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A thresholding based technique to extract retinal blood vessels from fundus images

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Abstract

Retinal imaging has become the significant tool among all the medical imaging technology, due to its capability to extract many data which is linked to various eye diseases. So, the accurate extraction of blood vessel is necessary that helps the eye care specialists and ophthalmologist to identify the diseases at the early stages. In this paper, we have proposed a computerized technique for extraction of blood vessels from fundus images. The process is conducted in three phases: (i) pre-processing where the image is enhanced using contrast limited adaptive histogram equalization and median filter, (ii) segmentation using mean-C thresholding to extract retinal blood vessels, (iii) post-processing where morphological cleaning operation is used to remove isolated pixels. The performance of the proposed method is tested on and experimental results show that our method achieve an accuracies of 0.955 and 0.954 on Digital retinal images for vessel extraction (DRIVE) and Child heart and health study in England (CHASE_DB1) databases respectively.

Keywords: Retinal imaging; Blood vessels; Mean-C; DRIVE and CHASE_DB1 databases; Medical imaging; Ophthalmologist

1. Introduction

The exponential growth of the quantity of digital images has covered the direction towards the study of computer vision [1]. Exploration in medical informatics focuses predominantly on assimilating computer technology into the practice of medicine in order to advance in the area of analysis and treatment [2]. The retinal vasculature offers facts which is used to localize the optic disc and fovea, and act as a main part for recognition of pathological changes in automated diagnostic system [3]. Fundus imaging in ophthalmology is a method for medical verdict and exploration of numerous diseases like hypertension, diabetic retinopathy, cataract, glaucoma and cardiovascular diseases [4]. In fundus image analysis the automatic extraction of object from background is an essential task. But there are certain difficulties for this such as the variability in vessel width and low resolution databases that includes nose and changes in brightness [5].

Many methods have already proposed for blood vessel segmentation by taking different databases which can be mainly categorized as: machine learning method, filtering based method and model based method. The supervised methods are coming under machine-learning methods where the pixels are marked either as vessels or non-vessels. In supervised learning, classifiers are accomplished with data from hand-labeled images [6]. In Ref. [6], the author proposed a supervised method where the image is initially enhanced and then features are extracted using 7D feature vector and to this features undergoes neural network classification for labeling the pixels as vessels or nonvessel. Finally, a post-processing step is applied for gap filling and removal of insulated pixels. Fraz et al. [7], suggested a supervised technique that utilizes a

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collaboration of bagged and boosted decision trees utilizes a feature vector to analyze both healthy and pathological images. In Ref. [8], the author introduced a method where in the earlier stage two binary images are created from green plane using high pass filtering and morphological reconstruction method. Next, the two binary image common areas are extracted as main vessels. All the remaining pixels in the two binary images are categorized using a Gaussian mixture model (GMM) with a set of eight features that are extracted based on pixel neighborhood and first and second-order gradient images. In the final post processing stage, the major vessels are joined with the classified vessel pixels. In the filtered based approach, retinal vessel segmentation is performed using morphological operators. In morphological image processing, the form is known priory which generates a structuring element that is used for filtering the objects from the background [5]. In Ref. [5] the author developed a new method for identification of blood vessels. This method segments the large blood vessels as a solid structure without artifacts. A methodology that includes vessel skeletal recognition with morphological bit planes for segmentation of retinal blood vessels is offered by Fraz et al. [9]. An automated novel segmentation method has been introduced by Azzopardi et al. [10]. It is based on the combination of receptive fields (CORF) raking model of a simple cell in the visual cortex and its employment called combination of shifted filter responses (COSFIRE). For the extraction of retinal blood vessels a rod-shaped COSFIRE non-linear filter is used. In Ref. [11], the author introduced a system that utilizes the conception of matched filter with first order derivative of Gaussian considering that the vessel cross section is a symmetric Gaussian function. To extract the blood vessels a pair of zero mean Gaussian filter and the first order derivative of Gaussian is used. Roychowdhury et al. [12], presents a first-hand method where the new pixels generated iteratively by adaptive global thresholding for vessel approximations. A stopping condition is used to dismiss the iterative vessel addition process and hence reduce the false positives. In model based approach, a vessel model is useful to identify the retinal blood vessels. These approaches are sensitive to their parameterization. Here, the trouble is that the parameters should be selected sensibly to extract thin and large vessels at once [13]. In Ref. [14], a structure is used where initially the Hessian method is used to segment the blood vessels from the rescaled image and after this again it is back sampled to original size. Subsequently blood vessels are take-out using Hysteresis thresholding. At the last stage image fusion is applied to obtain a final segmented image. In Ref. [15], the author introduced a new vessel segmentation algorithm where the image is pre-processed in order to get an enhanced and smoothed image. The blood vessels are then extracted using level set. In Ref. [16], Cinsdikici et al. introduced a method that extract the blood vessels using improved ant colony method.

For study of retinal imaging, detection of blood vessels is a basic step. Although several methods are introduced for segmenting retinal blood vessel still accurate blood vessels separation is a challenging task due to vessel width disparity and low quality retinal images. Many thresholding technique have been proposed for segmenting retinal images but we have used here the local adaptive thresholding for segmenting retinal blood vessels as it can gives better segmentation performance with a lower execution time as compared to other conventional thresholding approaches. This paper presents an automated segmentation algorithm which is carried out in three stages: pre-processing, vessel extraction and post-processing. In the pre-processing stage the image is enhanced using contrast limited adaptive histogram equalization (CLAHE) [17] and then the image is thresholded using mean-C thresholding in order to detect the required blood vessels from the background. A post-processing phase is carried out in order to obtain a final segmented image. Many authors have proposed a variety of algorithm to segment the blood vessels of the retinal images but we have presents a very simple, time efficient thresholding method that gives a good accuracy as compared to many of the existing blood vessel segmentation approaches.

2. Proposed method

The proposed method for extraction of retinal blood vessels comprises of three phases: pre-processing, segmentation and post-processing. For the purpose of vessel extraction the green channel of RGB image undergo different phases. The green channel is chosen because red and blue channel suffers from poor illuminance [18]. Fig. 1 (a) and (b) shows the original RGB and green channel image respectively. All the three phases responsible for blood vessel extraction are explained below.

2.1. Pre-processing

The fundus images may suffers from nonuniform illumination, so before extraction of blood vessels pre-processing is

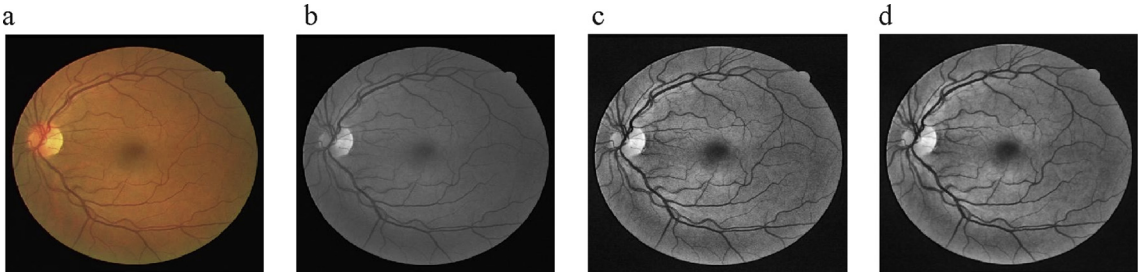

Fig. 1. (a) Original retinal image, (b) Extracted green channel image, (c) Contrast limited adaptive histogram equalized image and (d) Median filtered image.

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