AUTOMATIC SEGMENTATION OF RETINAL VASCULATURE

Renoh Johnson Chalakkal and Waleed Abdulla

Department of Electrical & Computer Engineering

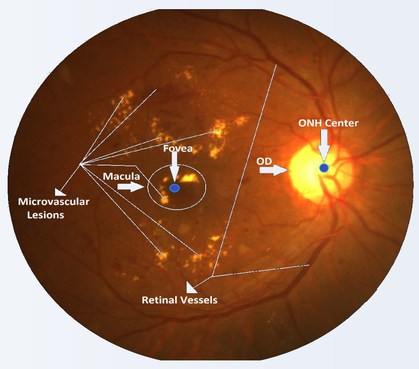
University of Auckland

New Zealand

Abstract

- Unsupervised automatic method capable of segmenting the vessels from retinal images is developed.
- The method is based on the image processing techniques like contrast enhancement, adaptive histogram equalization, anisotropic diffusion filtering, edge enhancement using curvelet transform, morphological processing and connected component analysis.
- Fuzzy C-mean classification is used for the final classification of vessel pixels.
- The performance of the method is evaluated on images from DRIVE database and the results are superior to other existing state-of-art methods.
- The developed method performs well on both healthy and pathological images.

Fig. 1. (a) Retinal imaging



(b) Retinal image features

Objectives

- Develop an automatic unsupervised retinal vessel segmentation algorithm with improved accuracy and reduced misclassification error.
- Compare the performance of the developed algorithm with other state-of-art methods.

Method

- Five major steps: retinal image contrast enhancement, retinal vessel edge enhancement, optic disk removal, vessel segmentation and the post-processing.
- Retinal images from DRIVE database is used for testing and evaluating the performance.

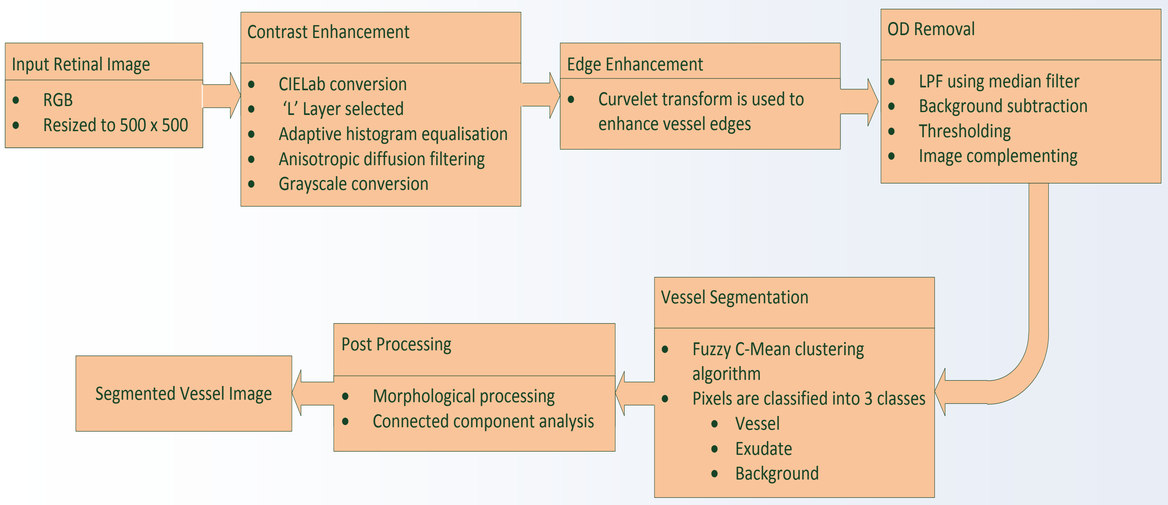


Fig. 2. Automatic segmentation of retinal vasculature

Results

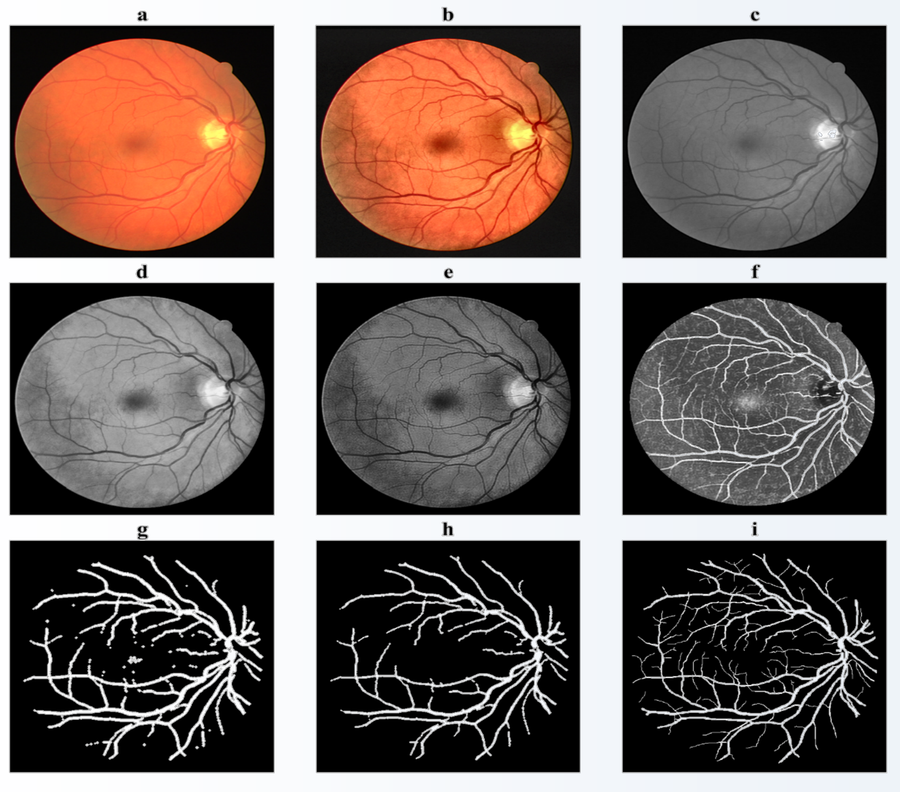


Fig. 3. (a) original retinal fundus image ('02_test.tif' from DRIVE database), (b) contrast enhanced image, (c) green channel image of original image, (d) weighted scale image, (e) vessel edge enhanced image, (f) OD removed vessel enhanced image, (g) segmented vessels after applying FCM, (h) final result of vessel segmentation (after morphological processing and CCA), (i) manually segmented reference image ('02_manual1.gif') from DRIVE database.

Method	Sensitivity	Specificity	Accuracy
Zana et al. [1]	0.6971	-	0.9377
Mendonca et al. [2]	0.7344	0.9764	0.9452
Fraz et al. [3]	0.7152	0.9759	0.9430
Niemeijer et al. [4]	-	-	0.9416
Staal et al. [5]	-	-	0.9441
Proposed method	**0.7386**	**0.9769**	**0.9518**

Table 1. Comparison of vessel extraction results on DRIVE database

Conclusion

- The proposed method achieves the highest sensitivity and accuracy.
- The retinal image contrast enhancement and the vessel edge enhancement using the curvelet transform makes the proposed method perform well on images with uneven contrast and illumination.
- Optic disk removal helps to reduce the misclassification error thereby improving the accuracy of the method.
- Our next immediate task is to improve the proposed algorithm to detect the delicate and thin vessels in the retinal images which can further increase the overall segmentation accuracy of the algorithm.

References

1. F. Zana and J. Klein, "*Segmentation of vessel- like patterns using mathematical morphology and curvature evaluation*," IEEE Transactions On Image Processing, vol. 10, pp. 1010-1019, 2001.
2. A. M. Mendonca and A. Campilho, "*Segmentation of retinal blood vessels by combining the detection of centerlines and morphological reconstruction*," IEEE Transactions On Medical Imaging, vol. 25, pp. 1200-1213, 2006.
3. M. M. Fraz, S. A. Barman, P. Remagnino, A. Hoppe, A. Basit, B. Uyyanonvara, A. R. Rudnicka and C. G. Owen, "*An approach to localize the retinal blood vessels using bit planes and centerline detection*," Comput. Methods Programs Biomed., vol. 108, pp. 600-616, 2012.
4. M. Niemeijer, J. Staal, B. Van Ginneken, M. Loog, M. D. Abràmoff and M. D. Niemeijer, "*Comparative study of retinal vessel segmentation methods on a new publicly available database*," Proc SPIE Int Soc Opt Eng, vol. 5370, pp. 648-656, 2004.
5. J. Staal, M. D. Abramoff, M. Niemeijer, M. A. Viergever and B. van Ginneken, "*Ridge-based vessel segmentation in color images of the retina*," IEEE Transactions On Medical Imaging, vol. 23, pp. 501-509, 2004.