Automatic Fovea Detection and Grading of Diabetic Maculopathy Severity Levels

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***Abstract*—In this work, localization of the fovea automatically is done by getting information of the Optic Disk and the blood vessel structure and hence to localize the fovea region further accurately by mathematical morphology method. The algorithm which proposed has two stages such as the first stage deals with the detection of the blood vessels of the retinal fundus image and then the proceeding stage utilizes the geometrical distance between Optic Disk and fovea region and the structure of the blood vessels to perfectly localize the fovea region. The extracted macula and fovea region may help in further automatic detection and grading the severity level of diabetic maculopathy.**

***Index Terms*— blood vessel, optic disk, fovea, diabetic maculopathy, mathematical morphology.**

I. INTRODUCTION

Image processing, analysis and computer vision techniques are widely used today in all fields of medical sciences and especially to modern ophthalmology, as it is heavily dependent as visually oriented signs[1]. Hence retina is the only location where blood vessels can be directly visualized non-invasively in vivo.

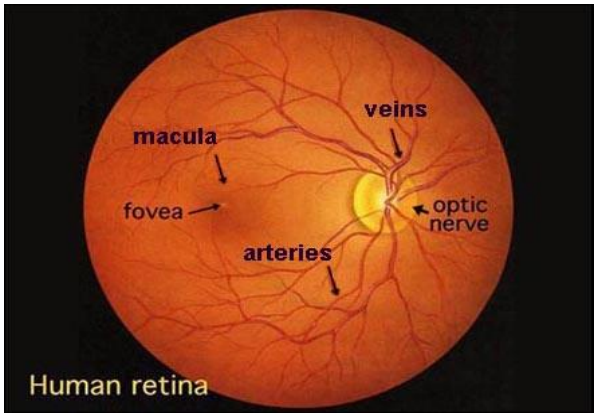

Fig.1.The human retina

In colour fundus images optic disk and fovea are two important anatomical landmarks that is used in retinal disease screening .This paper presents a new, fast, fully automatic optic disk and fovea localization algorithm has been developed for diabetic maculopathy.

The optic disc or optic nerve head is the location where ganglion cell axon exits the eye to form the optic nerve. The fovea is the part of the eye located in the centre of the macula region of the retina. The fovea is responsible for sharp central vision [2] .The foveal region is made up of cones if the delicate cones in the fovea are destroyed the person become blind .Manual detection of fovea region by ophthalmologist is time consuming hence automation is highly needed. Hence this paper mainly deals with fovea localization in which the fundus retinal image the macula is the most darker part approximated by a circle and also geometrically fovea is said to be located at a distance 2.5 times the diameter of the optic disk from its center. Thus fovea localization thus have done using morphological operation and geometric features. After locating the fovea and macular region depending upon the diameter variations the disease such as diabetic maculopathy severity level is estimated. The diabetic maculopathy is a pathological disorder of the macula which frequently develops in diabetic patients. It is charactized by odemea, hard exudates, micro aneurysms and ischemia in the macular area. If the odemea is severe visual acuity will be reduced but a blue-yellow colour vision defect is usually noted before the loss of acuity.

II DATA COLLECTION

The retinal images are collected from DRIVE database. The drive database images are acquired using a canon CR5 non-mydriatic 3CCD camera with a 45 degree field of view [3]. Each image was captured using 8 bits per color plane at 768 by 584 pixels. The FOV of each image is circular with a diameter of approximately 540 pixels. For this database, the images have been cropped around the FOV.

III PROPOSED METHOD

The method has four parts:

Blood vessel extraction
Optic disk detection
Fovea detection
Grading the diseased part

A) ALGORITHM FOR BLOOD VESSEL EXTRACTION

The blood vessel is a network like structure. The optic disk originates from the blood vessel and hence the blood vessel extraction is mainly used for optic disk detection. Fovea is an region where there is no blood vessel and hence this criteria is also helpful in finding the foveal region[4].

There are several methods adopted for blood vessel extraction such as blood vessel extraction by two dimensional matched filters[5], the ridge based blood vessel extraction[6] .The method adopted in this blood vessel extraction is morphology based scheme which is an simple enough and most accurate[7][8].

Step 1 The image is taken and read in MATLAB.
Step 2 The colour image is converted to gray scale image.
Step 3 The image is resized for further processing.
Step 4 The morphological opening operator is applied on image with disk shaped structuring element.
Step 5 The morphological closing operator is used to remove vessel structure.
Step 6 The top hat transformation is used on the image to extract the blood vessel structure.
Step 7 The image is then converted to binary image by thresholding.
Step 8 By using connected component analysis extract the blood vessel from the image.

B) ALGORITHM FOR OPTIC DISK DETECTION

There are various methods that has been proposed for optic disk detection such as geometric model of vessel structure [9], optic disk detection by adaptive morphological approach [10]. In this work the optic disk detection is based on median filter method since optic disk is having highest intensity pixel the suitable median filter is used to extract optic disk [11].

Step 1 A mask is generated for the particular region of interest (i.e) optic disc over the image.
Step 2 The mask is the applied over the image.
Step 3 The morphological operators closing and opening were applied to give the final ROI.
Step 4 After the detection of optic disk the diameter of the optic disk is calculated.

C) ALGORITHM FOR FOVEA DETECTION

The fovea detection is done depending on the information of the optic disk diameter estimation [4]. It has been found that fovea is located at 2.5 times the diameter of the optic disk .Hence using this calculation fovea detection is done [12].

Step 1 Locate a point P horizontally at a distance 2.5×d from G towards the centroid.
Step 2 Consider a vertical strip of width k pixels around P perpendicular to GP.
Step 3 Apply a k × k sliding window along the strip and form the chain of numbers denoting the black pixels in the window.
Step 4 Find the maximum run length of zeros, L in the number chain.
Step 5 Let S and E are the start and end position corresponding to L and D be the mid position of S and E.
Step6 Consider a binary image BW of size same as the input image with only a black pixel at position D. Dilate BW by a disc of radius DS to obtain BWd.
Step 7 Obtain R as the portion of the gray-scale image, $I1$ corresponding to the black region in BWd.
Step 8 Binarize R to approximate macula region.
Step 9 Refine binarized R by removing noise and fitting the circle to obtain final macula region.
Step 10 Detect fovea region as the small area around the center of macula.

D) ALGORITHM FOR DIABETIC MACULOPATHY SEVERITY LEVELS ESTIMATION

The grading of diabetic maculopathy is done in such a way that once the optic disk diameter and fovea region is estimated [13] .The macula which is surrounding the fovea is drawn three circles with radii 1/3 of optic disc diameter such as 1 DD (Disk Diameter) ,2 DD,3 DD. Then the grading is done in such a way that [14]

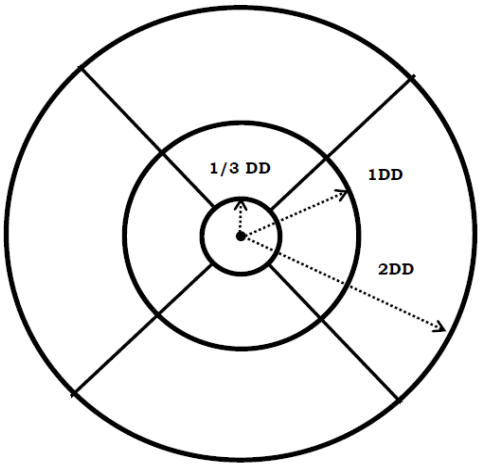

Fig. 2.Grading of diabetic maculopathy severity level

Table 1: Classifications of various levels

LOCATION	CONDITION
Exudates absent	Normal
Exudates present but outside 2 DD	Clinically Non Significant Diabetic Macular Edema
Exudates present inside 2 DD	Clinically Significant Diabetic Macular Edema
Outside 1DD	Mild
Inside 1DD	Moderate
1/3 DD	Severe

IV RESULTS AND DISCUSSIONS

We have tested our proposed algorithm in a publically available DRIVE database. The method was implemented in MATLAB and testing of fovea was done in following images.

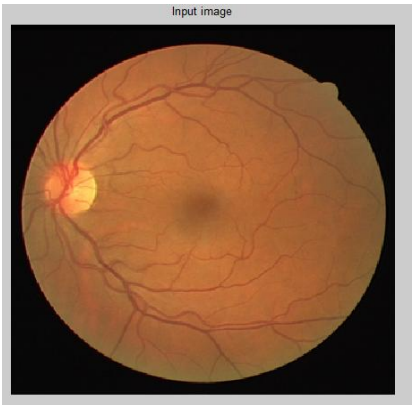

Fig.3. Input retinal image

Fig.4. Gray scale image

Fig.5. Opening the image

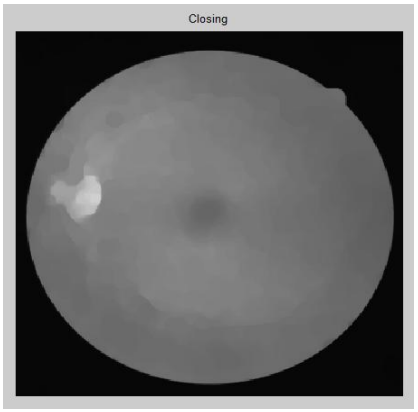

Fig.6. Closing the image

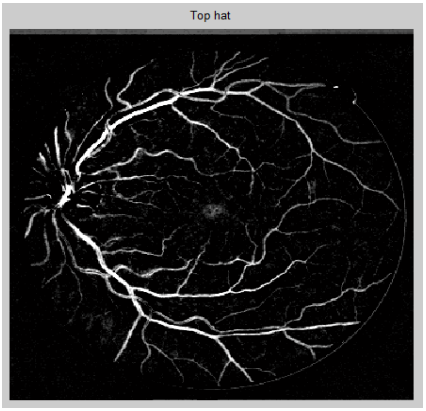

Fig.7.Top Hat transformed image

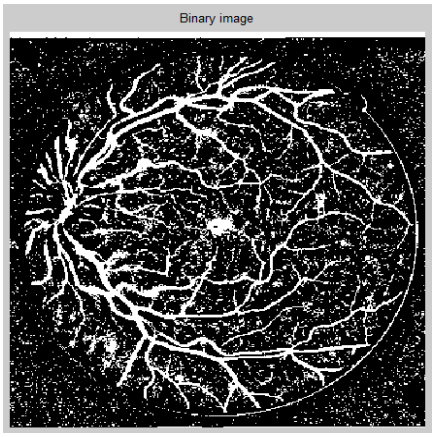

Fig.8. Binarised image

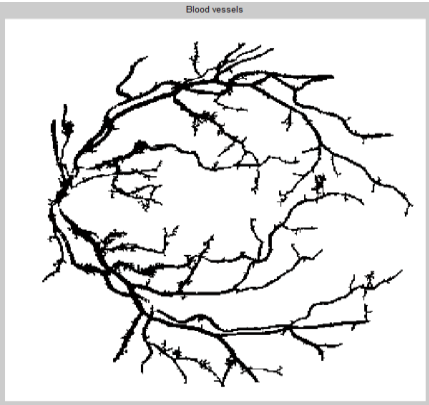

Fig.9. Blood vessel extracted image

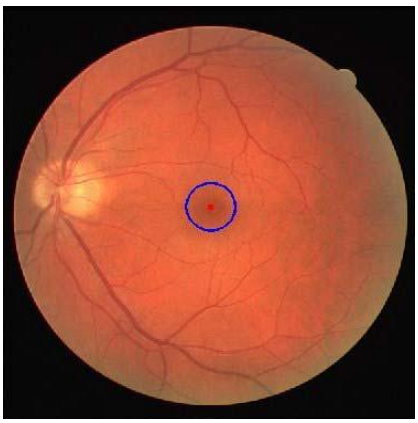

Fig.8.Fovea detected image

IV CONCLUSION AND FUTURE ENHANCEMENT

In this paper fovea detection has been done by getting information of the optic disk and extracted blood vessel. The main algorithm proposed are based on image morphology. This algorithm has been tested on retinal images and this method has been used for automatic fovea detection which replaces any manual intervention. Thus in the future work fovea detections are then mainly used for grading of diabetic maculopathy severity levels.

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