

Blood vessel extraction for diagnosis of Diabetic Retinopathy

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Abstract— Diabetic retinopathy (DR) is a leading cause of vision loss in diabetic patients. DR is mainly caused due to the damage of retinal blood vessels in the diabetic patients. It is essential to detect and segment the retinal blood vessels for DR detection and diagnosis, which prevents earlier vision loss in diabetic patients. *It is an eye disease caused by the increase of insulin in blood and it is one of the main causes of blindness. It is a progressive disease and needs an early detection and treatment.* Blood vessels are extracted in this project for the identification of diabetic retinopathy.

Index Terms— Blood vessels, Diabetic retinopathy, Adaptive histogram equalization, Segmentation, Morphological operations etc

I. INTRODUCTION

Blood vessels are extracted in this project for the identification of diabetic retinopathy. The contrast of the fundus image tends to be bright in the centre and diminish at the side, hence preprocessing is essential to minimize this effect and have a more uniform image. After which, the green channel of the image is applied with morphological image processing to remove the optical disk. Image segmentation is then performed to adjust the contrast intensity and small pixels considered to be noise are removed. Another green channel image is processed with image segmentation and combined with the mask layer. These two images are compared and the differences are removed. The obtained image would represent the blood vessels of the original image.

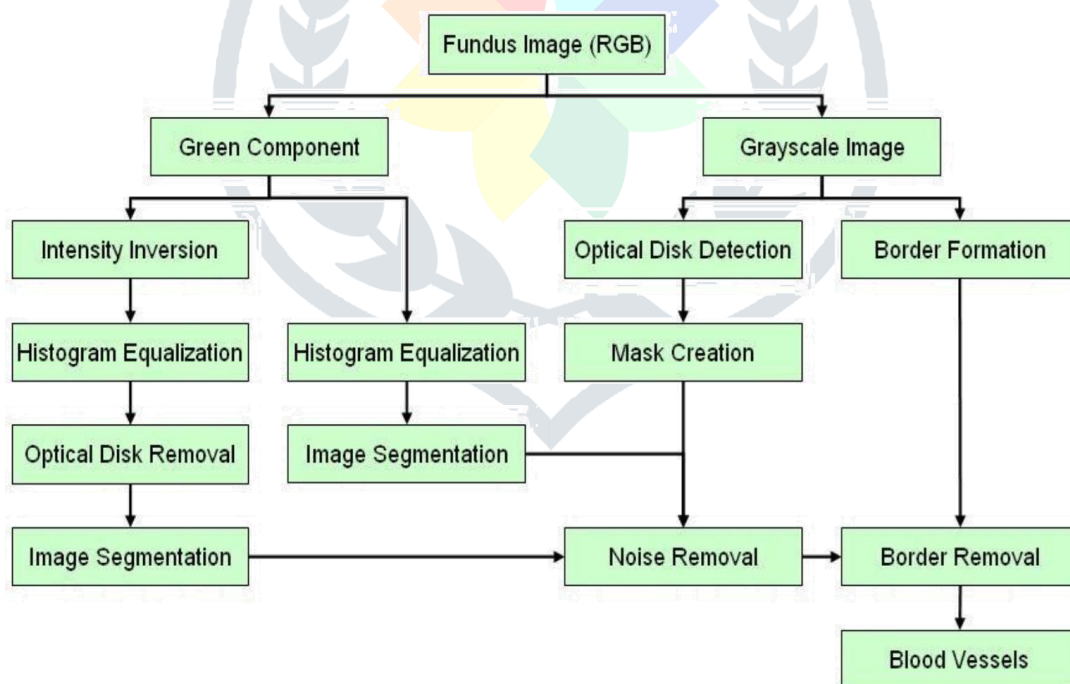


Fig.1 Block Diagram for Blood Vessels Detection

Experimental procedure for Detection of blood vessels

This section discusses in greater detail of the extraction of the blood vessels. The fundus image is first preprocessed to standardize its size to 576x720. The intensity of the green channel is then inverted before adaptive histogram equalization is applied.



Fig.2 Original fundus image

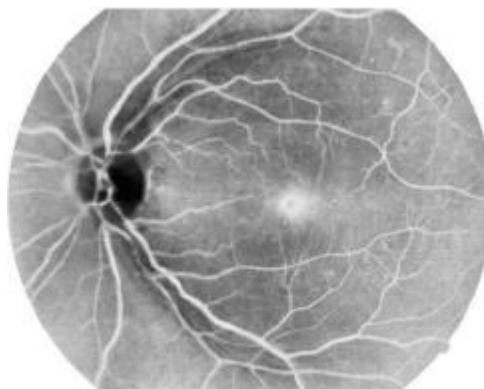


Fig.3 Inversed image after histogram equalization

The optical disk is a black patch in the image as shown at Fig 3. Morphological opening which consisted of erode followed by dilate is applied. Erode function protects the small blood vessels by reducing their sizes while dilate function blows up the larger remaining details which are intended to be removed. The optical disk is then removed by subtracting Fig 3 with Fig 4

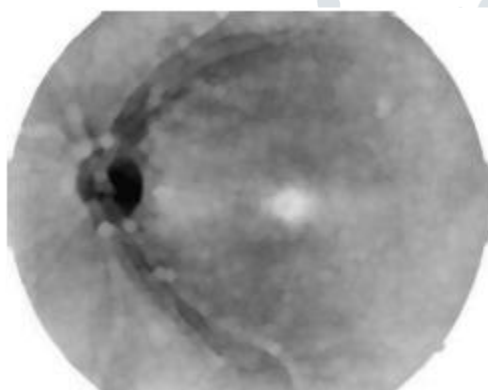


Fig.4 Image after Morphological Image



Fig.5 Image after optical disk removed

The image (Figure 4) is then converted to a binary image using the function im2bw. The pixels of the input image are converted to binary 1 (white) for values greater than the selected threshold and to binary 0 (black) if otherwise. The converted binary image (Figure 4.2.6) at this point is still noisy and function bwareaopen is applied remove the small area of pixels considered to be noise.

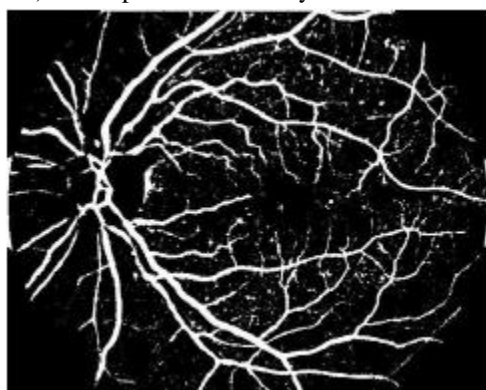


Fig.6 Binary image after Image segmentation

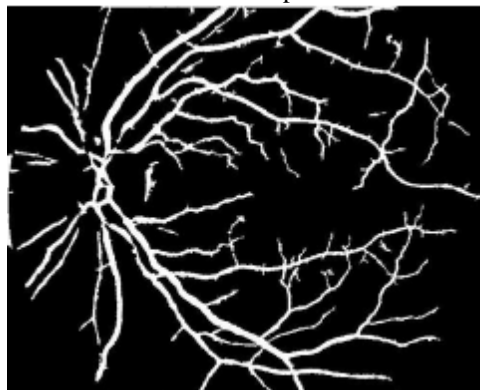


Fig.7 Blood vessels after removal of noise

The green component image (Figure 1) is also applied with adaptive histogram equalization thrice and image segmentation to select the blood vessels area. Small pixels which are considered as noise are also removed.

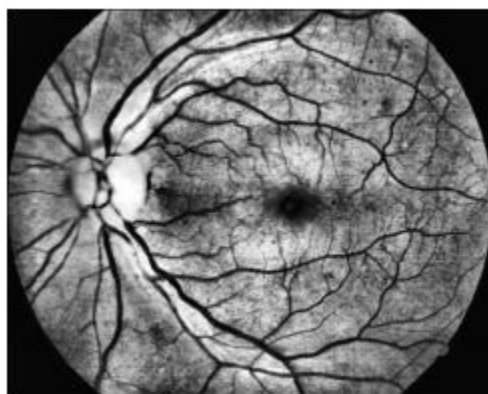


Fig.8 Image after histogram equalization



Fig.9 Blood vessels after image Segmentation and removal of noise

Some blood vessels are lost at the optical disk region after applying image segmentation. Hence, a mask is created to retain those blood vessels located when AND logic is applied.

The image (Fig 8) is combined with the mask and compared with the earlier blood vessel image (Fig 6) using AND logic. The similar pixels are output as binary 1 (white) and represent the blood vessels. The final blood vessels image (Fig 11) is obtained after the removal of the circular border.

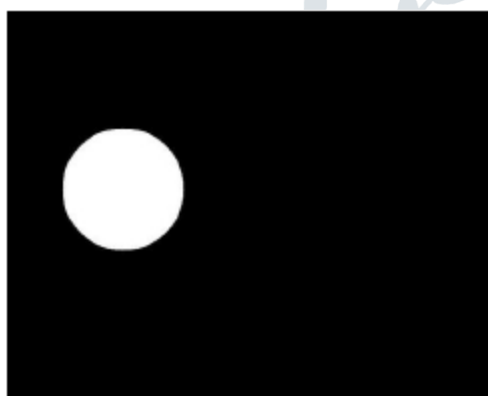


Fig.10 Mask at the optical disk area

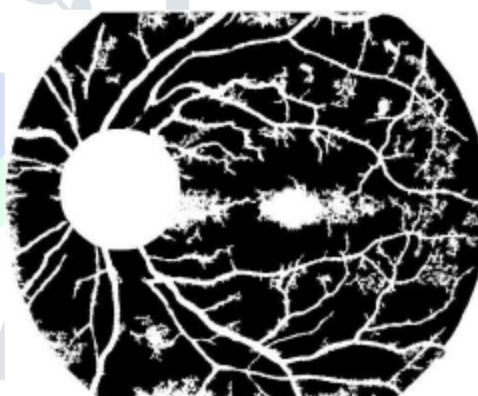


Fig.11 Combined image after removing noise

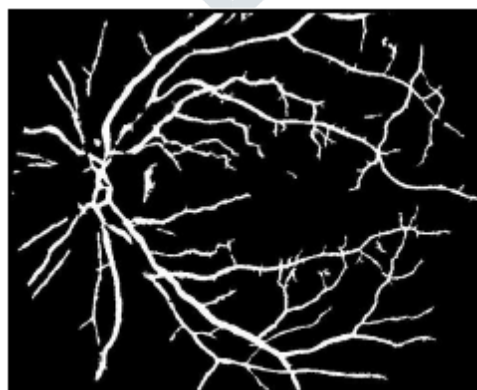


Fig.12 Image of Blood vessels

EXPERIMENTAL PROCEDURE FOR BORDER FORMATION

There are two methods in detecting the circular border of the image. Both methods are essential as each method could not work for a few of the images due to their intensity contrast. Deploying both methods allows the detection of all the images. Border formation is to clean o_ the noisy edges and is also used during Exudates and Microaneurysms detection.

Border Formation Method 1

Grayscale image instead of the green channel is used as it is more efficient in border detection. The first method uses canny method to detect the edges before enclosing the circular region with a top and bottom bar. Function imfill is then applied to fill the region. The circular border is obtained after subtracting the dilated image with the eroded image.

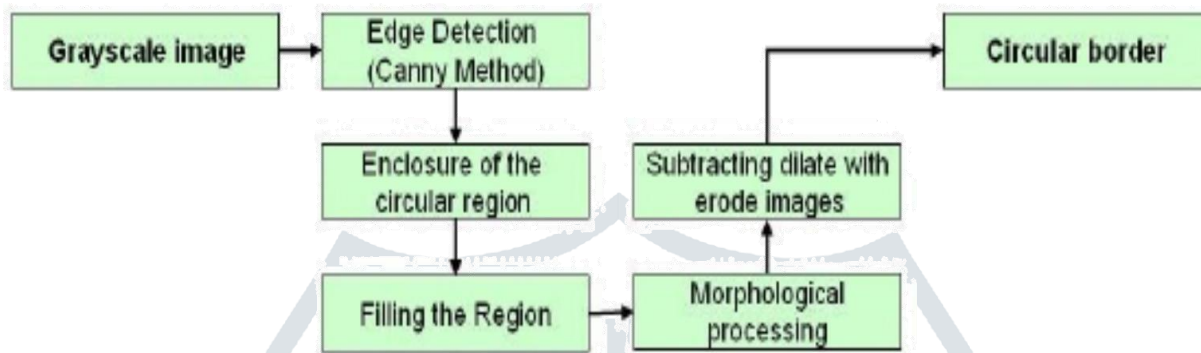


Fig.13 Block Diagram for Border Formation - Method 1

Border Formation Method 2

Method 2 is activated when a noisy image is obtained instead of a circular border. This method inverses the intensity of the image first before image segmentation is applied with the function im2bw. The circular region is filled as a result and the circular border is obtained after subtracting the dilated image with the eroded image.

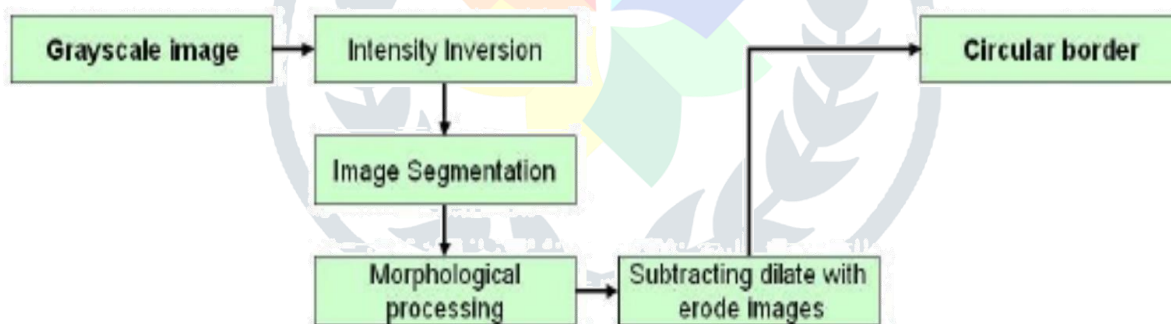


Fig.14 Block Diagram for Border Formation - Method 2



Fig.15 Example of Circular border obtained using either method

EXPERIMENTAL PROCEDURE FOR MASK CREATION FOR OPTICAL DISK

As the optical disk is made up of a group of bright spots, it is not suitable to use loops and locate the largest value. This would only point to one spot and most likely to be on the side of the optical disk. The mask required to cover the optical disk would be inefficient as it would be much larger and covers more details. Mask creation is used in the detection of blood vessels, exudates and microaneurysms.

Grayscale image instead of the green channel is used as it is more efficient in the detection. The above lines would first find the max value for each of the 720 columns of the image before locating the largest value. The coordinates (row and column) of all brightest point(s) are then determined and the median is taken if there is more than one point.

After locating the optical disk, a mask needs to be created. A simple square mask created using loops would be easy but this would result in error when the optical disk is close to the border of the image. The above lines are used instead to generate the circular mask. The function meshgrid is to generate X and Y matrices while the next line that creates the mask is the equation for drawing circle. H and K are the coordinates (row and column) and R as the Radius.

EXPERIMENTAL PROCEDURE FOR AND LOGIC

Two methods of detecting the blood vessels are used. Both methods would generally detect different locations of the images like exudates as blood vessels; hence by computing their similarity, the non blood vessels area could be filtered.

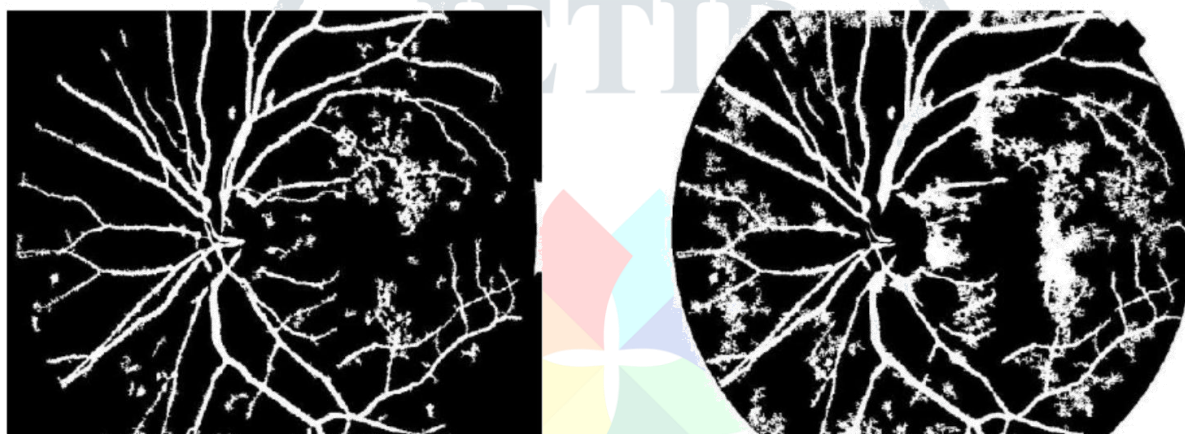


Fig.16 comparing blood vessels images obtained

AND logic is applied to mark out the similar pixels of the two images. The output pixel is registered as binary 1 (white) when the both images pixels are binary 1 (white). The obtained image would be a clearer blood vessels image.

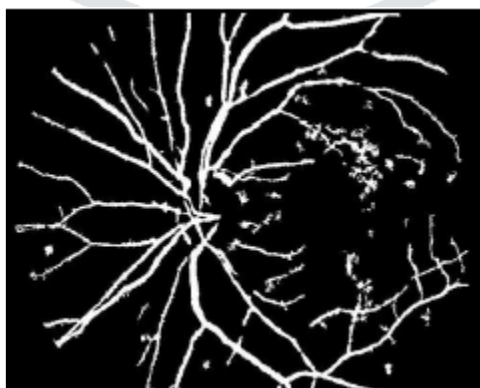


Fig.17 Blood vessels image after apply AND logic

RESULTS

The area of the blood vessels is obtained by using two loops to count the number of pixels with binary 1 (white) in the final blood vessel image.

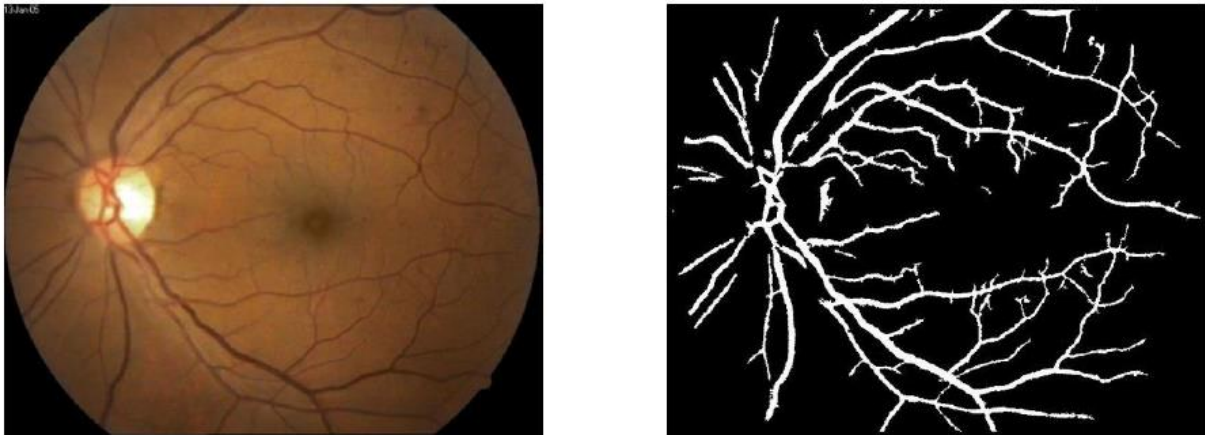


Fig.18 Fundus image (Left) with its blood vessels image (Right)

DISCUSSION

Masking at the optical disk is essential for AND logic as some of blood vessels there are lost after applying adaptive histogram equalization and image segmentation. It is noted that some of the images have noise within the mask area and detect as blood vessels but it is still trivial to affect the overall value.

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