Chapter 4

EXTRACTION OF MICROANEURYSMS

Microaneurysms are the first clinically evident sign of diabetic non-proliferative eye disease, so the recognition of microaneurysms can be the first step in prevention of diabetic retinopathy progression. This chapter describes a method for extracting microaneurysms from fundus images using morphological operations. The green channel of input size normalized image is subjected to median filtering for denoising. Adaptive histogram is applied to enhance the image. Segmentation and morphological operations are performed to extract and eliminate retinal structures such as blood vessels and optic disc and also pathologies like exudates, large hemorrhages and noise to facilitate extraction of microaneurysms. The extracted microaneurysms are verified by an expert for its correctness.

4.1 Introduction

Microaneurysms are small saccular out pouching that involve capillaries of retinal blood vessels. According to ophthalmologists they are the hallmark of diabetic retinopathy. Their importance is underscored by the fact that they are the first clinically evident sign of diabetic non-proliferative eye disease, so the recognition of microaneurysms can be the first step in prevention of diabetic retinopathy progression and consequent severe vision loss. Ophthalmological clinical examination reveals that microaneurysms are small circular deep-red dots in the fundus (balloon-like swelling in the retina’s tiny blood vessels) [figure 18] ranging from 10μm to 100μm [73] in diameter.
Microaneurysms are difficult to distinguish from dot-hemorrhages in color retinal images. Dot hemorrhages appear as bright red dots the size of large microaneurysms and they rarely exceed a size of 200µm in diameter. Detection of microaneurysms not only helps ophthalmologist in treating diabetic retinopathy and their by prevent blindness but also alternates the time consuming manual process which is prone to observers errors. Since, microaneurysms and dot hemorrhages are similar in appearance, there is clinically no need for distinguish between them. Fluorescein angiographic images give a better visualization of microaneurysms and dot- hemorrhages. This is not possible with color fundus images.

In early literature the algorithms were developed to detect microaneurysms in the Fluorescein angiograms. In [16-18], a series of morphological operations were applied to remove the retinal blood vessel network to facilitate the extraction of small structures that could be the candidate microaneurysms, exudates or noise. The contrast between blood vessels, lesions and background is more in Fluorescein Angiogram images because an intravenous contrast agent in injected into the patient. This is not the case with color fundus images. Hence more sophisticated algorithms are required when working with color fundus images. In [26], a background subtraction with a large median filter followed by two different adaptive thresholding approaches segments the candidate microaneurysms. In [81], similar steps where performed by exploiting the response from the Gaussian filter banks. In [82], a template matching approach on the sub-bands of the wavelet space of the image was used. In [83], after detecting the initial candidates, two modified double ring filters were applied to
remove the lesions lying in the vasculature. 12 features were used to classify the microaneurysms and other lesions.

From the literature it is clear that various method aiming at extracting microaneurysms are been developed, but these methods have been experimented on few set of fundus images in particular images from standard database. Since microaneurysms are the first sign of diabetic retinopathy, it is essential that the proposed method should work for large set of images to ensure robustness of the method. This motivated us to develop a method based on morphological operations yielding better recognition rate for large set of fundus images.

4.2 Methodology

The method proposed for detection of microaneurysms from fundus consists of following operations.

Segmentation: Edge detection is applied to pre-processed images to extract the edges of blood vessels and pathologies. Shape feature is used to distinguish between blood vessels and pathologies as blood vessel are long and pipe like structures where as microaneurysms and exudates appear to be circular.

The candidate microaneurysms are marked by filling them based on their size and shape. Finally all other objects other than candidate microaneurysms are eliminated using thresholding.

Morphological operation: Optic disc elimination is another important step in microaneurysm detection. In order to find the boundary of optic disc and to eliminate it, blood vessels must be removed because out-coming blood vessels in optic disc breaks its boundary. Hence to obtain a continuous optic disc boundary blood vessels are eliminated. Morphologic opening is applied using sufficiently large ball shaped structuring element of size 11.

Active Contour: A novel, multistage active contour method to detect the boundary of the optic disc is designed. It provides a better segmentation for images with weak boundaries.

4.3 Algorithm

In pre-processing stage, the input image is resized and the green channel is extracted. Contrast enhancement is achieved using adaptive histogram equalization method.
Segmentation stage involves edge detection of microaneurysms and blood vessels. Thresholding is applied for removal of exudates and noise. Blood vessels are eliminated by using morphological operations. Finally, optic disc is detected and eliminated using active contour, leaving microaneurysms in the resulting images.

**Algorithm:**

**Input:** RGB fundus image.

**Output:** Binary image with microaneurysms and 4 feature values representing area occupied by microaneurysms in 4 quadrants.

**Method:**

Step 1: Pre processing

i. Normalize the image with respect to size.
ii. Extract green channel of the RGB image.
iii. Apply adaptive histogram equalization thrice, to enhance the image.

Step 2: Segmentation

i. Apply canny edge detector to find the edges of blood vessels and pathologies.
ii. The candidate microaneurysms are selected by filling them based on their shape and size.

Step 3: Morphological operation: morphological opening with large ball shaped structuring element of size 11 is used to eliminate blood vessels.

Step 4: Boundary of optic disc is marked using an active contour method and is eliminated by converting the pixels inside the boundary to background.
Step 5: Area Calculation: The resultant image is divided into four quadrants and the area occupied by microaneurysms in each quadrant is calculated.

4.4 Experimental results

A microaneurysms extraction algorithm using morphological operations and active contour is presented. A total of 100 images of dimension 4288X2848 are used to evaluate the performance of the proposed method. The performance has been evaluated by the experts.

In case of normal retina no microaneurysms are found. Presence of at least one microaneurysm is a sign of mild NPDR. Presence of multiple microaneurysms and other pathologies in at least two quadrants indicates moderate NPDR and sever NPDR subsequently.
Figure 20: Results of MA Extraction Algorithm for Normal Images
Figure 21: Results of MA Extraction Algorithm for Mild Images
Figure 22: Results of MA Extraction Algorithm for Moderate Images
Figure 23: Results of MA Extraction Algorithm for Severe Images
4.5 Summary

An efficient method for extracting microaneurysms from fundus images using morphological operations and active contour method is presented. Experiments have been carried out on 100 fundus images collected from Karnataka Institute of Diabetology, Bangalore. The proposed method aimed at extracting microaneurysms from fundus images has yielded encouraging results. The results have been verified by the experts for its correctness. The major contribution of the proposed method is in pre processing the images collected for local database, because they are more prone to noise and in deciding the structuring element that worked well with both local and public databases in extracting blood vessels and microaneurysms.