ISSN: 2277-9655
Impact Factor: 1.852

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

Detection of Low Vision with the help of Segmented Retinal Images

V.Jefrins
PG Student, Chandy College of Engineering, Tuticorin, Tamil Nadu, 628 005, India
jefrins47@gmail.com

Abstract

Retinal Blood Vessel segmentation is much required for detecting the cardiovascular diseases like ophthalmic pathologies, hypertension etc. The available techniques not having the features like measuring the individual blood vessel length, blood vessel diameter, count of the true blood vessels. This paper presents a new method for identifying the true vessels by segmenting blood vessels in retinal images. The proposed novel technique automatically tracks true vessels from retinal images without the need of user invention and produces the better result for detection of low vision with the help of diameter calculation as well as count of true vessels. Isotropic un-decimated wavelet with threshold based two level decomposition is applied for the image taken from the DRIVE data base for segmentation. The proposed algorithm being simple and easy to implement and the detection of low vision problem is done in a successful manner.

Keywords: Retinal blood vessel, cardiovascular disease, ophthalmic pathologies, Retinal image, Low vision.

Introduction

Retinal image provides a snapshot of what is happening inside the human body. Eye is an organ associated with vision. The retinal image is captured by the fundus digital camera. Many diseases like hypertension, coronary heart disease, stroke and low vision can be addressed with the help of few morphological parameters of the true blood vessels [1].Retinal blood vessel segmentation and calculation of morphological features like length of the blood. Vessels, width of the blood vessels, tortuosity are helpful for detecting the diseases mentioned above. The calculation of diameters is widely used for the detection of low vision as well as hyper tension [2]. The images required for the simulation purpose are widely available in the data bases like DRIVE (Digital Retinal Image for Vessel Extraction**)** and STARE (Structured Analysis of the Retina). Figure 1 (a) and (b) are sample retinal images used in the current work.

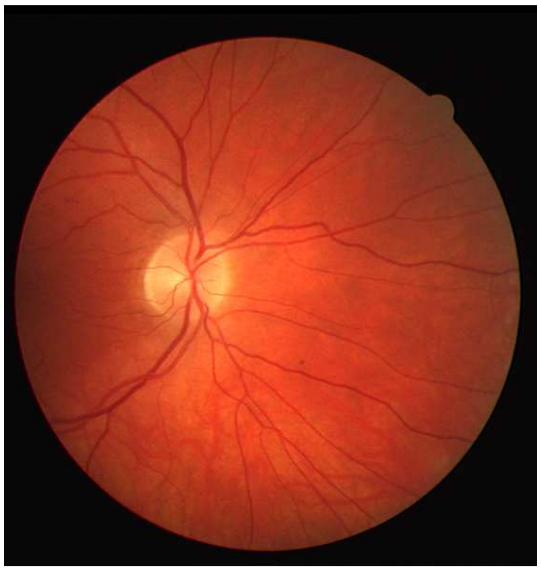

Fig -1 (a) Sample retinal Image 1

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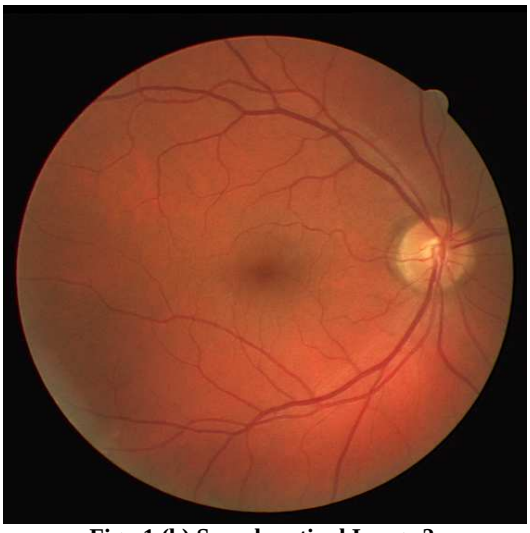

Fig - 1 (b) Sample retinal Image 2

The important problem faced during identifying the true vessels for the vessel segmentation is the miss judgment of overlapping and bifurcation. Mostly crossovers make count of bifurcation or vice versa which in turn results in the wrong count of the true vessels. This poor identification of the true vessels will lead to wrong clinical decision. The crossovers and bifurcation phenomena in the blood vessels are clearly bestowed in the figures 3 where the square 1 represents the crossover and that of 2 the bifurcation.

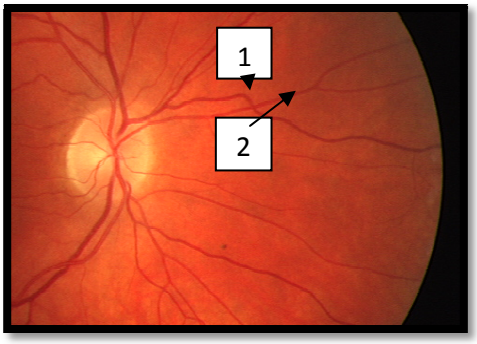

Fig 2 – Crossover and Bifurcation details

The problem of miscount can be rectified by our proposed vessel tracing technique through graph theory and the corresponding tracer referred as graph tracer. The ultimate aim of this project work is to detect the low vision problem in the human vision with help of calculating the diameter of the individual blood vessels, the minimum and the maximum diameters of the vessels, number of diameters in each and every segments, the total number of true vessel count, length of the vessels .The paper work is organized as follows. In Section II, Existing work is evaluated. The current work is discussed in the Section III then the implementation and results are given in the Section IV. At last in Section V conclusion and the future enhancement of the paper is illustrated.

Existing Work

Retinal vessel segmentation and delineation of morphological attributes of retinal blood vessels, such as length, width, tortuosity and/or branching pattern and angles are utilized for diagnosis, screening, treatment, and evaluation of various cardiovascular and ophthalmologic diseases such as diabetes, hypertension, arteriosclerosis and chorodial nerve- secularization [2]. Manuel Emilio Gegundez-Arias et al, in their paper titles as, “A Function for Quality Evaluation of Retinal Vessel Segmentations ”, proposed the retinal blood vessel segmentation with the technique of quality evaluation the measurement of a success or failure rate in the detected pixels, obtained by means of pixel-to-pixel comparison between the automated segmentation and a manually-labelled reference image. The DRIVE database was used for the work [6]. Ridge-Based Vessel Segmentation in Colour Images of the Retina was proposed by Joes Staal et al wherein the ridge based vessel segmentation was done in two dimensional colour images of retina. This paper outperforms, for better than rule-based methods [7]. Retinal blood vessel segmentation proposed by Shilpa Joshi et al work is compared [11], and found that the green channel of the fundus RGB (Red Green Blue) image was used for obtaining the traces of blood vessels. Contrast-Limited Adaptive Histogram Equalization (CLAHE) is used for contrast enhancement. Retinal Blood Vessel Segmentation Using Gabor Wavelet and Line Operator was proposed by Reza Kharghanian and his co authors and narrated the retinal segmentation by extraction of information by Gabor wavelet and line operator, and here the retinal images are taken from the DRIVE data base [12]. Blood vessel segmentation for high resolution retinal images proposed by J.Benadict Raja et al enhances the speed and accuracy of segmentation for high resolution retinal images by involving a data partition scheme and segmentation algorithm for parallel environment. Insight segmentation and registration Tool Kit is effectively used for the vessel segmentation done in [13]. A Fast, Efficient and Automated method to detect Retinal Blood Vessels from colour fundus Images was developed by Jaspreet Kaur et al. Filter based approach with a bank of Gabor filters are used to segment the vessels. Few other algorithms utilised the frequency and orientation of Gabor filter to match that of a part of vessel to be extracted in a green channel image [14]. Splat Feature Classification with Application to Retinal Hemorrhage Detection in

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Fundus Images was proposed by Li Tang et al. The supervised approach of the retinal colour images are partitioned into non overlapping segments [3]. Local Morphology Fitting Active Contour for Automatic Vascular Segmentation was proposed by Kaiqiong Sun et al in this paper active contour model using local morphology fitting for automatic vascular segmentation on 2-D angiogram is used [4].

When compared with these previous existing algorithms, our approach differs from the existing works wherein the blood vessels are identified accurately by separating the crossovers and bifurcation vessels with excellent tracing techniques.

Proposed Work

A. Systematic Overview

Accurate retinal blood vessel extraction is needed as pre-processing steps of all these automatic disease detection and also for the screening .This proposed algorithm is designed for true blood vessel identification. The 40 colour fundus photographs from publically available database DRIVE are used in this paper. All this photographs were obtained from the Diabetic Retinopathy (DR) screening problem in the Netherlands. The main modules of this work were:

- Pre-Processing.
- Mask operation.
- Threshold based retinal blood vessel Segmentation using Isotropic Un-Decimated Wavelet Transform.
- Calculation of diameter and length.
- Calculation, true blood vessel count.
- Detection of diseases.

B. Pre-processing

Vessel segmentation is mostly based on applying skeletonization operation. While applying this skeletonization process extracted vessels are captured in the form of line images. The lines in these images show the connectivity of the particular vessel structure. Three important definitions are used to find out the connected pixels, pixel crossing number and junction pixels in the extracted line image. The definitions are explained by the neighbourhood structure as detailed below

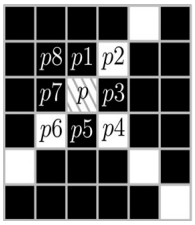
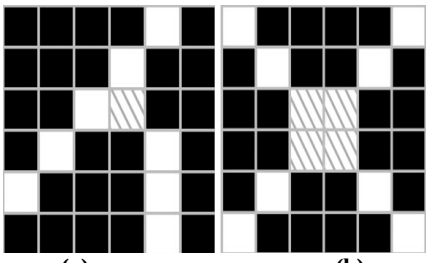


Fig – 3 eight neighbourhood structure from p1 to p8 with the centre pixel p.



(a) (b)

Fig 4 (a) Neighbourhood pixels not having junction. (b) Neighbourhood pixels having junction

Consider P is having set of white pixels in the line image. Two pixels namely pi, pj € P, and said to be neighbouring pixels only if pj € neigh8(pi),where neigh8(p) = {p1,p2,p3, . . . ,p8}.

1. Connected pixels:

Connected pixels are determined by the following condition, say

Pixels pi, pj ∈ P are connected, i.e., conn(pi, pj), if adj(pi, pj) or ∃pc ∈ P − {pi, pj }.

If the pixel is available in the adjacent format then that particular pixel is said to be connected pixel. For example i=1 and j=5 then connected pixel pc value is, pc ∈ P – {p1,p5}.

2. Pixel crossing number*:*

Consider p1, p2, . .p8 in the clockwise sequence of eight neighbouring pixels in P. In that case xnum(P) is calculated by the number of transition from black to white pixels in the neighbour pixels of p. With the help of this pixel crossing number the junction pixels are easily found.

3. Junction:

If the following condition is true then the pixel is called as a junction pixel, the condition :

$$YP = \{p \in P | xnum(p) > 2 \vee |white8(p)| > 3\}.$$

The below two examples clearly shows the concept of junction pixels. In the fig 4(a) the condition was not satisfied because its pixel crossing number is only 2 and so it is not a junction pixel he Then in second example both pixel crossing number and whit pixel counts satisfies the conditions, so fig-4(b) having the junction pixel on it.

C. Mask Operation

The mask erode operation is true if an erosion operation should be applied to the mask. This reduces its size by at least 2 pixels, or around 2.5% of the total FOV (Field of View) diameter for large images. This is usually a good idea, because the transition that often occurs at the boundary of the FOV can lead to erroneous detections. Mask dark threshold and mask bright threshold – pixels with values between these two thresholds will be

ISSN: 2277-9655
Impact Factor: 1.852

considered part of the FOV. Mask largest region is true if the largest contiguous region should be counted as the FOV, false if all regions meeting the threshold criteria should be kept, irrespective of size.

D. Isotropic Undecimated Wavelet Transform (IUWT)

The IUWT algorithm is well suitable in the medical image domain, because it is well adapted to retinal data where objects are more or less isotropic in most cases. Requirements for a good analysis of such data are as follows.

• Filters must be symmetric ($\bar{h}[k] = h[k]$, and $\bar{g}[k] = g[k]$).

• In 2-D or a higher dimension, must be nearly isotropic.

Filters do not need to be orthogonal or bi-orthogonal and this lack of the need for orthogonality or bi-orthogonality is beneficial for design freedom. For computational reasons, we also prefer to have the separability; $h[k,l] = h[k]h[l]$. Separability is not a required condition, but it allows us to have a fast calculation, which is important for a large data set. This has motivated the following choice for the analysis

Scaling and wavelet functions of a IUW is

$$\emptyset\_1\ (x) = 1/(12\ )\ (|x-2|\hat{}(3) - 4\,|x-1|\hat{}(3) + 6|x|\hat{}(3) - 4|\,x+1|\hat{}(3) + \big|\,x+2|\hat{}(3)\ ).$$

$$\emptyset 1(x,y) = \emptyset_1(\mathrm{x})\,\emptyset_1(y).$$

$$\tfrac{1}{4}\,\varphi\left(\tfrac{x}{2}\,,\tfrac{y}{2}\right) = \varphi(x,y) - \tfrac{1}{4}\,\emptyset_1(\,\tfrac{x}{2},\tfrac{y}{2}).$$

where is $\emptyset 1$ the spline of order 3, and the wavelet function is defined as the difference between two resolutions. The related filters h and g are defined by

$$h^{1D}[k] = \frac{[1,4,6,1]}{16}, k = -2, \ldots 2.$$

$$h[k,l] = h^{1D}[k]h^{1D}[l].$$
$$g[k,l] = \delta[k,l] - h[k,l].$$

Where δ is defined as $\delta[0,0] = 1$ and $\delta[k,l] = 0$ for all (k,l) different from (0, 0).

E. Threshold Based Retinal Blood Vessel Segmentation

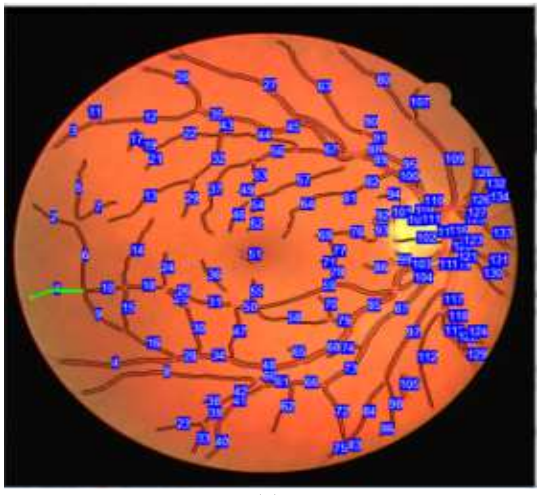
The initial input image is a greyscale image. A binary mask is applied in the Region of Interest (ROI). If the vessels are darker than their surroundings then keep the pixels as it is and to be considered as true pixels. If not they are to be omitted. The pixels outside the region defined by the mask should be assigned the value of the closest unmasked pixels prior to filtering. The numeric vector specify the default wavelet levels of decomposition to be carried out and the threshold to be used depends on the intensity of the input image The input image now is in a 2D matrix containing the image data. The mask is generated by applying a fixed threshold of 20 to image and applying 3x3 erosion. This is suitable for the DRIVE database, but may well be inappropriate for other images.

Threshold the darkest 15% of coefficients from wavelet levels 2 & 3 of the IUWT of image. Then remove objects < 75 pixels and fill holes > 20 pixels.

Implementation and Result

A. Experimental Evaluation

The simulation is carried out with the help of MATLAB software. The fundus imaged retrieved from the DRIVE database found to have the screening population consists of 453 subjects between 31 and 86 years of age. Each image has been JPEG compressed, which is common practice in screening programs. Of the 40 images in the database, 7 contain pathology, namely exudates, haemorrhages and pigment epithelium changes. After segmentation the output image is produced by the MATLAB GUI (Graphic User Interface) is in the above form. In figure 5 (a) the good retinal image is displays and figure 5 (b) the affected retinal image is displays. Compare to fig 5 (b), fig (a) has the number of count as well as the number of diameters in every vessels are high.



(a)

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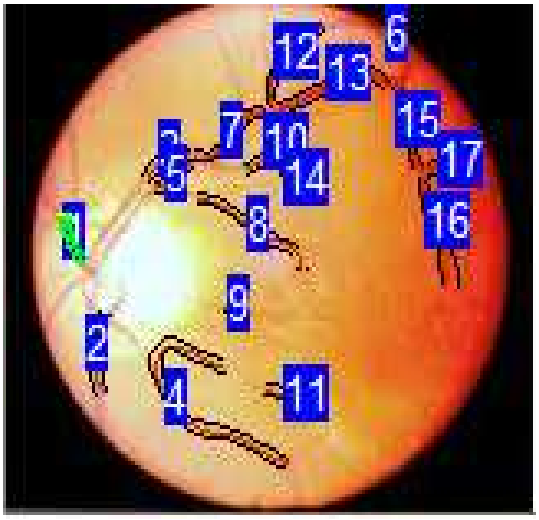

(a)

Fig – 5 Segmented retinal image (a) Good fundus image (b) Affected fundus Image

B. Count of true vessels

The count of true vessels was helpful to know about the amount of blood flowing through vessels in a particular retinal image. The diabetic retinopathy disease and cardiovascular diseases such as diabetes, hypertension, and arthrosclerosis was identified by means of this count of true vessels. The figure 7 is displayed the count of true vessels.

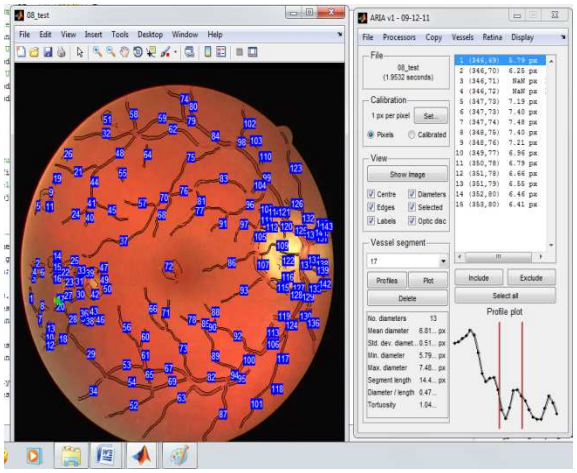

Fig – 6 Count of true vessels.

C. Zone of interest, separation of zone of interest

Both the two images from the figure 8 express the particular zone of interest which in turn helps for finding the radius of the optic disc, and the separation of zone of interest required for detecting the disease and it can be cured by proper treatment.

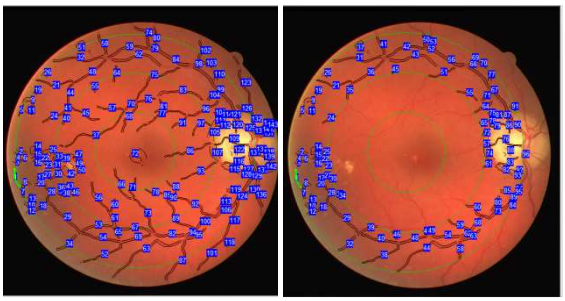

Fig – 7 Zone of interest and extraction of zone of interest

Conclusion

The segmentation of the blood vessels in the retina has been a heavily researched area in recent years. The proposed novel technique is automatically tracks true vessels from retinal images without the need of user invention and produces the better result for detection of low vision with the help of diameter calculation as well as count of true vessels. The simulation is accomplished with MATLAB and the results show that the proposed approach leads to accurate identification of vessels and is scalable. The counts of true vessels, vessels sorted by length, mean diameter, zone of interest and extraction of particular zone within the retinal images is also achieved by this proposed method, these measurements are useful one for detecting and screening the disease.

Acknowledgment

The author would like to thank the DRIVE data base management for make their database publicly available

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ISSN: 2277-9655
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