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ROI and Blood Vessel Segmentation Based on Gradient Vector Algorithm in RGB Retinal Fundus Images

M. K. Turan
Medical Biology Department
Karabük University, Karabük, Turkey
kamilturan@karabuk.edu.tr

E. Şehirli
Biomedical Engineering Department
Karabük University, Karabük, Turkey
eftalsehirli@karabuk.edu.tr

Abstract: *In this paper, a method is proposed for segmentation of ROI and blood vessels on pathological and non-pathological RGB retinal fundus images. In the proposed method, a preprocessing stage to make image enhancement is applied. Gradient vector algorithm is applied based on gradient vectors of pixels. Connected component analysis is applied to remove small objects that behave like blood vessels. The proposed method is tested with 113 anonym images and results of the study demonstrate that the proposed method produces result images with quite high accuracy in average 8.8 seconds.*

Keywords: *Blood vessel, Gradient vector algorithm, Region of interest, connected component analysis*

1. INTRODUCTION

Eye is a sense organ located in eyehole surrounded by bones. Eye has three layers such as the external layer, the intermediate layer and the internal layer known as retina. Retina is a structure which provides human with seeing process. In addition to this, retina is a structure which normal features like blood vessels, optic disk and fovea locate. When retina has abnormal structures like microaneurysm, hemorrhages and exudate, normal structures are generally segmented and extracted from retina surface. Hence, segmentation and extraction of blood vessels become important and useful to detect pathologies and make analysis on patients' retina. In addition to that, blood vessels are detected to diagnose diseases like diabetes, hypertension, arteriosclerosis, cardiovascular and stroke [1] [2]. Since shape and structure of blood vessels give information about grading disease level. Retinal vessels also play roles to get information about the place of optic disc and fovea [3] [4].

There are several methods to segment retinal blood vessels on retina surfaces. Kande et al. [2] used matched filtering, thresholding based on spatially weighted fuzzy c-means clustering algorithm and label filtering to detect blood vessels in digital fundus images. Onkaew et al. [5] detected blood vessels by analysing the gradient orientation of the retinal images. Lam et al. [6] proposed a technique to detect blood vessels by using Laplacian operator and gradient vector algorithm. Chaudhuri et al. [7] proposed a method based on matched filter response that applies Gaussian filter for segmentation of blood vessels. Their method determines pixels whether they belong to blood vessel or not according to large values of pixels.

Our main objective in this study is to improve a software application that segments retinal blood vessels automatically for ophthalmologists and obtain results in a short time with a very high accuracy. This paper consists of three sections such as Proposed Algorithm, Results and Discussions, Conclusion. In Proposed Algorithm section, steps and details of proposed algorithm are presented. In Results and Discussions section, obtained results are shown. In Conclusion section, conclusions are presented.

2. THE PROPOSED ALGORITHM

The proposed algorithm is designed as a fully automatic system which segments region of interest (ROI) and blood vessels in RGB retinal fundus images. While the system takes RGB retinal fundus images as input, it gives RGB retinal images whose ROI and blood vessels are marked as outputs. Figure 1 shows the block diagram of the system.

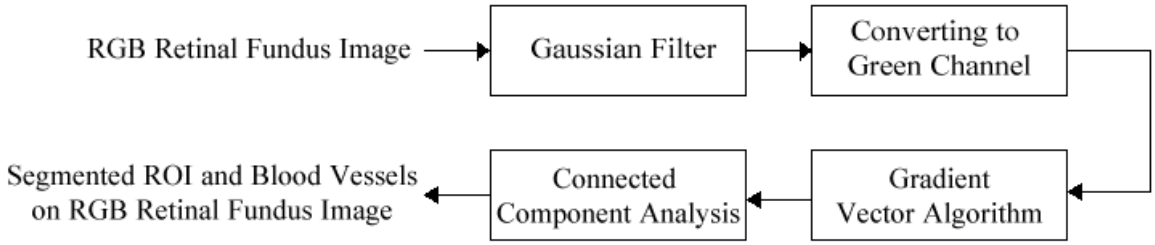

Fig1. *Block diagram of the system*

First of all, Gaussian smoothing is applied on input image. As a result of this, noises on images are reduced, edges of anatomic structures are blurred. It is guaranteed to have gradient changes on anatomic structures. Gaussian smoothing is done by using the formula given below.

$$G_\sigma(x,y) = e^{-(x^2+y^2)/2\sigma^2} / (2\pi\sigma^2) \quad (1)$$

where x represents horizontal coordinates, *y* represents vertical coordinates and σ is standard deviation of Gaussian distribution. Moreover, Gaussian smoothing is supported by median filter by using different size windows. However, the proposed algorithm does not need to use median filter, because final results are not affected by median filter.

Blood vessels have a better contrast property in green channel images [8]. Therefore, images are converted to green channel. Green channel pixel values in the direction of x and y are taken derivatives by using forward and backward differences methods [8]. To take derivatives, forward and backward differences methods are used and their formulas are given below [9].

$$f'(x) = (f(x+h) - f(x))/h \quad (2)$$

$$f'(x) = (f(x) - f(x+h))/h \quad (3)$$

To compute the gradient vector of each image coordinate, a 3x3 window is walked on whole image. By means of the window, derivatives according to forward and backward differences formulas are taken with 0 and 45 degree angles. This process is done for each pixel on image. Figure 2 shows forward and backward differences method in the direction of x and y according to 0 and 45 degree angles.

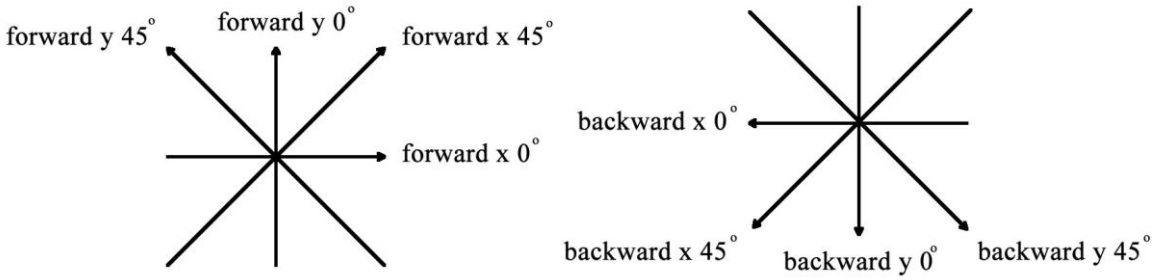

Fig2. *Forward and backward difference method in the direction of x-y according to 0-45 degree*

Both forward and backward differences methods have been used in this study. Because there is no difference except for colour change, forward difference method has been changed. Gradient vector algorithm gives vectors diverted towards the most intensive place of gradient increments. Length of a vector is equal to value of gradient changes [10].

After gradient vector algorithm is applied, connected component analysis is applied to remove individual small objects which do not belong to any part of retina structures like ROI and blood vessels. Connected component analysis is a method to classify pixels based on pixel connectivity on images. Hence, connected component analysis is a powerful tool to remove individual small objects in this study. Connected component analysis is applied by using eight-connected neighbourhood and label propagation [2] [11].

3. RESULTS AND DISCUSSIONS

One hundred thirteen anonym RGB retinal fundus images are put to test by the proposed algorithm in order to segment ROI and blood vessels on retina surface. All anonym images which are used for education have been captured by eye hospital of the university. There exist three types of images according to properties of fitting into image frame. While one type of images completely fits into frame, one loses top and bottom edges and one loses left edges as well as top and bottom edges. When the proposed algorithm is performed, result images of three types are shown in Figure 3.

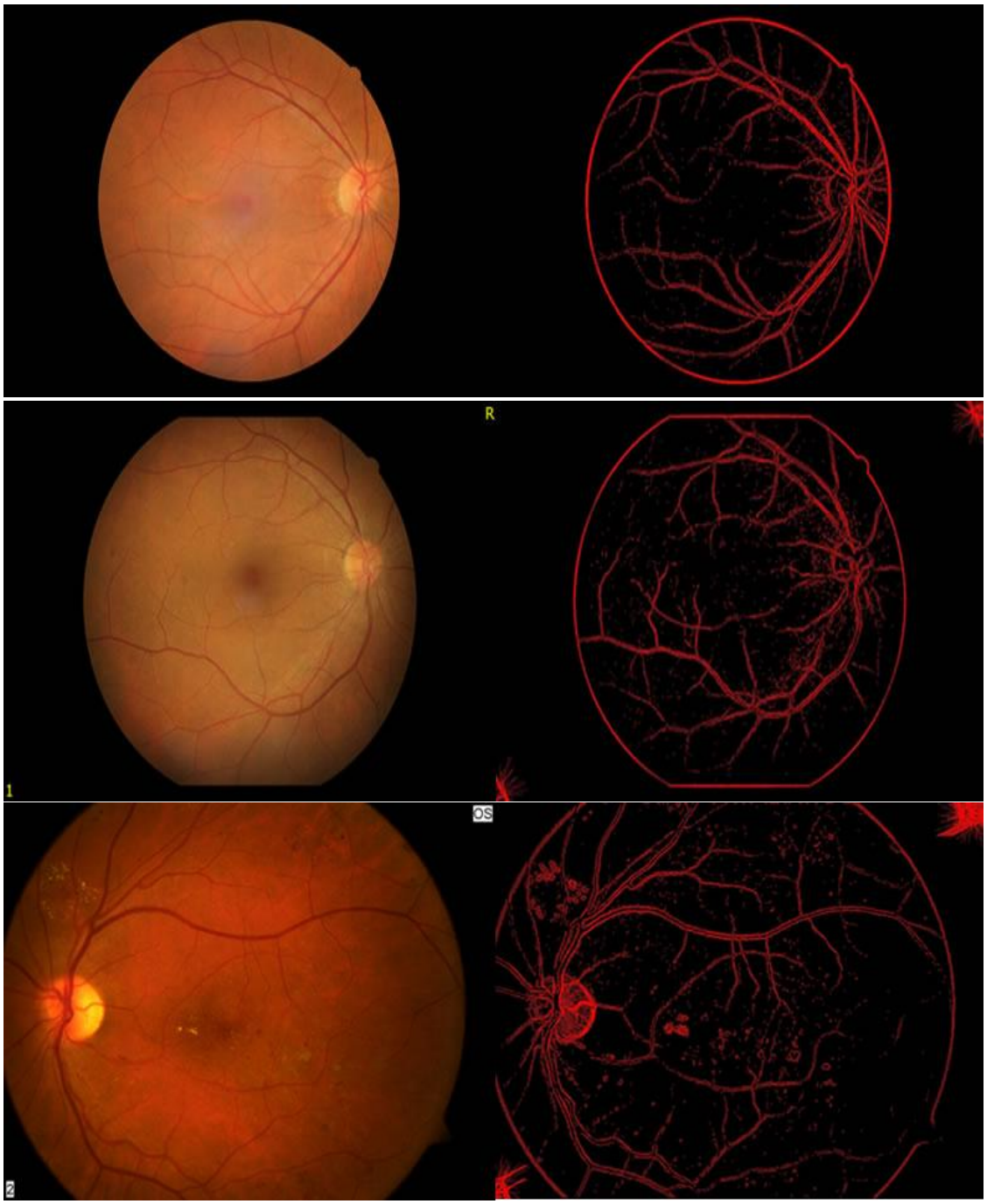

Fig3. *Result images whose ROI and blood vessels are segmented*

All 2048x1536 images are put to test on an i7 4.00 GHz PC using Visual Studio program. Software is developed by using C# programming language. The proposed algorithm responses all images at average 8.8 seconds although image resolutions are high.

4. CONCLUSION

In this paper, gradient vector algorithm for segmentation of ROI and blood vessels in RGB retinal fundus images is presented. Because of atmospheric conditions, images are passed from a preprocessing stage. Gaussian smoothing is applied to enhance images. Due to the gradient vector information of pixels, gradient vector algorithm is applied to segment ROI and blood vessels in retina images. To remove individual small objects on images, connected component analysis is applied. The developed software application gives a response as an image in averagely 8.8 seconds although image resolutions are high enough.

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AUTHORS' BIOGRAPHY

Muhammed Kamil Turan is an assistant professor in medicine faculty of Karabük University. He received his Ph.D. from Samsun Ondokuz Mayıs University (2000) in the field of medical biology. He received his M.Sc. degree from Sasmun Ondokuz Mayıs Univeristy (1996) in the field of medicine. He received his B.Sc. degree from Samsun Ondokuz Mayıs University (1990) in the field of medicine.

Eftâl Şehirli is a Ph.D. student in computer engineering department of Karabük University. He received his M.Sc. degree from Karabük Univeristy (2014) in the field of computer engineering. He received his B.Sc. degree from Doğuş University (2012) in the field of computer engineering.