PRE PROCESSING OF VESSEL SEGMENTATION FOR THE IDENTIFICATION OF CARDIOVASCULAR DISEASES WITH RETINAL IMAGES

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Abstract - Identification of Retinal Blood Vessel is much required for detecting vision capacity, Diabetic retinopathy, and also cardiovascular diseases like ophthalmic pathologies, hypertension. This work examines the blood vessel segmentation methodology in two dimensional retinal images acquired from a fundus camera. Many deduction methods are available but the results are not satisfactory. The measurement of the various morphology parameters of these retinal blood vessels plays a vital role for detecting the diseases and obviously clear that the wrong identification of these measurements leads to a wrong clinical diagnosis. Hence there comes the need for identifying the true vessels of the segmented retinal images. The proposed project work presents a new method for identifying the true vessels with apparent pre processing phase: as a first step the acquired images are pre-processed with three steps as i. Gray scale conversion, ii. Detection of edges and corners, iii. Median filtering for the removal of any salt and pepper noise if present, and then a Gaussian model for segmentation. True vessels are identified based on the connectivity of the eight neighbourhoods and also on the black to non black transition in the morphological opening. In the second step the pre processed and then segmented image is used for the identification of true vessels by modelling the segmented graph though finding the morphological parameters. Locating the cross over’s and the bifurcations are slightly the hard-hitting effort and done in various ways. The work was carried out with the images from the publicly available DRIVE and STARE databases which are widely used for this purpose, since they contain retinal images where the vascular structure has been precisely marked. Algorithm is simulated in Matlab and the results suggest that our proposed system can be efficiently used to identify the true blood vessels,

Keywords - Graph tracer, True vessels identification, Impairing vision etc.,

I. INTRODUCTION

Diabetic retinopathy is the leading cause of blindness among adults aged 20-74 years in the United States. According to the World Health Organization (WHO), screening retina for diabetic retinopathy is essential for diabetic patients and will reduce the burden of disease. Eye is an organ associated with vision. It is housed in socket of bone called orbit and is protected from the external air by the eyelids. In particular, the state of the retinal vessels has been shown to reflect the cardiovascular condition of the body. A retinal image provides a snapshot of what is happening inside the human body. In particular the retinal eye images provide many details about blood vessels. However, these images are difficult to interpret, and computational image analysis is needed to increase the diagnostic efficiency and accuracy of the screening process. Measurements to quantify retinal vascular structure and properties have shown to provide good diagnostic capabilities for the risk of cardiovascular diseases.

A fuzzy vessel tracking algorithm for retinal images based on fuzzy clustering was developed by Yannis A. Tolias in this paper author present a new unsupervised fuzzy algorithm for vessel tracking that is applied to the detection of the ocular fondues vessels. Retinal vascular tree morphology, a semi-automatic quantification was proposed by M. Elena Martinez-Perez and Kim H. Parker the system is a semi-automatic method to measure and quantify geometrical and topological properties of continuous vascular trees in clinical fondues images is described. Measurements are made from binary images obtained with a previously described segmentation process. Automatic grading of retinal vessel calibre was developed by Huiqi Li, Wynne Hsu, Mong Li Lee and Tien Yin Wong where the new clinical studies suggest that narrowing of the retinal blood vessels may be an early indicator of cardiovascular diseases. Retinal image segmentation was done by hessian matrix and clustering algorithm which in turn was proposed by Salem. Retinal blood vessel segmentation using Gabor wavelet and line operator was proposed by Shilpa Joshi, Dr P.T. Karule by extracting two sets of features for image classification: four features from Gabor wavelet transform in different scales and two features from orthogonal line operators. Another approach resolves the connection between the bifurcation and cross-over before identifying the true vessels. Mahadevan in his work identified, the true vessels using supervised classifier approach through vascular structure segmentation, a post processing algorithm. Matched filtering for blood vessel segmentation has first been developed in 1989. Since then, several different algorithms were developed based on this approach. K.A. Vermeer et.al described the blood vessel segmentation initially with Laplace and a proper threshold which is subsequently followed by a classification algorithm.
The proposed algorithm is implemented with four sections. Section II describes about the pre-processing required for the retinal image analysis. Section III is focused on the segmentation of the retinal image with junction pixels using eight neighborhood regions. Section IV demonstrates the way in which the vessels are classified for identifying the cross over and bifurcations. Section V presents the results and conclusions and finally section VI briefs about the feature enhancement.

II. PRE-PROCESSING OF THE RETINAL IMAGES

The retinal images say the fundus images are of basically colour in nature. To perform efficiently the segmentation and further identification there comes the need to do the three preliminary processes as:

a) Conversion of colour image into a gray scale image
b) Detection of edges and corners
c) Filtering in the spatial domain

a. Conversion of colour image into a gray scale image
This step increases the speed of the process since the chroma information is not that much needed for the segmentation and analysis.
The simple RGB to Y Cr Cb conversion is implemented in this project. The input and the output image of this process are given in Figure 1 and Figure 2 respectively.

b. Detection of edges and corners
The converted gray scale image now is operated using the Canny edge detector and consequently with Gaussian operation. This in turn yields the output image with fine tuned edges and corners. The output image of this stage is bestowed in Figure 3.

c. Filtering in the spatial domain
During capturing of these images at times the information are corrupted by noises, and these are to be eliminated for the analysis and recognition. Median filtering is used for this purpose with the kernel of size 3*3. To improve the quality further an adaptive spatial LPF is to be used for the removal of artifacts of the compressed images and other disturbances. The output image is projected in Figure 4.

III. SEGMENTATION OF TRUE VESSELS BY LINE DETECTION

Separation of the blood vessel structure from the background is much needed for identification of the true vessels and can be done using line detection on multiple scales. Vessel structures can be approximated as piecewise linear for identification purpose. Vessel segmentation is mostly based on applying skeletonization operation, wherein the extracted vessels are captured in the form of line images. By
Pre Processing Of Vessel Segmentation For The Identification Of Cardiovascular Diseases With Retinal Images

using lines of multiple lengths, vessels of different sizes and scales can be detected; problematic features, such as the small-scale vessel central light reflex (described above) have limited impact on the result at larger scales. The segmented lines with white pixels show the connectivity of the particular vessel structure.

**Step 2. Computing Pixel crossing number: xnum(P)**

Considering the same region of the step 1, the pixels p1, p2, ..., p8 are taken into account. With reference to a particular pixel the adjacent pixels are to be compared for the intensity transition. For instance let p1 be the reference pixel; comparing p1 and p2; check the transition black to white; if it is yes count get increased by one; And the comparison has to continue in the clockwise direction for the remaining eight neighbouring pixels in the set of P as p2 and p3 and so on . The total count at the end of comparison of this region is referred as xnum (P).

The above mentioned parameters are much useful for the detection of junction pixel to be carried out in the next step and also in the subsequent steps.

**The steps required for this line segmentation is narrated below by way of three key terms as:** connected pixels, pixels crossing number and the Junction pixel, in the extracted line image. Analysis is carried out with the 8 neighbourhood pixel as demonstrated below.

**Step 1 : Locate the connected Pixels: \( \text{conn}(pc,pj) \)**

Let P represents the set of white pixels in the line image. Then any two pixels referred pi, pj ∈ P, are said to be connected pixels by satisfying the condition that if and only if \( pj \in \text{neigh8}(pi) \), where \( \text{neigh8}(p) = \{p1, p2, p3, ..., p8\} \) as shown. i.e., \( \text{conn}(pi, pj) \), if \( \text{adj}(pi, pj) \) or \( \exists pc \in P - \{pi, pj\} \).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, \( pc \in P - \{p1, p5\} \), represented as \( \text{conn}(pi, pc) \cup \text{conn}(pc, pj) \). The one is illustrated in Figure 5.

**Step 3. Detecting the Junction pixel:**

A junction pixel referred as Jp may be deduced with two following conditions again in the same region which we considered already

i. Among the eight a neighbourhood pixels, the minimum number of transition from black to non black of that region should be two. Mathematically represented as
given the set of white pixels that are neighbours of p, Jp = \( \{p \in P |xnum(p) > 2 \lor \text{white8}(p) > 3\} \)
i. Number of white pixels in the 8 neighbourhood region should be minimum3 and this may be mathematically represented as that \( \forall pi,pj = I \in J, \text{conn}(pi,pj) \), where conn is restricted to the set Jp. Then, the set of all junctions in P is Jp. Figures 6 and 7 clearly indicate the detection of the junction or no junction pixels.

In the first image the condition was not satisfied because of its pixel crossing number as only 2 so it is not a junction pixel, whereas in the second example both pixel crossing number and whit pixel counts are satisfied and so it is a junction pixel.

IV. VESSEL IDENTIFICATION

Vessel tracking algorithms segment a vessel between two points using local information and work at the level of a single vessel rather than the entire vasculature. The centre of the longitudinal cross-section of a vessel is determined with various properties of the vessel including average width gray level intensity and tortuosity measured during tracking. Tracking consists of following vessel centre lines guided by local information, usually trying to find the path which best matches a vessel profile model. The main advantage of vessel tracking methods is that they provide highly accurate vessel widths, and can provide information about individual.
Generally, the vessel tracking algorithms are used in conjunction with matched filters of morphological operators. Some modifications and improvements are also suggested in the literature to deal with the above mentioned problems. To deal with the problem of the central light reflex area, supposed the vessel intensity profiles can be modelled as twin Gaussian functions.

V. RESULTS AND CONCLUSIONS

The proposed work is implemented in Matlab. Matlab is an interactive system whose basic data element is arrays that do not require dimensioning. This allows you to solve many technical computing problems; especially those with matrix and vector formulation, in a fraction of the time it would take to write a program in scalar non interactive existing languages.

The input retinal images were taken from two publicly available databases DRIVE (Digital Retinal Images for Vessel Extraction) and STARE (STructured Analysis of the REtina). For each retinal image the vessels is obtained using the automated retinal image analysis tool (ARIA). Results are bestowed for the image from the DRIVE data base.

Visual inspection on the results reveals that the proposed algorithm traces the overlapping vessel segments or wrongly connected bifurcations that lead to better measurements. Experiment results on a large real world population study show that the proposed approach leads to accurate identification of vessels and is scalable. 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 artherosclerosis were identified by means of this count of true vessels.
VI. FUTURE ENHANCEMENT

Crossover and bifurcations are detected only to a small extent through line segmentation. In spite the work may be carried out using graph tracer method. Graph tracer method may be much useful for measuring the count of true vessels, which can be optimised. The graph tracer technique may be implemented with two main steps, identification of crossovers and search for the optimal forest for the vessel graph structure

Searching of optimal forest gives the best set of vessel trees from the segment graph and also produces a small number of individual vessel features like length of the blood vessels, mean diameter, count of true vessels, and also the vessels sorted by length and mean diameter. In addition in future the work may be extended for the other medical images also

REFERENCES


