

Retinal Blood Vessel Segmentation Using Graphical User Interface (GUI) for Diagnosis of Disease

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ABSTRACT: The blood vessel detection and segmentation technique plays a useful clinical role in an automated retinopathy analysis system. But manual segmentation of vessels requires expertise. It is a very tedious and time consuming task. Employing computational intelligence for this purpose would help in efficient retinal analysis. An user friendly graphical user interface (GUI) that is MATLAB based tool used to segments the blood vessels by means of several operations applied on the retinal image including Grayscale conversion , Gabor filtering , Image Binarization , Principal component analysis , Fuzzy c-means clustering proposed in this paper. The paper is validated on images from publicly available DRIVE database and achieves an accuracy of 94.61 % with sensitivity of 73.38% and specificity of 98.20%, which is comparable with the existing blood vessel segmentation technique.

KEYWORDS: Color conversion, Binarization, Principal component analysis ,Gabor filtering, Fuzzy c-means Clustering.

I. INTRODUCTION

The anatomical structure of the retina can be disclosed with the help of fundus images. Fundus images give a valuable resource for the investigation of the retina. The anatomical structure includes optic disk, abnormal structures, retinal vasculature, and macula. Optic disk represents the start of optic nerve head(white stock) which connects the eye to the brain and it is also a entry point for major blood vessels to the eye. 'Macula' is a very small area (situated at the center of the retina) responsible for the pin point and high-resolution vision. A tree-like structure called blood vasculature (a very high frequency component) spanning across the fundus image. Blood vessels present in the retina are the most important structures providing blood supply to the retina and indicate the presence and severity for diseases like diabetic retinopathy, occlusion, glaucoma etc. Most of the diseases in retina cause changes in the vasculature network, if they aren't detected at the initial stage, they can lead to vision loss. Hence, an accurate automated segmentation of blood vessels in the fundus image is a very important issue in diagnosis of retinal vascular disorder. Even for the ophthalmologists, investigation of blood vessel feature through manual segmentation is a time consuming and human effort prone task due to complicated vessel structures. Utilizing automatic segmentation approach can ease the ophthalmologist in segmenting the blood vessels with computerized intelligence in the fundus images. This could help in retinal diseases detection at early stage and prevent the vision impairment.

In this paper, we present a GUI based automatic segmentation approach for retinal blood vessels. The work is divided into seven stages 1).Load image 2).Grayscale conversion 3). Gabor filtering 4). Binarization 5).Principal component analysis 6). fuzzy c-means clustering algorithm 7). Detection

This paper is structured as follows : Section II presents the review of the state of art techniques and the difference between them. Section III presents the dataset used for the validation, the different phases of the proposed segmentation system. Section IV discusses the experimental results of the work. Finally, Section V presents a conclusion and future insight.

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II. RELATED WORK

Various algorithms were deployed for vessel segmentation, which achieved different results and performances. Mathematical morphology approach [1] based retinal blood vessel segmentation for diagnosis of disease was used by . It also employs k-means clustering algorithm to segment the vessels. Experimental results achieved for this work is 95.10% of accuracy. Marios Vlachos [2] proposed an algorithm based on multi-scale line tracking procedure which achieved an accuracy of 92.9% with 74.7% sensitivity and 95.5% specificity. Multi-scale line tracking algorithm is compared with supervised and unsupervised methods and investigated in noisy situations. R.Geetha Ramani [3] work involves three phases of image pre-processing , unsupervised and supervised learning and image post processing techniques. K-means clustering is executed on the images to group the pixel in two clusters for vessel or non-vessels. This wok achieves a comparable accuracy of 95.36%. Kande et.al [4] employed the idea of fuzzy c-mean clustering that accommodates the spatial distribution of gray levels to threshold with the matched filter response. The accuracy acquired by this work is 89.11%. Frangi [5] came up with vesselness filter uses eigenvector of the hessian to execute and investigate the likeliness of a vessel region in the image.

III. AUTOMATIC RETINAL BLOOD VESSEL SEGMENTATION USING GUI BUTTON SYSTEM

For our paper, the retinal image is acquired from the publically [6] available DRIVE database containing 40 color fundus images. These digital images were captured by a canon CR5 non-mydrriatic 3CCD camera. The database is divided into two test and training sets both of each containing 20 digital images. For the test set of image two manual segmentations are available out of which one is used as a principal standard and other is used to compare a computer generated segmentations with human observer segmented images and a complete set of 40 images were used for clinical diagnosis.

The purpose of this work is to segment the blood vessels automatically through button system from the fundus image for analysis of retinal vasculature and diagnosis of disease. The proposed system is developed using MATLAB based Graphical User Interface (GUI) tool. This allows a non-technical user to see the result easily using a button system. In this work, an algorithm was written to segment the blood vessels in fundus images by applying above discussed stages in sequence. Load image, Grayscale conversion , Gabor filtering , Image Binarization , Principal component analysis , Fuzzy c-means clustering, Detection these are the seven stages proposed in the work.

Fig 1.shows the process flow of the algorithm's implementation.

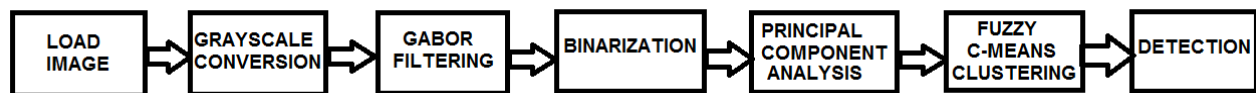


Fig. 1.Process flow

The algorithm steps are summarized as:

- 1.Load the retinal fundus image from the computer/Laptop.
- 2.Converting the RGB space image to grayscale.
- 3.Constructing the Gabor filter by utilizing the parameters and apply it on the images to enhance the retinal blood vessels.
- 4.Convert the gray-scale image to a binary image by clicking on Binarization button on GUI interface.
- 5.Applying the feature extraction technique called principal component analysis on the gray scale image to create a new set of feature vectors.
6. Applying the unsupervised Fuzzy c-means clustering algorithm to group the vessels and non-vessels in different clusters.

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7. Segmented image will display after clicking detection button on GUI interface.

Step 1. Load Image :

In the GUI-based system to select an image we have to click on "Load Image" button, then fundus image fig. 2,3 (a) of retina is loaded from the dataset containing 20 images in each set A and B respectively saved in the laptop/computer.

Step 2. Grayscale Conversion:

Initially, image belongs to RGB channel which is composed of three, Red, Green and Blue color components is converted to grayscale because vessels are only visible in the green channel. In grayscale image value of each pixel is a single sample while in the RGB channel each pixel carries 3 values. Grayscale images are also known as black and white as they are composed of more shades of gray.

In grayscale, images fig 2,3 (b) intensity values ranging from a minimum to a maximum depicting absolute black and white respectively and in between varying shades of gray. Grayscale acquire only 1 value per pixel. A popular method of RGB to grayscale conversion is utilized by matching the luminance of the grayscale image to the luminance of the RGB image. To transform any color to a grayscale representation, the values of its red, green, and blue (RGB) primaries must be known. To encode grayscale intensity in RGB, all the three primaries should be set to equal the calculated luminance.

Step 3. Gabor Filtering:

The image from the previous stage is considered for further analysis. Gabor filters are sinusoidal modulated gaussian functions, through which the blood vessels take the shape of gaussian approximation. Gaussian functions [3] have optimal localization in both frequency and space domain and they are taken to enhance the vessels in retinal images. At this stage, we initialize the filter parameters such as wavelength, bandwidth, orientation, etc and by utilizing these parameters we computed the size of gabor filter kernel and constructed a mask grid and then 2D gabor filter kernel were constructed with the correct choice of parametric values and finally combine the image with the filter kernel.

Step 4. Binarization :

In binarization, an image has only two possible values for each pixel. For a binary image typically two colors are used black and white though any two other colors can be used. In the image the color used for the object is the foreground color while the remaining part of the image is the background color. For the fundus image of retina, vessel part treated as an object.

Here output image replaces all pixels in the input image which acquire luminance more than particular level with the value 1(white) and rest of the pixel with the value 0(black). In the output image, black color is allocated to all the pixels that have luminosity greater than a threshold level and the others as white.

Step 5. Principal Component Analysis :

In image processing and pattern recognition, feature extraction is performed on an initial set of measured data, and it usually builds features (derived values) those are intended to be informative and non-redundant, making the subsequent learning and generalized steps. Feature extraction is related to dimensionality reduction, it causes the reduction in the amount of resources which are required to describe a large set of data.

For an algorithm, when the input data is too large to be processed and it is conjecture to be redundant, then it can be modified into a reduced set of features also known as features vector and this process is known as feature selection. The selected features are likely to carry the necessary information from the input data, so that the desired process can be performed by utilizing this reduced representation rather on the complete initial data. Here for blood vessels enhancement, feature extraction technique called principal component analysis is used, it is applied to some dimensional feature vector to arrive at a new set of more dimensional features represented as eigenvectors. Firstly we

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(An ISO 3297: 2007 Certified Organization)

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computed the mean of every attribute and then subtracted this mean from each of the data present in the attribute. After calculating, mean we required to calculate covariance matrix. For the covariance matrix, eigenvector and eigenvalue are need to be calculated. It then, transpose the eigenvectors and multiply it on the left of the original transposed data.

Step 6. Fuzzy c-means Clustering :

Fuzzy c-means clustering (FCM) is an unsupervised technique whose aim is to group the data based on a measure of similarity. It provides membership to each data point corresponding to each cluster center on the basis of distance between the data point and cluster center, more the data is near to the cluster more is its membership towards the specific cluster center, membership summation of each data point, should be equal to one. After each iteration membership and cluster centers updated according to the formula and algorithm steps. In this paper, fuzzy c-means clustering is employed to group vessels and non-vessels in different clusters, here the number of clusters generated using fuzzy logic. In this paper, the segmentation is produced by classifying each pixel of the image as vessel or non-vessel. As a result, uneven size clusters are obtained. The clusters with high cardinality are considered as a cluster containing non-vessel pixels and the clusters with low cardinality is considered as vessel pixels.

Step 7. Detection

By pressing detection button on the GUI based system, final vessel segmented image fig2,3.(e) is displayed.

IV. EXPERIMENTAL RESULTS

Figures shows the results of blood vessel segmentation algorithm applying on the retinal image (left and right eye respectively). Fig. 2(a) shows the left eye fundus image, 2(b) shows the image obtained by applying gray scale conversion, 2(c) shows the gabor filter output image, 2(d) represents the principal component analysis output used for feature extraction, 2(e) represents the final segmented outcome from detection stage.

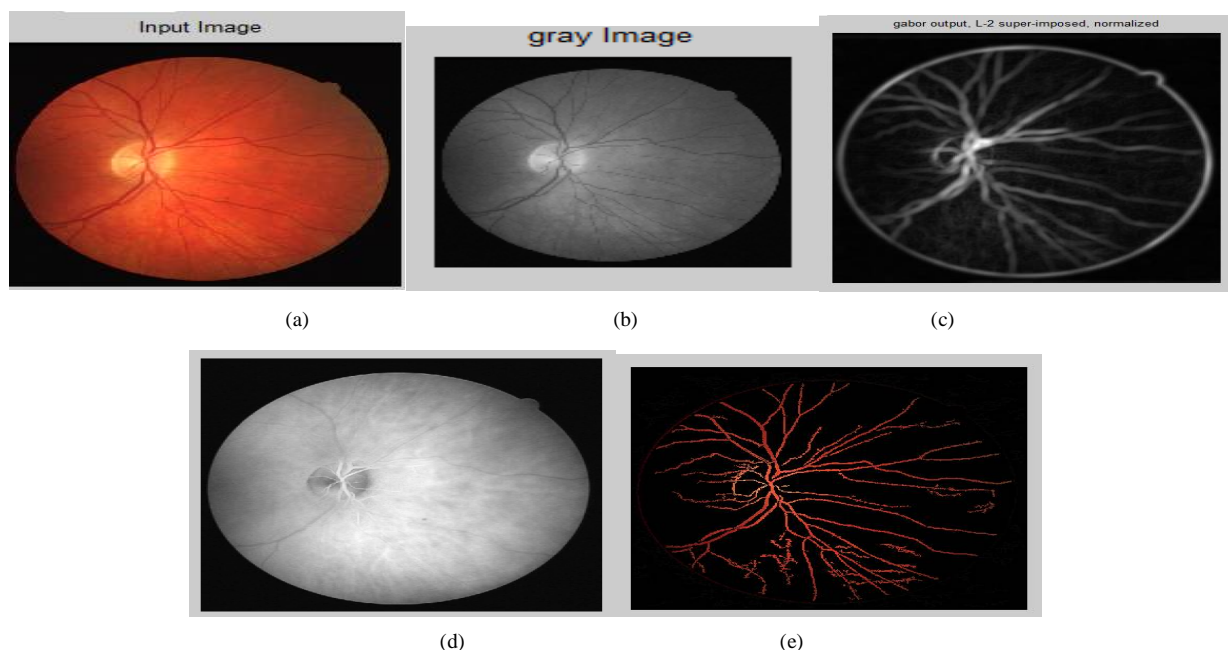


Fig. 2. Automatic retinal blood vessel segmentation using GUI button system (a) the left eye fundus image (b) the image obtained after applying grayscale conversion (c) the Gabor filter output image (d) the principal component analysis output used for feature extraction (e) final segmented outcome from detection stage.

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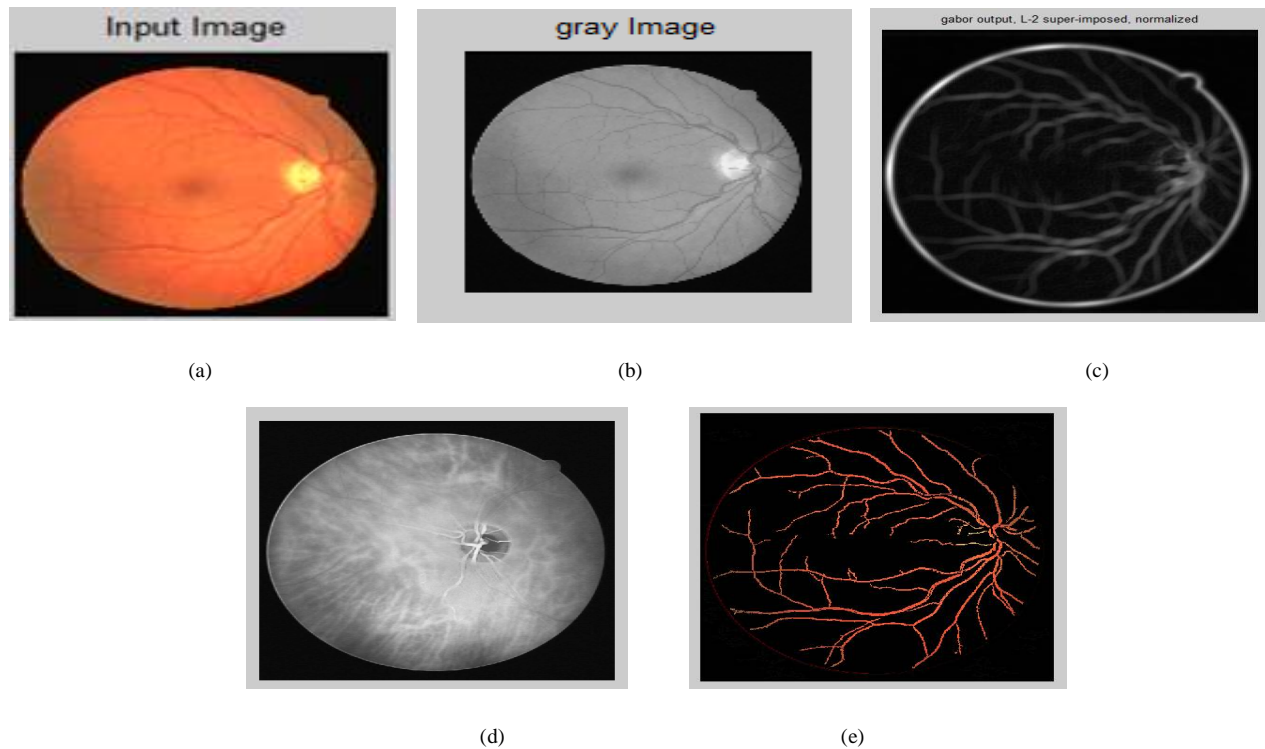


Fig. 3 Automatic retinal blood vessel segmentation using GUI button system (a) the right eye fundus image (b) the image obtained after applying gray scale conversion (c) the Gabor filter output image (d) the principal component analysis output used for feature extraction (e) final segmented outcome from detection stage.

From the fundus image of retina, we convert it to a grayscale image as vessels are prominently visible only in the green channel. Gabor filtering is the most commonly used technique to enhance the blood vessels, its performance is greatly depends on the parameters. Therefore various parameters setting were tried and the best yielded results from gabor filter are reported here. Based on thresholding, we obtain a binary image of retina which is then used in the principal component analysis for feature vessel extraction. Then the unsupervised fuzzy c-means clustering are used to categorize the vessels and non-vessels in different clusters. And finally the segmented blood vessels are obtained by clicking detection button on the GUI interface.

VI. CONCLUSION

In this paper we have implemented an automatic retinal blood vessel segmentation technique for the early diagnosis of diseases. Our algorithm successfully detects the blood vessels from the background and accomplish an accuracy of 94.61% with 73.38% sensitivity and with 98.20% specificity. We have applied our algorithm on many images and found that it successfully segment the blood vessels from the fundus image of retina.

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