Chapter 48
Retinal Blood Vessel Extraction From Fundus Images Using Improved Otsu Method

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ABSTRACT

In the present time, the identification of blood vessels is a basic task for diagnosis of various eye abnormalities. So, this article offers an instinctive approach for identification of blood vessels in ophthalmoscope images. This approach includes three different phases: pre-processing, vessel extraction and post-processing for getting a final vessel segmentation outcome. In the presented method, formerly log transformation and contrast limited adaptive histogram equalization are used for the enhancement of retinal images. The enhanced image is then filtered using a morphological opening operation and subsequently the optic disk is removed. The second phase includes the application of the improved Otsu method on the pre-processed image for the identification of blood vessels. Lastly, the resultant vessel-segmented image is obtained by using the morphological cleaning operation. The proposed method is fast, time efficient, and gives consistent accuracy for all retinal images. It is more robust and easier to implement compared to other traditional methods. The performance of the presented method is evaluated using ten different mathematical measures. It achieves average sensitivity, specificity and accuracy of 0.710, 0.982 and 0.956 for the digital retinal images for vessel extraction (DRIVE) database, 0.738, 0.982 and 0.954 for the structure analysis of the retina (STARE) database and 0.737, 0.964 and 0.949 for the child heart and health study in England (CHASE_DB1) database. The presented method also performs better in segmenting thin vessels by giving average accuracies of 0.964, 0.954 and 0.965 for DRIVE, STARE and CHASE_DB1 databases respectively.

DOI: 10.4018/978-1-6684-7544-7.ch048

INTRODUCTION

Retinal imaging is a digital image taken of the retina, blood vessels and optic nerve placed at the posterior of the eyes. This supports the optometrists to support and cope various eye abnormalities. Computer aided identification of retinal blood vessels by means of fundus imaging has played a crucial part for study of many eye syndromes like proliferative and non-proliferative diabetic retinopathy, cataract, glaucoma, vein occlusion etc. Based on the research report of American Diabetic Association, in the year 2011, around 4.2 million Americans are affected with diabetic retinopathy and around 2.3 million are affected with glaucoma (Roychowdhury et al., 2015). Therefore, exact segmentation of blood vessels is a crucial job. However, there are numerous challenges which interrupts the segmentation process: including blood vessels some other structures such as optic disk, fovea, epithelium, exudates are present that confuse the segmentation, the blood vessels have extensive range of widths and tortuosity and thin vessels have lower illumination than background which is a hurdles in object detection (Zhao et al., 2014). The manual investigation of retinal images is time consuming and expensive. So, automatic segmentation process is a necessary step before the decision of the ophthalmologist for diagnosis of a specific eye disease (Azzopardi et al., 2015).

This paper presents a three-step unsupervised method using an improved Otsu method for segmentation of retinal blood vessels. In the first step, a pre-processing step is carried out in order to get an enhanced image using log transformation and then the optic disk is removed. This image is segmented in the second stage using improved Otsu method which may contain some unwanted pixels. So, finally a segmented image without any unwanted pixel is obtained in the post-processing stage using a morphological cleaning operation. The presented method is better than many of the existing method as it is very simple, robust and fast in nature. The proposed technique has significant clinical implication for screening and diagnosis of different eye diseases like screening of diabetic retinopathy, evaluation of retinopathy prematurity, computer assisted laser surgery and vessel diameter estimation, etc.

The organization of this paper is as follows. In Section 2, the retinal vessel extraction approaches offered in the literature are studied. The method and implementation details are presented in Section 3. In Section 4, the experimental results are evaluated and discussed. Lastly, a conclusion is given in Section 5.

RELATED WORK

Various techniques have already offered for blood vessel segmentation by taking different databases which can be generally categorized as supervised and unsupervised methods.

In supervised method, the pixels are classified either as vessel or non-vessel. Here the classifiers are accomplished with the data from manually segmented images (Dash, et al., 2017). Roychowdhury et al. (2015) introduced a three-stage novel retinal blood vessel segmentation algorithm using fundus photographs. In You et al., (2011), a new technique has been suggested by You et al., for segmentation of the retinal blood vessels using radial projection and vessel centerline detection. Marin et al. (2011), anticipated a supervised method where a 7D feature vector is take out from the input retinal images and given as input to the neural network. The classification result acquired from neural network is thresholded to categorize the pixels as vessels or non-vessels. In Soares et al., (2006), the author Soares et al. presented a technique by means of 2D Gabor wavelet and supervised classification where the process classify each image pixel either as vessel or non-vessel grounded on pixels feature vector. In Fraz et al.