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Glaucoma Detection from Color Fundus Images Using Multithresholding Method with Median Filter

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Abstract:
Glaucoma is a pathological condition, progressive neurodegeneration of the optic nerve, which causes vision loss. The damage to the optic nerve occurs due to the increase in pressure within the eye. Glaucoma is evaluated by monitoring intra ocular pressure (IOP), visual field and the optic disc appearance (cup-to-disc ratio). Cup-to disc ratio (CDR) is normally a time invariant feature. Therefore, it is one of the most accepted indicators of this disease and the disease progression. In this paper, Multi thresholding method with median filter is used to find the CDR from the color fundus images to determine pathological process of glaucoma. The method is applied on 25 nos of color fundus images obtained from optic disc organization UK having normal and pathological images. The proposed technique able to categorize all the glaucoma disease images.

***Keywords**: Gluacoma, Multi Thresholding Method, Median filter, Cup to disk ratio*

1. Introduction

Eduard Jaeger (1854) described glaucoma as the silent thief of sight which is a specific optic nerve disease with the progressive break down of nerve fibres. It occurs due to the elevated pressure in the optic nerve head. The optic nerve fibres carry the image information to the brain. When a significant number of nerve fibres are damaged by high fluid pressure, blind spot develops in the field of vision and causes permanent vision loss. Fig. 1 [1] shows how the objects are perceived by normal vision and a patient having glaucoma. It is the second leading cause of vision loss in the whole world and its progression is expected to increase [2]. Early diagnosis and optical treatment including a screening examination of the retinal fundus photographs [3] can minimize vision loss. Glaucoma diagnosis is based on the patient's family medical history, thin corneas, high intraocular pressure and manual assessment of the ONH from the color fundus images [4]. One of the glaucomatous changes observed in the color fundus images is the appearance of optic disc (OD) i.e., enlargement of the depression called cup and thinning of the neuro-retinal rim (shown in Fig 1).

Optic disc (OD) is the brightest feature in a normal fundus image and it has an elliptical shape. It appears bright orange-pink with a pale centre. Orange-pink appearance represents the healthy neuro-retinal tissue. Due to pathologies, the orange-pink color gradually disappears and appears pale. Blood vessels and the optic nerves are emanating out from the OD. Its size is about one seventh of the entire image.

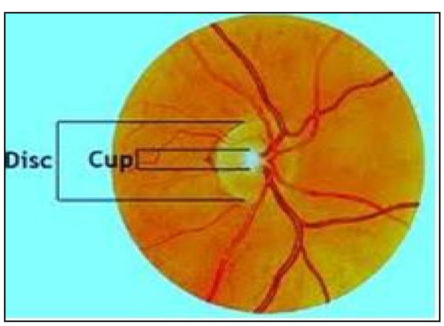

Figure 1: optic disk and cup structure

The pale centre is devoid of neuroretinal tissue and is called the cup. The vertical size of this cup can be estimated in relation to the disc as a whole and presented as a cup-to-disc ratio. The cup-to-disc ratio (CDR) expresses the proportion of the disc occupied by the cup and it is widely accepted index for the assessment of glaucoma [5]. For normal eye it is found to be 0.3 to 0.5 [4]. As the neuro-retinal degeneration occurs the ratio increases and at the CDR value of 0.8 the vision is lost completely. There is no cure of glaucoma yet, although it can be treated. Worldwide, it is the second leading cause of blindness [Global data on visual impairment in the year 2002]. It affects one in two hundred people aged fifty years and younger, and one in ten over the age of eighty years. The damage to the optic nerve from glaucoma cannot be reversed. However, lowering the pressure in the eye can prevent further damage to the optic nerve and further peripheral vision loss.

2. Method to Find CDR
In this work, the cup and the OD are segmented for calculation of CDR and determination of glaucoma. The basic block diagram is shown in Fig. 2. Here the green channel is used for processing, as the red channel is saturated and the blue channel is noisy. The following Fig.2. shows the steps for detection of glaucoma using Multithresholding with median filtering.

2.1. Pre-Processing
In this pre processing is used for better visualization. Image pre-processing can significantly increase the reliability of an optical inspection. Several filter operations which intensify or reduce certain image details enable an easier or faster evaluation. In this work pre processing is done with median filter for better visualization. Median Filter in images finds the median pixel value within the diameter that specified. It removes bright or dim features. Median filters are very effective in removing salt and pepper and impulse noise while retaining image details because they do not depend on values which are significantly different from typical values in the neighborhood. Median filters work in successive image windows in a fashion similar to linear filter.
It sorts all the pixels in an increasing order and takes the middle one. If the number of pixels is even, the median is taken as the average of the middle two pixels after sorting.

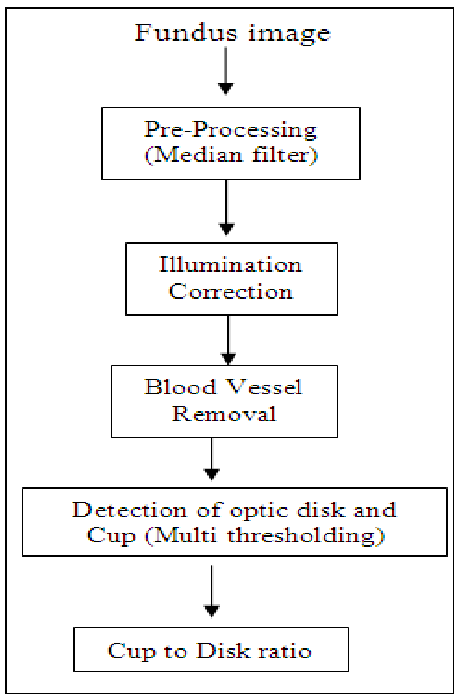

Figure 2: Steps for Glaucoma detection

Median filtering can preserve discontinuities in a step function and can smooth a few pixels whose values differ significantly from their surroundings without affecting the other pixels.

2.2. Illumination Correction
Due to different visual angles during the image acquisition, the bright speckles are distributed over the images. Due to the curve retinal surface and the geometrical position of the light source and the camera, the peripheral part of the retina appears darker than the central region. This influences the performances of statistical analysis methods for the glaucoma detection [5]. Mathematical morphology (MM) is the science of appearance, shape and organization. MM deals with non-linear processes which can be applied to an image to remove details smaller than a certain reference shape called the structuring element. MM is also the foundation of morphological image processing, which consists of a set of operators that transform images according to the above characterizations. The most widely used morphological operations used in image processing are dilation, erosion, opening and closing. MM was

originally developed for binary images, and was later extended to grayscale functions and images. In MM, top-hat transform is an operation that extracts small elements and details from given images. There exist two types of top-hat transforms. The white top-hat transform, which is defined as the difference between the input image and its opening by some structuring element. Top-hat transforms are used for various image processing tasks, such as feature extraction, background equalization, image enhancement, and others. Binary images are best suited for performing morphological operations. Dilation is an operation in which the binary image is expanded from its original shape. The degree of expansion is controlled by the structuring element. The dilation process is similar to convolution, in which the structuring element is reflected and shifted from left to right and then from top to bottom. In this process, any overlapping pixels under the centre position of the structuring element are assigned with 1 or black values. Erosion operator is a thinning operator that shrinks an image. The amount by which the shrinking takes place is again determined by the structuring element. Here, if there is a complete overlapping with the structuring element, the pixel is set white or 0. Opening is done by first performing erosion, followed by dilation. Opening smoothens the inside of object contours, breaks narrow strips and eliminates thin portions of the image.

2.3. Blood vessels removal

Optic nerve fibers are mainly affected by glaucoma. Vessels are removed as their characteristics (such as diameter, location) are minimally affected by glaucoma. To suppress the behavior of vessels in the fundus image, in painting of the blood vessels is performed. A large number of vessel segmentation techniques are available in the literature. In this work, morphology based vessel segmentation is used as this method achieves higher accuracy. So, image in painting is used to replace the blood vessels regions of the retinal image with plausible background. Fig. 3 shows the output of the in painting process, where the blood vessels are suppressed. Fig.4 (a) is a normal fundus image. The extracted blood vessels are shown in Fig. 4(c), which is used as a mask for in painting. Fig. 4(d) is the in painted image. The in painted image does not contain any blood vessels. By using this in painted image we can see the optic disk and cup clearly without any disturbance of blood vessel.

The boundary and area of the cup and OD is determined by multi-thresholding. The cup is assigned a higher threshold value as compared to the OD. In this work, Multi Thresholding Method is used for detection of cup and OD.

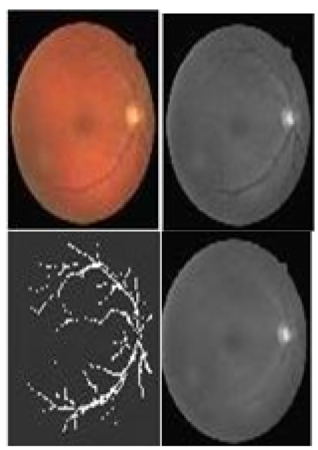

Figure 3: (a) fundus image (b) Preprocessing, (c) extracted blood vessel (d) in painted image

2.4. Detection of Cup and OD using Multi Thresholding

The boundary and area of the cup and OD is determined by multi-thresholding and active contour method. The cup is assigned a higher threshold value as compared to the OD. In this work, Multi Thresholding Method is used for detection of cup and OD.

2.4.11. Multi-Thresholding

This segmentation technique is based on thresholding. Its basic principle is to determine a value as a threshold, generally in a gray tone that is within the range of tones used in the image. For example, in an image with an 8 bit resolution, the threshold may be between 0 and 255. After establishing the threshold of all the regions in the image, it is possible to label every pixel, associating it to the value band established in each region. When there are just two regions for classification, one of these receives the label 0 and the other 1, and in this case the technique is called binarization. More than one threshold can be established in the same image; this technique is called multi-thresholding. This technique subdivides the image in more than two regions, establishing the lower and the higher limits of each region of interest. Since the optical disc in equalized image is corresponding to maximum brightness regions. Thus in order to segment the optical disc the suitable threshold is selected as;

$Th = f(x,y)$

$245 < f(x,y) < 255$

Where, $f(x,y)$ is the gray level value of the equalized image. The threshold is set to 175 in this paper. Now the segmentation is perfumed based on the selected threshold and the segmented image is given as;

G (x,y) = {255 if a(x,y)>TH2
= {0 otherwise
Where, g(x,y) is a logical segmented image.

2.5. Cup to Disk Ratio

After obtaining the disc and cup, various features can be computed. We follow the clinical convention to compute the CDR. As mentioned in the introduction, CDR is an important indicator for glaucoma screening computed as follows:

CDR=VCD/VDD

Where

- VCD = Vertical Cup Diameter.
- VDD = Vertical Disc Diameter.

The computed CDR is used for glaucoma screening. When CDR is greater than a threshold, it is glaucomatous, else healthy eye. Usually for healthy eye the ratio is of 0.2 - 0.3.mostly the CDR ratio is mostly calculated for glaucoma screening than other parameter. Also the proposed method reduces the time required for testing than other techniques. So that the patients can avail their result quickly.

3. Results

The above discussed method is applied to the publicly available Messidor and Optic-disc databases. They consist of normal and pathological fundus images. Messidor [13] retinal images are divided into 4 zipped sub sets containing 100 images, with 1488×2240 pixels in TIFF format. The images are acquired with pupil dilation and without pupil dilation. Twenty five images are available from optic-disc organization consist of 7 normal and 18 pathological images. They have 144×144 pixels in JPEG format. Fig. 6 shows the output of different steps for determination of CDR. Here a normal fundus image is shown (Fig. 3(a)). Then the green channel image is used for further processing as this image has higher contrast between the blood vessels and the background.

Blood vessels are extracted by morphological method as it helps in smoothing the images. The extracted blood vessels are shown in Fig. 3(c). Then the cup and disc are determined by thresholding. For this image the CDR is found to be 0.2. For normal images CDR is found to be less than 0.5 where as for glaucoma images it is found to be greater than o.5. Fig. 5 shows cup and disc for the glaucoma images. Seven normal and 18 pathological images are taken for the study. The CDR value is correctly determined for all the pathological images. For normal fundus images the CDR value lies between 0.3 to 0.5. For pathological images CDR varies between 0.5 to 0.8 and also this proposed method compares the result with opthmologist ratios.

IMAGE NO.	CALCULATED CDR	OPTHALMOLOGIST
Normal 1	0.2001	0.3004
Normal 2	0.3708	0.3781
Normal 3	0.2000	0.2441
Normal 4	0.3111	0.3042
Normal 5	0.2111	0.3594
Normal 6	0.3522	0.3986
Normal 7	0.3060	0.4986
Normal 8	0.2945	0.2945
Normal 9	0.3221	0.3941
Normal 10	0.3421	0.3007

Table 1: Comparison of Results with HRT and Ophthalmologists (Normal)

4. Conclusion

In this paper CDR is determined for both glaucoma affected and normal fundus images. The method Success for all images due to the presence of pre processing technique. The CDR value gives the progression about the disease. This approach can be improved by any advanced techniques.

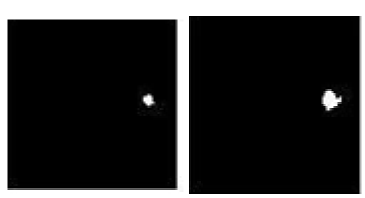

Figure 4: a) detection of cup, b) detection of disk

5. References

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