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Morphological Segmentation of Blood Vessels in Retinal Image

Prof. Manjusha S. Borse[1]

[1] Department of Electronics & Telecommunication, Savitribai Phule Pune University, Late G. N. Sapkal COE Nashik, Maharashtra 422213, India

Abstract

Retinal vascular segmentation is the primary stage of any retinal image analysis system. This vascular segmentation is useful in automated retinal disease detection and in diagnosis system, as it is found that retina indicates early signs of various systemic diseases like hypertension, diabetes, cardiovascular diseases and retinopathy of prematurity. In this, retinal image segmentation plays a vital role in image processing; with this approach in this paper we have proposed an improved method for retinal blood vessel segmentation using morphological image processing. In this proposed work not only the entire retinal graph network is extracted from retina but here we classifies vessels branching and crossing in the whole network by assigning the class of end point, intersection point, splitting point. The results of given method are compared with all existing segmentation systems and here we found that our method outperforms by giving accuracy of 90% in vascular segmentation.

Keywords: *Retina, Morphology, Segmentation, Structuring elements, Nodal analysis, Retinal vessels.*

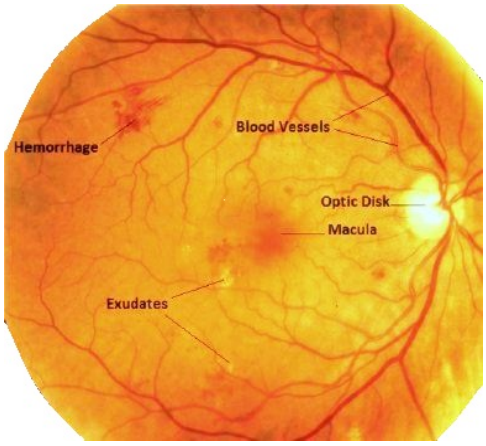

Fig. 1 Structure of Retina with Uneven Background, Optic Disc, Macula and Hemorrhage

1. Introduction

The analysis of vascular features like vascular width, branching angle, vessels tortuosity, fractal dimensions are key performance structural parameters that are used in identification, treatment & assessment of several ophthalmologic diseases like hypertension, diabetes, hypertensive retinopathy [1] [2] [3].

Automated segmentation and analysis of retinal vessels will assist the diagnosis and treatment of above mentioned diseases [4]. If the retinal network is complicated or the images to be processed are in large size then manual segmentation of such retinal image becomes more tedious, hectic. Automating the retinal segmentation offers greater potential to serve for oversized screening programs. This automatic segmentation currently adopted by almost all biomedical fields [5].

Retinal blood vessel segmentation is a challenging task as retina consists of blood vessels which are further classified as arteries and veins, optic disc, macula, exudates, hemorrhage, cotton-wool spots etc. [6] Retinal segmentation operation becomes more difficult as vascular images having irregular illumination.

Many clinical objectives are described in case retinal segmentations like widening veins in patient are sign of diabetes [7] [8]. Narrower artery leads to pancreas disease. Hypertensive retinopathy is diagnosed with help of vessel tortuosity and arteriolar narrowing, segmentation also useful in computer screening of diabetic retinopathy [9]. Cardiovascular diseases and hypertension are diagnosed by measuring vessel caliber [10]. Age related macular degeneration also identified with vascular segmentation. This useful in finding the fovea localization and optic disc position in retina. Furthermore, in biometric identification segmentation contribute to a great extent by adopting techniques like matching vascular graph for image registration [11] [12].

In this paper, we proposed an automatic method for vascular segmentation of retinal blood vessels network with help of morphological image processing, Centerline extraction, using morphological operators for filling segments of vessels, several transformations. Various structural and morphological properties of vessels are taken into account for successfully extracting the retinal vascular network in this given approach. Following are the main stages of proposed morphological vascular

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segmentation: 1) Retinal image Preprocessing which involves background normalization by improving contrast of an image. 2) Morphological segmentation & vessel filing for extracting vascular network of vessels & reconstructing the vessels link by filing holes in operation. 3) Vessel centerline extraction to extract final segmented graph of retina.

2. Methods for Vessel Segmentation

There are several approaches for retinal vascular segmentation like supervised methods, unsupervised methods, matched filtering, vessel tracking approach, multi-scale based, vessel profile models, deformable models, parallel/hardware based approaches etc. These all images taking retinal intensity based profile approach for vascular segmentation

I supervised methods; with help of algorithm rules for extracting vessels are learned with reference to manually segmented images which are also called gold standard images. Nekovei and Ying [13] proposed blood vessel segmentation in angiography with help of back propagation algorithm. Where, this algorithm applies neural network directly to pixels of an image. Feature vectors are generated with help of gray scale values. Sinthanayothin [14] gives the approach by combining principal component analysis using neural network. Here it has achieved 0.8560 of accuracy.

Nemeijer [15] described a method by extracting green channel from ray scale image and processing it with help of Gaussian matched filtering followed by k-NN classifier which finds probability of retinal pixels fitting to vessels. Staal [16] proposed ridge approach for vascular segmentation using STARE database, here they found accuracy of 0.9516 by using k-NN classifier.

Unsupervised vessel segmentation method proposed by Kande [17] using fuzzy modeling which worked on red, green extracted retinal fundal images where matched filtering is adopted to enhance the retinal image. For getting vascular segmentation a fuzzy based C-means clustering is adopted. This method uses DRIVE & STARE databases.

Matched filtering technique is presented by Hoover [18] it combines local as well as regional properties of retinal vessels for extracting segmented blood vessels using appropriate threshold values.

Epsona [19] presents an approach with snakes in combination with blood vessel structuring properties for segmentation further this research was extended to morphological snake processing. Martines-Parez [20] described an approached based on maximum principal curvature, region growing & magnitude gradient which is multi-scale tracking method. Miri [21] proposed a method based on curvelet transformation & various structuring elements using morphology this is vessel tracing approach to segment retinal blood vessels. Marin proposed a neural network, moment invariant based with gray image with supervised classification.

3. Proposed Method: Morphological Vessel Segmentation

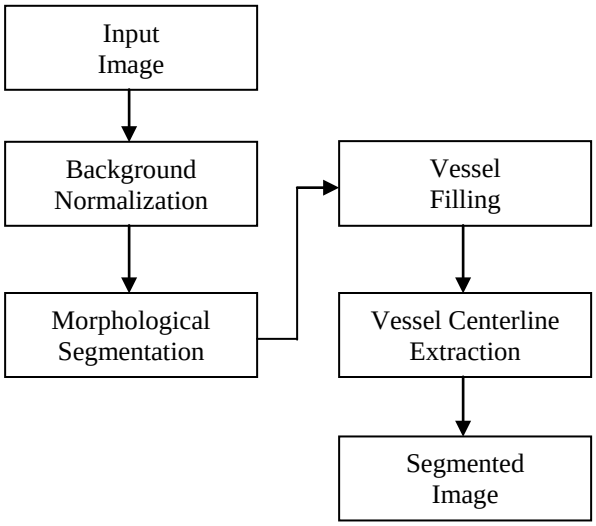

Fig. 2 Block Diagram of the Proposed Method for Retinal Vessel Segmentation

The proposed method in this paper follows a morphological image processing approach. The block diagram schematically described in fig. 2 in which three main functional phases: 1) Retinal image Preprocessing 2) Morphological segmentation & vessel filing 3) Vessel centerline extraction

3.1 Retinal Image Preprocessing Phase

As we know retina having uneven illumination throughout image hence before processing such image we have to normalize its background. For this the input retinal image which is in RGB form which we have to convert in gray scale image. We convert these images to red channel, green channel and blue channel.

For segmentation we use green channel image as it increases the contrast between background plane and retinal blood vessels. We are also able to get bright and too dark retinal images if we extract red and blue channels respectively.

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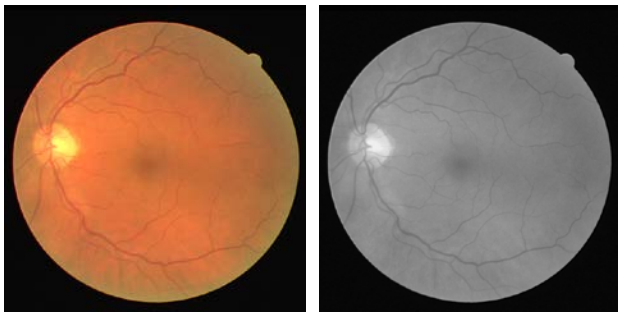
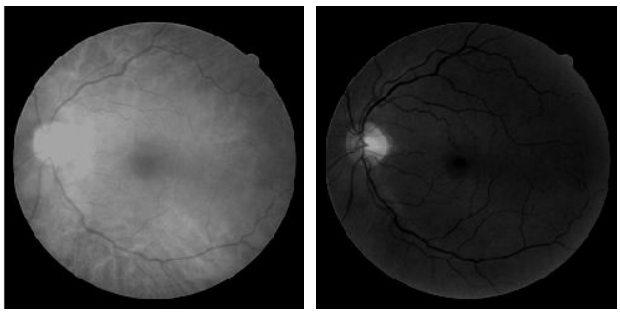
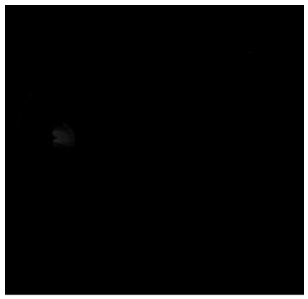


(a) (b)

Fig. 3 Input Image; (a) Original Image (b) Gray Scale Image



(a) (b)



(c)

Fig. 4 RGB Channel Conversion (a) Red Channel (b) Green Channel (c) Blue Channel

3.2 Morphological Segmentation & Vessel Filing

We know image morphology for analyzing specific shapes of an image. Mathematical morphology mainly involves two operations in it those are erosion and dilation.
This process two sets of images where one is actual image which is to be processed and other is small set of pixels generally called kernel or structuring element (SE).Dilation is used for expanding objects ,filling hole purposes while erosion shrinks an object by applying SE. We have implemented the top-hat transformation in morphological segmentation of retinal vessels. For segmentation we processed gray scale image with top-hat operators by using various structuring elements those are ball shaped, disc shaped, square shaped, line shaped, global structuring element.
The results for structuring elements are shown in Fig. 5 where ball shaped structuring element having radius of ball in 0,2,4,6 pixel which covers entire caliber range of vessels. As in Fig. 6 Disc shaped structuring element morphological operation is performed by using disc radius equal to 3 pixels. Fig. 7 gives an output for square size structuring element with size of 5,while line structuring element gives overall global structuring element by combining output of line segmented morphological operation in horizontal(0^o),vertical(90^o),diagonal(45^o and 135^o) with constant length of pixels which are shown in Fig 8.

3.3 Vessel Centerline Extraction

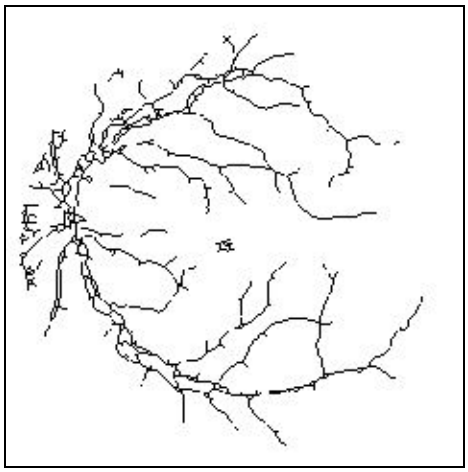


Fig. 5 Morphological Segmentation Output: Ball Shape SE

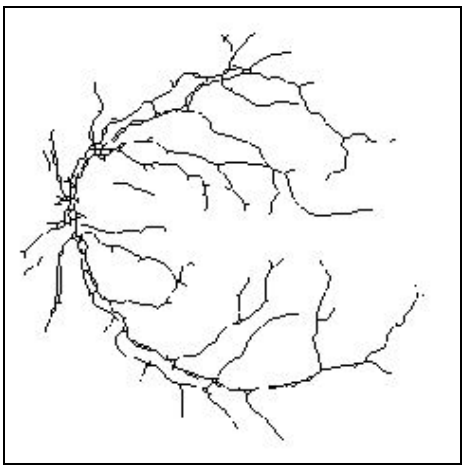


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Fig. 6 Morphological Segmentation Output: Disc Shape SE

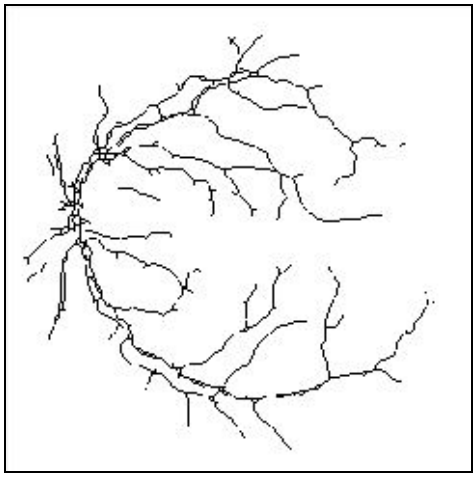

Fig. 7 Morphological Segmentation Output: Square Shape SE

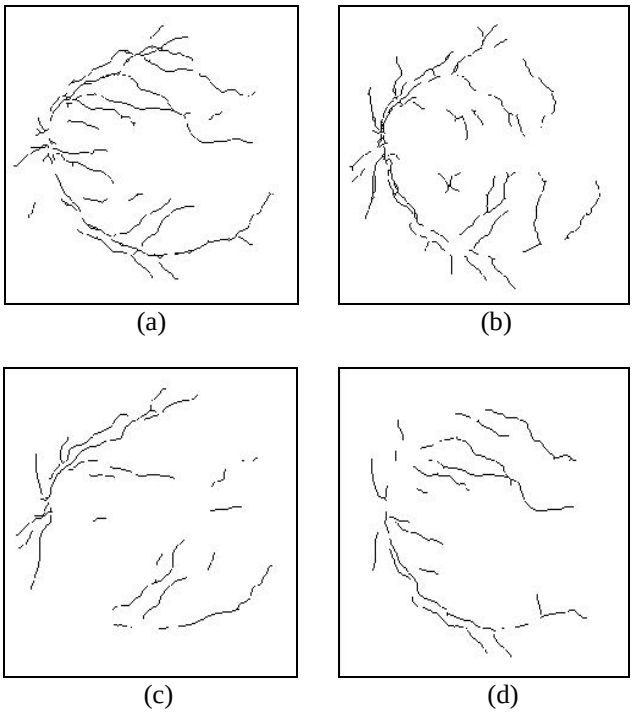

Fig. 8 Morphological Segmentation Output: Line Shape SE (a) Horizontal (b) Vertical (c) Diagonal-45° and (d) Diagonal-135°

4. Results and Discussion

Here proposed method uses images of DRIVE database which is publically available. The proposed method of vascular segmentation gives better result compared with all existing techniques .We have found better accuracy of given vessel segmentation is about 0.9679 which implies that this proposed method is best suitable for retinal vascular segmentation.

4. Conclusions

On basis of proved segmentation result the proposed method in this paper to be a reliable method for vascular segmentation of retinal blood vessels. The results in term of accuracy are much better than whatever work has been up till now in this field. We are not only extracting vessels from specific region from retina but extracting whole vascular network from an image successfully.

The proposed method does not restrict to extracting vascular graph for major retinal vessels but it extracts minor components of retinal vasculature. We have successfully implemented this morphological vascular segmentation approach with help of disc, square, ball, line shaped various structuring elements in various dimensions to achieve better results.

Future work is planned for automated segmentation of retinal blood vessels in artery and veins which will be next step for automated diagnosis of various systemic diseases lie hypertension, diabetic retinopathy & other cardiovascular diseases.

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