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SMART DETECTION OF MICROANEURYSMS FROM COLOR FUNDUS IMAGES IN DIABETIC RETINOPATHY BY IMAGE PROCESSING TECHNIQUE

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ABSTRACT

Diabetic retinopathy is a complication and main cause of vision loss for the diabetic patients. Microaneurysms are the major sign of diabetic retinopathy. This paper presents a morphology-based method for the smart detection of diabetic retinopathy through Microaneurysms from color fundus images. Proposed approach is applied on fundus images and results are satisfactory and are compared with the ophthalmologists' hand drawn ground truths.

KEYWORDS: Diabetic, Retinopathy, Microaneurysms, Exudates, Haemorrhages, Blindness

INTRODUCTION

Retinopathy is a common complication of diabetes and main cause of blindness in the working population of western countries. The disease can only be recognized by the patient when the changes in retina progressed such a level that the treatment is complicated and nearly impossible [5]. 12 percent of people who register as blind in UK each year have diabetic related eye diseases [1]-[3]. Diabetic retinopathy occurs due to the damage of retina blood vessels, which may lead to blindness by hemorrhage and scarring [6]. Regular screening of diabetes can lessen the risk of blindness in the patients by around 50% [5]-[8]. Early diagnosis and timely treatment can reduce the risk of blindness by 95% [9]. Early detection of diabetic retinopathy by smart screening system enables laser therapy to prevent or delay visual loss, which may encourage improvement in diabetic control and lessen the health care costs [10]-[11].

As the primary sign of diabetic retinopathy is exudates, if diabetic retinopathy is detected at an early stage, then the blindness of diabetic patients can be prevented. There is a good number of different approaches for detection of exudates in diabetic retinopathy. None of these methods are perfect. In this paper we have developed a morphology-based system for early detection of diabetic retinopathy. The rest of the paper is organized as follows. Section 2 presents medical knowledge of diabetic retinopathy, section 3 shows the diabetic retinopathy detection system, section 4 analyzes the result and finally section 5 draws conclusion of the paper.

Medical Knowledge of Diabetic Retinopathy

Diabetic retinopathy is a microvascular change of the retina caused by diabetes that can ultimately lead to blindness [13], [14]. Diabetic retinopathy changes the blood vessels of the retina in which blood vessel may bloat and leak fluid. Figure 1 shows the defects that are diagnosable in the retina. Signs of diabetic retinopathy include microaneurysms, haemorrhages, hard exudates and soft exudates or cotton-wool spots. The description of these signs are given below.

Microaneurysms are the first and primary abnormality occurring in the eye because of diabetic retinopathy. These are identified as small, dark red spots and causes intra retinal haemorrhages, which may appear alone or in clusters. Microaneurysms are circular in shape and their sizes vary from 10-100 microns.

Haemorrhages (that are termed as blot haemorrhages) are located in the compact middle layers of the retina. Flam shaped haemorrhages is originated in the retinal nerve fibre layer.

Hard exudates vary in sizes and have weak blots. These are very important symptoms of diabetic retinopathy.

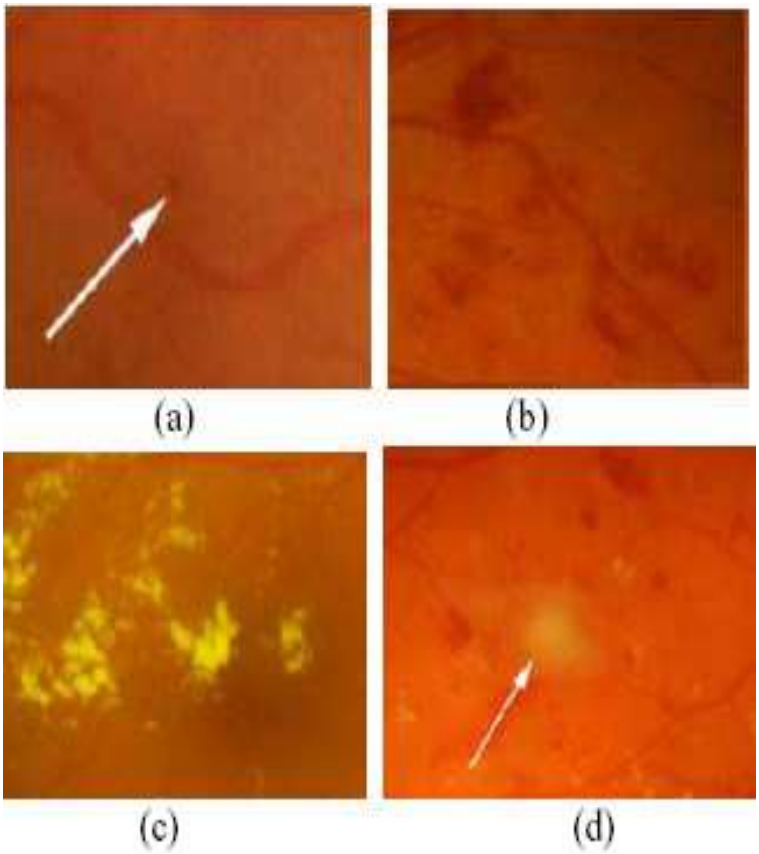

Figure 1: Defects in the Digital Fund us Images (a) Microaneurysms (Marked with an Arrow) (b) Haemorrhages (c) Hard Exudates (d) Soft Exudates (Marked with an Arrow) (Images Are Taken from Ref. [12])

In severe stages of diabetic retinopathy, certain spots named ‘cotton wool spots’ are seen, these are the soft exudates. The retinal pre-capillary arterioles supplying blood to the nerve fiber layer are blocked and the local nerve fiber axons get swollen creating a cotton wool spot.

It is hard to detect diabetic retinopathy at early stage. Microaneurysms are early signs of diabetic retinopathy. So our aim is to detect microaneurysms for early diagnosis of diabetic retinopathy and to protect the diabetic patients from blindness.

Diabetic Retinopathy Detection System

The flow diagram of the system is shown in Figure 2. At first we have to take the color fundus image as input. The fundus image is not uniform and suffers from non-uniform illumination, lighting variations, poor contrast and noise [15], [16]. To enhance the contrast, we used histogram equalization after converting the color image into grayscale. After histogram equalization the image is thresholded to convert it to binary by using the Eq. (1).

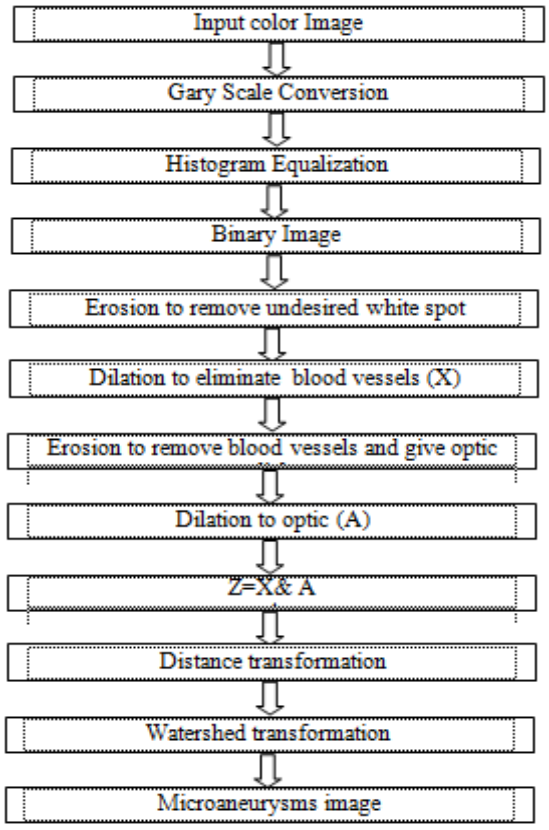

Figure 2: Flow Diagram of the Microaneurysms Detection System

$$f(x) = \begin{cases} 1, if\ f(x) > 240 \\ 0 \quad otherwise \end{cases} \quad (1)$$

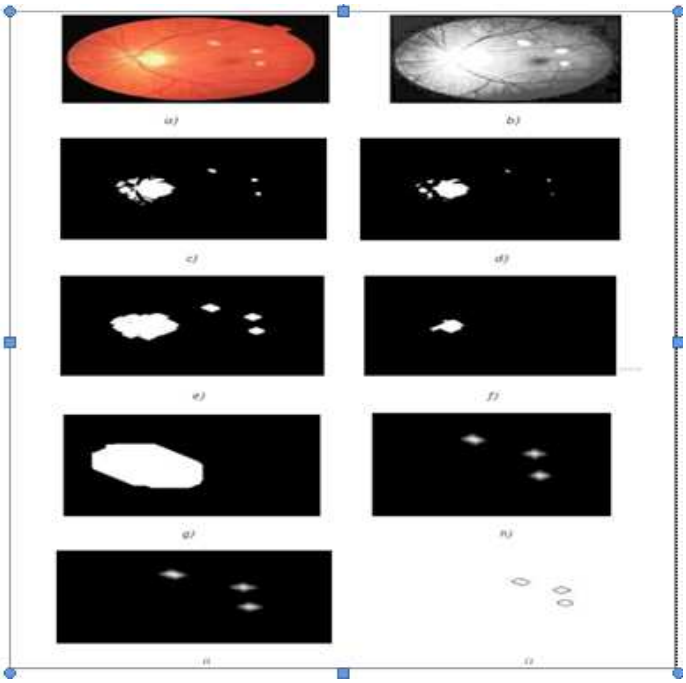

Figure 3: Microaneurysms Detection (a) Input Image, (b) Histogram Equalized Grayscale Image, (c) Binary Image by Thresholding, (d) Eroded Image (e) Dilated Image (x), (f) Erosion to Remove Microaneurysms and Gives Only Optic Disk, (G) Dilation of Optic Disk, h) Z=X&Ā, i) Distance Transform of the Image z, and j) Exudates Image by Watershed Transform Ref [17]

The optic disk represents white region and the rest part of the image remain black. Then erosion operation is applied to the thresholded image. After the erosion operation the unnecessary white pixels are removed from the eroded image. Then dilation operation is applied to remove blood vessel of the eroded image and it is treated as X. Again erosion is applied to the dilated image to remove microaneurysms. After microaneurysms removal we get optic disk only. Then dilation is applied to the optic disk that is termed as A. This dilated image is then inverted. In the inverted image the optic disk is black and the other part is white. After that logical 'AND' operation is applied between X and $\bar{A}$. That is

$$Z = X \,\&\, A \tag{2}$$

Distance transform is applied to the Z image. The watershed transform is applied to the distance transformed image and convert the image to RGB such that the background is cyan and microaneurysms are pink or close to pink. Figure 3. shows the visual outputs at different steps of the detection system.

ANALYSIS OF THE RESULT

We have collected retinopathy color fundus images from Jyoti Eye Hospital, Visnagar, India and tested our system with 100 images.

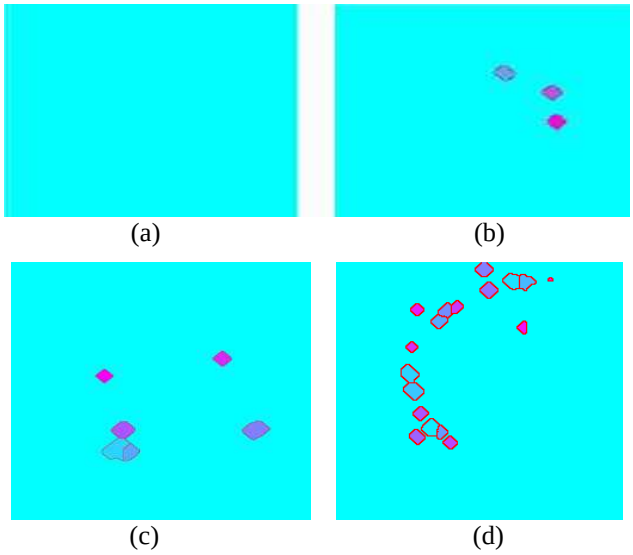

Figure 4: (a) Output of a Normal Image without Microaneurysms, (b) Output of a Mildly Affected Image, (c) Output of a Moderately Affected Image, (d) Output of a Severely Affected Image

Table 1: Ranges of Microaneurysms Affected in Diabetic Retinopathy [17]

Normal	Mild	Moderate	Severe
Below 0.14%	0.14% to 2.6%	2.6% to 4.2%	Greater than 4.2%

We calculated the ratio (in percentage) of detected microaneurysms pixels to the total pixels of the retina image. We categorize these images into normal, mild, moderate and severe diabetic retinopathy according to the percentage of the area of microaneurysms [17]. Table 1 shows the ranges of the ratio in each category. Figure 4. a) shows the output of a normal image without microaneurysms, b) output of a mildly affected image, c) output of a moderately affected image, and d) output of a severely affected image. Among 100 images the proposed technique finds 44 images are normal, 35 are mild diabetic retinopathy, 7 images are moderately affected, 13 images are severely affected and 1 image gives wrong result. The detected results are similar to opthamologist hand-drawn ground truths. The accuracy of the traditional texture segmentation method is 85% [9], fuzzy C-means clustering method is 92.18% [10] and our method is 99%. The results confirmed the superiority of our method.

CONCLUSIONS

Microaneurysms are the primary sign of diabetic retinopathy. We have proposed smart system for the detection of microaneurysms. Experimental results confirm that our method is better than the traditional methods. We hope that our method will be useful for both patients and doctors.

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