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Retinal blood vessel segmentation approach based on mathematical morphology

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Abstract

Diabetic retinopathy is a disease, which forms a severe threat on sight. It may reach to blindness among working age people. By analysing and detecting of vasculature structures in retinal images, we can early detect the diabetes in advanced stages by comparison of its states of retinal blood vessels. In this paper, we present blood vessel segmentation approach, which can be used in computer based retinal image analysis to extract the retinal image vessels. Mathematical morphology and K-means clustering are used to segment the vessels. To enhance the blood vessels and suppress the background information, we perform smoothing operation on the retinal image using mathematical morphology. Then the enhanced image is segmented using K-means clustering algorithm. The proposed approach is tested on the DRIVE dataset and is compared with alternative approaches. Experimental results obtained by the proposed approach showed that it is effective as it achieved average accuracy of 95.10% and best accuracy of 96.25%.

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Keywords: blood vessel extraction; k-means clustering; mathematical morphology; vessel segmentation; retinal image.

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1. Introduction

Among the modern health care community, medical imaging has become the most important tool; this is because of the visual documentation and record storing for the patients and for its ability to information extraction about many diseases. For retinal image analysis, there are several applications, such as diabetic retinopathy, where it can be used in addition to their important roles in some diseases detection in early stages [1, 2]. Because of segmentation of retinal image structures using in modern ophthalmology as a non-invasive diagnosis; it has been a very interested topic. For retinal diseases such as hypertension, diabetic retinopathy, hemorrhages, macular degeneration, glaucoma, neo-vascularization and vein occlusion, working on the optic disc and the retinal blood vessel morphology is one of the basic indicators for assessing the presence and severity for each of these diseases. Assessment of the retinal blood vessels diameter and tortuosity or the optic disc shape manually has many disadvantages such as, time consuming and prone with human error, especially with complicated vessel structure and a large number of images [3].

Some of diseases listed above such as glaucoma, diabetic retinopathy, and macular degeneration are very dangerous. If they aren't detected correctly and in time, they can lead to blindness. Therefore, an accurate automated segmentation approach for retinal blood vessel and optic disc is a very important issue in computer aided-diagnosis [2]. The automation of segmentation and investigation of retinal blood vessel features helps ophthalmologist and eye care specialists to carry out mass vision screening exams for retinal diseases detection in early stages and treatment evaluation. This could help at prevention and reduction of vision impairments; age related diseases and many cardiovascular diseases as well as screening cost reduction [4].

This article presents an automated segmentation approach for retinal blood vessel. It based on some morphological operation and k-means algorithm.
The rest of this article is organized as follows: Section 2 presents the related works about our approach, their methodologies and the differences between them. Section 3 presents the core concepts of morphological processing and K-means algorithm. Section 4 describes the different phases of the proposed content-based segmentation system; namely mathematical morphology pre-processing, and classification phases using K-means. Section 5 discusses the tested image dataset and presented the obtained experimental results. Finally, Section 6 presents conclusions and future work.

2. Related Work

Many different algorithms were deployed for vessels segmentation, which achieved various results and performances. Fraz, Rudnicka and Barman [5] introduced supervised method. Dual Gaussian is used; a collection of second derivative of Gaussian and Gabor filters, feature vector is generated using some morphological transformation. This feature vector gives information which helping on handling the normal vessels and the vessels with the central reflex. The proposed system achieved accuracy, sensitivity and specificity of 0.96, 0.74 and 0.98, respectively. A supervised method, Yin and Bourennane [6] introduced, they used this method for vessel segmentation taking into account vessel edge detection on the retinal image. To detect vessel edge points in this method, they with maximum a posteriori (MAP) as criterion. This method achieves sensitivity and specificity 0.7248 and 0.9666, respectively on DRIVE.

Another method is morphological processing which consist of techniques [7] dealing with digital image processing using mathematical morphology by applying some structure element (SE) to binary images and sometimes to gray-level images. Roychowdhury, Koozekanani and Parhi developed a novel three-stage blood vessel segmentation algorithm. The first stage is pre-processing by high-pass filtering then extracting a binary image and another binary image is reconstructed from morphologically enhanced image for the vessel regions. Next the major vessels are extracted which is common regions from these two images. Then the second stage, Gaussian Mixture Model (GMM) classifier is used to classify all pixels in the two binary images which are remained from previous stage .Set of 8 features are used in GMM which extracted depending on first and second order gradient images and pixel