Automated Retinal Vessel Segmentation Using Morphological Operation And Threshold

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Abstract— Assessment of retinal vessel is an important factor for the many medical disorders. The retinal vessel analysis can be done by first extracting the retinal images from the background. The changes in the retinal vessels due to the pathologies can be easily identified by segmenting the retinal vessels. In this paper we describe the automatic methods for retinal vessel segmentation. Segmentation of retinal vessels is done to identify the early diagnosis of the disease like diabetic retinopathy, hypertensive retinopathy and arteriosclerosis. In this the blood vessel is segmented using morphological operation with the disc shaped structuring element is used. This method is applied on the publicly available DRIVE database.

Index Terms— Blood vessels, Fundus images, Morphological operations, Retinal vessel segmentation, Threshold, Blood vessel extraction, Retinal images.

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1 INTRODUCTION

The diagnosis of the fundus image is widely used in many medical diagnosis. Image segmentation [1] in the fundus image is the important factor for identifying the retinal pathology. The analysis of the human retina helps the ophthalmologists to identify the retinal disease. The disease such as the diabetes, hypertension and arteriosclerosis affect the retina and causes the changes in the retinal blood vessels [2]. The changes in the blood vessel and the retinal pathology can be identified by first segmenting the retinal vessels and by proper analysis of the retinal blood vessels.

Automatic segmentation of retinal vessels is important for early diagnosis of eye diseases like diabetic retinopathy [3]. There are various segmentation methods for segmenting the retinal vessels in the fundus image which segments the retinal vessels using two dimensional matched filters and by piecewise threshold probing [4], [5]. There are other segmentation processes which include segmentation of retinal vessels using the Mumford-Shah model and Gabor wavelet filter [6]. Extraction of retinal blood vessels is done using Weiner filter and the Morphological operations like opening and closing operation [7].

This paper focuses on segmentation of the retinal vessels to identify the changes in the retinal vessel which occurs due to retinal pathologies like diabetic retinopathy [10].

Vessel segmentation is done using Max-Tree to represent the image and the branches filtering approach to segment the image [12]. Mathematical morphology is mostly used for analysis the shape of the image. The two main processes which involves are dilation and erosion. The algorithms of opening and closing are based on these processes. These algorithms are combined to detect the edges and identifying the specific shapes in the image and also for the background removal [14].

Retinal vessel segmentation is done to classify the pixel as the vessel and non-vessel using morphological thresholding [8]. The retinal blood vessel is extracted by first smoothening the image and enhanced by applying the fuzzy c- means clustering algorithm [12].

In this paper we used the morphological operation and threshold on the image to get the properly segmented output image.

2 METHODS

2.1 Overview of the method

This paper proposes the novel method for retinal vessel segmentation. The fundus image used in this research is obtained from Digital Retinal Images for Vessel Extraction (DRIVE database). The segmentation of the retinal blood vessel should be accurate and automatic for the diagnosis of the retinal disease. The input to the segmentation process is the color fundus image and the input RGB image is converted to the green channel image and the morphological close operation is used with two different structuring elements and finally the threshold is applied on the image and the output will be the binary image of the retinal vessel extracted from the background.

2.2 RGB to Green channel conversion

The color fundus image is converted to green channel image to make the segmentation process easy and to decrease the computational time [8]. The green channel image provides the maximum contrast between the image and the background. The retinal blood vessel information is clear only in the green channel image [13].

2.3 Image segmentation

The retinal vessel segmentation is done using morphological close operation. It applies the structuring element to

the image and output the image of same size. The morphological close operation is a process that does morphological dilation followed by erosion. Closing operation is done using structuring elements.

The disk shaped structuring element used is of two different sizes. One with size 30 for higher structuring element, and one with size 2 for lower structuring element. And the image with higher structuring element is subtracted from image with lower structuring element.

The output image obtained is the retinal blood vessel extracted from the background. The closing operation of A by B is obtained by dilation of A by B followed by erosion of resulting structure by B. Closing operation is define by

$$A \bullet B = (A \oplus B)\Theta B$$

Dilation is an operation that thickens the objects in the binary image. The dilation in green channel enlarges the brighter regions.

$$A \oplus B = A1(x, y) = \max(A(x - i, y - j) + B(i, j)i, j \in B$$

The erosion is to shrink the objects back to the original shape. After the extraction of the retinal blood vessels the threshold value is applied on the image.

$$A\Theta B = A2(x, y) = \min(A(x - i, y - j) + B(i, j)i, j \in B1$$

2.4 Applying Threshold

The threshold is applied on the extracted retinal vessels. After applying the threshold the back ground is eliminated and the properly segmented binary image of the retinal vessel is obtained. The threshold image is the binary image either 0 or 1.
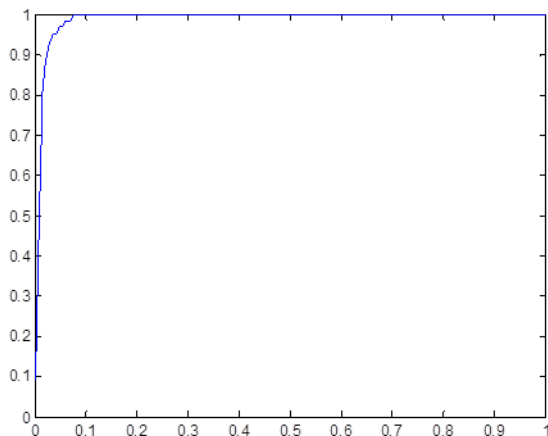
Fig.1 This figure shows the histogram equalized plot of the extracted blood vessels and using this plot the threshold value is selected.

Thresholding is the simplest non-contextual segmentation technique. In this paper we choose the single threshold which transforms the extracted blood vessel to the binary image. The binary image consists of two regions one of them containing pixels with input data values smaller than the threshold and the other containing the values larger than the threshold.

Since the blood vessel has higher intensity than the background we can select the threshold value by plotting the histogram of the corresponding green channel image.

The threshold value is chosen based on the histogram equalization. From the fig.1 we can decide that the threshold lies between 0 to 0.09. We took half of the maximum value in the histogram as threshold value, T. The threshold value for our segmentation is 0.045. This value gives good result for all the images.

Then each pixel is tested, and those with gray levels greater than T are changed to a light shade of gray, while those whose values are less than or equal to T are given a dark gray level.

The most common image property to threshold is pixel gray level.

g(x,y) = 0 if f(x,y) < T
g(x,y) = 1 if f(x,y) ≥ T
where T is the threshold.

3 RESULTS

Figures 2-7 shows the sample results of the segmentation process obtained from the fundus image taken from DRIVE database. About 30 images from the databases of DRIVE and diaretdb1 are taken and used to test the automatic segmentation of retinal vessels with the proposed algorithm for segmentation.
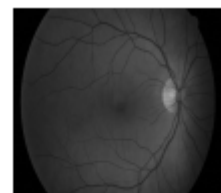

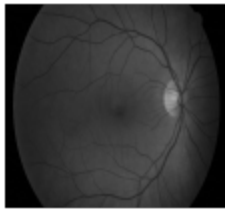Fig. 2 Original RGB image   Fig. 3 Green channel image

Fig.4 Image with lower structuring element
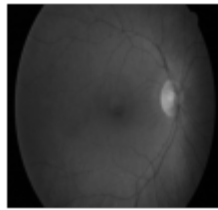

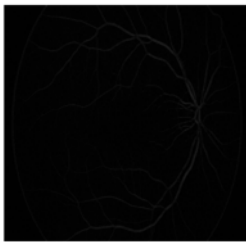Fig.5 Image with higher structuring element
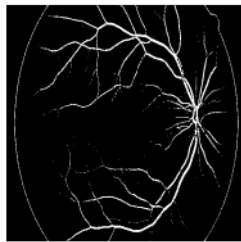

Fig. 6 Extracted blood vessel

Fig. 7 Threshold image

First the original RGB image is taken as the input image and the RGB is converted to green channel as shown in the fig.3 and the two different structuring elements are applied on the image one with lower structuring element of two and the other with the higher structuring element of 30 is taken. And the two images are subtracted and the blood vessel extraction is done as shown in fig.6. Finally the threshold value determined from the histogram is applied on the image and the output image is the threshold image as shown in fig.7. In this study, 30 images belonging to people affected by diabetic retinopathy was chosen from the database and segmentation was performed.
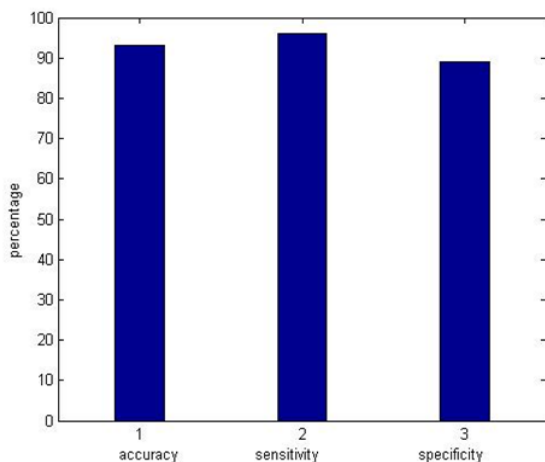

Fig 8. Plot of accuracy, sensitivity and specificity

Fig. 8 shows the measured value of the accuracy, sensitivity and specificity for 30 images.

Using our segmentation method accuracy value we obtained is 93% and the sensitivity value is 96% and specificity value is 89% for all 30 images.

The evaluation of the segmentation is done using true positive (TP), true negative (TN), false positive (FP) and false negative (FN). Where true positive (TP) indicates the correctly identified vessel pixels, false positive (FP) indicates the incorrectly identified vessel pixels, false negative (FN) incorrectly identified non vessel pixels and true negative (TN) is correctly identified non vessel pixels.

The formula for measuring the sensitivity, specificity and accuracy is given below

$$Sensitivity = \frac{TP}{TP + FN}$$

$$Specificity = \frac{TN}{TN + FP}$$

$$Accuracy = \frac{(TP + TN)}{(TP + TN + FP + FN)}$$

4 CONCLUSION

Automatic method of retinal vessel segmentation described in this paper is the morphological operation based segmentation of retinal vessels has been presented in this paper. Segmenting the retinal vessels helps to identify the diseases like diabetic retinopathy and hypertensive retinopathy. This paper focused on segmentation processes that can be done easily by morphological operation and thresholding proposed. This method is fast and efficient method and can be applied to large number of images to automatically segment the large number of images.

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