SEGMENTATION OF OPTIC DISC IN RETINAL IMAGES USING CUMULATIVE SUM FIELDS AND VESSEL ENHANCEMENT METHODS

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***Abstract*— Our model describes an automatic method for the optic disc localization in retinal images. The described method reveals very effective dealing with retinal images with large pathological signs. The algorithm begins with a new vessel enhancement method based on a modified corner detector. Subsequently, a weighted version of the vessel enhancement is combined with morphological operators, to detect the four main vessels orientations *f*0*o;* 45*o;* 90*o;* 135*og*. These four image functions have all the necessary information to determine initial optic disc localization, resulting in two images that are respectively divided along the vertical or horizontal orientations with different division sizes. Each division is averaged creating a 2*D* step function, and a cumulative sum of the different sizes step functions is calculated in the vertical and horizontal orientations, resulting in an initial optic disc position. The final optic disc localization is determined by a vessel convergence algorithm using its two most relevant features; high vasculature convergence and high intensity values.**

Keywords—Blood vessel, optic disc, segmentation, identification, detection, retinal vessels enhancement.

I.INTRODUCTION

The eye and retinal diseases such as diabetic retinopathy, occlusion, and glaucoma are the major causes of blindness in the developed and developing countries. The detection and quantitative measurement of different parts of retina such as blood vessels, optic disc, and fovea, is an important step in the computer-aided diagnosis of these diseases. Manual or semiautomatic detection of retinal landmarks is labor intensive and timeconsuming, especially in a large database of retinal images. Thus, the development of automatic methods for robust detection of these landmarks is valuable. In the literature, several techniques have been reported for detecting and analyzing retinal landmarks like blood vessels, fovea, and optic disc. Since the vessels are originated from the center of the optic disc, some methods have tried to find the strongest vessel network convergence as the primary feature for detection of the optic disc. The center of the optic disc can be estimated as the convergence point of vessels. The direction of vessels in the optic disc is another feature of this region that has been used to estimate the location of the optic disc. Since the directions of the main vessels inside the optic disc are vertical, Youssif et al. have proposed the directional matched filter to highlight this feature of the optic disc region. The center of the optic disc is estimated as a point with the highest response to the directional matched filter.

In this paper, an efficient method is presented for automatic extraction of the optic disc location and boundary. The first is Cumulative sum fields and second approach is Vessel Enhancement method.

Image Processing:

Image processing is a method to perform some operations on an image, in order to get an enhanced image or to extract some useful information from it. It is a type of signal processing in which input is an image and output may be image or characteristics/features associated with that image. Nowadays, image processing is among rapidly growing technologies. It forms core research area within engineering and computer science disciplines too.

Image processing basically includes the following three steps:

- Importing the image via image acquisition tools;
- Analyzing and manipulating the image;
- Output in which result can be altered image or report that is based on image analysis.

There are two types of methods used for image processing namely, analogue and digital image processing. Analogue image processing can be used for the hard copies like printouts and photographs. Image analysts use various fundamentals of interpretation while using these visual techniques. Digital image processing techniques help in manipulation of the digital images by using computers.

1.Analog Image Processing:

The analog image processing is applied on analog signals and it processes only two-dimensional signals. The images are manipulated by electrical signals. In analog image processing, analog signals can be periodic or non-periodic. It refers to the alteration of image through electrical means.

Examples of analog images are television images, photographs, paintings, and medical images etc.

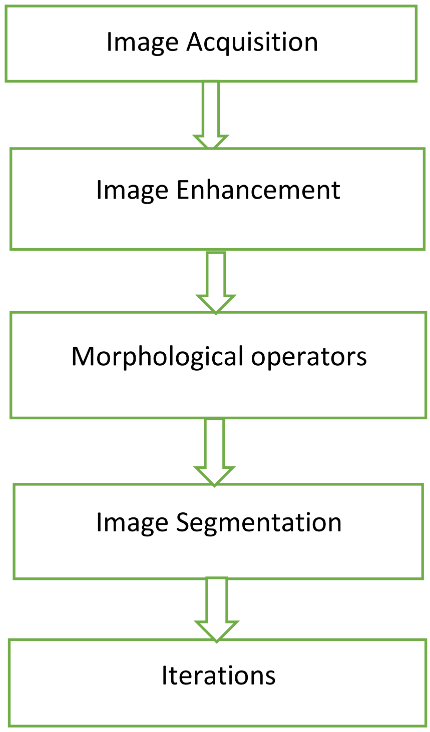
2.Digital Image Processing:A digital image processing is applied to digital images (a matrix of small pixels and elements). For manipulating the images, there is a number of software and algorithms that are applied to perform changes. Digital image processing is one of the fastest growing industry which affects everyone's life.

Examples of digital images are color processing, image recognition, video processing, etc.

Steps used in image processing:

1. Image Acquisition
2. Image Enhancement
3. Image Restoration
4. Color Image Processing
5. Compression
6. Morphological Processing
7. Image Segmentation
8. Image Representation

FLOW CHAT REPRESENTATION OF IMAGE PROCESSIING STEPS:



II. RELATED WORK

1.N.S.Kavitha, N.Kasthuri, K.Hemalatha, G.Ravivarma "Automatic Diagnosis of Glaucoma using Image Processing Technique" (IJITEE) ISSN: 2278-3075, Volume-9 Issue-2, December 2019.

Glaucoma is a human eye condition which will affect the optic nerve present in the retina. This condition occurs due to the abnormal ocular pressure in human eye. If it is not diagnosed and treated well in advance, it may lead to blindness. This is the major problem of elderly people all over the world. The best way to avoid vision loss due to glaucoma is to detect the disease at the early stage and treat it as soon as possible. These are the keys to prevent blindness. As vision is an important organ in human body it is advisable to keep it healthy. The optic cup in the retina will be pulled in towards the optic nerve away from the optic disc. At one point, the cup will be detached from the retina, causing blindness. So if one can monitor by measuring the optic disc to cup ratio, the progression of glaucoma can be diagnosed earlier. The proposed method detects the optic disc and cup using thresholding method. Direct least square fitting algorithm is used here to fit the ellipse in order to calculate the cup height and disc height. Then the ratio is calculated. If the calculated ratio is above the threshold value, it is considered as glaucoma affected eye otherwise not. The CDR is calculated using the formula VDH/VCH (Vertical Disc Height to the Vertical Cup Height). Thus, the proposed method helps to automatically detect the glaucoma disease with better sensitivity and specificity.

2. Ahmed E. Mahfouz and Ahmed S. Fahmy* "Fast Localization of the Optic Disc Using Projection of Image Features" January 2011.

Optic Disc (OD) localization is an important preprocessing step that significantly simplifies subsequent segmentation of the OD and other retinal structures. Current OD localization techniques suffer from impractically-high computation times (few minutes per image). In this work, we present a fast technique that requires less than a second to localize the OD. The technique is based on obtaining two projections of certain image features that encode the x- and y- coordinates of the OD. The resulting 1D projections are then searched to determine the location of the OD. This avoids searching the 2D image space and thus enhances the speed of the OD localization process. Image features such as retinal vessels orientation and the OD brightness are used in the current method. Four publicly-available databases, including STARE and DRIVE, are used to evaluate the proposed technique. The OD was successfully located in 330 images out of 340 images (97%) with an average computation time of 0.65 seconds.

3.Murugan Raman1, Reeba Korah2, and Kavitha Tamilselvan3 1College of Engineering Guindy, Anna University, "An Automatic Localization of Optic Disc in Low Resolution Retinal Images by Modified Directional Matched Filter" (IJIT)Vol. 16, No. 1, January 2019.

An automatic optic disc localization in retinal images used to screen eye related diseases like diabetic retinopathy. Many techniques are available to detect Optic Disc (OD) in high-resolution retinal images. Unfortunately, there are no efficient methods available to detect OD in low-resolution retinal images. The objective of this research paper is to develop an automated method for localization of Optic Disc in low resolution retinal images. This paper proposes a modified directional matched filter parameter of the retinal blood vessels to localize the center of optic disc. The proposed method was implemented in MATLAB and evaluated both normal and abnormal low-resolution retinal images using the subset of Optic Nerve Head Segmentation Dataset (ONHSD) and the success percentage was found to be an average of 96.96% with 23seconds.

III. PROBLEMS FACED ON EXISTING SYSTEM

- Model-based methods depend mainly on extracting and analyzing the structure of the retinal vessels and defining the location of the OD as the point where all the retinal vessels originate.
- Techniques such as geometrical models, template matching, and convergence of vasculature, have a relatively high success rate in diseased images, but they are computationally very expensive because they require segmentation of the retinal vessels as an initial step of the localization process.
- Often fail on pathological images, where other regions of fundus may be characterized by round shape and/or elevated brightness, e.g., large exudative lesions.
- No automatic system for the localization of OD in the retinal images.
- No possibilities for immediate analysis of the retinal information.

They can be divided in two main approaches: Appearance based methods and model-based methods. Appearance based methods, rely on shape characteristics and on the fact that the OD is usually the brightest region in normal retinal images.

Model-based methods make use of the vasculature information and of the fact that the vessels emerge from the OD. This approach tends to be the most effective and reliable, even in the presence of retinal diseases. Most relevant examples of this approach are the geometrical model proposed by Foracchia et al, where there tinal vessels are model led as two parabolas, with the vertex located in the OD position. Fuzzy convergence is a voting type algorithm developed by Hoover et al., where the originating vessel map convergence point near the OD center is determined. Kande et al. proposed to identify the region with most vessels' branches, and thus the OD localization. Youssif et al. and Frank terHaar, proposed to fit the vasculature orientations on a directional model, being the OD located in the point where the maximum matching is achieved. Tobin et al. segmented the retinal vasculature and considered several OD and vessel properties. Subsequently a two-class Bayesian classifier and some prior knowledge is used to predict the OD localization. Although most of these methods result in effective OD localization, they tend to require large computation time, becoming impractical for clinical use. Hence, a recent effort has been made for the development of simultaneously fast and reliable methods. Mahfouz et al. developed a technique where two projections of certain image features that encode the x and y coordinates of the OD are obtained. The resulting 1D projections are then searched to determine the localization of the OD. Yuetal initially determines the using template matching at different resolutions subsequently.

IV.PROPOSED WORK

We propose an efficient and reliable method for OD localization in retinal images. Several important contributions are made. First, a new vessel enhancement is proposed. Second, a new technique designated by cumulative sum fields is introduced. Third, the proposed method was tested in a large number of publicly-available datasets achieving an improved performance to other state-of-the-art methods. Fourth, a detailed performance comparison is made with a large number of several methods.

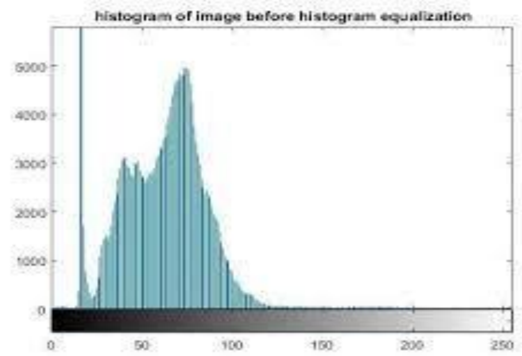
The retinal image is taken from Drive database. Optic disc and cup is the area of interest. So the disc and cup are located and localized. The Disc and cup are segmented using thresholding technique. Elliptical fitting is achieved through Least Square criterion algorithm to fit the ellipse on the disc to measure the vertical height. Once the height of the disc and cup are measured, it is applied to the formula to get the cup to disc ratio. If the obtained value is above 0.6 then it is considered to be abnormal eye. If it is less than 0.6, it will be considered as normal eye. This automatic method will assist ophthalmologist to diagnose the eye disease more quickly without going for multiple opinions. But to achieve the correct CDR, the segmentation of the cup and disc should be accurate. Thresholding technique used here has high percentage of accuracy in segmenting the cup and disc region.

V.MATERIALSANDMETHODOLOGIES

The materials and methods used in this paper are shown below:

A.HISTOGRAMEQUAILIZEDIMAGE

Histogram equalization involves transforming the intensity values so that the histogram of the output image approximately matches a specified histogram. By default, the histogram equalization function, histeq, tries to match a flat histogram with 64 bins, but you can specify a different histogram instead.



B. CUP TO DISC RATIO CALCULATION

The developed methodology is tested on 30 different retinal images obtained from the database. The Optic Cup to Optic Disc ratio (CDR) value is obtained using the following formula,

- •CDR = Vertical Cup Diameter (VCD) / Vertical Disc Diameter VDD.

The blood vessels enter into the retina from optic disc. So the retinal image will have the blood vessels near the optic disc. The objective here is to locate the optic disc and remove the blood vessels near the disc and then segment the OD (optic disc) and OC (optic cup).

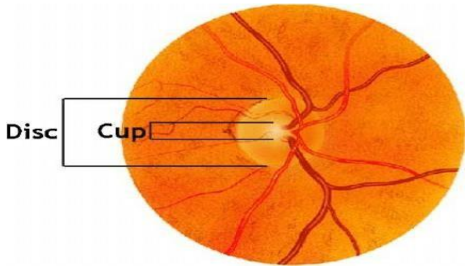


Fig: Retinal image with optic disc and cup marked

C. REGION OF INTEREST

The sub region of the image for which the image processing is needed is referred as region of interest. In the proposed method, the image taken is the fundus image. The fundus Image has all the retinal information such as blood vessels, macula, fovea, arteries, optic disc and optic cup. Here the optic disc and cup are the area of interest. The disc region is localized using edge detection algorithm. Usually a binary mask is created to get the region of interest. Here the aim is to get the optic disc using a filter or mask. The mask is of the same size of the image but the region of interest is set to 1 in the mask and rest of the pictorial elements are set zero. The disc region may be specified using any of the mathematical primitives, such as point, line, circle, polygon etc.

D. VESSEL ENHANCEMENT

A good vessel enhancement method must be fast and minimize the detection of non-vessel structures or pathological signs [21], [22]. The influence of noise and the presence of bright central reflections in arteries must also be considered. The proposed vessel enhancement is specifically constructed to deal with all the previous mentioned aspects, being a modified version of the corner detector. First, we create a filtered image L by blurring IG with a normalized Gaussian filter with a $\sigma = 4$ and a kernel size of [13×13], reducing noise and eliminating the arterial central bright regions. The initial corner detector K proposed is, $K = (\nabla 2L)2 - c|\nabla L|2$, where $\nabla 2L$ is the Laplacian and $|\nabla L|$ is the absolute value of the gradient of the image L, considered as an intensity surface. K enhances regions where a rapid change in the edge direction occurs. The parameter c defines how edgephobic is K, being set to $c = 1$ in our implementation.

E. THE FOUR MAIN VESSELS ORIENTATIONS DETECTION:

The retinal vessels emerge from the OD vertically and branch out horizontally. Although other regions in retina may have vertical vessels (e.g. around macula), these are thinner than the ones around the OD. Between the vertical and horizontal orientations, the vessels assume mainly oblique (approximately 45o and 135o) orientations. Morphological operators provide an efficient extraction methodology of the four main vessels orientations $\alpha = \{0o,45o,90o,135o\}$. Since we intend to enhance linear structures, a logical choicefor a structuring element is a “line” with a variablelength and a variable angle covering both the short and long vessels.
The morphological opening of Γ by a “line” structuring element S with an angle θ and a length l, can be defined as, $\gamma = \Gamma \circ S\ \theta\ l$. The opening operation is performed in a set of θ values, and the maxima are detected for each l value. The orientation vessel enhancement in the α orientation is defined as the summation of the maxima obtained for each l value, with, For each $\alpha =$ $\{0o,45o,90o,135o\}$, the following θ values are used specifically,

F. INITIAL OD DETECTION

The orientation vessel enhancement functions $\gamma\alpha$, provide all the necessary information for the determination of an initial OD position, designated by (px, py). To calculate (px, py) the horizontal px, and vertical py coordinates are determined separately. Two specific functions, one for each coordinate respectively are created according to the following equations, $f1 = \gamma 0o - \gamma 90o$ and $f2 = \gamma 90o + \gamma 45o + \gamma 135$
Although the vessels that emerge from the OD have a dominant vertical orientation, in some cases they can exhibit some variation. The same situation can be found when the vessels branch horizontally, where they also exhibit some variation. Hence, to improve the method

reliability, both vertical and horizontal orientations also consider oblique orientations.

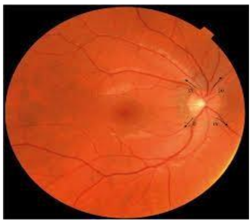


Fig: Initial OD detection

G. FINAL OD DETECTION

The final step of the described method consists of the determination of the final OD localization. To achieve this, a technique based on the two most distinct features of the OD was developed: High convergence of vessels and high intensity values. First, vessels convergence regions are defined. Subsequently the maximum point of the vessels convergence, designated by (cx,cy), is computed inside those regions.

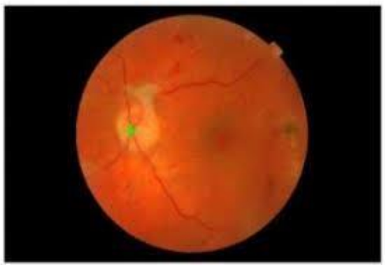


Fig: Final OD Detection

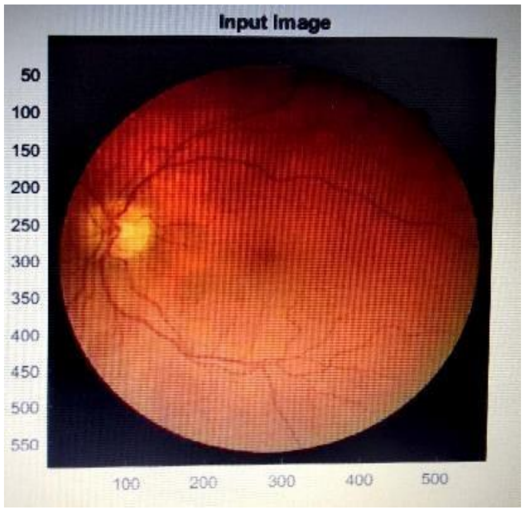
OD Localization results:

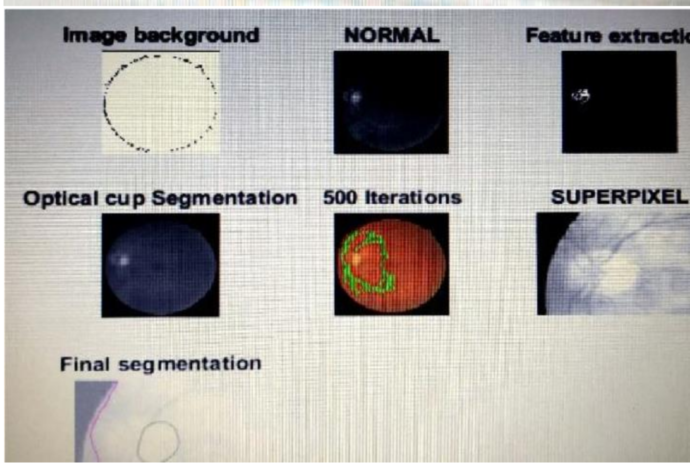
A MATLAB algorithm of the proposed method was implemented on a laptop with 2 GHz Intel Core i7 and 6 GB of RAM. Quantitative results for the proposed method without the final localization.

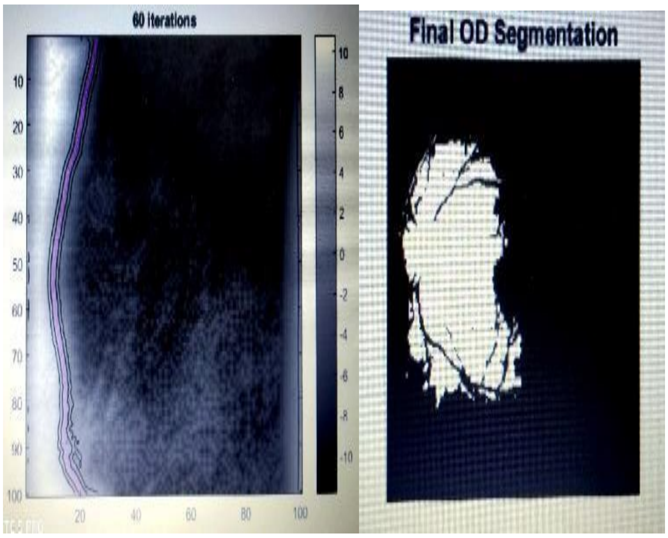
VI. EXPERIMENTAL RESULTS

The proposed method was implemented in MATLAB R2015 where runs needed an average of 23 seconds for each image on a laptop intel Dual-Core i5 CPU and 8.00 GB RAM 64-bit OS). The proposed method was evaluated both normal and abnormal low-resolution retinal images using the subset and the success percentage was found to be 99.96%. The optic disc center is located correctly in 96 out of 99 images (Normal: 30, Glaucoma: 38, DR: 31).

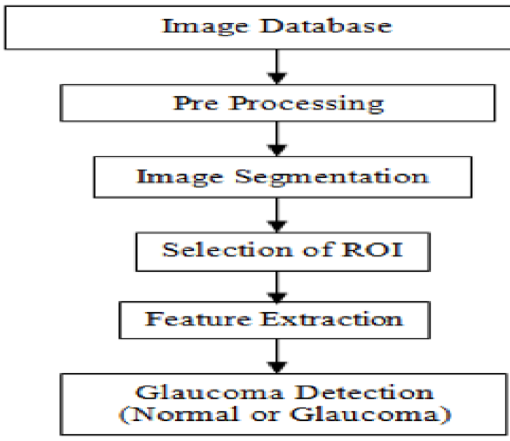
The results of this optic disc localization are shown in the following figures:







VII.ARCHITECTURE



VIII.CONCLUSION

This paper presented a most efficient technique for OD center detection. This will help the ophthalmologists in diabetic retinopathy and other eye disease screening process to detect symptoms faster and more easily. This is not the final result of application but it can be a preliminary diagnosis tool or decision support system for ophthalmologists. Human ophthalmologists are still needed for the cases where detection results are not very obvious.

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