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Analyzing the Retinal Blood Vessels Extraction and Bifurcation Points in Color Retina Fundus Image

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Abstract: ***The extraction of retinal blood vessels in retinal fundus images can help the physicians for purpose of diagnosing diseases such as diabetes, hypertension, patients screening, diabetes retinopathy (DOR) has been subjected of several large scale clinical studies. Proposed algorithm efficiently extract and measure the blood vessel of retina and find the bifurcation points of retinal blood vessels is general enough that can be applied to high resolution ocular fundus image. Proposed algorithm has employed modulus such as pre-processing, 2D Median Filter, Morphological Operations, Thresholding and minutiae technique to find bifurcation points of extracted blood vessel. Proposed algorithm is being simple and easy to implement, is best suited for fast processing applications.***

Keywords: Blood Vessels, Fundus Images, Retinal Images, 2D Median Filter, Morphological Operations, Bifurcation, Thresholding

1. Introduction

Retinal images of humans play a crucial role in the detection and diagnosis of several eye diseases for the oculists [1-2].The patients might not notice a loss of vision until it becomes too severe, hence early diagnosis and timely treatment is vital to delay or prevent blindness. Retinal fundus images provide a unique possibility to take a non – invasive look at the eye and the systematic status of the human body. Besides ocular diseases, such as age-related macular degeneration and glaucoma that are two of the leading causes of blindness, other diseases are also manifested in the retina.

The retina can thus be considered as important for the health status of a person. A fundus image which is taken from different diseased patients are not of good quality and are low contrast, poor light conditioning, noisy, and thus affecting both the retinal background texture and the blood vessels structure. Features of the blood vessels will be more complex, so as to detect the structures of vascular which is not constant even along the same vessel. Their structure will be complex and it includes bifurcations and overlaps that may mix up to detect the system. Therefore, To detect the retinal images is necessary, and among them the detection of blood vessels is most important. As blood vessels detection becomes more essential to diagnosis the diseases in clinical, many researchers have been done in this medical field. In order to utilize these useful characteristics of retinal blood vessels, it is very important to obtain their locations and shape accurately. Therefore, the proposed algorithm efficiently locates and extracts blood vessels in ocular fundus images. It is a huge challenge, since large variability is observed and a natural variation is reported in the appearance of the retina.

The proposed algorithm composed of following steps pre-processing, 2D Median Filter, Morphological Operations, Thresholding, Minutiae Techniques to detect bifurcation points of extracted blood vessels. A typical fundus image of the retina is shown in Fig 1.1.The blood vessels in a retinal image are complex and with low contrast and more than 100 bifurcations can be seen in a retinal fundus image, so the manual detection is difficult. Hence, a manual measurement becomes tedious and time consuming process. Therefore, the proposed algorithm efficiently locates and extracts blood vessels in ocular fundus images.

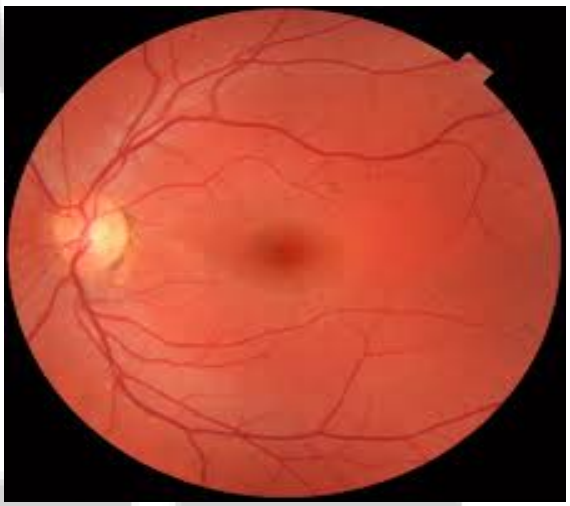

Figure 1.1: Retinal Image

2. Methodology

There are some image processing techniques which are used in this algorithm to enhance the blood vessels. The main modules are pre-processing, 2D Median Filter, Morphological Operations, Thresholding and organized to determine and remove the area that binds more than blood vessels (bifurcation points) found in retinal blood vessels. The figure 2.1 shows the block diagram for proposed method.

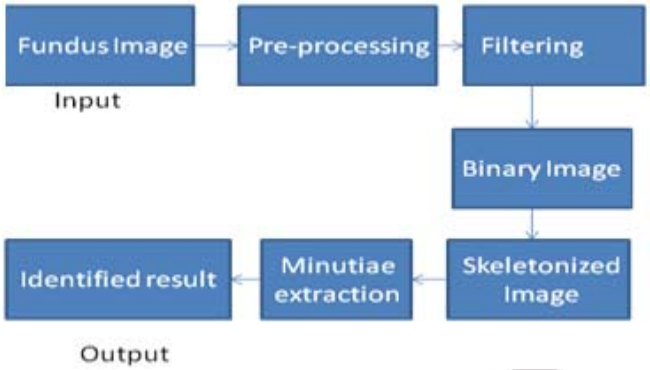

Figure 2.1: Block Diagram for proposed method

2.1 Preprocessing

The retinal blood vessel extraction is required as a pre-processing step in diagnose cardio-vascular diseases. The input is original fundus image of human retina which is captured from fundus camera and the skeletionzed binary image of blood vessels is an output. In the fundus image the contrast tends to be bright in centre, light in variations, noise influence, hence to minimize this effect pre-processing is essential and have more uniform image. In the first stage color fundus image is converted in to gray –scale/ green – channel image to exhibit the greatest contrast in blood vessels. Then use the complement function for enhancing the blood vessels of the retina. In the binary image the (black) background pixel become foreground pixel (white).For grey scale the procedure is to replace each pixel value I_{input} (i,j) as follows –

$$I_{output}(i,j) = MAX - I_{input}(i,j)$$

Where MAX = 255 is max possible value in given image representation. The contrast between blood vessels (foreground) and the retinal tissue (background) is generally poor or non – uniform lighting condition. Therefore, it is necessary to deepen the contrast of these images to provide better transform representation for subsequent image analysis steps. Adaptive Histogram Equalization function is used for contrast enhancing complimentary image. To analyze shapes within the image and to estimate the background, morphological operations are used which are the set of image processing. Structuring element is applied to the image and same size of the image will be the output.

The number of pixels being added or removed from the object in the image is affected by the size and shape of the structuring element. The morphological open function is used for thickening the retinal blood vessels. Morphological operation [3] is erosion followed by dilation using same structuring element for both operation. Opening operation has effect to remove the object that cannot contain complete structuring element. To get more uniform background subtract background image from the processed image.

2.2 2D Median Filter

The median filter uses 2D linear structuring element for vessel identification. 2D Median Filter is used for highlighting and removes the noise from morphological open function. As the 2D median filter is non – linear, each pixel value is replaced by median of gray level in neighborhood of pixel. a window of the size 3 x 3 pixels is used in which there are eight neighboring pixels to the central pixel.

$$G(x,y) = T[f(x,y)]$$

2.3 Thresholding

The main purpose in this step is to eliminate background variations in illumination from an image so that foreground objects may be more easily analyzed .Binary image is produced in which the value of each pixel is either 1(blood vessel) or 0 (background).Then the binary image is skeletionized to reduce all the objects in an image to thin line strokes that retain important information about the shape of original object.

2.4 Detection of bifurcation points

Retinal vessel land marks are bifurcation point, crossing point and end point. Among these features bifurcation point is reliable and abundant feature in fundus image. One of the unique features is bifurcation points. The junction on vessels from where two child nerves are generated. To detect the bifurcation points, skeleton image for retinal image is taken as input .A region of interest containing the skeleton vessels [4]. The area that binds more than one blood vessel in skeleton image is to be detected and removed.

To extract the bifurcation point minutiae extraction is important, It is implemented on skeleton image by using a concept of crossing number (CN).A window of the size 3 x 3 pixels is used in which there are eight neighboring pixels to the central pixel. For 3 x 3 windows, if central pixel is 1and has exactly 3 one-value neighborhoods, then the central pixel is a bifurcation point. If central pixel is 1and has only 1 one-value neighborhoods, then the central pixel is a ridge ending point (ridge point where it ends) that constitute blood vessel pattern. i.e. if CN(P)==1,it is a ridge and if CN(P)==3,then it is a bifurcation point. At each step have to compute, In order to see whether a pixel is a bifurcation point of a vessel or binded more than blood vessel, place this window on the image so that the considered pixel is at the center of the window and find the bifurcation point. If the central pixel does not lie on any vessel, it is not a bifurcation point. If the centre pixel lie on the vessel then it is a bifurcation point .The window is applied to all image pixels (except for the pixels on the edges) and all points are classified into bifurcation points or crossover points (one vessel cross other vessel). The Figure 2.2a and 2.2b shows bifurcation point and crossover point.

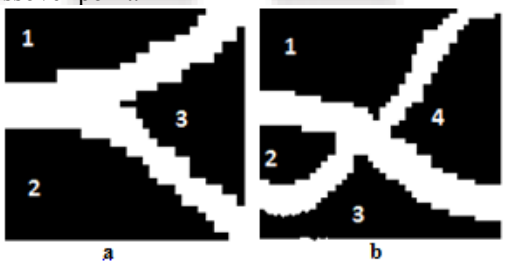

Figure 2.2: (a) Bifurcation points and (b) Crossover points.

3. Result and Discussion

Digital retinal imaging playing an increasingly prominent role in the diagnosis and treatment of eye diseases and the extraction of clinically useful information has become important task. The proposed algorithm was originally developed for fundus images but it is equally effective for other types of vascular images. The images of retina are collected from DRIVE database [5]. Proposed algorithm may provide a great benefit to ophthalmologists while monitoring, diagnosing and treating the diseases and other ocular-related diseases. Further, the idea developed in this paper can be applied to other images where it is of interest to detect intersections and perform analysis of various vascular objects. Hence, the accuracy was high and all the nodes in image located, detected. For this proposed algorithm GUI is designed in MATLAB for retinal blood vessel extraction and detection of bifurcation points. Figure 3.1 shows the result for extraction of blood vessels and detection of bifurcation points.

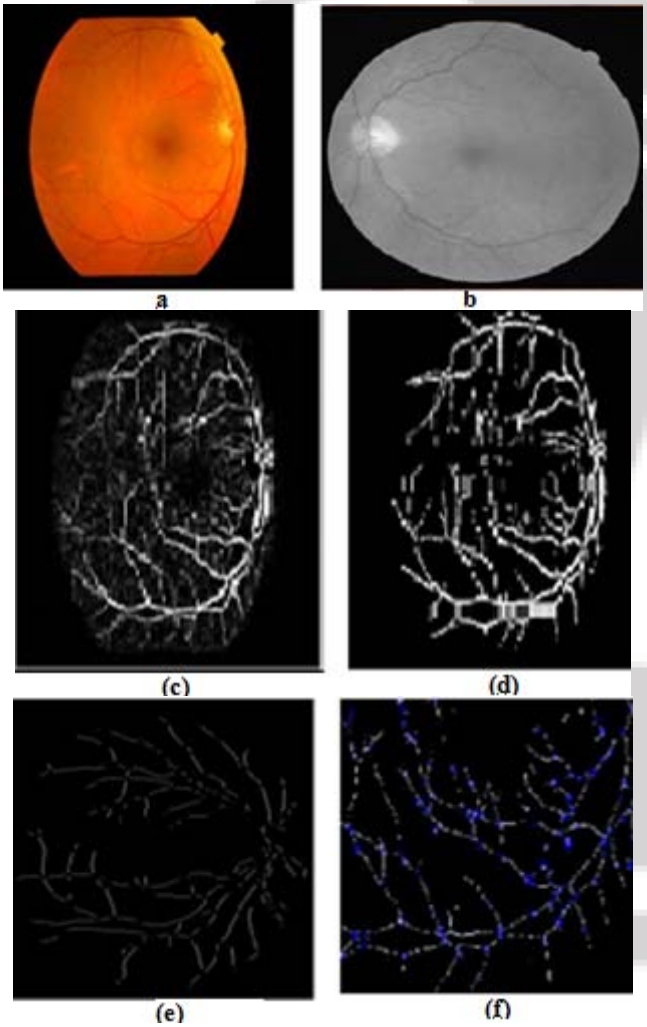

Figure 3.1: (a) original image, (b) gray channel, (c) 2D Median Filter, (d) Threshold image (e) skeleton image, (f) bifurcation points on skeleton image

4. Conclusion

Image processing techniques are used in this proposed algorithm for extracting the blood vessel of the retina and detecting the bifurcation points of extracted blood vessels. It is easy, simple, reliable, high accurate and efficient algorithm for extracting the blood vessel of the retina and detecting the bifurcation points of extracted blood vessels. Proposed vessel extraction technique does not require any user intervention, and for both normal and abnormal images has consistent performance.

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