ISSN (Online) 2278-1021
ISSN (Print) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 4, Issue 6, June 2015

Automated Glaucoma Detection in Retina from Cup to Disk Ratio Using Morphology and Vessel Bend Techniques

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Abstract: Retinal image analysis is gaining popularity due to automated disease detection. More and more opthalmists are performing computer aided scanning of the eye. In such an environment, sophisticated feature extraction of retina can lead to better diagnosis of the eye diseases. Retinal image analysis is challenging because different parts of retina like cup, disk and vessels are independent entities and yet affects the detection of one another. Past works of retinal feature analysis is focused towards extraction of either disk area of the retina or the vessels. The study of retina abnormality and its detection is also studied under separate algorithm. Firstly, morphological technique is used to extract the disk ROI. We then locate the disk area by calculating the vessels and determining the bend. An iterative process is adopted for detecting the Cup area within the disk that follows the energy flow towards the bend. Green color channel analysis method is used for vessels extraction. We also compare canny edge based boundary tracing for Disk detection with that of Circularity based boundary tracing technique. Therefore in this paper we develop a framework for automated retinal feature analysis which can detect the retina features like cup, disk, vessels and finding of CDR ratio.

Keywords: Optic cup to disk ratio, Vessel bend extraction, canny edge, Circle based tracking.

I. INTRODUCTION

Glaucoma is one of the leading causes of blindness with about 79 million in the world likely to be afflicted with glaucoma by the year 2020 [13]. It is a disease of optic nerve which involves loss of retinal ganglion cells in a characteristic pattern of optic neuropathy. As blood has pressure same way eye has pressure called Intraocular pressure (IOP). When this IOP increases to certain level then it causes damage to optic nerve which leads to eventual blindness. There are basically two types of glaucoma one is open angle or chronic glaucoma and another is closed angle or acute glaucoma, both are responsible for increasing of IOP [14]. The Cup to Disc ratio (CDR) is a key indicator for the detection of Glaucoma. The optic disk (OD) is an area where ganglion cell axons exit from the eye to form optic nerve through which visual information of photo receptors is transmitted to the brain. The OD can be divided into two distinct regions namely, a central bright region called cup and a peripheral region called neuroretinal rim where the nerve fibres bend into cup region [15].The wide seen diseases of retina are hypertension, diabetes and generally retina is subjected to factors that affect human vasculature.

Disk is the brightest part of the retina image. Therefore most of the past work suggests thresholding based disk detection. However if there are abnormalities in the eye, those abnormalities also appear as bright spot. This affects the accuracy of the disk detection adversely. Therefore more sophisticated disk detection technique needs to be developed that can detect the disk area accurately even in the presence of such abnormalities.

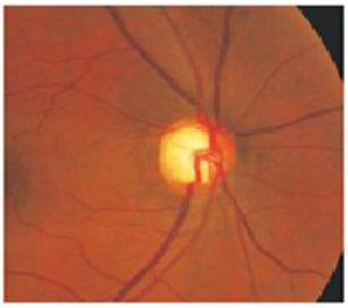


Fig 1.Fundus photograph of an increased cup to disk ratio in a patient who is being observed as a glaucoma suspect

Vessels can be extracted as contours from the green channel. Most of the past literature suggests that vessels can be detected using edge detection method like canny by equalizing the green channel. In abnormal retina, the glaucoma part may appear as vessels. Therefore technique needs to be developed that can eliminate such abnormalities and detect the vessel. Also the disk area and its boundary must not be accepted while detecting the vessel part.

Glaucoma detection on the other hand deals with detection of CDR Ratio. CDR ratio calculation is a challenging task and semi automated techniques are mainly being used. However in such techniques partial user input like cup and disk ROI is essential. But this needs prior knowledge of the domain. The objective of this work is to develop a single retina analysis system that

ISSN (Online) 2278-1021
ISSN (Print) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 4, Issue 6, June 2015

can perform all the aforementioned parts with high accuracy.

II. PROPOSED SYSTEM

Proposed system is divided into three distinct parts: Disk extraction, cup extraction, vessel detection and lesion detection.

Disk extraction is performed in two stages: ROI extraction and disk boundary detection. In ROI extraction first a probable disk area is located by thresholding the image and selecting part of the image with highest brightness with largest area. This ROI image is then processed to detect the exact disk boundary. The process is fast as no classification is employed and entire region is processed together. Once the disk area is obtained, cup needs to be located within this boundary. But due to convergence of the vessels in the disk, the cup suffers discontinuity. In order to overcome this problem, tracking based vessel detection is employed. Once vessels are detected, they are masked within the disk boundary. Now cup can be extracted using region growing technique. Region growing technique calculates the angle of the vessels within the disk area and merges the algorithm towards it. Therefore the detection starts from boundary and converges towards the center.

Vessels are detected by first calculating the high frequency components and the selecting lines with direction towards the center. This process eliminates other high frequency components like disk and cup boundaries from the vessel extraction. However the method suffers from inclusion of the lesions. We therefore post process the detection to eliminate the vessels with smaller length and which are at different directions.

Once Cup and Disk area are detected, they can be used to calculate cup to disk ratio. This ratio is used to determine the Glaucoma. The database offers truth images along with the retina image. The truth image provides a mask of the actual disk boundary. We determine the accuracy of the system by comparing the detected disk mask with the given mask. The below figure 2 illustrates the overall block diagram

III. IMPLEMENTATION

A. Disk Extraction

First all the three channels constituting the image are separated. Each of these three images is threshold where the threshold values for the channels are 80%, 90% and 90% for Red, green and blue channels respectively. These binary images are then anded to get the final mask image which presents the probable disk area. The detected area is as shown below in figure 2. We can clearly see that the boundary of this disk region is not smooth. Therefore it is processed using morphological operation.

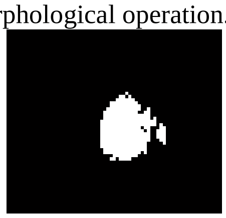


Fig.2

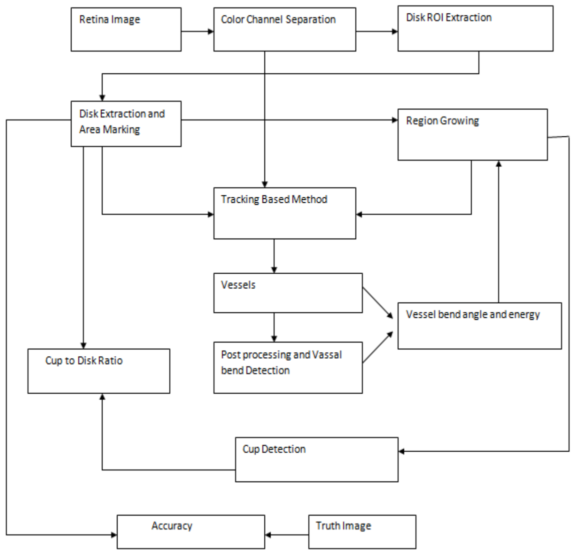


Fig 2.Overall Block Diagram

Then the ROI extraction is performed. ROI image is as shown below in figure 3

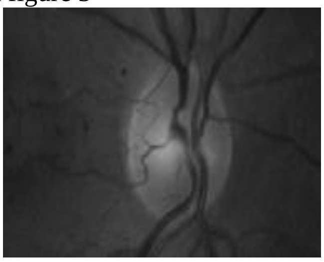


Fig.3.ROI Image

Once the disk ROI is located, disk is extracted from this. Firstly the ROI image's red channel is extracted and Histogram equalization is performed. Now we obtain a binary mask. This process completely eliminates the inner vessels as shown in figure 4.

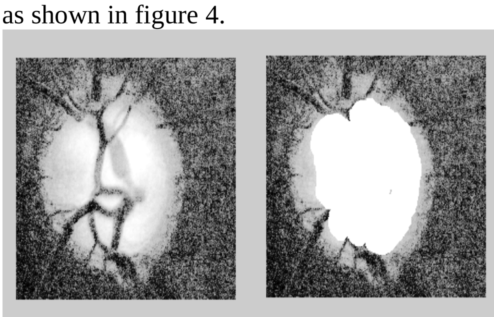


Fig.4

The dialated edge detected over the disk area is superimposed over the image to obtain the actual disk as shown in the figure 5.

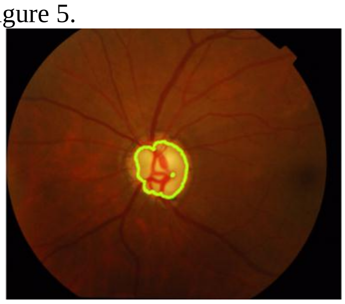


Fig.5.Actual Disk

ISSN (Online) 2278-1021
ISSN (Print) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 4, Issue 6, June 2015

Next vessel extraction is performed. Vessel Extraction process first extracts the green channel and then perform histogram equalization. It follows the process by extracting the edges in the images which is median filtered. Firstly the whole image boundary is extracted so that it can be segmented out from the rest of the detection process. Detection takes processed green channel and the boundary edge image. These images are generated from a function by name: FnTrackInt8. This function calculates the edge boundary. We now take two thresholds 0 and 100 and keep checking in the image pixels where neighbor pixels satisfy these thresholds. Finally we select the pixels which are in range of the area that satisfies both high and the low pixels. Then calculate the area which contains high frequency components inside the detection method using iterative process and the result is obtained in the figure 6.

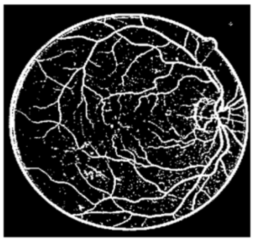


Fig.6

It can be seen that this part has vessels as well as exdudes and boundary. It's corresponding edge boundary as detected earlier is given below in figure 7

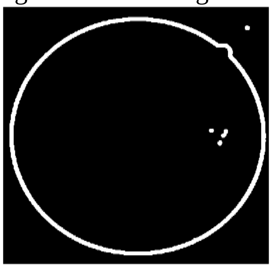


Fig.7

If we subtract both these images shown in figure 6 and figure 7 we can eliminate the edge as shown in figure 8.

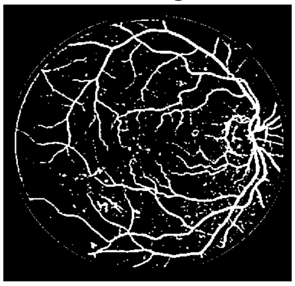


Fig.8

However the above image still has plenty of exdudes. These are removed using median filtering and smoothing the image using line operation in all possible directions.

B. Vessel Bend Extraction

Vessel bend is the technique used for extracting the cup. Here first, from 0' to 180' all possible angles are considered. Vessel orientation is calculated and each angular bend are strengthened. Now we obtain a cleaned image as shown in figure 9

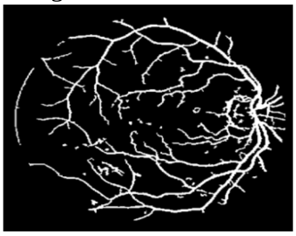


Fig.9.Vessel Image

The cleaned image obtained is known as the vessel image and is now superimposed over the original retina image to get an approximation of the vessel structure as shown in figure 10.

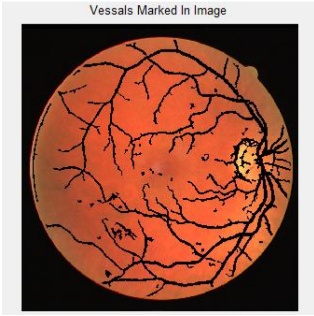


Fig.10

Having obtained the vessel image we also load the truth image provided with the database and compare the percentage of the similarity of the truth image with the actual edge as shown in result section.

IV. RESULT

A. Accuracy on Circle Based Method

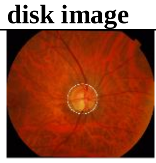
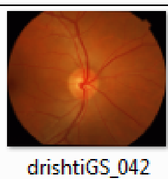
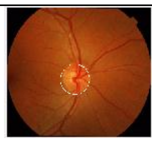
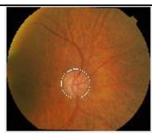
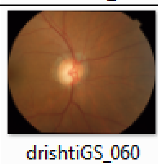
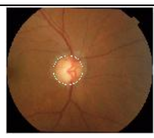
Image	Superimposed disk image	CDR	Accuracy in %
		0.34512	100
		0.42057	96.9295
		0.38593	100
		0.29055	100

TABLE 1

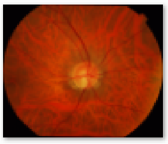
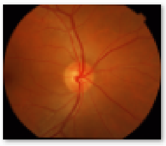
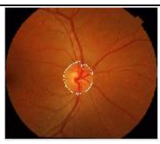
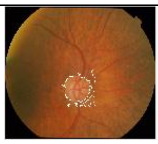
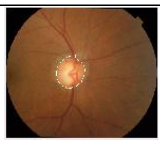
B. Accuracy Based on Morphology Method

DOI 10.17148/IJARCCE.2015.4631

ISSN (Online) 2278-1021
ISSN (Print) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 4, Issue 6, June 2015

TABLE 2

Image	**Superimposed disk image**	**CDR**	**Accuracy in %**
 drishtiGS_016		0.32242	99.8728
 drishtiGS_042		0.29366	98.758
 drishtiGS_004		0.40586	99.4847
 drishtiGS_060		0.29766	99.9603

In the above tables, if the CDR is greater than 0.35 than the respective image is glaucomatous or else it is non glaucomatous.

V. CONCLUSION

Glaucoma detection from Cup to disk ratio in Retina images is one of the most popular techniques for Retina analysis. However detecting exact disk and cup boundary presents several challenges due to presence of blood vessels in the image. Hence smooth tracking of regions and their boundary is quite difficult. Semi automated techniques makes the job of computer analysis much easier by taking seed points as inputs from the user. However semi automatic technique needs expert's seed points. As the overall objective is to determine the cup to disk ratio with automated methods, such techniques are not acceptable.

Hence in this paper we have presented an entirely automated technique for cup to disk ratio detection by separately identifying disk ROI and then tracking the disk region. This is followed by vessel extraction. The areas of bend of the vessels are determined and then a region growing technique grows the seed points towards possible bends. As the vessels merges towards the center and bends most from the outer cup boundary, the technique provides a very good approximation for the region growing technique to converge. In this paper we have also proposed a circularity based tracking of the boundary with that of morphology and canny based tracking. We conclude that both the methods are efficient but morphology in comparison with circular based tracking is more efficient.

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 DOI 10.17148/IJARCCE.2015.4631