

Chapter 16

Non-Compactness Attribute Filtering to Extract Retinal Blood Vessels in Fundus Images

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ABSTRACT

Retinal blood vessels can give information about abnormalities or disease by examining its pathological changes. One abnormality is diabetic retinopathy, characterized by a disorder of retinal blood vessels resulting from diabetes mellitus. Currently, diabetic retinopathy is one of the major causes of human vision abnormalities and blindness. Hence, early detection can lead to proper treatment, and segmentation of the abnormality provides a map of retinal vessels that can facilitate the assessment of the characteristics of these vessels. In this paper, the authors propose a new method, consisting of a sequence of procedures, to segment blood vessels in a retinal image. In the method, attribute filtering with a so-called Max-Tree is used to represent the image based on its gray value. The filtering process is done using the branches filtering approach in which the tree branches are selected based on the non-compactness of the nodes. The selection is started from the leaves. This experiment was performed on 40 retinal images, and utilized the manual segmentation created by an observer to validate the results. The proposed method can deliver an average accuracy of 94.21%.

INTRODUCTION

Retinal images show the interior surface of the eye, and can help to observe the abnormalities related to the inner structures in the eye including the vessels. Manual detection of blood vessels is difficult since the appearance of blood vessels in a retinal image is complex and has low contrast (Yang, 2008). Hence, a manual measurement becomes tiresome and automatic, reliable detection methods are needed.

To automatically detect the blood vessels, several segmentation methods have been proposed. The methods usually use contrast difference between blood vessels and its neighboring background, where all vessels are connected each other (Heneghan et al., 2002). Yang et al. (2008) proposed a novel hybrid approach. The method consists of mathematical morphology and a fuzzy clustering algorithm followed by a purification procedure to reduce the weak edges and noise. Adaptive local threshold framework based on verification-based multi-threshold was proposed by Jiang and Mojon (2003). They used the method since the retinal blood vessel cannot be segmented using global threshold. A different approach by using a family of operators from mathematical morphology was proposed by Zana and Klein (2001). They calculate the supremum of openings by linear structuring elements of the retinal image. Noise minimization on the image uses geodesic reconstruction and unwanted texture is removed by applying Laplacian and apply special filter before finally apply threshold method to obtain the blood vessel. Niemeijer et al. (2004) implement a vessel segmentation method based on pixel classification. For each pixel, the feature is extracted from the green-channel image, and feature vector is constructed and a classifier is trained with these feature vectors. A kNN classifier perform a soft classification indicates the probability of a vessel pixel.

Although the authors of the above methods claim that the accuracy was high, they did not

pay much attention to the properties of retinal blood vessels. The vessels are complex structures and may containing long curvilinear and branching parts. Hence, such a segmentation method should concern these properties. In this research, a new segmentation method for blood vessels in retinal images is proposed. The method consists of image enhancement procedure to strengthen blood vessel contrast in the image, and then represents the image based on its gray levels using a so-called Max-Tree (Salembier et al., 1998). Afterwards, the tree is filtered using branches filtering approach (Purnama et al., 2007) based on its non-compactness attribute (Wilkinson & Westenberg, 2001).

MATERIALS AND METHODS

Retinal Image Source

The proposed method are tested and evaluated on DRIVE database that is publicly available and consists of 40 colored retinal images. The DRIVE that stands for Digital Retinal Images for Vessel Extraction (DRIVE) was established by Staal et al. (2004). Each image of DRIVE has resolution of 565x584 pixels, and stored in GIF format.

The images of DRIVE database consists of 20 training images and 20 test images. One benefit of using DRIVE is the available reference images resulted from the manual segmentation procedure. The reference images are required to calculate the accuracy of the proposed method. Each training image has one reference image that was created by an observer, while each test image has two reference images created by two different observers. Our experiment is not related with the training procedure. Hence, we used 40 reference images created by the first observer. As it is mentioned in their web site, the observers were instructed and trained by an experienced ophthalmologist. They were asked to mark all pixels of the expected vessel. Figure 1a shows one of the retinal images

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