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Exudates and Microaneurism Detection for Diabetic Retinopathy

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ABSTRACT

Diabetic-related eye disease is a major cause of preventable blindness in the world. It is a complication of diabetes which can also affect various parts of the body. The detection of microaneurysms in digital color fundus photographs is a critical first step in automated screening for diabetic retinopathy (DR), a common complication of diabetes. Diabetic retinopathy (DR) is the damage caused by complications of diabetes to the retina. It is one of the leading causes of blindness across the world. Hence, an accurate, premature diagnosis of DR is an essential task because of its potentiality for reducing the number of cases of blindness across the globe. In this paper we present a procedure to detect the presences of abnormalities in the retina such as microaneurysms, exudates using image processing techniques.

Keywords: Fundus image, blood vessel, image processing, Exudates, Microaneurity, diabetic retinopathy.

I. INTRODUCTION

i. Exudates Detection

Exudates appeared as bright yellow-white deposits on the retina due to the leakage of blood from abnormal vessels. Their shape and size will vary with the different retinopathy stages. The grayscale image is first pre-processed for uniformity before the morphological image processing is applied to remove the blood vessels and identify the exudates region. The exudates are detected after removing the border, optical disk and non-exudates area.

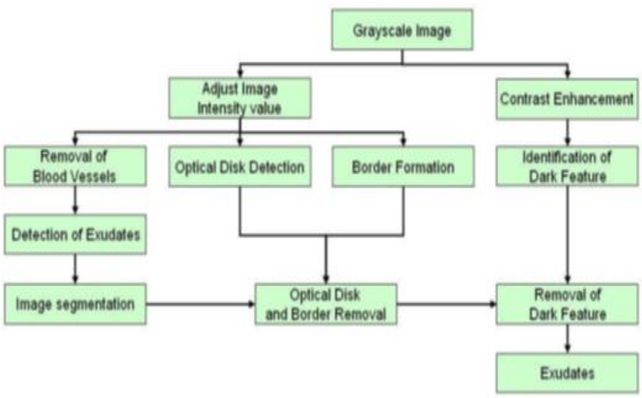

Figure 1.1. Block Diagram for Exudates Detection

ii. Microaneurysms Detection

Microaneurysms appeared as small dark round dots (~15 to 60microns in diameter) on the fundus images. They are small bulges developed from the weak blood vessels and are the earliest clinical sign of diabetic retinopathy [9]. Hence, it is essential to detect them during the mild stage. The number of microaneurysms would increase with the stage of the retinopathy.

The grayscale image is used to detect the circular border and optical disk mask. The green channel of the image first finds the edges using canny method before removing the circular border to fill the enclosed small area. The larger areas are then removed and applied with AND logic to remove the exudates. The blood vessels and optical disk are then removed to obtain the microaneurysms.

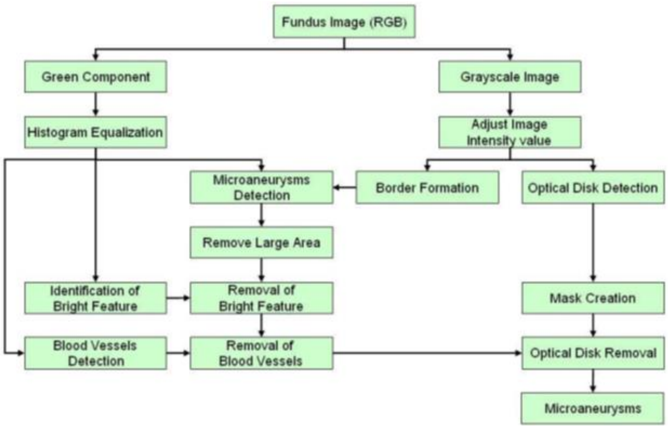

Figure 1.2 : Block Diagram for Microaneurysms Detection

II. METHODS AND MATERIAL

A. Experimental procedure - Detection of Exudates

This section discusses in greater detail of the extraction of the exudates. The fundus image is first preprocessed to standardize its size to 576x720 and the intensity of the grayscale image is then adjusted.

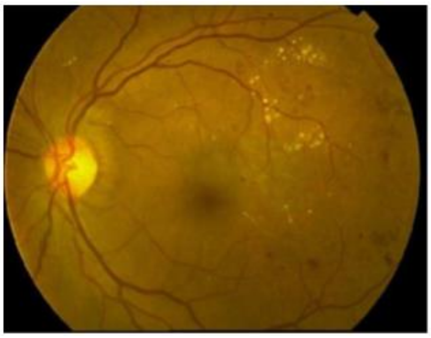

Figure 2. Original fundus image

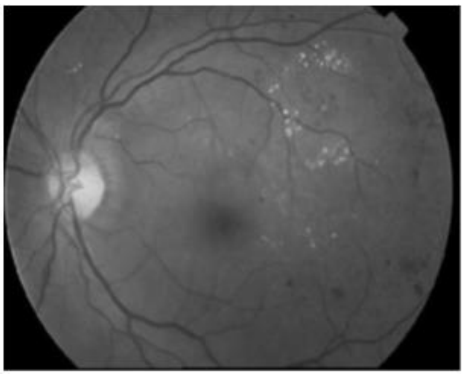

Figure 3. Intensity adjusted grayscale image

Morphological closing which consisted of dilate followed by erode is applied to remove the blood vessels. The dilate function expands the exudates area while erode function removes the blood vessels. The image (Figure 4) is then converted to double-precision value for function "colfilt" to mark the exudates region before converted back to uint8 as shown in (Figure 5). This image is converted back to binary using the function "im2bw" with a threshold value to filter out the exudates.

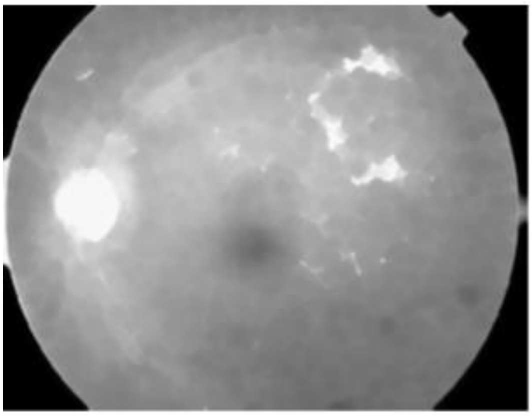

Figure 4. Image After Morphological Closing

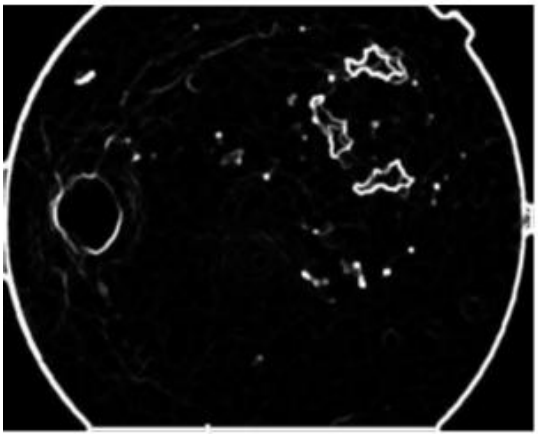

Figure 5. Image After Column Filter

The location of the optical disk is detected by the brightest point(s) on the grayscale image. It is usually the maximum value and a circular mask is then created to cover it.

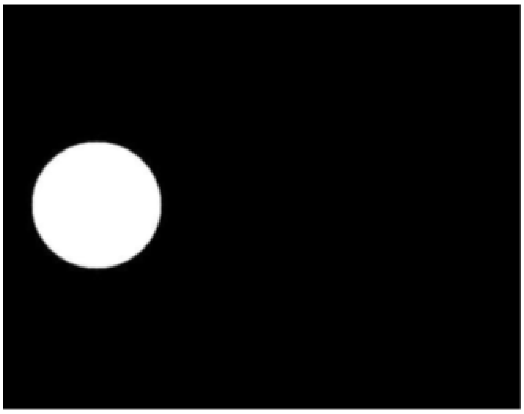

Figure 6. Mask for the Optical Disk

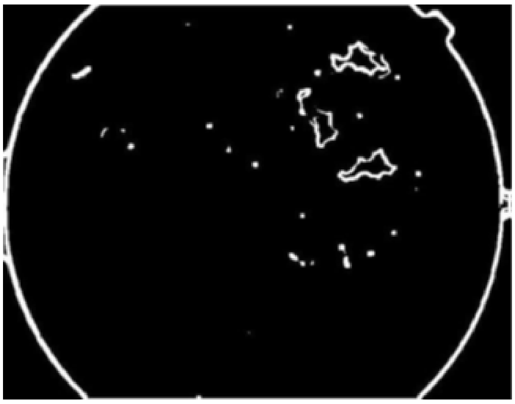

Figure 7. Image with Optical Disk Removed

The regions of the exudates are obtained after the removal of the circular border. Morphological closing is then applied to the image. The dilate function is to fill the exudates while erode function is to expand their sizes

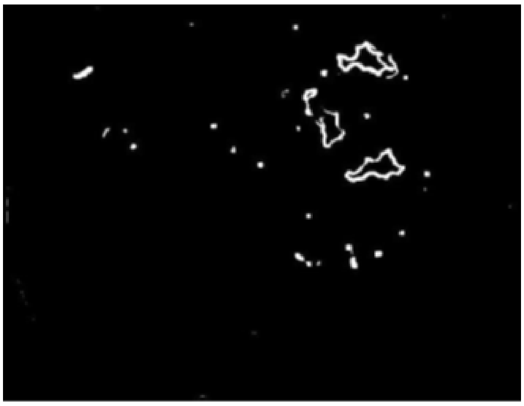

Figure 8. Regions of Exudates

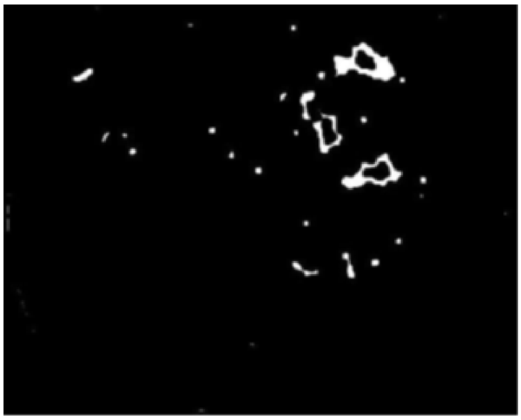

Figure 9. Image after Morphological Closing

Non-exudates (dark features) are extracted from the grayscale image using function “im2bw” and are represented as binary 1 (white) after intensity inversion. AND logic is then applied to the images (Figure 9 and Figure 10) to detect the exudates (Figure 11).

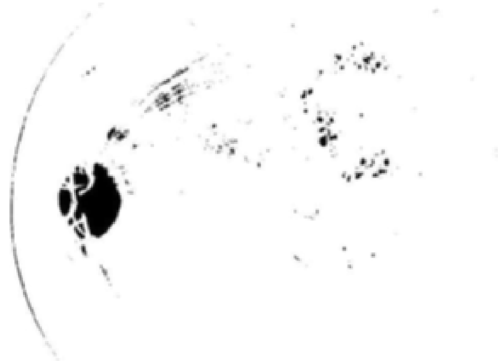

Figure 10. Image with Dark features(represented as white)

Figure 11. Exudates after performing ‘AND’ logic

B. Experimental procedure - AND logic

AND logic is used to remove noise for the detection of exudates. Regions with exudates are marked out after applying column filter but this includes non-exudates such as hemorrhages and has to be removed as noise.

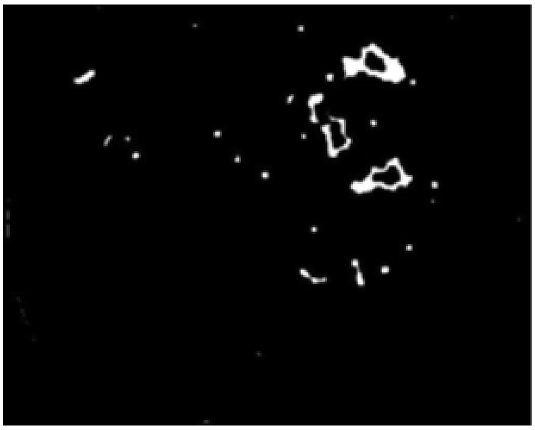

Figure 12. Expanded exudates regions after Morphological closing

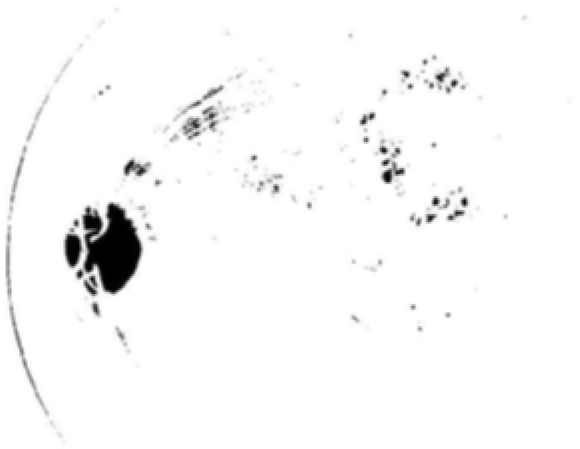

Figure 13. Dark features represented as white

By removing the non-exudates from the detected regions, the exudates can be determined. Image segmentation is applied to the grayscale image to extract the bright spots for comparison. These areas (bright features) are represented by binary 0 (black) while the non-exudates (dark features) are represented as binary 1 (white) as shown in Fig.13

By applying AND logic to Fig.12 and Fig.13, the non-exudates regions are set to set to binary 0 (black) and removed when the pixels for both images are binary 1 (white). As a result, the exudates area is obtained.

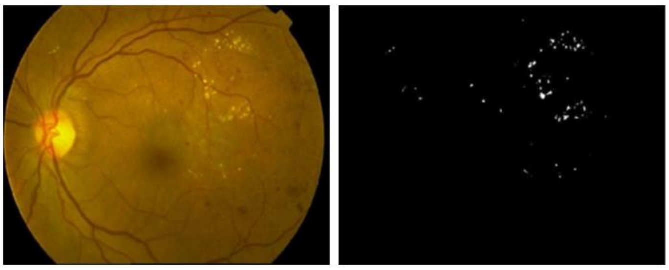

Figure.14. Fundus image (Left) with its exudates image (Right)

C. Experimental procedure - Detection of Microaneurysms

This section discusses in greater detail of the extraction of the microaneurysms. The fundus image is first preprocessed to standardize its size to 576x720 and the intensity of the grayscale image is then adjusted.

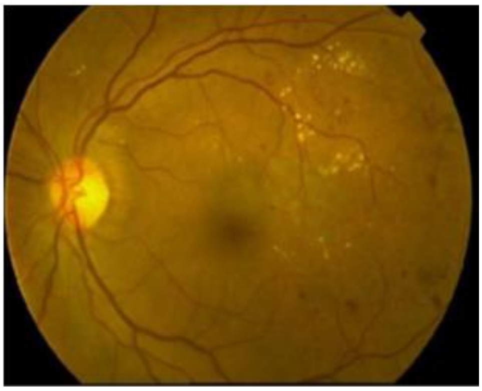

Figure 15. Original Fundus Image

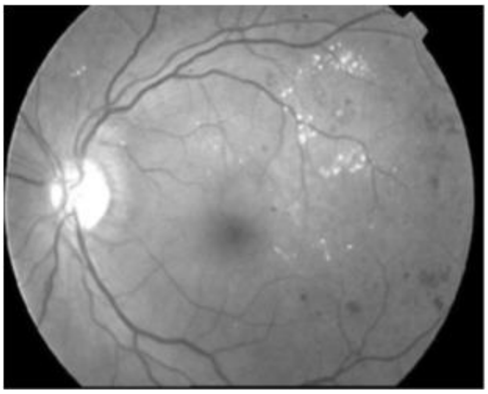

Figure 16. Intensity Adjusted Grayscale Image

The image’s contrast is stretched by applying adaptive histogram equalization before using edge detection (canny method) to detect the outlines of the image (Fig.18).

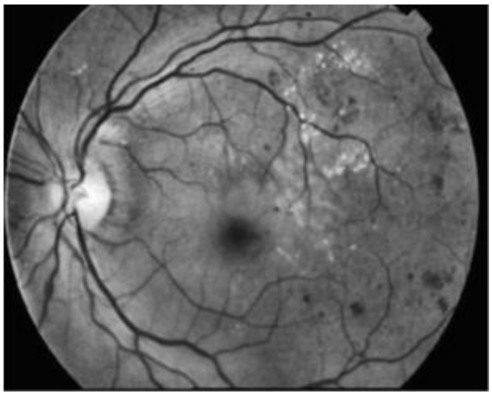

Figure 17. Image after Histogram Equalization

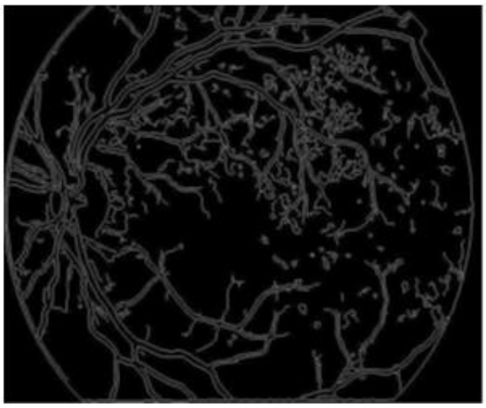

Figure 18. Image of Edge

The circular border is then removed before applying the function "imfill" to fill up the enclosed area (Fig.19). The holes (microaneurysms and noise) image is obtained by subtracting away the edges image and removing the larger area using function "bwareaopen". However, the image would still contain noise like blood vessels and exudates.

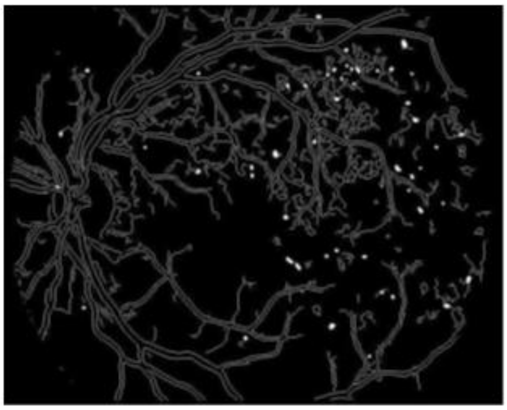

Figure 19. Image after function "imfill"

Figure 20. Image after Removing The Larger Area

As the exudates are bright spots on the image, the image (**Fig.16**) is applied with adaptive histogram equalization twice and image segmentation to "bring" out the exudates (**Fig.22**). These bright features are compared with (**Fig.20**) using AND logic to remove the exudates.

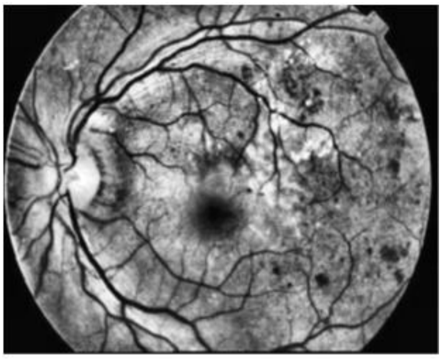

Figure 21. Image after applying histogram equalization twice

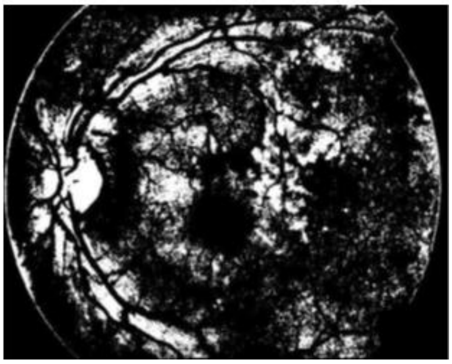

Figure 22. Image after image segmentation

Blood vessels are extracted after the image (Figure 16) is applied with equalization twice and image segmentation of another threshold value. A clearer image of blood vessels (Figure 23) is acquired after removing the small area of noise. This image is compared using AND logic with the result from the previous AND logic to remove the blood vessels. The final microaneurysms image is obtained after removing the small noise and optical disk area.

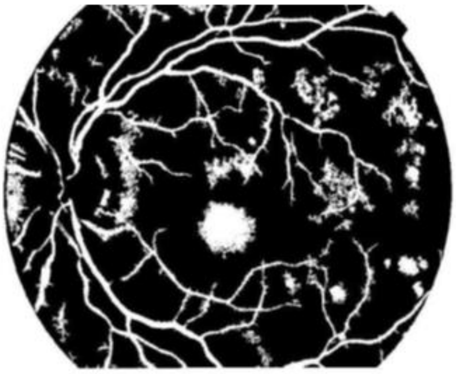

Figure 23. Blood Vessels after removing small area of noise

Figure 24. Microaneurysms

III. RESULTS AND DISCUSSION

The higher stage of the diabetic retinopathy would have more exudates due to damages or leakages of the blood vessels and the overall obtained result matched it. The mask detection of the optical disk could take the exudates coordinates instead when they are much brighter or close together and forms a larger area than the optical disk. Some of the images had exudates area masked as a result; however it is trivial to affect the overall value as those images generally had a large area of exudates.

Blood vessels and exudates would sometimes occur from edge detection using canny method. As they are considered noise, they need to be removed at the output. Exudates can be easily removed as they are bright spots on the original image. However, it would be harder to differentiate tiny blood vessels and microaneurysms as they are of the same color intensity in the image.

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