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AUTOMATIC DETECTION OF GLAUCOMA THROUGH CHANNEL EXTRACTION ADAPTIVE THRESHOLD METHOD

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ABSTRACT

The diagnosis of any disease is an invasive technique performed by image processing system. Glaucoma is a chronic disease which if not detected in early stages can lead to permanent blindness. The medical techniques used by ophthalmologists like HRT and OCT is costly and time consuming. Hence there is a need to develop automatic computer aided system which can detect glaucoma efficiently and takes less time. Optic disk and optic cup are prime features which help in diagnosing glaucoma. Thus proper segmentation of optic disk and optic cup plays an important role in detecting the disorder. For developing an automatic computer aided system which can detect glaucoma efficiently in less time, we propose a method using ocular parameters, cup- disc ratio and rim-disc ratio. Our proposed Channel Extraction Adaptive Threshold (CEAT) method is independent of image quality. This method is also invariant to noise and is used to segment optic disk, optic cup. Neuro retinal rim and cup to disk ratio is calculated to screen glaucoma. We have considered the ocular parameter, rim to disk ratio in combination with CDR which gives more reliability in determining glaucoma and makes the

Key words: Glaucoma, Ocular, Optic Disk, and Optic Cup.

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1. INTRODUCTION

Glaucoma is the ocular disorder which leads to permanent blindness especially in aged humans. As the disorder is irreversible it is important to detect in its early stages. The medical techniques used by ophthalmologists such as Heidelberg retinal tomography (HRT) and Ocular coherence tomography (OCT) to screen glaucoma are time consuming and requires special skill and equipment's. Hence there is a need for computer based automatic systems which make screening of glaucoma easier and faster. A digital fundus image is used for screening glaucoma as it consumes less time, having higher accuracy and requires no skilled force. The common way to detect glaucoma is by finding cup- disk ratio and rim-disc ratio. Detection of optic disk is essential in developing automatic diagnosis systems and its segmentation is a crucial and a vital step. In order to detect glaucoma, the most important region of interest is optic disk which is detected using the red component of the gray scale fundus image. Optic cup is detected using the green component of the gray scale fundus image. Rim to Disc Ratio is computed and is used along with Cup to Disc Ratio for classifying the images as glaucomatic or normal.

2. LITERATURE SURVEY

Identification of Glaucoma using fundus images involves the measurement of the size, shape of the Optic cup and Neuro retinal rim. Optic Cup detection is a challenging task because of the interweavement of cup with the blood vessels. The method [1] differs by initial optic cup region detection followed by the erasure of blood vessels. The performance of the proposed technique is compared with Neural Network and SVM (support vector machine) Classifier in terms of classification accuracy and convergence time.

The morphological operations and SVM classifier are used to detect and segment the blood vessels from the retinal image [2]. The proposed system consists of three stages. The first stage is pre-processing of retinal image to separate the green channel and second stage is retinal image enhancement and third stage is blood vessel segmentation using morphological operations and SVM classifier. The performance of the proposed system is analyzed using publicly available dataset. The segmentation of Optic Disc [3] from fundus images based on circular Optic Disc boundary approximation is used. For that, an Optic Disc Pixel is obtained using voting type algorithm. Then Optic Disc boundary segmentation is done. The algorithm [4] allows segmenting the optic disc from a fundus image. An approach to automatically extract the main features in color fundus images is proposed in [5]. The least square fitting algorithm aims to improve the accuracy of the boundary estimation. The Simple Linear Iterative Clustering algorithm [6] is incorporated to segment the fundus retinal image into compact and uniform super pixels by using Gabor wavelet transform and thresholding. The method in [7] use blood vessel segmentation from the retinal images using a soft clustering method known as Fuzzy C Means clustering which assigns membership values to the pixels instead of separating the pixels. Optic cup and optic disc segmentation is used [8] for assessment of optic nerve head. The detection of pixels is integrated [9] around the retinal optic disc to line operator method so that those pixels can be excluded from the vessel pixels.

K-means clustering [10] is a proposed Method to detect the optic disc area with perfected using adaptive morphology. The system for locating the optic disc in digital retinal images is done by shade-correction method. An automated method is developed to locate and outline blood vessels in images of the ocular fundus. The system gives a bird's eye over all the detection technique toward fair segmentation of optic nerves using gradient descent method. The semi-automatic method for segmentation of the optic disc in retinal images using threshold and boundary extraction. The Segmentation of blood vessels from colour retinal images using a novel clustering algorithm and scale space features. The automatic segmentation of the optic disc from a fundus image is done to find the position approximately. The automatic method for analysis of retinal image which make use of region based segmentation to the segment a optic disk (OD) and optic cup. The method proposed is to identify and model the optic disc in colour retinal images. The radial projection method to locate the vessel centre lines. Then the supervised classification is used for extracting the major structures of vessels.

2.1. Existing Techniques

Glaucoma is a chronic, progressive eye disease that damages the optic nerve. It is the second leading cause of blindness worldwide. Progression of the disease can be slowed when treated early. Currently, ophthalmologists use three methods to detect glaucoma.

1. First method is the assessment of increased pressure inside the eyeball. This method is not sensitive enough to detect glaucoma early and is not specific to the disease, which sometimes occurs without increased pressure.
2. Second method is the assessment of abnormal vision. This requires specialized equipment, rendering it unsuitable for widespread screening.
3. Third method is the assessment of the damage to the head optic nerve and this process is time-consuming, expensive and highly subjective.

Existing medical techniques used by ophthalmologist like HRT and OCT is costly and time consuming.

2.2. Glaucoma

Glaucoma is characterized by a vertical elongation of the optic cup, a white area at the centre of the optic nerve head, or optic disc. This elongation alters the cup-to- disc ratio (CDR) but does not affect vision. The technique uses an algorithm that divides the images into hundreds of segments called super pixels and classifies each segment as part of either the optic cup or the optic disc. The cup and disc measurements can then be used to compute the CDR.

Fundus image of an eye is the photograph of the interior surface of the eye which includes retinal blood vessels, macula, fovea, optic disk and optic cup. Since glaucoma affects optic disk and optic cup by changing cup to disk ratio and rim to disk ratio, so proper segmentation of both the features is essential for glaucoma detection. RGB fundus image is used as input. In order to detect glaucoma, the most important region of interest is optic disk. Thus, instead of processing on the whole retinal image, region around optic disk is extracted. This ROI is a small image which helps in faster processing and large automated screening of glaucoma.

3. PROPOSED WORK

Glaucoma is the ocular disorder which leads to permanent blindness especially in aged humans. The main objective of this paper is Glaucoma detection since this disorder is irreversible and it is important to detect in early stages. Optic disk and optic cup are automatically segmented from digital fundus images using image adaptive thresholding techniques.

In order to detect glaucoma, the most important region of interest is optic disk which is detected using the red component of the gray scale fundus image. Optic cup is detected using the green component of the gray scale fundus image. Rim to Disc Ratio is computed and is used along with Cup to Disc Ratio for classifying the images as glaucomatic or normal. Cup-disc ratio is the ratio of optic cup to optic disc and rim-disc ratio is the ratio between optic rim and optic disc.

3.1. System Architecture

RGB fundus image is used as an input. In order to detect glaucoma, the most important region of interest is optic disk. Thus, instead of processing on the whole retinal image, region around optic disk is extracted. The extracted ROI image consists of three channels, red, green and blue. To detect optic disk, red channel is used as in this channel, optic disk appears to be the brightest and blood vessels are also suppressed in this channel. Hence it is easier and accurate to segment optic disk in red channel of input fundus image. Otsu thresholding technique is used to segment the optic disk which makes the segmentation independent of image quality. Optic cup is segmented using green component of ROI image using the Otsu technique. After segmenting of optic disk and optic cup, NRR (Neuro Retinal Rim) is obtained by subtracting optic cup from optic disk. The change in appearance of this area helps in identifying damage to the disk due to glaucoma. Thickness of the rim is an important feature to detect whether the fundus image is glaucomatic or not. The healthy optic disk is thicker in inferior portion then in superior, then nasally and thinnest temporally. In a glaucomatic eye, cup increases in its area vertically reducing the thickness of the rim in infero - temporal disk sectors. Thus rim- disk ratio for infero-temporal region of the rim can be evaluated to determine glaucoma. The System architecture is shown in figure 1.

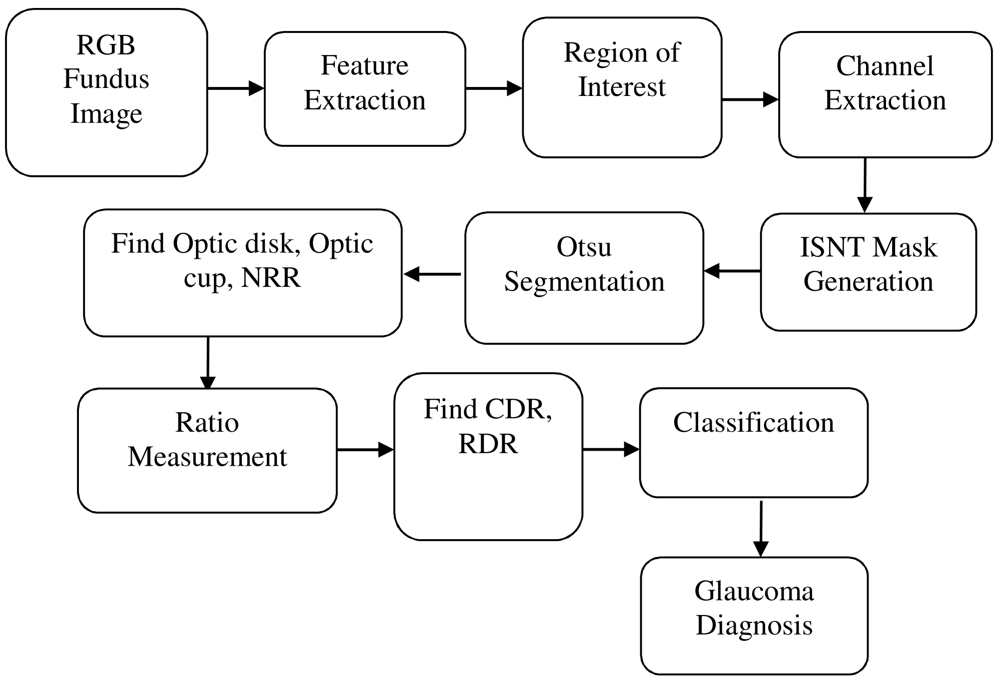

Figure 1 System Architecture

Classification of images as glaucomatic or healthy is done on the basis of two parameters, Cup to disk ratio and rim to disk ratio. The first parameter that we use to detect glaucoma is CDR. CDR is defined as ratio of total segmented cup area to total segmented disk area. This calculated CDR is used for screening of Glaucoma. The fundus image under test by considering some threshold is said to be glaucomatic else it is healthy. Second parameter is the Rim to disk ratio here some value is decided as threshold for classifying images as glaucomatic or not. Our approach is tested on the STARE database, the results demonstrate that our algorithm can yield better segmentation.

4. CHANNEL EXTRACTION ADAPTIVE THRESHOLD METHOD

4.1. Functional Modules

- ROI Identification
- Optic Disk and Optic Cup Segmentation.
- NRR Identification.
- Ratio Measurement.

4.2. Overall Framework

The overall algorithm for the proposed Channel Extraction Adaptive Threshold (CEAT) is shown below in Algorithm 1.

Algorithm 1: CEAT ( )

Input: RGB fundus image Output: Detection of Glaucoma

[1] Receive the RGB fundus image
[2] Perform the feature extraction
[3] Identify the Region of Interest
[4] call ROIIdentification( )
[5] Perform Channel Extraction in the image.
[6] call ChannelExtraction( )
[7] Extract the Red, Green and Blue channel of the image
[8] Perform ISNT Mask generation
[9] Perform Otsu segmentation
[10] call NRRIdentification( )
[11] Find Optic disk of the ROI image
[12] Find Optic cup of the ROI image
[13] Find NRR of the ROI image
[14] call RatioMeasurement( )
[15] Find RDR and CDR of the image.
[16] Detection of Glaucoma

4.3. ROI Identification

In order to extract the region around optic disk, centre of optic disk is first computed. After the calculation of centroid of the input fundus image, find the X and Y co-ordinates of the centroid. To calculate ROI (region of interest) we need to minus the centroid with some values. The ROI Identification is shown in Algorithm 2.

Algorithm 2: ROIIdentification( )

Input: RGB fundus image Output: Extraction of ROI

[1] Receive the RGB fundus image
[2] Perform the Region propping and Bounding box
[3] Crop the image in the bounded box
[4] Perform ISNT Mask Generation
[5] Extract the ROI of the image.

4.4. Optic Disk and Optic Cup Segmentation

The extracted ROI of the colour image consist of three channel red channel, green channel, and blue channel. Optic disk is detected using the red channel and optic cup is detected by using the green channel. By applying Otsu segmentation technique, optic disk and optic cup are segmented from ROI of the fundus image and the algorithm is shown in Algorithm 3.

Algorithm 3: ChannelExtraction ( )

Input: ROI of the image   Output: Optic disk and optic cup

[1] Receive the ROI of the image
[2] Perform the Channel extraction
[3] Identify the Red, Green and Blue channel of the image
[4] Perform Otsu segmentation
[5] Call NRRIdentification( )
[6] Find Optic disk from image Red channel
[7] Find Optic cup from image Green channel

4.5. NRR Identification

Rim area is the area located between the optic disk and optic cup. Neuro retinal rim is obtained by subtracting optic cup from optic disk. Changes in appearance of neuro retinal rim helps in identifying the damages. So the thickness of the rim is considered along with the detection of glaucoma. ISNT mask generation on ROI is done. Then each quadrant mask is multiplied individually with neuro retinal. Total area of rim is calculated in inferior and temporal regions and rim to disk ratio is considered along with the calculations and the algorithm is shown in Algorithm 4.

Algorithm 4: NRRIdentification ( )

Input: Optic disk and optic cup
Output: NRR and Rim Area

[1] Receive the Optic disk and optic cup
[2] Find NRR of the image
[3] NRR = Area(optic disk - optic cup)
[4] Perform ISNT Mask generation
[5] Find the quadrants of ROI Image
[6] Calculate Rim Width
[7] Find the Superior Region of ROI
[8] Find the Inferior Region of ROI
[9] Find the Temporal Region of ROI
[10] Find the Nasal Region of ROI
[11] Find Rim area of Inferior Temporal Region

4.6. Ratio Measurement

Classification of images as glaucomatic or healthy is done on this stage. Cup to disk ratio and rim to disk ratio are the two parameters. Calculated CDR is used for screening glaucoma. 0.3 is the globally accepted value for CDR. If CDR is greater than 0.3, the fundus image is glaucomatic. Rim to disk ratio (RDR) is the ratio of rim area in inferior temporal region to optic disk area. Calculated RDR is used for screening glaucoma. 0.4 is the globally accepted value for RDR. If RDR is less than or equal to 0.4, the fundus image is glaucomatic. Cup to disk ratio (CDR) is the ratio of optic cup area to optic disk area and the algorithm is shown in the Algorithm 5.

Algorithm 5: RatioMeasurement ( )

Input: Optic disk and optic cup, Rim Area Output: Detection of Glaucoma

[1] Find RDR of the image

[2] RDR = Rim Area in Inferior Temporal region / Optic Disk

[3] NRR = Area (optic disk - optic cup)

[4] Find CDR of the image

[5] CDR = Optic cup / Optic Disk

[6] Diagnose the output to detect Glaucoma

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5. IMPLEMENTATION

Our proposed Channel Extraction Adaptive Threshold (CEAT) is implemented by MATLAB-R-2014a.RGB fundus image is used as an input. In order to detect glaucoma, the most important region of interest is optic disk. Thus, instead of processing on the whole retinal image, region around optic disk is extracted.

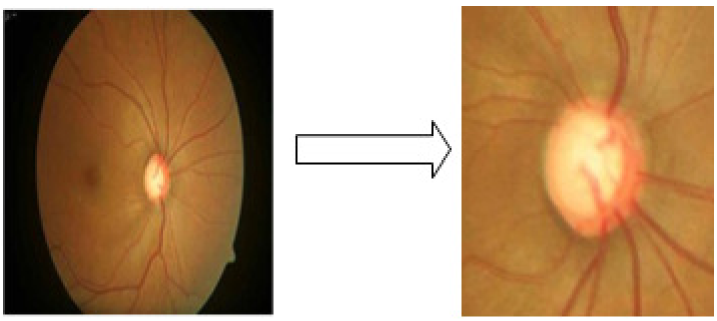

Figure 2 Effects of selecting different switching under dynamic condition

The extracted ROI image consists of three channels, red, green and blue. To detect optic disk, red channel is used as in this channel, optic disk appears to be the brightest and blood vessels are also suppressed in this channel. Optic cup is segmented using green component of ROI image.

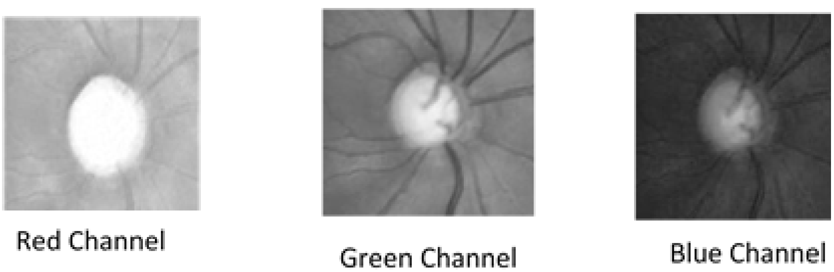

Figure 3 Channels of ROI Image

Neuro retinal rim is the region located between the edge of optic disk and optic cup. After segmenting of optic disk and optic cup, NRR is obtained by subtracting optic cup from optic disk.

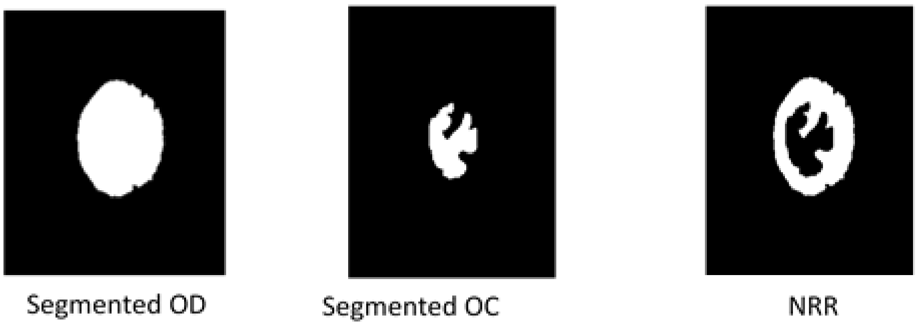

Figure 4 Optic Disk, Cup, NRR

The change in appearance of this area helps in identifying damage to the disk due to glaucoma. Thickness of the rim is an important feature to detect whether the fundus image is glaucomatic or not. The healthy optic disk is thicker in inferior portion then in superior, then nasally and thinnest temporally. In a glaucomatic eye, cup increases in its area vertically reducing the thickness of the rim in infero - temporal disk sectors. Thus rim-disk ratio for infero-temporal region of the rim can be evaluated to determine glaucoma.

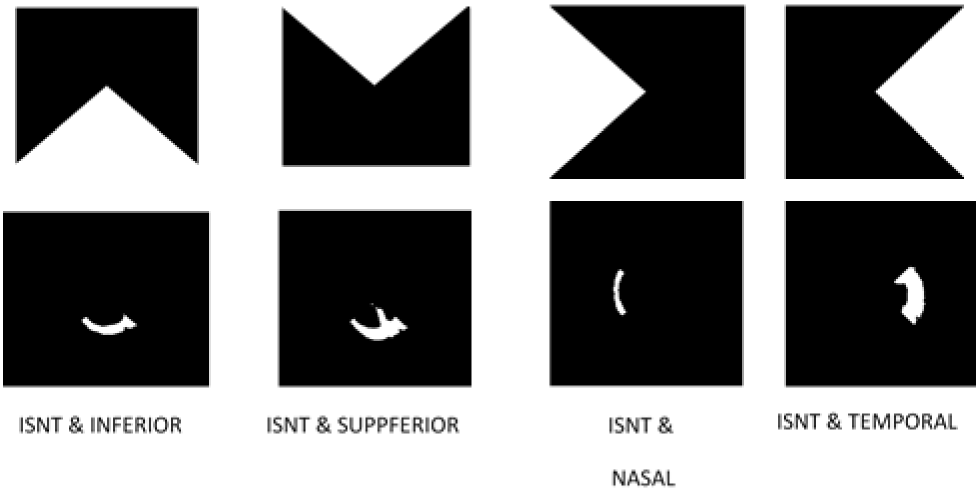

Figure 5 Regions of ROI

6. CONCLUSION

Our proposed proposed Channel Extraction Adaptive Threshold (CEAT) work is implemented by considering two different ocular parameters such as cup to disc ratio and rim to disc ratio. These ratios are useful to classify the input fundus image as glaucomatic or healthy. Threshold based technique is used for segmenting the image and then classify the image into normal or glaucomatic. Our future work may involve extracting more parameters in fundus image which reflects glaucoma symptoms such as disk hemorrhage, focal notching, peripappilary atrophy, ISNT ratio, etc. Study of these factors requires deep processing of fundus image. Extending these parameters to the proposed work can make the system more automatic and reliable giving greater accuracy.

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