International Journal of Medical, Medicine and Health Sciences
ISSN: 2517-9969
Vol:4, No:4, 2010

Automated Thickness Measurement of Retinal Blood Vessels for Implementation of Clinical Decision Support Systems in Diagnostic Diabetic Retinopathy

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***Abstract*—**The structure of retinal vessels is a prominent feature, that reveals information on the state of disease that are reflected in the form of measurable abnormalities in thickness and colour. Vascular structures of retina, for implementation of clinical diabetic retinopathy decision making system is presented in this paper. Retinal Vascular structure is with thin blood vessel, whose accuracy is highly dependent upon the vessel segmentation. In this paper the blood vessel thickness is automatically detected using preprocessing techniques and vessel segmentation algorithm. First the capture image is binarized to get the blood vessel structure clearly, then it is skeletonised to get the overall structure of all the terminal and branching nodes of the blood vessels. By identifying the terminal node and the branching points automatically, the main and branching blood vessel thickness is estimated. Results are presented and compared with those provided by clinical classification on 50 vessels collected from Bejan Singh Eye hospital..

***Keywords*—**Diabetic retinopathy, Binarization, Segmentation Clinical Decision Support Systems.

I. Introduction

THE tortousity of blood vessels in the human retina is minute and prone to many diseases, Such as arthrosclerosis and hypertension. A number of measures have been proposed for thickness measurement [1-5]. The commonly used measurement is distance metric [3] which defines the ratio of the vessel length to the chord length between end to end points. Other measures proposed are based on curvature of the vessel axis [4,5] and on direction changes along the vessel [2]. Al measures proposed, represent blood vessels as one –dimensional curves. The main goal of this screening process is to reliably identify subjects who have progressed to threshold disease, so they can be promptly treated. At present this screening process is carried out by ophthalmologists skilled in the examination of infants' eyes. Any system which can assist ophthalmologists in increasing the accuracy of their screening, or which could allow less highly trained individuals to carry out the screening (e.g., ophthalmic nurses) may be of clinical benefit. A possibility of providing some automated assistance in this screening process lies in accurate computer measurement of vessel width and tortuosity near the posterior pole (back) of the retina. The clinical justification for this is that it has been recently demonstrated that the absence of dilated and tortuous vessels in the posterior pole is a reliable marker for the absence of threshold ROP (Saunders et al., 2000; Wallace et al., 2000), lessening the need for indirect ophthalmoscopy of the peripheral retina The posterior pole can be more easily visualised using a direct ophthalmoscope (which is considerably easier to use), or a fundus camera. Therefore analysis of the region near the posterior pole can be used as a screening test in its own right, since only subjects with changes in this region will exhibit threshold disease. This opens the possibility of screening for ROP by non-ophthalmologists using a direct ophthalmoscope (Saunders et al., 2000), or by automated techniques which provide quantitative measurements of vessel width and tortuosity in the posterior pole.

This paper presents a measure of blood vessel thickness better than the traditional used measures [4], [5], [6]. An algorithm is used to identify automatically a vasculature segments connecting two points. In this paper the blood vessel thickness is automatically detected using preprocessing techniques and vessel segmentation algorithm. First the capture image is binarized to get the blood vessel structure clearly, then it is skeletonised to get the overall structure of all the terminal and branching nodes of the blood vessels. By identifying the terminal node and the branching points automatically, the main and branching blood vessel thickness is estimated. The remaining of the paper is organized as follows : Section II explains the overall outline of the proposed algorithm and

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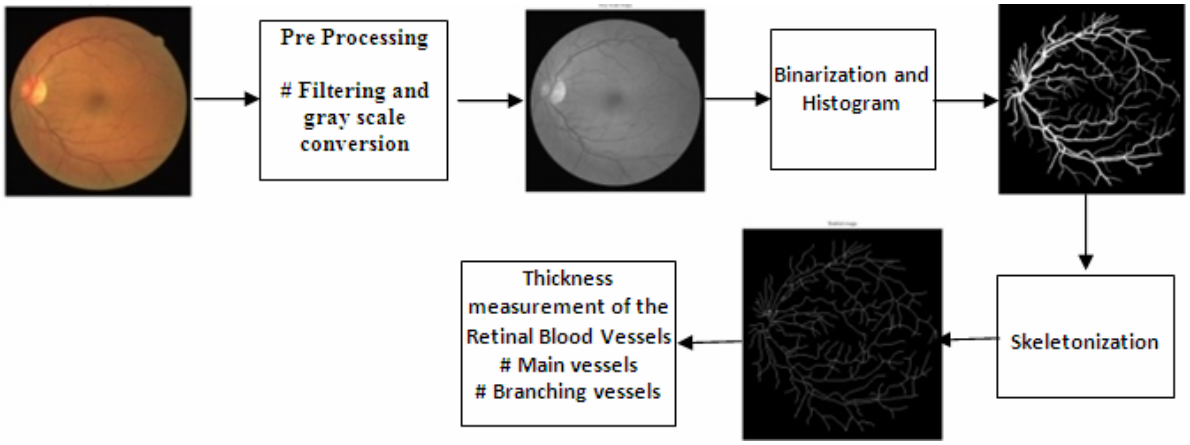

Fig. 1 : Process flow diagram for the proposed approach

section III briefs about pre-processing of the images. Section IV explain vessel segmentation; then section V explain skeletonization of the segmented vessel image. Section VI gives details about thickness measurement. The final part, section VII presents, results and compares the vessel estimates, generated by the human physical system and by a clinician.ocument is a template for *Word (doc)* versions. If you are reading a paper version of this document, so you can use it to prepare your manuscript.

II. Feature Extraction Scheme

The algorithm is organized in two stages: (a) To determine the features of a target vessel (section IV and V), and (b) estimation of vessel thickness (section VI) Fig. 1 shows a breakdown of the two stages into modules discussed below: The input is a binary image of retinal image of a bright area of the vascular network. A Region of Interest (ROI) contains the vessels for which thickness is to be estimated is selected Automatically. All other operations are taken place within the ROI. Initially vessel segmentation, skelectonisation and compute a graph representation of vessel network are performed. Thickness of terminal and branching nodes are then located. The end points of a vessel, must be estimated are then selected. The path gives the vessel segment on which thickness is estimated.

A. Image Denoising

In a image a noise is removed for the purpose of next iteration pre processing of a retinal image based on Filtering which gray scale conversion is made . It can be removed by antiblurring filter Then it is converted into RGB to gray scale conversion. For gray scale conversion Gs (i,j) = 0.299 R(i,j) +0.5870 G (i,j)+0.114 B (i,j) where R= red component of image, B= blue component of image G= green component of image.

B. Vessel Segmentation

The histogram of a digital image with gray levels in the range [0, L-1] is a discrete function $h(r_k) = n_k$, where r_k is the K^{th} gray level and n_k is the number of pixels in the image having gray level r_k. A common practice is normalize a histogram by dividing each of its values by the total number of pixels in the image, demoted by n. Thus, a normalized histogram in given by $P(r_k) = n_k/n$, for k=0,1… L-1. Histogram manipulation can be used effectively for image enhancement. The horizontal axis of each histogram plot corresponds to gray level values, r_k. The vertical axis corresponds to values of $h(r_k) = n_k$ or $P(r_k) = n_{k/n}$ if the values are normalized. The histogram plots are simply polts of $h(r_k) = n_k$ versus r_k or $P(r_k) = n_k/n$ versus r_k.

The gray level histogram corresponds to an image f(x,y), composed of light objects on a dark background, in such a way that object and background pixels have gray levels grouped extract the objects from the background is to select a threshold T that separates these modes. Then any point (x,y) for which f (x,y) > T is called an object point; otherwise, the point is called a background point.

C. Skelectionzation

From Fig (2), the notation of a skeleton, S(x), of a set X is intuitively simple. We deduce from this fig that

1. z is a point of S(x) and (D)z is the largest disk centred at z and contained in X, one cannot find a larger disk (not necessarily centered at Z) containing (D)z and included in A. The disk $(D)_z$ is called a maximum disk.
2. The disk $(D)_z$ touches the boundary of X at two or more different places. The skeleton of X can be expressed in terms of erosions and opening. That is it can be shown that

$$S(X) = \bigcup_{k=0}^{K} S_k(X) \quad (1)$$

With $S_k(X) = (X \theta kY) - (X \theta kY) oY$ (2)

where Y is structuring element, and $(X\theta kY)$ indicates k successive erosions of A

$$(X \theta kY) = (\ldots(X \theta Y) \theta Y)\theta \ldots) \theta Y \quad (3)$$

k times, and Kis the last iterative step before X erodes to an empty set. In other words.

$$K = \max \{k/ (X \theta kY) \neq \emptyset) \quad (4)$$

The formulation given in eqes (1) and (2) states that S(x) can be obtained as the union of the skeleton subsets $S_k(X)$. Also, it can be shown that X can be reconstructed from these subsets by using the equation .

$$X = \bigcup_{k=0}^{k} (S_k(X) \oplus kY) \quad (5)$$

where $S_k(X) \oplus kY$ denotes k successive dilations of S_k (X); that is

$$(S_k(X) \oplus kY) = ((\ldots\ldots(S_k(X) \oplus Y) \oplus Y) \oplus \ldots) \oplus B \quad (6)$$

D. Vessel Thickness Measurement

The measurement of vessel width is classified into two types. They are (i) End point and (ii) Branching point. The end point measures vessel thickness of branching point while branching point measures Vessel thickness of main vessel using the skeleton image the end point and branching points are determined. The number t of transitions from black to white moving clockwise around the Eight neighbourhood point is counted which is classified as follows:

t = 1; determines a terminal node
t =0,2; determines a non significant node
t ≥ 3; determines a branching point

Results for the example above are shown in fig (2). The main vessel thickness is measured from the branching node. It is measured by three pixel value before the branching the point from that point it is perpendicular to the skeletal image of the thickness is measured in the binary image. The branch vessel thickness is measured from the terminal node. It is measured by three pixel value before the terminal point from that point it is perpendicular to the skeletal image of the thickness is measured in the binary image.

II. RESULTS AND DISCUSSION

Test image data base: The method described was tested on images of Bejan Singh Eye Hospital. The Data base contains 50 colour images of the retina, with 564 x 584 pixels and 8 bits per colour channel in LZW compressed TIFF format. These images are originally captured from a ZEISS camera made in Germany with Visupack software is used. In this paper, sample images from Bejan Singh eye hospital is used for experimental. The colour images are converted to gray Scale. The blurred images are removed by using anti blurring filter. The output of the anti blurring filter is gray scale image is subjected to segmentation process.

Segmentation of retinal vascular structure is achieved by using Binarization of histogram techniques (fig. 2c, 2d). Then it is skeletonized (fig. 2e). Finally the thickness measurement is measured of the retinal blood vessels of the main vessels and branching vessels. The thickness measurement of the graph is shown in fig (2f) and (2g).

The result of applying anti blurring filter and Binarization is shown in fig (2c). It can be clearly seen that the vascular network is clearly segmented using Binarization techniques. The vessel structures, vessel endings and bifurcation are clearly visible, giving the health care professionals a better visibility and clarity for efficient decision making. As the vascular network in clearly visible, the extractions of features can be made more accurately, hence the thickness measurement for main vessels and branching vessels can be evaluated efficiently. It increases the efficiency of automated clinical decision making system.

TABLE I OBTAINED VALUES OF VESSEL THICKNESS FOR CDSS IN DIABETIC RETINOPATHY

Subject No	CDSS	
	Main Vessel Thickness	**Branch Vessel Thickness**
Subject 1	5	1
Subject 2	6	2
Subject 3	4	1
Subject 4	7	2
Subject 5	5	1
Subject 6	6	2
Subject 7	4	1

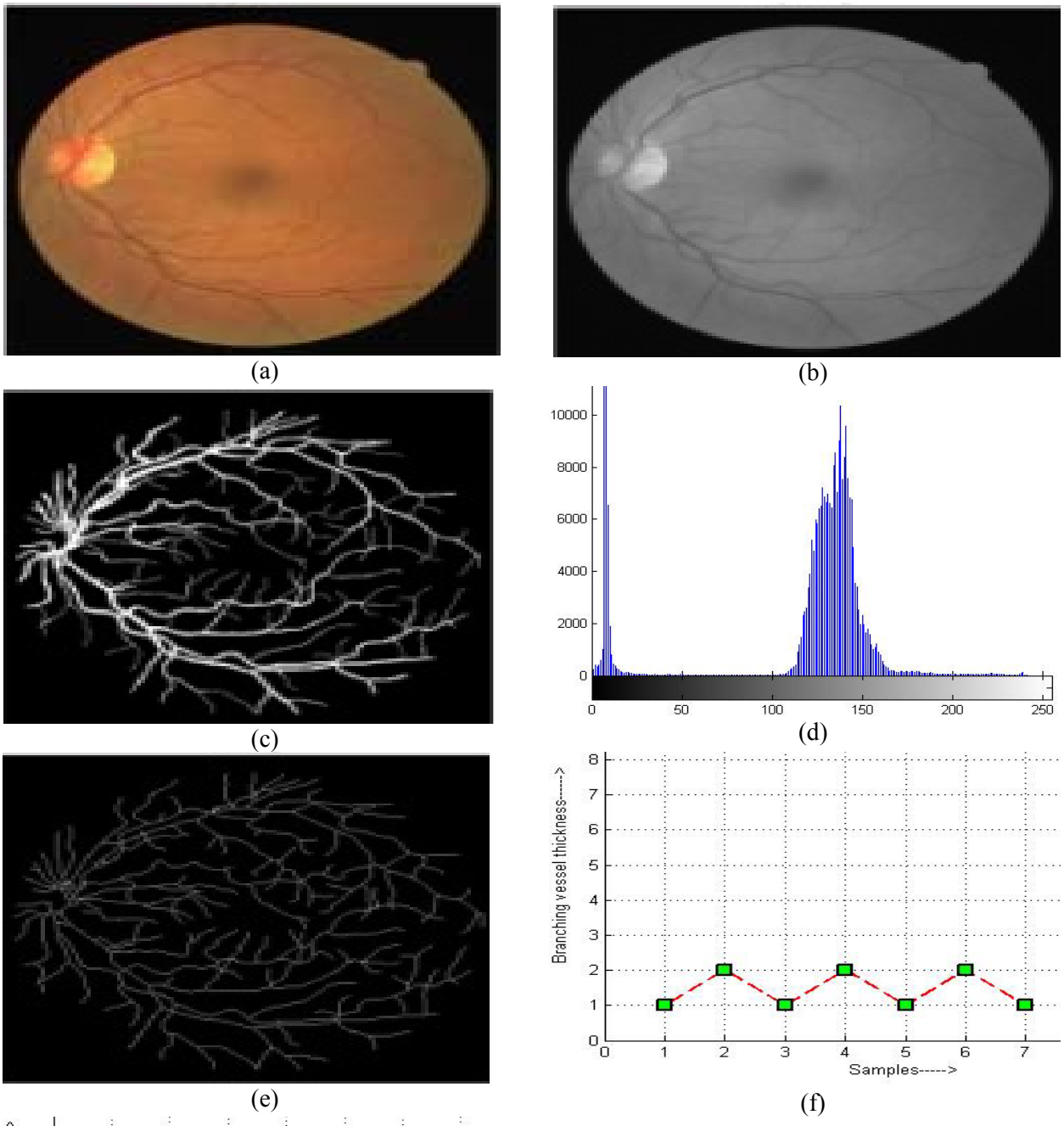

Fig. 2: Thickness measurement result obtained by subjecting the sample image from Bejan Singh Eye Hospital Date base. (a)Original Image (b) Gray Scale image (c) Binarized image (d) Histogram of Binarization (e) Skeletonized image (f) Plot of thickness measurement of main vessel (g) Plot of thickness measurement of branch vessel.

IV. Conclusion

Thickness measurement of Retinal vascular structures for enhanced feature extraction by skeletnizations of the retinal vascular structure is implemented in this paper. The developed algorithm is better than the traditional thickness measurement schemes. Experimental results has shown that it has been able to detect the thickness of the vascular structures making it suitable scheme for the development of computer aided diagnosis and decision making system.

Acknowledgment

The authors would like to acknowledge the support of Dr Bejan Singh and the clinicians at the retinal care centre of Bejan Singh Eye Hospital Nagercoil for the data and the support extended throughout the study.

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