Motorized Detection of Blood Vessels in Retinal Images using Line Detecting Kernel Principle with Hough Transform

M. Amala
MPhil Student, Department of Computer Science, Bharath Institute of Higher Education and Research, (Deemed University), Chennai.

M. Priya
Bharath Institute of Higher Education and Research, (Deemed University), Chennai.

ABSTRACT

This paper presents automatic detection blood vessels in retinal images. The purpose of detecting blood vessels is to identify the disease called diabetic retinopathy. Diabetic retinopathy is a harmful disease caused by complications of diabetics. This proposed work comprises following steps: Image preprocessing, background acclimatization, image enhancement, extraction of vessels and rear processing. After that here some more methods such as white and black pixel calculation, Ground truth image, have been included for comparison process. The efficacy of the proposed method have been calculated with the help of statistical analysis methods and time taken for execution. The results shows that the proposed method developed here were really potential and capable with respect to its accuracy and compatibility.

Keywords - Diabetic Retinopathy, Retinal Blood vessel, Line Detection algorithm, Hough transform, kernal, Image Enhancement, Filtering, Extraction.

I. INTRODUCTION

Diabetic Retinopathy (DR) is the most unexceptional diabetic eye disease, occurs when some transformation happen in blood vessels. It causes the growth of
abnormal vessels on retinal surface. Occasionally these vessels can lead to swelling in the retinal surface and burst fluid. The retina is the layer of tissue at the back of the inner eye. The visuals that are entering into the eyes are sent to the brain through retinal optic nerves. Encompassing severe diabetics for a long duration of time will increase the possibilities of getting retinopathy.

In the first stage which is called non-proliferative diabetic retinopathy (NPDR) there are no symptoms, the signs are not visible to the eye and patients will have 20/20 vision. The only way to detect NPDR is by fundus photography, in which microaneurysms can be seen. In the second stage, abnormal new blood vessels (neovascularisation) form at the back of the eye as part of proliferative diabetic retinopathy (PDR), these can burst and bleed (vitreous hemorrhage) and blur the vision, because these new blood vessels are fragile. Without timely treatment, these new blood vessels can bleed, cloud vision and destroy the retina.

II. LITERATURE REVIEW

The following are the studies which have been carried over here:

Chandhani Nayak et al. [1] proposed the work retinal blood vessel segmentation algorithm for diabetic retinopathy using wavelet: a survey. They presented a method that uses Gabor wavelet for vessel enhancement due to their ability to enhance directional structures and euclidean distance technique for accurate vessel segmentation.

Shuying Huang et al. [2] proposed an automatic approach for segmentation of retinal image and comprises two steps. In the first step after analyzing the feature of retinal images, mathematical operations are used to smooth and strength images in order to remove background and enhance the brightness of retinal blood vessels. In second step, maximal entropic thresholding algorithm is used to extract retinal blood vessels.

M. Z. Che Azemin et al. [3] proposed a method to perform retinal vascular fractal analysis from retinal images. In this method they used the Gabor wavelet transform so that retinal image enhances and they used Gabor wavelet on green component of the image for pre-processing. Fourier fractal dimension is applicable on these pre-processed images and they do not require segmentation of the vessels. They had used DIARETDB0 database for performance evaluation.

Sivakumar, chitra et al.[4] proposed segmentation of blood vessel in retinal images using local entropy thresholding. In this paper, blood vessels from the green channel of the fundus image are enhanced using a two dimensional matched filter which enhances the contrast of the blood vessel against the background. The contrast enhanced blood vessels are then segmented using line detection algorithms which uses four directional filters. The final segmented vasculature is obtained by integrating the outputs from the directional filters.

K. Jeyasri et al. [12] proposed a new algorithm for the detection of blood vessels. Firstly enhancement of the image is carried
out with the help of curvelet transform. Morphology processing with multistructural elements is used to extract blood vessels from retinal images. A simple thresholding with connected components analysis indicates the remaining ridges indicate the remaining ridges belonging to vessels.

Diego Martin et al. [15] presented a robust method for segmentation of blood vessels in retinal images. They had done preprocessing with contrast enhancement and Gaussian blur and also they include background characteristics. They used a new method that is Neural Network scheme for pixel classification and consists of 7-D vector composed of grey scale and moment invariants based features for pixel classification.

X. Merlin Sheeba and S. Vasanthi et al. [17] had proposed an efficient elm approach for blood vessel segmentation in retinal images. This novel approach uses an Extreme Learning Machine (ELM) approach for pixel classification and calculates a 7-D vector comprises of gray-level and moment invariants-based features for pixel representation. The approach is based on pixel classification using a 7-D feature vector obtained from preprocessed retinal images and given as input to a ELM.

III. PROPOSED METHOD

In this paper our proposed method has divided into four subparts. The output obtained from one part is taken as input to the next part.

3.1 PRE-PROCESSING

Color images have some quality issues such as noise and color imperfections. To reduce these imperfections the following pre-processing methods have been used.

Step 1: Convert input image into grey scale image. The grey scale exhibits the best contrast between the vessels and background while the red and blue ones tend to be more noise.

Step 2: Noise Reduction

The box filter is a spatial domain linear filter in which each pixel in the resulting image has a value equal to the average value of its neighboring pixels in the input image. It is a form of low pass blurring filter. This is the typical step to improve the results of later procedures.

Step 3: Image Enhancement:

Image enhancement is based on contrast enhancement technique. Contrast is an important factor in any subjective evaluation of image quality. In other words, contrast is the difference in visual properties that makes an object distinguishable from other objects and the background.

In visual perception, contrast is determined by the difference in the colour and brightness of the object with other objects. Our visual system is more sensitive to contrast than absolute luminance; therefore, we can perceive the world similarly regardless of the considerable changes in illumination conditions. Many algorithms for accomplishing contrast enhancement have been developed and applied to problems in image processing.
Here the gray level histogram enhancement technique is done.

**Gray-level Histogram:** Most contrast enhancement methods make use of the gray-level histogram, created by counting the number of times each gray-level value occurs in the image, then dividing by the total number of pixels in the image to create a distribution of the percentage of each gray level in the image. The gray-level histogram describes the statistical distribution of the gray levels in the image but contains no spatial information about the image.

Contrast enhancement processes adjust the relative brightness and darkness of objects in the scene to improve their visibility. The contrast and tone of the image can be changed by mapping the gray levels in the image to new values through a gray-level transform. The mapping function reassigns the current gray level \( GL \) to a new gray level \( GL' \).

To eliminate the background color variations, a shade-corrected image is accomplished from a background estimate. First 3x3 weighted mean filter is applied to the background which can be predicted with gray value. Further adjustment and smoothing is performed by including the resultant image is performed by kernel of dimensions \( m \times m = 9 \times 9 \) and mean=0.19 and sigma=1.63.

Weighted Mean filtering is very simple, and effective when it applies to noise. It works on the image with the use of mean and sigma value. It filter the noise by averaging the neighbour pixel value with the current pixel value.

![Fig 2: Background acclimatized image](image)

**Fig 1. Pre-processing: (a) Original image (b) Pre-processed image**

3.2 BACKGROUND ACCLIMATIZATION

It is necessary to adjust the background because it helps to identify the boundaries, lines and edges. The image contains some varying connected components that forms regions, which should get smoothed to avoid unnecessary components included in blood vessel area.

Now the segmentation process starts with the use of line detecting principle. Line detecting principle is based on edge detection, the process is based on finding all lines of interest in an input image.

The four kernel masks is shown below can be used to detect lines at various orientations.
Fig 4: The four line detection kernels which respond maximally to horizontal, vertical and oblique (+45 and -45 degree) single pixel wide lines.

Fig 0º shows horizontal line detection, 90º shows vertical line detection, 45º angle (i.e. acute) direction, and 135 º angle (obtuse) directions. Other than the above degrees the 30º, 60º,180º also be obtains with the help of other line kernel which include 3X3 matrix format. Beyond that still some lines are there to find vessels in an accurate manner.

**Hough Transform:** This method has the potential and cappability to cover all possible direction. Its finds the connection between image (x,y) and future resultant image called Hough (m,b) spaces

- A line in the image corresponds to a point in Hough space
- To go from image space to Hough space the following principle should be adopted

Procedure:

- given a set of points (x,y), find all (m,b) such that y = mx + b
- the solutions of b = -x₀m + y₀
- this is a line in Hough space.

Typically use a different parameterization

\[ d = x\cos\theta + y\sin\theta \]

- \(d\) is the perpendicular distance from the line to the origin
- \(\theta\) is the angle this perpendicular makes with the x axis

Elemental Hough transform algorithm:

Initialize \(H[d, 0]=0\)

for each edge point \(I[x,y]\) in the image

for \(\theta = 0\) to 180

\[ d = x\cos\theta + y\sin\theta \]

\(H[d, \theta] += 1\)

Find the value(s) of \((d, \theta)\) where \(H[d, \theta]\) is maximum

\(d = x\cos\theta + y\sin\theta.\)

The detected line in the image is given by

3.4 REAR-PROCESSING

Now the last resultant image should contains pixels of vessels and some smaller disconnected regions and some unnecessary
issues. Due to remove these smaller disconnected regions the resultant image needs to be processed.

In this process morphological operation is implemented on the resultant image.

- Implement open operator with different angles using the structure element as line.
- Implement erode operator with five pixel diameter. Here we use disk as structure element
- Construct the image with image reconstruction operation for the above two output images.

At this time circle which is in outer region is cleared. Then there is a necessity to remove the tiny disconnected regions, for that pixels in each connected region is calculated. Therefore the region connected to an area which is below 35 pixels that have been considered as non-vessel.

The ultimate retinal blood vessel extracted image after rear-processing is shown below

Fig 4: Ultimate extracted image after Rear-processing

IV. PERFORMANCE ANALYSIS

For the experimental analysis of the proposed method, the final extracted image has been correlates with publicly available databases such as DRIVE (Digital Retinal Images for Vessel Extraction) and STARE. The DRIVE database includes 40 retinal images and STARE contains 100 images. DRIVE database contains 40 manually extracted images (ground truth image) are used for analysing the execution of proposed methods. Statistical testing also done here to prove the efficiency of this method with respect to extract the vessels. The time taken for execution also calculated.

<table>
<thead>
<tr>
<th>Methods</th>
<th>Average Accuracy</th>
<th>Standard Deviation</th>
<th>Average time (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposed Method</td>
<td>95.67</td>
<td>3.953</td>
<td>2.16</td>
</tr>
</tbody>
</table>

Table 1: Evaluated results were predicted using statistical analysis such as mean & SD and average time.

V. CONCLUSION

In this paper, easiest and computationally efficient procedure for retinal blood vessel extraction have been presented. The proposed method have employed modules such as preprocessing, background acclimatization, extraction of vessels and rear-processing. In pre-processing stage the original image was converted in to grey scale image, so that we can obtain the vessel structure very clearly. Next step is applying filter, filters are basically used to remove noise and other variations that affects the image, here box filter has been used and remove the noise from the image.
For extraction of vessels, line detection principle has been used. In that algorithm the various degrees of lines has been detected by using line masks and also hough transform has been utilized and in this hough transform the normal xy plane is converted in to ab plane to detect the line in different angles. After that the results has been slightly modified for better results, for that rear processing work has been done. The rear processing stage includes morphological operations and reconstruction of the image. Finally the performance of this proposed work also been analysed. Then the results shows this work might be useful for extracting the vessels.

VI. REFERENCES


