AUTOMATIC DETECTION OF BLOODVESSELS IN RETINAL IMAGES FOR DIABETIC RETINOPATHY DISEASE

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ABSTRACT:

In this paper, the detection of blood vessels in retinal images for diabetic retinopathy diagnosis automatically has been presented. The objective of this project is to help biomedical engineers and medical physicists for the diagnosis & treatment of diabetic retinopathy (DR), glaucoma, hypertension and age related macular degeneration (AMD) etc diseases can be done with the help of fundus images takenfrom a fundus camera & are further processed to help in diagnosis & treatment. This disease can be caused by blindness due to change in blood vessels of the retina.

For the detection purpose we use 3 different methods. 1) Segmentation of the retinal blood vessel 2) Using 2- D Gabor wavelet to enhance the vascular pattern. 3) Using star networked pixel tracking algorithm. All these methods are processed using MATLAB platform in GUI interface. With this software graphically taking input & writing related software program.

With this technique, the accurate detection and segmentation of the retinal vascular structure forms the backbone of a verity of automated computer aided system for detection of the diseases. In real life applications, retinal vessels segmentation systems will not replace the expert's role in diagnosis. This technique will have high accuracy, time and computational complexity and high robustness.

1 INTRODUCTION:

1.1 INTRODUCTION TO DIABETIC RETINOPATHY:

Diabetic retinopathy is the most common diabetic eye disease and a leading cause of blindness**.** In recent times, Sweden and other parts of the world have been faced with an increase in age and society related diseases like diabetes. According to survey, 4% of the country population has been diagnosed of diabetes disease alone and it have been recognize and accepted as one of the main cause of blindness in the country if not properly treated and managed. Early detection and diagnosis have been identified as one of the way to achieve a reduction in the percentage of visual impairment caused by diabetes with more emphasis on routine medical check which the use of special facilities for detection and monitoring of the said disease. The effect of this on the medical personnel need not be over emphasized, it has lead to increase work load on the personnel and the facilities, increase in diabetes screening activities just to mention a few. A lot of approaches have been suggested and identified as means of reducing the stress caused by this constant check up and screening related activities among which is the use medical digital image signal processing for diagnosis of diabetes related disease like diabetic retinopathy using images of the retina.

Diabetes is a disorder of metabolism. The energy required by the body is obtained from glucose which is produced as a result of food digestion. Digested food enters the body stream with the aid of a hormone called insulin which is produced by the pancreas, an organ that lies near the stomach. During eating, the pancreas automatically produces the correct amount of insulin needed for allowing glucose absorption from the blood into the cells. In individuals with diabetes, the pancreas either produces too little or no insulin or the cells do not react properly to the insulin that is produced. The buildup of glucose in the blood, overflows into the urine and then passes out of the body. Therefore, the body loses its main source of fuel even though the blood contains large amounts of glucose Basically there are three types of diabetes, Type 1 Diabetes, is caused as a result of auto immune problem. The immune system of the body destroys the insulin producing beta cells in the pancreas leading to no or less production of the required insulin by the pancreas. Type 2 Diabetes is a result of malfunctioning of the beta cell itself. This malfunction includes non-production of insulin or a situation known as insulin resistance. In insulin resistance, the muscles, fat and other cells do not respond to the insulin produced. Type 3 is known as gestational diabetes and only occurs during pregnancy. During this stage, the body resist the effect of insulin produced.

The effect of diabetes on the eye is called Diabetic Retinopathy (DR). It is known to damage the small blood vessel of the retina and this might lead to loss of vision. The disease is classified into three stages viz: Background Diabetic Retinopathy (BDR), Proliferate Diabetic Retinopathy (PDR) and Severe Diabetic Retinopathy (SDR). In BDR phase, the arteries in the retina become weakened and leak, forming small, dot- like hemorrhages. These leaking vessels often lead to swelling or edema in the retina and decreased vision. In the PDR phase, circulation problems cause areas of the retina to become oxygen-deprived or ischemic. New fragile, vessels develop as the circulatory system attempts to maintain adequate oxygen levels within the retina. This phenomenon is called neovascularization. Blood may leak into the retina and vitreous, causing spots or floaters, along with decreased vision. In the SDR phase of the disease, there is continued abnormal vessel growth and scar tissue, which may cause serious problems such as retinal detachment and glaucoma and gradual loss of vision.This research work is one of the method of applying digital image processing to the field of medical diagnosis in order to lessen the time and stress undergone by the ophthalmologist and other members of the team in the screening, diagnosis and treatment of diabetic retinopathy. This work determine the presence of BDR and PDR or otherwise in a patient by applying techniques of digital image processing on fundus images taken by the use of medical image camera by a medical personnel in hospital.

1.2. AIMS AND OBJECTIVE

The primary aim of this project is to develop a system that will be able to identify patients with BDR and PDR from either color image or gray level image obtained from the retina of the patient. These types of images are called fundus images. The different diabetic retinopathy diseases that are of interest include red spots, micro aneurysm and neovascularization and they fall between BDR and PDR stages of the disease. While SDR types are expected to be referred to the ophthalmologist.

The secondary aim includes developing a MATLAB based Graphic User Interface (GUI) tool to be used by the ophthalmologist in marking fundus images. The marked images a The thesis overview is as shown in Figure 1.1, the input fundus image is analyzed by the system and the output contains the grading and theresult with the co-ordinates of the detected abnormality shown on the GUI.The input image to the Pre-Processing stage can be a color or a gray level image. The Pre-Processing stage corrects the problem of Illumination variation that occurred when taken the pictures. Other problems corrected by this process include the enhancement of the contrast between the exudates and vein network and the background to aid in segmentation and detection of the abnormalities. Process involves in this stage include Color Space Conversion, Zero Padding of Image Edges, Median Filtering and Windowed Based Adaptive Histogram Equalization with Overlap Mean.The output of this stage is passed to the Segmentation stage. This stage segments the background pixel from the exudates and the vein networks using K- mean clustering algorithm with two cluster class centers. The exudates and the veinnetworks class centers also contain some noisy pixels that were over enhance. During the pre-processing stage and will be removed during the next stage called disease classifiers.

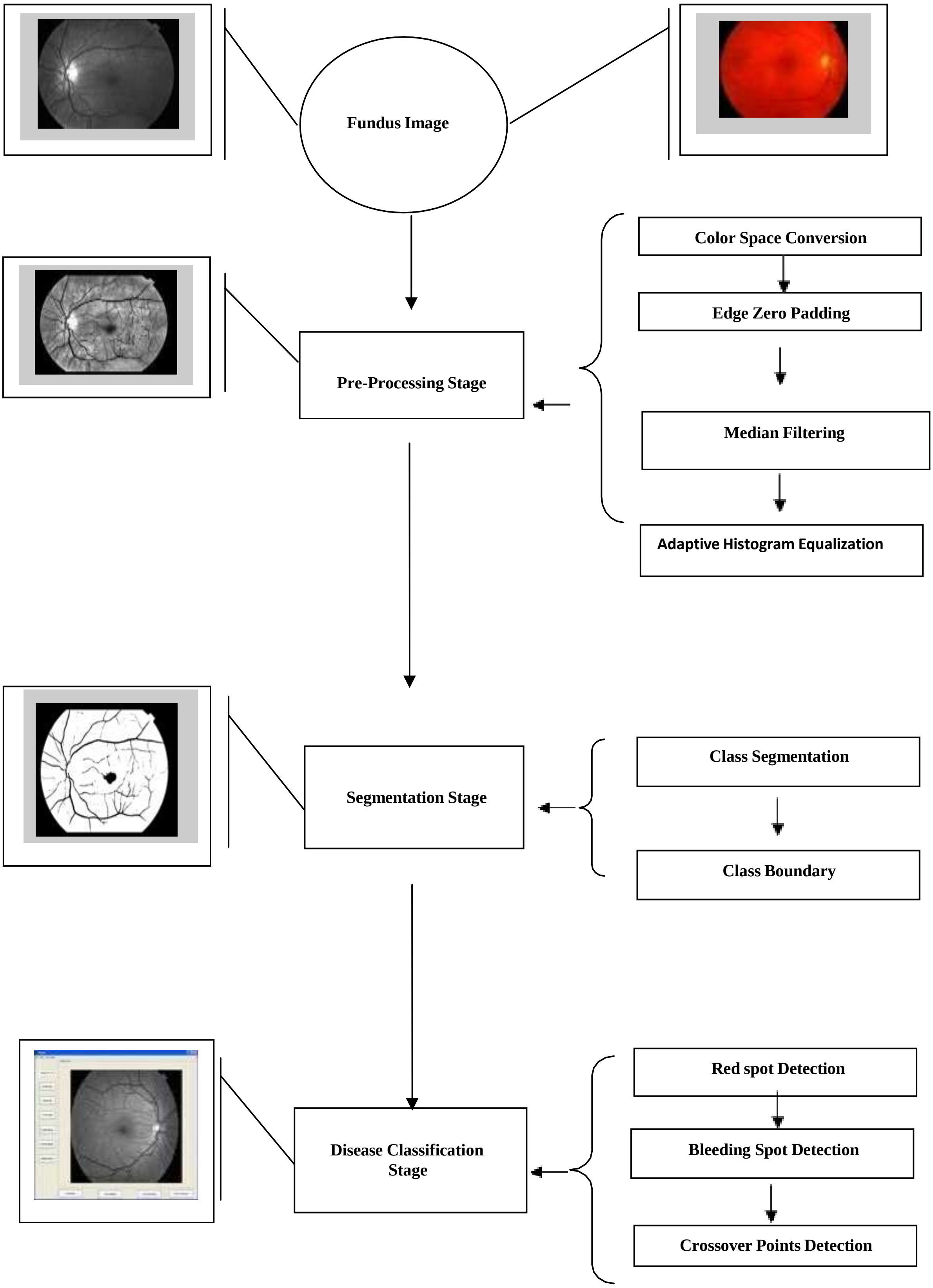

Figure 1.1: Block Diagram of Automatic Diagnosis of Diabetic Retinopathy using Fundus Images

The Disease Classification/Abnormality Detection consists of a series of classifiers and differentiating parameters with set of conditions in detecting and diagnosis of exudates, micro aneurysm, red spots, and crossover points. The criteria used for detecting image background based disease like exudates; micro aneurysm and red spots include Object Ratio Test, Compact Ratio Test, Length Test, Pixel Count Test and Region Hole Test. After detecting and removing these background based diseases, the image is then passed to the Vein-Processing stage for crossover points detection using Modified Cross point Number Method (MCNM). The Eye Structure.

2. EXISTING METODS:

The retina is the only location where blood vessels can be directly captured non-invasively in vivo. Over the past decade, the retinal image analysis has been widely used in medical community for diagnosing and monitoring the progression of diseases. And retinal blood vessels are important structures in retinal images. The information obtained from the examination of retinal blood vessels offers many useful parameters for the diagnosis or evaluation of ocular or systemic diseases. For example, the retinal blood vessel has shown some morphological changes such as diameter, length, branching angles or torturous for vascular or non-vascular pathology, such as hypertension, diabetes, cardiovascular diseases. Blood vessels are also used as landmarks for registration of retinal images of a same patient gathered from different sources. Sometimes, retinal blood vessel must be excluded for easy detection of pathological lesions like exudates or micro aneurysms. In all cases, proper segmentation of retinal blood vessel is crucial.

Actually, automatic detection of the blood vessels in retinal images is a challenging task. The contrast of retinal image diminishes as distance of a pixel from the center of the retinal image. And the presence of noise, the variability of vessel width, the presence of some pathological lesions, all make the task more difficult.

There are three basic approaches for automated segmentation of blood vessel:

threshold in g method, tracking method and machine trained classifiers. In the first method, many of different operators are used to enhance the contrast between vessel and background, such as Sobel operators, Laplacian operators, Gaussian filters which model the gray cross-section of a blood vessel .Then the gray threshold is selected to deter- mine the vessel. And this gray threshold is crucial, because small threshold induces more noises and great threshold causes loss of some fine vessels, so adaptive or local threshold is used to different sections of an image.

Vessel tracking is another technique for vessel segmentation, whereby vessel center locations are automatically sought along the vessel longitudinal axis from a starting point to the ending point . This method may be confused by vessel crossings and bifurcations. Many kinds of classifiers, such as Bayesian classifier, neural networks, support vector machine, have been employed for improved discrimination between vessel and non -vessel. Feature extraction and parameters selection of a classier are critical. All pixels in images are classified into vessel or non-vessel through the classifier.

In fact, a single generally acknowledged vessel segmentation algorithm does not exist due to the unique properties of each acquisition technique. Every segmentation method has difficulties when applied alone, a combination of them is presented to detect retinal blood vessel in this paper. This article is organized as follows. Section 2 describes the method of segmentation of blood vessel. Section 3 shows the results. The discussions and conclusions are presented in Section 4.

3 PROPOSED METHOD

3.1 USING STAR NETWORK PIXEL TRCKING ALGORITHM

Diabetic retinopathy is the most common diabetic eye disease and a leading cause of blindness. The estimated rate of this disease in the United States is 40.3% for diabetic adults 40 years or older. People with diabetes are at risk for developing diabetic retinopathy. Over the past decade, there have been many studies in developing algorithms for computerized fundus color image analysis to detect vessel structure, optic disc, and certain characteristic features of DR. The purpose of the present study is to develop an automatic vessel segmentation algorithm which is fast and reliable. Since diabetic retinopathy issue has grown in importance in the clinical field, it became very necessary to adopt an automatic retinal vessels segmentation which will help a lot in detection of the abnormalities and morphological changes of the retinal blood vessels, and assist ophthalmologists to make accurate and early diagnosing and screening. Many studies have been carried out to obtain accurate blood vessel segmentation in retinal images. These studies can be divided into two groups as unsupervised (ruled-based) methods and supervised methods.

Unsupervised methods employ vessel tracking methods, morphological operations, matching filters etc. in order to obtain the vasculature structure. Mendon and Camp-ion reported the highest average accuracies (0.9463 and 0.9479) on both databases among the unsupervised methods. Their method extracts the vessel center lines, which are used as guidelines for the subsequent vessel filling phase. The vessel segmentation is obtained using an iterative region growing method that integrates the contents of several binary images resulting from vessel width dependent morphological filters. Chaudhuri. Introduced an operator for feature extraction based on the optical and spatial characteristics of regions to be recognized. The gray-level profile of the cross section of a blood vessel was approximated by a Gaussian shaped curve. The idea of matched filter detection of signals was used to detect piece wise linear segments of blood vessels in these images. They reported an average accuracy using the DRIVE database. Cinsdikici and Ayden proposed a hybrid model. The ant colony algorithm is used to overcome the deficiency of the matched filter. Hoover proposed a rule-based method that it uses local and global vessel features cooperatively to segment the vessel network.

Their method complements local vessel attributes with region-based attributes of the network structure. A piece of the blood vessel network is hypothesized by probing an area of the matched filter response image, iteratively decreasing the threshold. At each iteration, region-based attributes of the piece are tested to consider probe continuation and ultimately to decide if the piece is vessel. The performance of their method is evaluated using the STARE database, and their accuracy is reported as 0.9275[11]. A general framework for model-based locally adaptive thresholding based on a verification-based multi-threshold probing scheme was presented by Jiang. This common methodology is enriched by incorporating relevant information related to retinal vessels into the verification process with the aim of enabling its application to retinal images. In terms of average accuracy, 0.8911 and 0.9009 were achieved on DRIVE and STARE databases, respectively.

Martinez proposed a method that achieves average accuracies of 0.9344 and 0.9410 using DRIVE and STARE databases, respectively. It is based upon multi- scale feature extraction. The local maxima over scales of the gradient magnitude and the maximum principal curvature of the Hessian tensor were used in a multiple pass region growing procedure. Growth progressively segmented the blood vessels by using both feature and spatial information.

Supervised methods are based on pixel classification, which consists on classifying each pixel into two classes, vessel and non-vessel, by using a feature set. The feature set contains parameters that are used to decide if a pixel is a part of a vessel or not. The dimension of the feature set affects the complexity and the accuracy of the classifier. Generally, supervised methods outperform rule-based methods. However they might require more computation time because of their complexity.

Unsupervised methods use matching filters, local adaptive thresholding methods, morphological techniques, or detecting the vessels through special tracking methods while supervised methods use classifiers to decide whether the processed pixel is a vessel or non-vessel. A detailed review, analysis, and categorization of the retinal vessel extraction algorithms can be found in the work of Franz. Supervised methods are more complex than unsupervised methods which lead to make them slower due to their complexity. In addition, the performance of supervised methods completely depends on the training data making the segmentation accuracy unreliable for unknown retinal image databases. For these reasons, we propose an unsupervised method which has less processing time and power consumption while achieving the same or higher level of accuracy with supervised methods for retinal vessel segmentation.

3.2. Image Databases.

For the evaluation of the proposed retinal vessel segmentation method, two publicly available retinal image databases, DRIVE and STARE, are used.

The DRIVE (Digital Retinal Images for Vessel Extraction) database contains forty eye -fundus color images (with and without present pathology) and their ground truth images. All images in DRIVE database are digitized by using a Canon CR5 non -mydriatic 3CCD camera with a 45 field-of-view (FOV). Each image is captured using 8 bits per color-channel at the image size of 565x584 pixels, and each was originally saved in JPEG format. Two ground truth vessel segmentation results were produced by two different experts for each image. The first expert's results are used to test our method.

The STARE database, originally collected by Coverall., contains twenty retinal fundus slides (ten of them contain pathology) and their ground truth images. The images are digitized by a Top con TRV-50 fundus camera with 35 degree FOV. Each slide is digitized to produce a 605x700 pixel image with 8 bits per color-channel and is available in the PPM format. All the twenty images are carefully labeled by hand to produce ground truth vessel segmentation by an expert. The database contains two sets of ground truth made by two different experts. First expert's ground truth results are used to test our method.

3.3. Methodology

The proceeding stages are

3.3.1 Pre-processing,

3.3.2 Vessel enhancement

3.3.3 Star networked pixel tracking

3.3.4 Local enhancement

3.3.5 Vessel segmentation and post processing.

The framework of the proposed method is given in Figure 3.1.

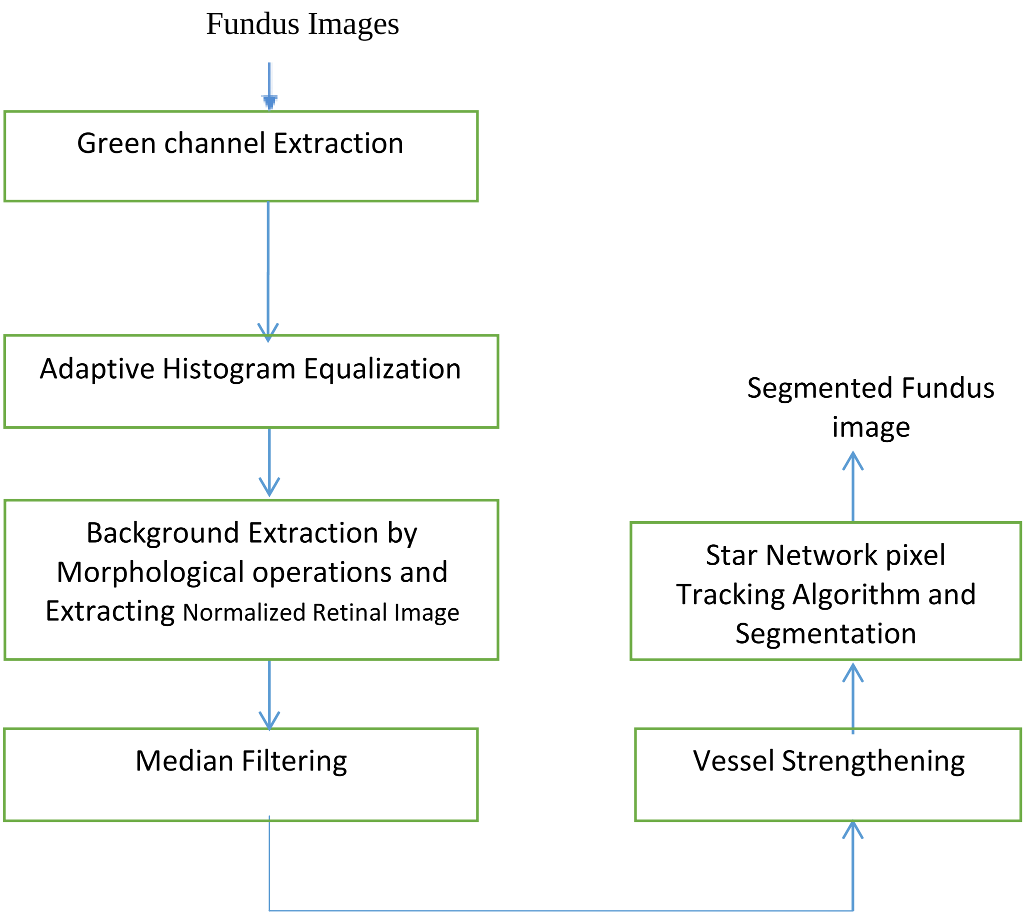

Figure 3.1: The framework of the proposed method

4.RESULTS:

4.1 STRUCTURE OF PANEL LAYOUT:

The panel layout structure is shown in figure 4.1

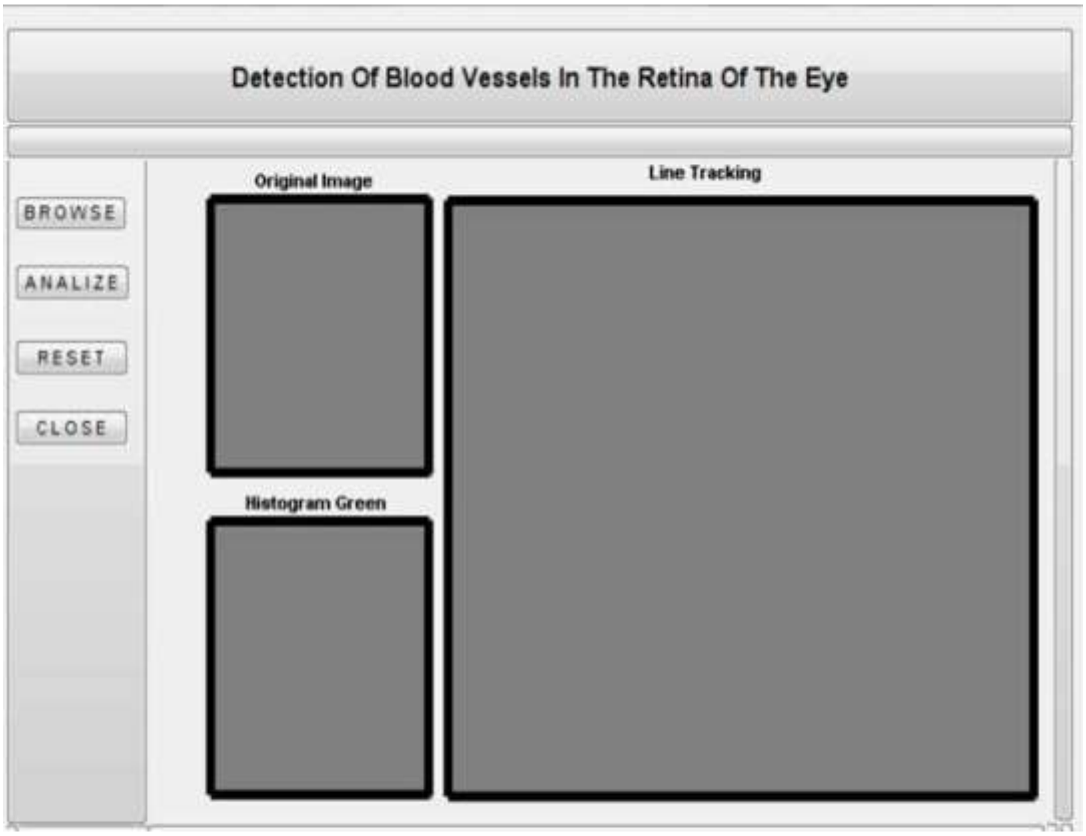

Figure 4.1: STRUCTURE OF PANEL LAYOUT

Figure 4.1 represents the structure of panel layout for detection of blood vesselsin the retina of the eye. In this we are using four push buttons. They are Browse, Analyze, Reset and Close. Push buttons having certain operation.

Push Button1: First push button is used to browse the input image or original image in different folders.

Push Button2: This button is used to analyze the original image

Push Button3: If we want to browse and analyze the another input image the reset button is used.

Push Button4: Close button is used to close the entire panel layout.

In this we are using three edit texts. They are:

1. Original image
2. Histogram green and
3. Line tracking.

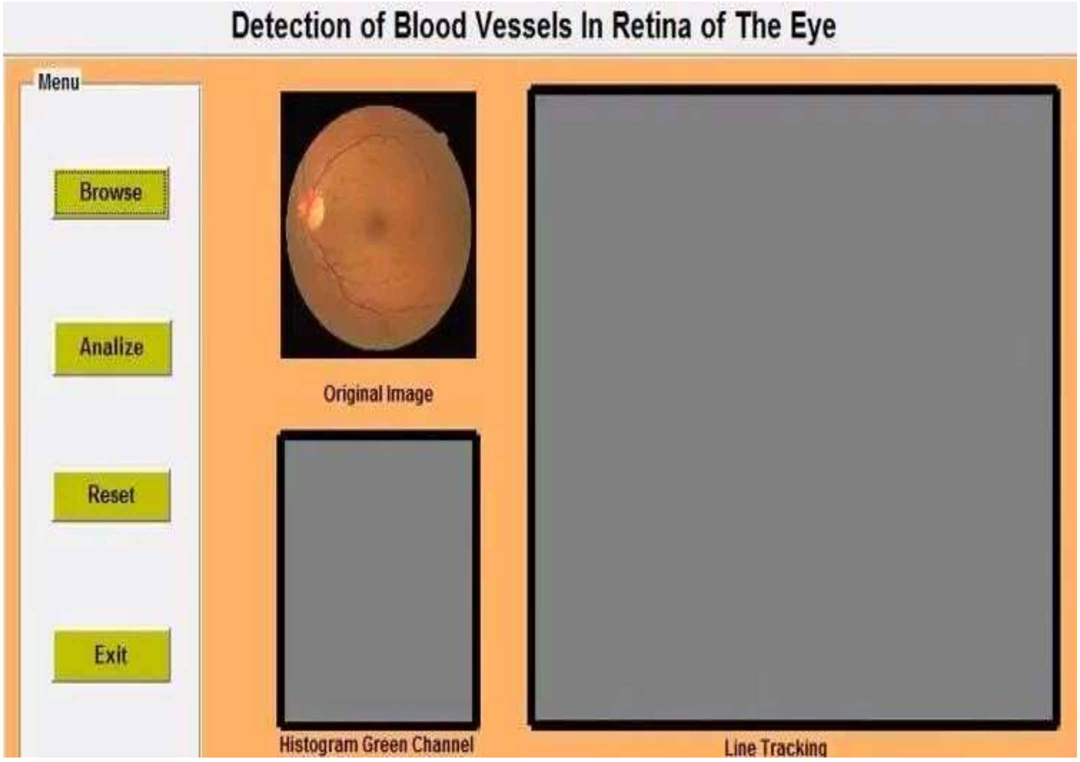

Figure 4.2: EXAMPLE IMAGE OF BROWSING

The browsing of the original image is shown in Figure 4.2. After browsing, the input image is analyzed and it is shown in the Figure 4.3.

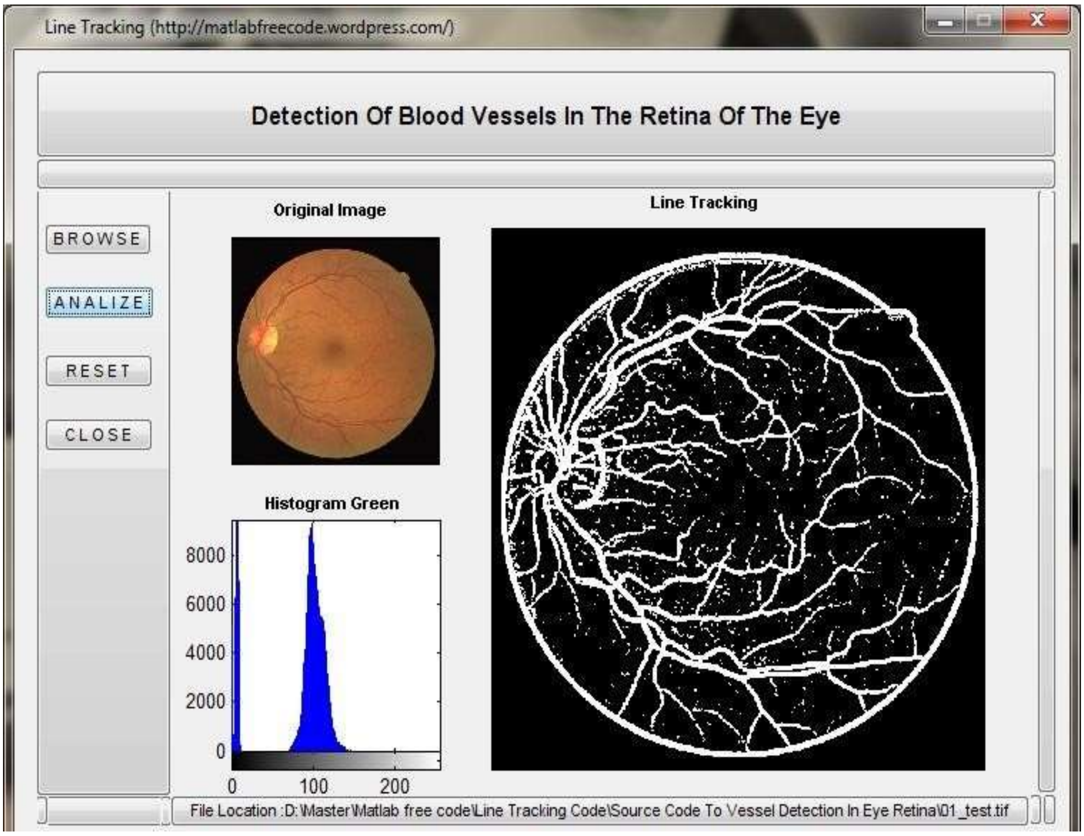

Figure 4.3: LINE TRACKING PROCESS

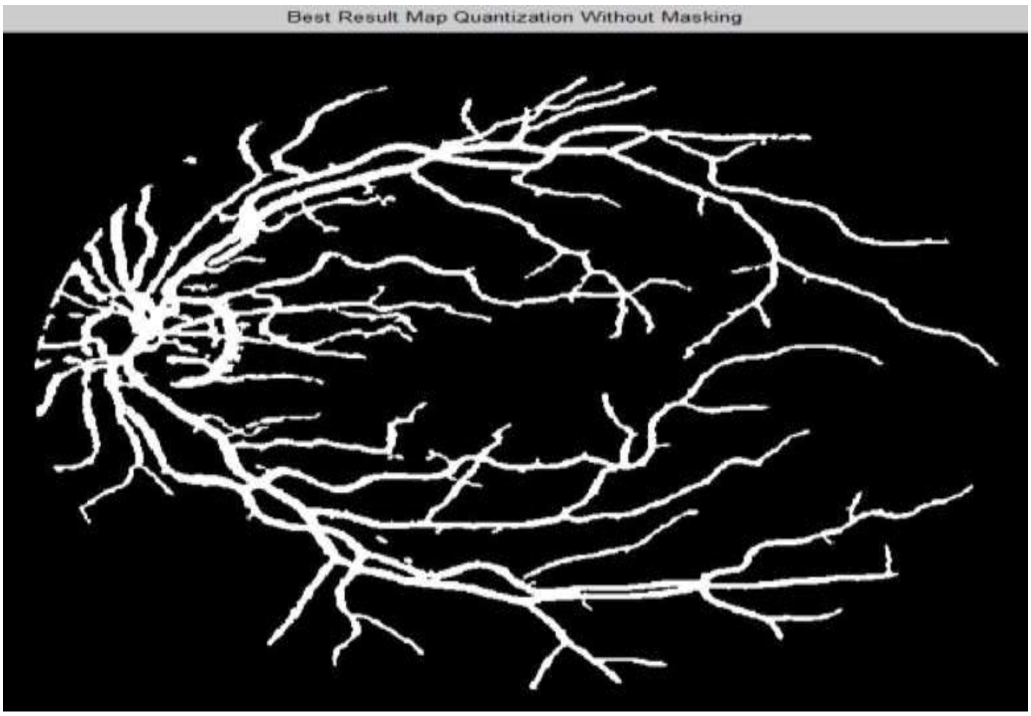

Figure 4.4: LINE TRACKING OUTPUT IMAGE

Line Tracking Method used to trace a line on the image with a certain angular orientation and diameter. By utilizing the image histogram, the pixel area boundaries will be determined to be tracked by the threshold value corresponding to the frequency of the intensity image.

In the above process the original image is analyzed then the line tracking algorithm is applied to the input image. Then the histogram is displayed in the histogram green. Here, histogram is defined as the representation of the pixels at each intensity and the histogram equalization is used to convert the low contrast image to high contrast image then the image is processed the line tracking output image is displayed. Based on the line tracking result we can identify whether the image is healthy or unhealthy. In this we observe the breaking of blood vessels. Due to this breaking of blood vessels the flow of blood become a major problem. This problem is caused a human vision and the line tracking is very helpful for finding these problems in the retinal images.

4.2 COMPARISION OF RETINAL IMAGES:

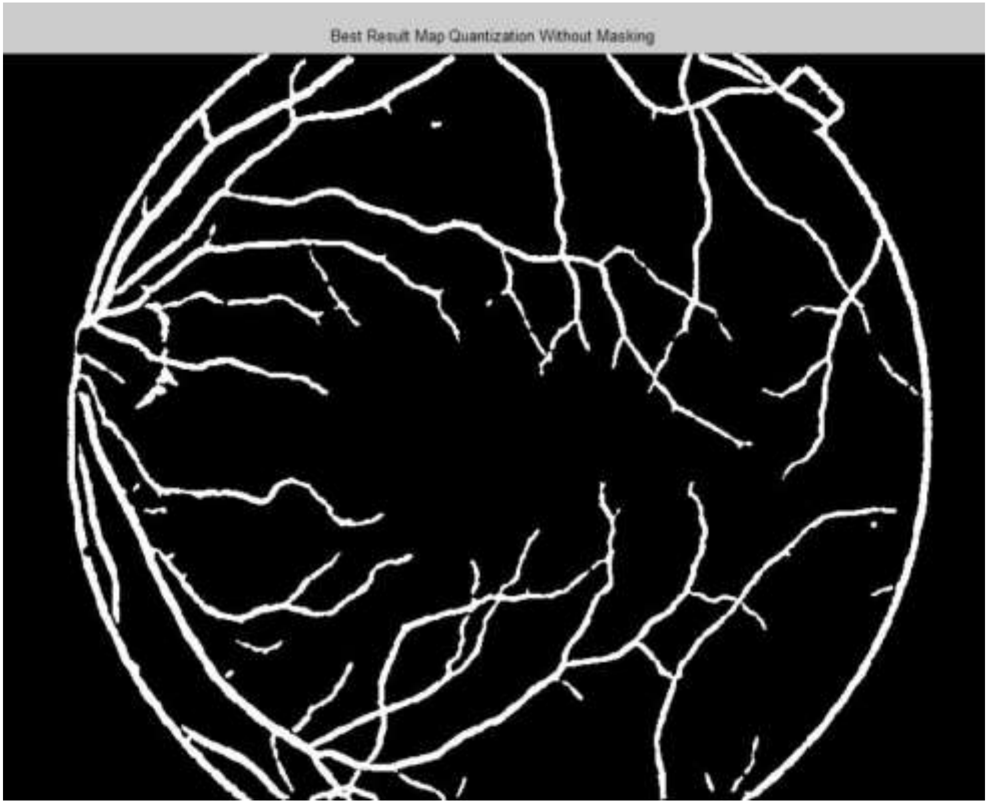

Figure 4.5: HEALTHY RETINAL IMAGE

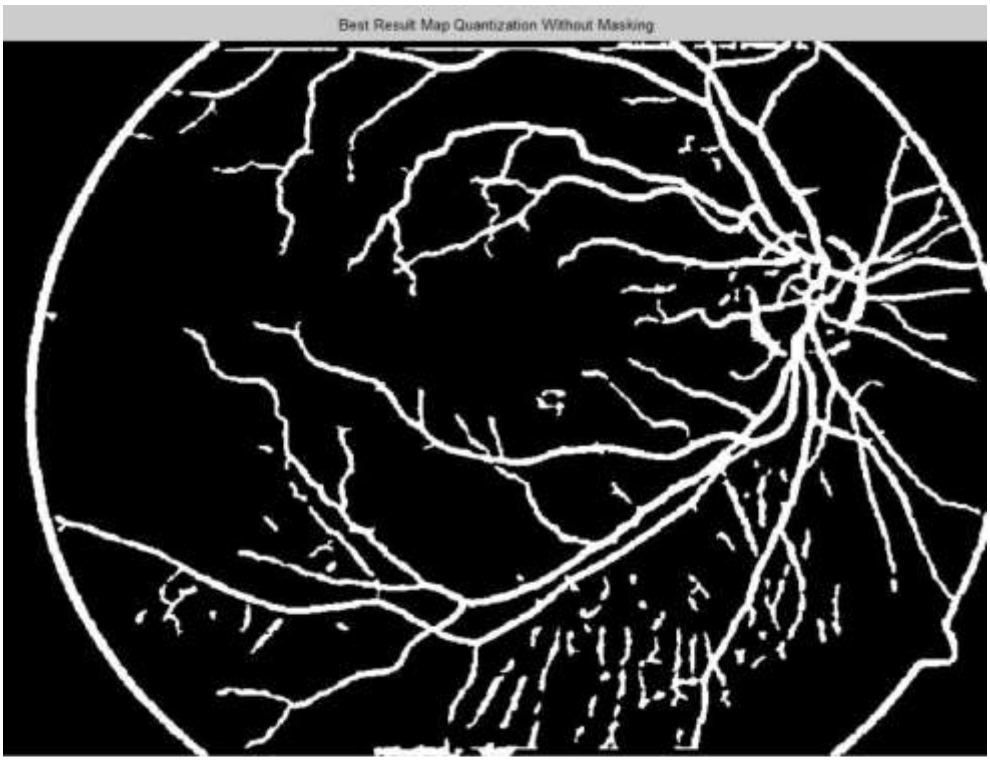

Figure 4.6: UNHEALTHY RETINAL IMAGE

Figure 4.7: UNHEALTHY INPUT

Figure 4.8: UNHEALTHY RETINAIMAGE AFTER LINETRACKING

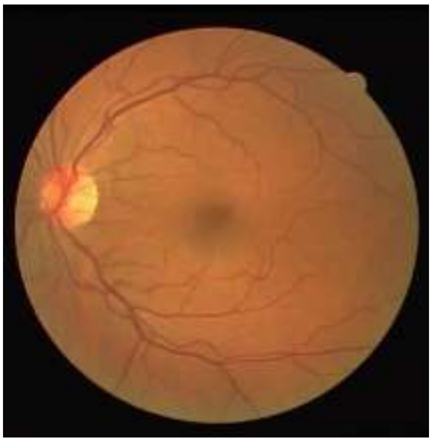

Figure 4.9: HEALTHY INPUTIMAGE

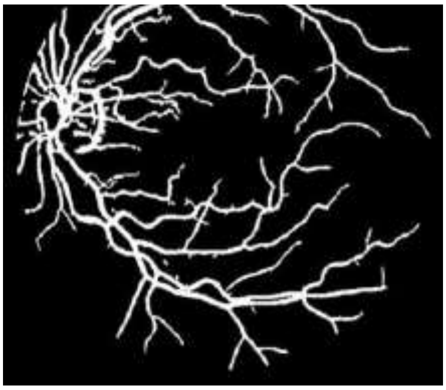

Figure 4.10: HEALTHY RETINAIMAGE AFTER FILTERINGFigure 4.5 to Figure 4.10 represents the comparison of the healthy retina and unhealthy retina images. In these images we can find the ocular differences in the output images of line tracking.

4.3 STAR NETWORK PIXEL TRACKING ALGORITHM:

The above images from Fig.4.7 to Fig.4.8 represent the steps of line tracking algorithm. Here, the input image is RGB image and it is here also first we will consider the green channel of the image as reference as it exhibits better contrast. Then we will take the complement of the green channel to which adaptive histogram equalization is applied in order to enhance the low contrast of an image. It individually processes the small regions of an image and equalizes the intensity levels by making the vessels clearer and brighter. As a result we will obtain a smoother background. Then the next step is to create a normalized image by taking a background image. This process done in the pre-processing.

In vessel segmentation, In general the thin vessels exhibits lower contrast than the thick vessels which can be improved by applying a morphological operation. Then the output of the vessel enhancement gives the enhanced blood vessel. In this the salt and pepper noise will be removed by using median filter. After removal of background image the line tracking is applied.

The Figure 4.7 represents the output of star network pixel tracking algorithm. In this the tracking is done in eight directions same as like star (*). In this, consider a reference pixel. With the help of reference pixel we can track the pixels with 45 degrees alignment. If the pixel is 0 then there is no vessel pixel (discontinuity) and if the pixel is 1 then pixel is a vessel pixel (continuity). This is the tracking process and same process is done for the remaining seven directions. In this we are using Local enhancement is used to highlight the smaller area in the image.

Figure 4.10 represents the final segmentation of the image. Final step is vessel segmentation and post processing. In this, for extraction of blood vessels from the background, automatic histogram equalization is applied to the normalized and processed image.

4.4 PERFORMANCE COMPARISION OF THREE METHODS:

As the above three methods consider accuracy as the common parameter for performance measure. In the Table 4.1 we compared the three methods in terms of their accuracy and observe the best among three. After comparison of three methods, the Star network pixel tracking algorithm has better accuracy compared to Novel segmentation method and 2-D Gabor wavelet method.

Table 4.1: Accuracy of three methods

S.NO.	METHOD	ACCURACY
1	Novel Segmentation Method	93.2%
2	2-D Gabor Wavelet Method	94.69%

3	Star Network Pixel Tracking Algorithm	95.8%

5. CONCLUSION:

This paper focuses on existing methodologies for detection of blood vessels in retinal images, in order to find out challenges for future work. Here all the above methods are tested on the publicly available DRIVE data base. We observed that method (a) avoids heavy computation that applied SVM to each pixel and thin vessel can be extracted by iterative linear extrapolation without manual given start points but it gives an accuracy of 93.2%. Method (b) enhanced the vascular pattern prior to detection and then vessel segmentation mask is created using thresholding which is important for any retinal vessel segmentation technique. But here the accuracy is 94.69%. The method (c), Star networked pixel tracking algorithm method for blood vessel detection method do not require user interaction in analyzing different retinal images because of its good behavior against images of different conditions and here 95.83% accuracy is found. From the above discussion it can be concluded that the third method outperforms the other two methods as it giving 95.83% accuracy. In order to do future research existing systems need to improve and new solutions to the problem should be found out.

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