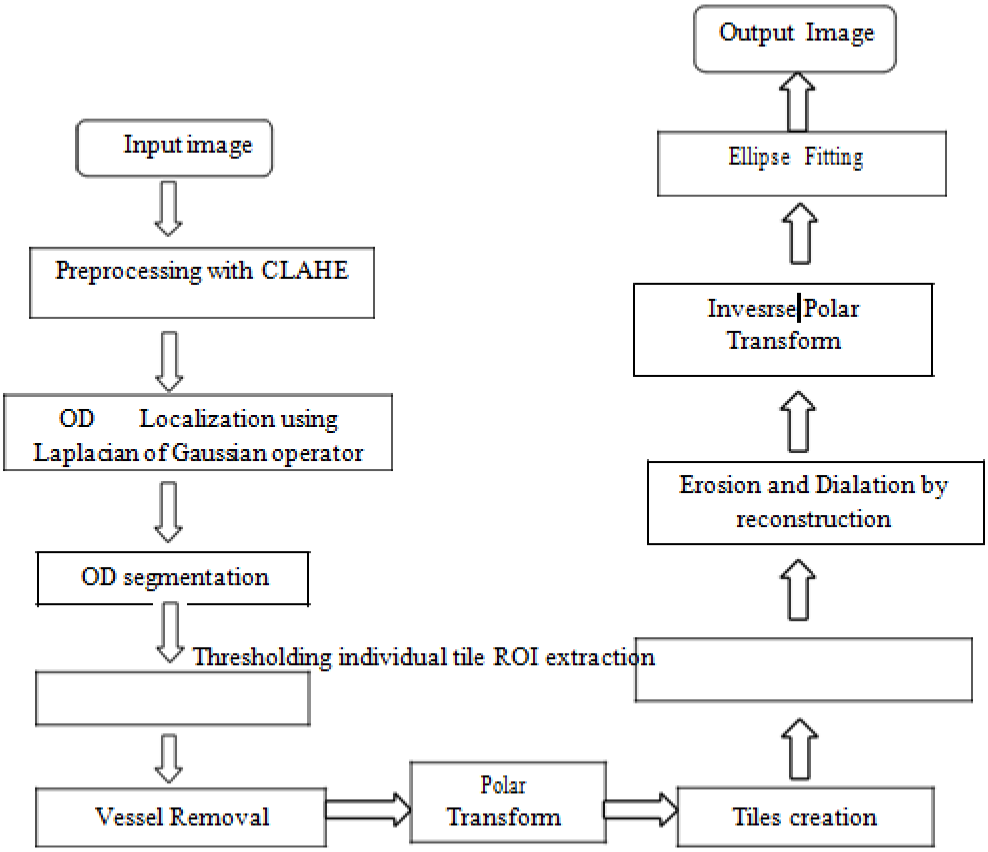

Fig 2. Proposed block diagram

Preprocessing

Preproceeing of an image is required because the selected input may contain some distortion s and that can hide most relevant information required for the experiment. The process of input data cleaning and transformation are techniques for removing noises and standardizing the input so that it can be used to construct a model more easily. During image capture things like noise, uneven illumination and contrast variations are the added challenges of automated optic disc detection and segmentation. In order to handle these images autonomously, preprocessing has to be applied. Here, CLAHE approach is used to improve the contrast of retinal images. The image is divided into small tiles by CLAHE, and local contrast is improved by equalising the corresponding histogram for each tile. Clip limitation technique is used for noise superseding in the local area. CLAHE should be run on the luminosity channel if possible. Figure 3 show the preprocessed output image in gray scale form.

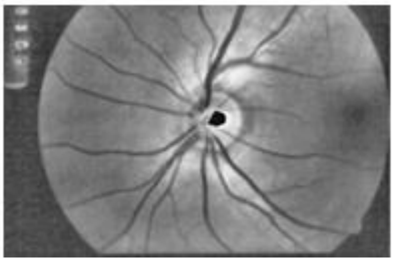

Fig 3. Preprocessed image with CLAHE

Optic disk localization

OD localization from preprocessed image is done with Marr-Hildreth operator

i) Marr-Hildreth Operator:

It is a Gaussian-based operator that takes the second derivative of an image using the Laplacian. This is especially useful when the grey level transition appears to be abrupt. It uses the zero-crossing technique, which states that when the second-order derivative crosses zero, the location corresponds to the maximum level. It's known as an edge location. The Gaussian operator is used to minimise the noise and the Laplacian operator detects the sharp edges.

The Gaussian function is given by the formula:

$$G(x, y) = \frac{1}{\sqrt{2\pi\sigma^2}} \exp - \left(\frac{x^2 + y^2}{2\sigma^2} \right)$$

Where,

σ is the standard deviation and Laplacian of Gaussian operator is computed from

$$\text{LoG} = \frac{\partial^2}{\partial x^2} G(x, y) + \frac{\partial^2}{\partial y^2} G(x, y) = \frac{x^2 + y^2 - 2\sigma^2}{\sigma^4} \exp\left(-\frac{x^2 + y^2}{2\sigma^2} \right)$$

LoG filter has following three step operations.

1. Exploits second order gradients of pixel intensity for an image.
2. Smoothening the image using Gaussian filter which can be defined by LoG (x, y) = 1 /π

3. Apply Log. The convolution mask of LoG operator is

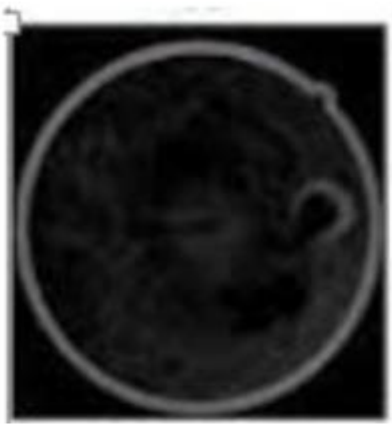

Fig 4.) Optic Disk Localization

ii) Optic disk segmentaion

To segment the optic disk, initially the region of interest 'I_{roi}' is calculated from the original image 'I_o'. It is obtained as follows

roisize= r+ c

Where,

r is the radius of the circle obtained by previous step and c is the number of additional pixels that are not part of the OD.ROI include OD pixels along with non-OD pixels. The precise boundary of OD is obtained by using Polar Transform. Polar transform can be defined as a 2D coordinate system where every point is calculated using distance from a reference point and an angle from a reference direction. Polar transform has been used a lot in automated segmentation of iris from image as is done. The process involved in this stage are explained below.

The ROI picture is measured, and the ROI's pixel coordinates are converted from Cartesian to Polar coordinates for OD segmentation. The ROI image's core serves as the origin point. The OD has been straightened as a result of this transformation. After that, the OD is divided into sub-tiles. Each tile is subjected to morphological erosion by reconstruction, followed by morphological dilation by reconstruction. Since a precise boundary of the Optic Disc is required at this stage,

morphological opening and closing is avoided, as this would eliminate the retinal structures that will be used as end boundary points to differentiate between Optic Disc pixels and the rest of the image. The shape of the components is preserved when opening by reconstruction.

Each tile is then thresholded using adaptive thresholding after being opened by reconstruction. If the output tile is successfully thresholded into two regions, it is passed on to the next level in its current state. If this is not the case, a blank tile (all black) will be forwarded. After that, the tiles are mixed and the Polar to Cartesian transformation is used. The ellipse equation is then used to draw an ellipse over the boundary obtained by thresholding. This determines the exact OD boundary.

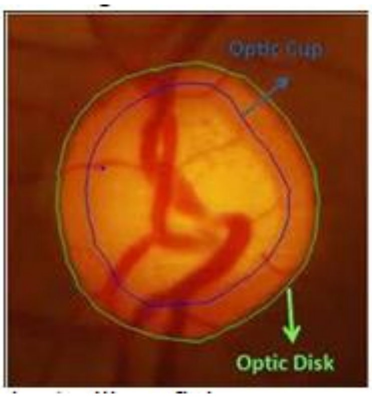

Fig 5) Ellipse fitting

4. Conclusion

In medical image analysis, image segmentation is crucial. This paper introduces and explores a different technique for defining the optic cup and optic disc, determining the radius by segmenting out the optic cup and optic disc, by using the Marr-Hildreth operator and polar transform from the fundus image. In terms of time efficiency, the proposed technique outperforms all previous approaches and needs less computational resources. Further this work can be expand into deep learning architecture centered on convolutional neural network to detect glaucoma by including multiple features.

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