Morphological and Otsu's Thresholding-Based Retinal Blood Vessel Segmentation for Detection of Retinopathy

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Abstract

Retinal blood vessel segmentation is crucial as it is the earliest process in measuring various indicators of retinopathy sign such as arterial-venous nicking, and focal arteriolar and generalized arteriolar narrowing. The segmentation can be clinically used if its accuracy is close to 100%. In this study, a new method of segmentation is developed for extraction of retinal blood vessel. In this paper, we present a new automated method to extract blood vessels in retinal fundus images. The proposed method comprises of two main parts and a few subcomponents which include pre-processing and segmentation. The main focus for the segmentation part is two morphological reconstructions which are the morphological reconstructions followed by the morphological top-hat transform. Then the technique to classify the vessel pixels and background pixels is Otsu's Thresholding. The image database used in this study is the High Resolution Fundus Image Database (HRFID). The developed segmentation method accuracies are 95.17%, 92.06% and 94.71% when tested on dataset of healthy, diabetic retinopathy (DR) and glaucoma patients respectively. Overall, the performance of the proposed method is comparable with existing methods with overall accuracies were more than 90 % for all three different categories: healthy, DR and glaucoma.

Keywords: *Detection; Morphological; Retinal blood vessels; Retinopathy; Segmentation; Thresholding.*

1. Introduction

Retinal blood vessel segmentation is crucial image processing step before performing feature extraction in retinal analysis. In retinal analysis, segmented blood vessel is useful for microvasculature analysis, vascular geometry extraction, measurement of various parameter such as artery and vein ratio. Retinal blood vessel segmentation also enable detection of haemorrhages, microaneurysms, irregularities in the route of blood vessels and neovascularization [1-5]. The accuracy of retinal blood vessel segmentation is important to ensure accurate extraction and measurement of features for detection/diagnosis of retinal related diseases, including stroke [6], hypertensive retinopathy (HR) [7], diabetic retinopathy [8], and retinopathy of prematurity [9]. Manual segmentation of the blood vessel is time consuming and prone to human error, thus not practical when number of images is large and the vessel structures are complicated [10, 11]. As a result, an automated blood vessels segmentation algorithm is desired.

Several automated methods have been developed to get accurate blood vessel segmentation [8]. The drawback of existing techniques is that they generally output poor segmentation results when applied on unhealthy retinal images that have the presence of lesions [11]. They also need more computational power when the size of an image increases, thus a simple yet fast method is required for real time processing.

In this paper, we present a new automated method to extract blood vessels in retinal fundus images. The main contributions of this study include: i) proposed new methodology for retinal blood vessel segmentation, ii) apply the proposed method of retinal blood vessel segmentation on the retinal fundus image of healthy and unhealthy subjects and iii) evaluate the performance of the proposed method by analyzing performance metrics such as accuracy, specificity and sensitivity and compare against existing techniques.

2. Related Work

The segmentation method can be divided into supervised and unsupervised method. In a supervised method, [11] used neural network to develop a pixel tracking based approaches or vectorial tracking or tracing to segment the retina blood vessel branches or structure. In this method, the retinal blood vessel is initially tracked by the detection of initial vessel seed points and then only the rest of the vessel pixels tracked by measuring the continuity of blood vessel characteristics. [2] used two neural network trainers for hierarchical retinal blood vessel segmentation process. The two trainers are known as convolutional neural network (CNN) and random forest (RF) classifier. CNN is a trainable hierarchical feature extractor and with the help of RF as a trainable classifier.

The unsupervised method or known as pixel processing based method process every pixel in the image and apply multiple operations on each pixel [10, 11]. An example of this technique is by [12]. The technique was first done the filtering enhancement of the retinal blood vessel by using multiple scales filtering technique based on the eigenvalue analysis of the Hessian matrix. After the contrast between vessels and other tissues is vastly improved then only an iterative thresholding method is applied on the retinal