Automated Segmentation of Blood Vasculature from Retinal Images

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Abstract

In this paper an algorithm is proposed for blood vessel extraction from an eye's fundus image. Blood vessels removal and detection is an important step to find features or abnormalities like red lesions, optic nerve and fovea used for retinal health diagnosis. The proposed method uses a strategic combination of green and L channel to develop the final vessel structure which increases the accuracy. A combination of morphological operators and intensity based thresholding are used which creates a method which is computationally efficient and less complex. A set of public DRIVE data of fundus image of an eye is used to test the proposed algorithm. The results show a better comprehensive performance of vessel extraction and computationally efficient method.

Proposed Algorithm

Blood vessel in retinal image plays a vital role in medical diagnosis of many diseases. Diabetic retinopathy is one of the diseases which damage the retina and leads to blindness. The extraction of blood veins and vessels from fundus image is proposed which using laplacian operator and morphological operations. To enhance the extraction of the desired blood vessels and veins, various pre-processing and post-processing techniques are used. The flow chart as shown in Fig.1 describes the proposed algorithm.

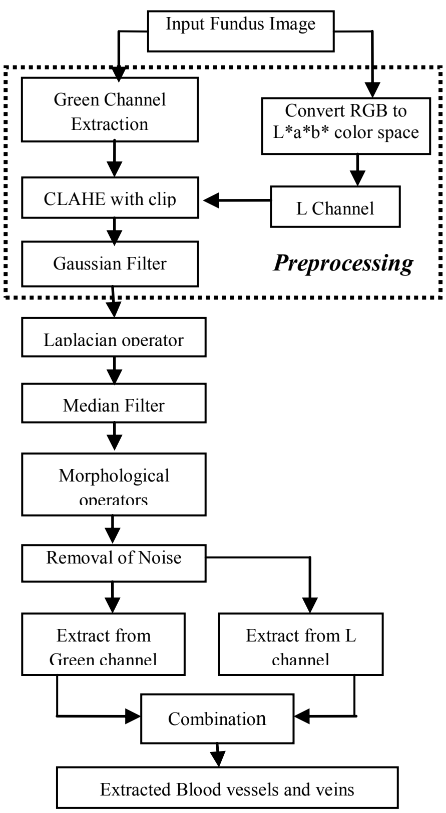

Fig.1. Flow Diagram of Proposed Algorithm

A. Preprocessing:

The input fundus image is analyzed to extract the green channel and L-channel of the image. In green channel image, the veins and vessels can be seen clearly.

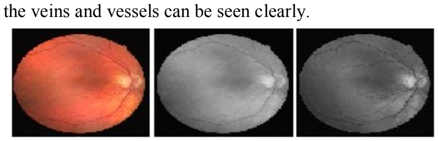

Fig.2. a) Input Image b) Green Channel c) L Channel

The second step of the pre-processing is histogram equalization. This is used to normalize the variation of brightness in the fundus image. Contrast Limited Adaptive Histogram Equalisation (CLAHE). To eliminate the unwanted elements i.e. noise from the retinal fundus image, the Gaussian filter is used. Laplacian is use to detect the edges, and is based on second partial derivation.

$$\nabla^2 g(x,y) = \frac{\partial^2 g(x,y)}{\partial x^2} + \frac{\partial^2 g(x,y)}{\partial y^2}.$$

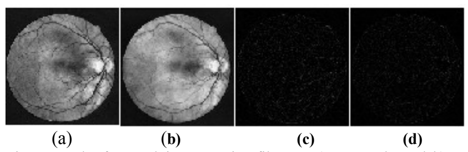

Fig.3. Result after applying Gaussian filter on a) Green channel b) L-Channel. Result after applying Laplacian operator on c) Green channel d) L Channel

B. Vessel Extraction using morphological operators

After application of Laplace operator, there is some noise left behind in the image. To remove that noise, median filtering is used. For removing the false positives, which were highlighted by Laplace operation, Top hat filter is used.

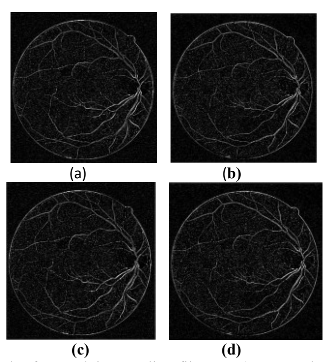

Fig.4. Result after applying Median filter on a) Green channel b) L-Channel. Result after applying Top hat filter on c) Green channel d) L Channel

C. Post processing - Removal of False Positives

Unwanted segments can be removed by eliminating the noise by specifying its size which is known as area opening. Both the processed images (green channel and L channel) are extracted and combined. The final image of extracted blood vessel and veins is obtained by segmenting the combined image of green and L channels.

Experimental Results

Extracted blood vessels were compared with training images provided by DRIVE database. For final evaluation of accuracy of proposed algorithm correlation coefficient is computed between manually extracted and vessel extracted using proposed method. Proposed method achieves 75 to 80% of correlation coefficient. Table 1 shows he computation time for different samples and it shows that the proposed method is computationally efficient which takes only 2.2 sec for vessel extraction.

For evaluating the proposed method, two sample images used and their results are shown in Fig. 5. It can be inferenced from the output result that most of the blood vessels are properly detected with less false positives. The combined result of vessel extraction from green channel and luminous channel gives low noise as compared to using only one channel. Table II shows the correlation coefficient of vessel extracted from the proposed method and manual extraction of vessels.

TABLE I. COMPUTATION TIME

Images	Computation time (in sec)
Sample 1	2.350123
Sample 2	2.380477
Sample 3	2.393586
Sample 4	2.329731
Sample 5	2.106704
Sample 6	2.247982
Sample 7	2.352926
Sample 8	2.144225
Sample 9	2.12003
Sample 10	2.34905

TABLE II. RESULTS OF CORRELATION COEFFICIENT

Images	Correlation coefficient of manually extracted vessels with		
	Vessel extracted from green channel	Vessel extracted from L channel	Combined
1	0.683	0.6622	0.7135
2	0.6632	0.659	0.6822
3	0.7043	0.681	0.7126
4	0.6535	0.6391	0.6669
5	0.7343	0.7177	0.7358
6	0.6890	0.7180	0.7258
7	0.7964	0.7889	0.8087
8	0.7837	0.7588	0.7846
9	0.7495	0.737	0.7518
10	0.7259	0.7165	0.7323

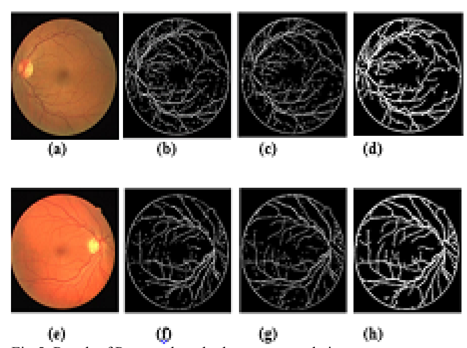

Fig 5. Result of Proposed method on two sample images

Conclusions

The methodology proposed for detection of blood vessels is automatic and its complexity is low, making the process suitable for real time applications. The unwanted noise, non-uniform illumination and low contrast between background and vessels are the major difficulty faced in segmentation of blood vessels, all these are addressed in this proposed work. The morphological operators used with Gaussian filter and Laplacian operator provides a better result and also computationally cheap. Future work in this direction may be to explore other methods of blood vessel extraction with more improved computational speed.

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