Extraction of Retinal Vasculature by using morphology in Fundus Images

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Introduction

The proposed work presents an image processing technique for the detection of blood vessels in the retinal images by combining morphological operators on two different types of channel, green channel and L channel of L*a*b* respectively. With varying qualities of fundus images, the intensity of blood vessels may vary from each other but in the proposed work an invariant threshold is used to extract the vessels. The proposed method may also give the approximate region of interest of macula position. The advantage of this method does not need any other type of preprocessing steps. The combination of different morphological operators and Gaussian low pass filter is used to detect the blood vessels from fundus image of an eye.

Proposed Algorithm

The block diagram of the proposed algorithm is as shown in Fig 1. Detection of blood vessels by using morphological operators includes different type of operators like Erosion, Dilation, Opening and Closing. By using the combination of different of morphological operators in two different channels of an image the blood vessels are segmented. The proposed methodology is divided into different stages in order to detect the blood vessels.

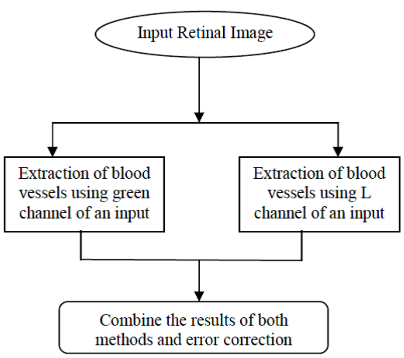

Figure 1. *Block Diagram of Proposed Algorithm*

Fundus image of an eye consist different artifacts and some abnormalities. The Optic disc, fovea and blood vessels are the main artifacts in fundus image of an eye. The pattern and contrast of blood vessels represents that may this part is extracted by using morphological operators.

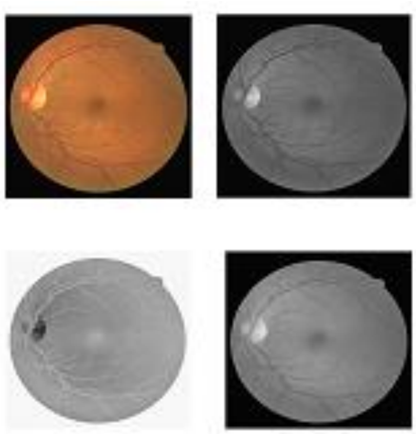

Figure 2. (a) Fundus image (original) (b) Green channel of fundus image (c) Inverted green channel image (d) L channel image

The accurate detection and measurement of blood vessels is an important task to diagnose systematic and ophthalmologic conditions. For diagnosis, evaluation and treatment of various diseases like hypertension, diabetes and chorodial neovascularization some attributes of retinal blood vessels such as width, branching pattern, length and angles are utilized.

In this method for extraction of blood vessels from green channel of fundus image apply combination of morphological operators to enhance the inverted green channel image. This method uses the top hat by opening and top hat by closing.

$$\theta_{TH} = G_{Inverted} - \theta\theta^{(s)}(G_{Inverted}) \quad (1)$$

$$\gamma_{TH} = \gamma^{(s)}(G_{Inverted}) - G_{Inverted} \quad (2)$$

Here equation (1) represents the top hat by opening operation where $\theta^{(s)} = \delta^{(s)}(\varepsilon^{(s)} G_{Inverted})$ is morphological opening where δ is dilation followed by erosion ε of $G_{Inverted}$ image, *s* is the structuring element. Here we use the non flat structuring element of type disk. Similarly $\gamma^{(s)} = \varepsilon^{(s)}(\delta^{(s)} G_{Inverted})$ is the morphological closing, here erosion followed by dilation.

By combining equation (1) and (2) the enhanced image is obtained by following equation-

$$I_1 = G_{Inverted} + \theta_{TH} - \gamma_{TH} \quad (3)$$

In next step the image is reconstructed by using erosion on above resultant image I_2 as marking image and histogram equalized image as masking image. The reconstructed image I_3 is further used for reconstruction using dilation on I_3 image as marking image and masking image same as above on I_3. Then a low pass Gaussian filter is applied on black and white resultant of I_3.

$$g(x,y) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{1}{2}\left(\frac{x^2+y^2}{\sigma^2}\right)} \quad (4)$$

Then an alternating sequential filter of window size 20 is used to detect the region in which macula is present on the resultant image. Then subtract this area from I_4 and apply area thresholding to detect the proper blood vessels. Then apply combination of morphological operators to enhance the L channel image. Same process is follow up to top hat by opening operation. Then in this process Gaussian low pass filter is applied on resultant image of top hat by opening operation.

Both the results are added to get the resultant blood vessels. Using the area thresholding the blood vessels structure is obtained by removing the unwanted noise

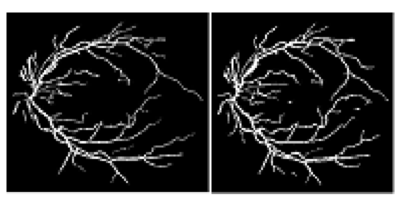

Figure 3. *(a) Vessel extracted from given fundus image by using L channel,(b) Vessel extracted from combination of results from green and L channel*

Resultant images from both channels green and L of L*a*b are combined to detect proper blood vessel structure as in both cases different veins are missing. So, after combining the result almost all vessels are detected.

Results

The proposed work was performed on a DRIVE data set of given fundus images. In all images the detection of region of interest in which macula is present is successfully obtained with high accuracy and for the detection of blood vessels the algorithm was successfully implemented and positive results with accuracy of 75 to 80% is obtained. The result indicates that most blood vessels are detected properly with low noise. However, there is a scope for improvement in the noise minimization. Results indicates that the combined result of vessel detection of fundus image of an eye from green channel and L channel gives better and accurate result with low noise in comparison of using only one channel.

Figure 4. *Sample 2 (a) Fundus image (original) (b) Vessel detected from Green channel of fundus image (c) Vessel detected from L channel of fundus image (d) Vessel detected from combination of results of both channel*

Table 1: CORRELATION COEFFICIENT OF MANUALLY EXTRACTED VESSEL WITH PROPOSED METHOD

Samples	**Correlation coefficient of manually extracted vessel structure with**		
	Vessel extracted from green channel	**Vessel extracted from L channel**	**Vessel extracted from combining method**
Sample 1	72.68	72.85	77.48
Sample 2	76.63	72.01	79.55
Sample 3	68.78	65.08	73.67
Sample 4	70.02	69.67	74.67
Sample 5	69.40	69.67	75.53

The correlation coefficient of manually extracted vessels structure with the vessel extracted by using proposed method is shown in Table 1. By combining the two channels for vessel extraction gives better result.

Conclusions

The proposed methodology of detection of vessels is an efficient approach as its complexity is low and this process also gives the approximate region of macula position. The major challenge faced in detection of blood vessels is imaging noise and low contrast between vessels and background. Here the morphological operators using with Gaussian filter gives the good results with less computation time. The future work may accuracy of the proposed work can be more improved by making the threshold values independent of image properties.

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