A COMPARATIVE ANALYSIS OF RETINAL BLOOD VESSEL SEGMENTATION METHODS

Dhiraj Amrutkar¹, Sumedh Dharia²

¹Assistant Professor, Department of Computer Science, Government Vidarbha Institute of Science and Humanities, Amravati (M.S.), India, dhirajamrutkar@gmail.com

²Assistant Professor, Department of Computer Science, Government Vidarbha Institute of Science and Humanities, Amravati (M.S.), India, sumedh_dharia@msn.com

ABSTRACT

Diabetic retinopathy is a major cause of adult optical incapacitation due to vicissitudes in blood vessel structure. The segmentation of blood vessels in retinal images can be a valuable tool for the detection of diabetic retinopathy and glaucoma diagnosis. Blood vessels, optic disc and diseases like lesions in fundus retinal images have been segmented using different segmentation techniques.

Segmentation of fundus retinal images and blood vessel detection are verified on publicly available STARE and DRIVE databases and compared to several state-of-the-art methods.

Key words – retinopathy, blood vessels, segmentation

INTRODUCTION

An eye disease called Diabetic Retinopathy could be the source of vision loss if left undiagnosed at an early stage. Color fundus images are used by ophthalmologists to study eye diseases like diabetic retinopathy. Early detection of diabetic retinopathy through regular screening is particularly important to prevent vision loss. [14] The blood vessels is the most stable object in retinal fundus image which can reflect the state of the disease. In diabetic retinopathy analysis of retinal blood vessels plays the significant role. Accurate and automated extraction of blood vessels in retinal images is vital step in computer based diagnosis. [3] Lot many segmentation techniques have been developed for segmentation of retinal blood vessel, optic disc etc.
The paper is structured as follows: Section 2 presents literature review on various segmentation models. The performance parameters are discussed in Section 3. The experimental results of different models are given in Section 4. Section 5 makes the concluding remarks.

2 REVIEW OF SEGMENTATION MODELS

Various segmentation models are used by researchers for blood vessel segmentation.

- **Detection of blood vessels in Retinal Images using Two Dimensional Matched Filter (S.Chaudhuri [1])**
  The author used simple operators for blood vessel detection and also take the advantage of edge detection model. They used concept of matched filter for the detection of linear segments in blood vessels and also discussed various issues while implementing matched filter. Segmentation model used is pixel processing.

- **Ridge-Based Vessel Segmentation in color images of Retina (Joes Staal et al.[2])**
  Joes Staal et al. presented method for the extraction of image ridges (line=pixel). Feature vectors are calculated for every pixel that makes use of properties of patches and line element. KNN classifiers and sequential forward selection are used as feature vector classifier. Segmentation model used is supervised learning.

- **Retinal Vessel Segmentation Using the 2-D Morlet Wavelet and Supervised Classification (Soares et al. [4])**
  Soares et al. classified segments as vessel or non vessel depending on pixel’s feature vector. Morlet wavelet tunes specific frequencies and thus allows vessel enhancement. The authors also used Bayesian classifier with class conditional probability for fast classification. Gaussian Mixture Model has fast classification and better performance. Segmentation model used is supervised learning and pixel processing.

- **Detection of blood vessels in ophthalmoscope images using MF/ant algorithm (M.Cinsdikici [12])**
M. Cinsikici says that only matched filter are not sufficient to accurately detect blood vessels and hence he proposed the hybrid approach of matched filter with ant colony algorithm for detection of blood vessel. Segmentation model used is pixel processing.

- **Effective combined algorithms for retinal blood vessel extraction (Yong Yang et al. [7])**

Yong Yang et al. proposed novel strategy for blood vessel extraction in 3 steps. Retinal image is enhanced using improved matched filter. Local entropy thresholding used for thin vessel while adaptive thresholding is used for thick vessel. Logical OR operation is used on thick and thin vessel.

- **An effective retinal blood vessel segmentation method using multi-scale line detection (Uyen T.V. Nguyen et al. [8])**

Uyen T.V. Nguyen et al. presented method based on the fact that line detectors at varying scale can be achieved by changing the length of line detectors. While maintaining the strength and removing drawback of individual line detector, line responses of at varying scales are linearly combined. The segmented method produced accurate segmentation on central reflex vessel.

- **Performance analysis of retinal image Blood vessel segmentation (D. Siva Sundhara Raja et al. [6])**

D. Siva Sundhara Raja et al. have used morphological and SVM classifier to detect and segment the blood vessels from the retinal images. The local binary pattern and GLCM features are extracted from the morphologically processed image and used as blood vessels features.

- **An approach to localize the retinal blood vessels using bit planes and centerline detection (Fraz et al. [23])**

In order to extract the blood vessel tree from fundus retinal images Fraz et al. have used the blending of vessel centerlines detection and morphological bit plane slicing. Using the first order derivative of a Gaussian filter in four orientations the centerlines are extracted. After extraction of centerlines the evaluation of derivative signs and average derivative values is performed.

- **Detection of retinal blood vessels based on nonlinear projections (Y. Zhang et al. [19])**

In order to get texture structure in retinal image the nonlinear projection were used by Y. Zhang et al. The extracted green channel of retinal image is projected on convex set consisting of oscillating functions with zero mean. While capturing the features of blood vessels the oscillating components of scanning retinal images are adopted.

- **Improvement of a retinal blood vessel segmentation method using the Insight Segmentation and Registration Toolkit (ITK) (M. E. M. Perez et al. [18])**

In order to measure and quantify the geometrical and topological properties of retinal vascular tree semi automatic method using scale space segmentation algorithm were described. The process
includes semi-automatic labeling of skeleton trees, measurement of length, area, diameter and branching angle of vessels.

2. PERFORMANCE PARAMETERS
In the retinal vessel segmentation process, the outcome is a pixel-based classification result. Any pixel is classified either as vessel or surrounding tissue (non-vessel). Consequently, there are four possibilities; two classifications and two misclassifications. The performance of blood vessel segmentation models is evaluated with the following parameters. If the pixel is recognized as both the ground truth and segmented image then classification is known as true positive (TP), it is true negative (TN) when a pixel is classified as a non-vessel in the ground truth and the segmented image. If the pixel is recognized as non-vessel in the segmented image but as a vessel pixel in the ground truth image it is called false negative (FN), it is false positive (FP) when a pixel is notified as vessel in the segmented image but non-vessel in the ground truth image.

- Sensitivity = TP/(TP+FN)
- Accuracy = (TP+TN)/(TP+FN+TN+FP)

3. EXPERIMENTAL RESULTS

Following table gives the performance analysis of segmentation model using different techniques.

In terms of performance Supervised classification of algorithms works better than their counterparts. If the images have non uniform illumination these methods do not works well as they generate false detection on the border of the hemorrhages, optic disc and other types of pathologies that present strong contrast. The matched filtering is not sufficient to handle vessel segmentation in fundus retinal images; hence it is used in association with other image processing techniques. The sensitivity and accuracy plots of some of the reviewed fundus retinal vessel segmentation techniques are shown in Fig. 2 (for DRIVE) and Fig. 3 (for STARE).

<table>
<thead>
<tr>
<th>Sr.No</th>
<th>Segmentation Method</th>
<th>DRIVE Database</th>
<th>STARE Database</th>
<th>Classification / Technique Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Staal et al. (2)</td>
<td>0.7194</td>
<td>0.6970</td>
<td>Supervised Learning</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.9442</td>
<td>0.9516</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Soares et al. (4)</td>
<td>0.7283</td>
<td>0.7211</td>
<td>Supervised Learning</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.9466</td>
<td>0.9479</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Chaudhuri et al. (1)</td>
<td>0.6168</td>
<td>0.6608</td>
<td>Matched filter</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.9284</td>
<td>0.9381</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Cinsdikici et al. (12)</td>
<td>-</td>
<td>0.6608</td>
<td>Matched filter</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.9293</td>
<td>0.9381</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Yong Yang et al. (7)</td>
<td>-</td>
<td>0.7842</td>
<td>Matched filter</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-</td>
<td>0.9220</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Siva Sundhara Raja et al. (6)</td>
<td>0.7800</td>
<td>0.7842</td>
<td>Morphological</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.9510</td>
<td>0.9220</td>
<td></td>
</tr>
</tbody>
</table>
3. CONCLUSION

The major problem in automatic processing of fundus retinal images is the detection of blood vessels. The vessels have certain characteristics namely diameter which may be the key indicator in the development of certain retinopathies. Out of all available techniques they are cost effective still there is chance to improve over the results. So authors are proposing new technique to detect blood vessel in retinal image based on supervised learning using K nearest neighbor.

REFERENCES


