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A Survey on Blood Vessel Segmentation and Optic Disc Segmentation of Retinal Images

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Abstract: Segmentation is the process of partitioning an image into set of components. Segmentation of blood vessel and optic disc is necessary for early detection of affected area in the retina. The eye is very unique part in human body where the vascular conditions are directly observed in vivo. The different approaches have been developed for blood vessel and optic disc detection; few of the approaches are discussed in this paper. The blood vessel identification is performed on the basis of blood vessel characteristics such as blood vessel's orientation, cross-sectional area, surface shapes, and abnormal regions volumes. The quantitative analysis of retinal images is of increasing importance in the diagnosis of the blood vessel abnormalities. An automated method for identification of optic disc has two methodologies location methodology and boundary segmentation methodology.

Keywords: Blood vessel, optic disc, segmentation, identification, detection, orientation.

I. INTRODUCTION

A computer aided fundus image analysis provides an immediate detection and properties of retinal features prior to specialist inspection. The image segmentation algorithms play an important role in numerous biomedical imaging applications such as diagnosis, localization o pathology, treatment planning, anatomical structure and treatment planning. This paper presents a survey of blood vessel and optic disc segmentation techniques and algorithms, putting the various approaches and techniques in perspective by means of a classification of the existing research. In the retina blood vessels and optic disc are important parts for an automatic eye detecting diseases, which are shown below. The retinal image is shown in the below figure.

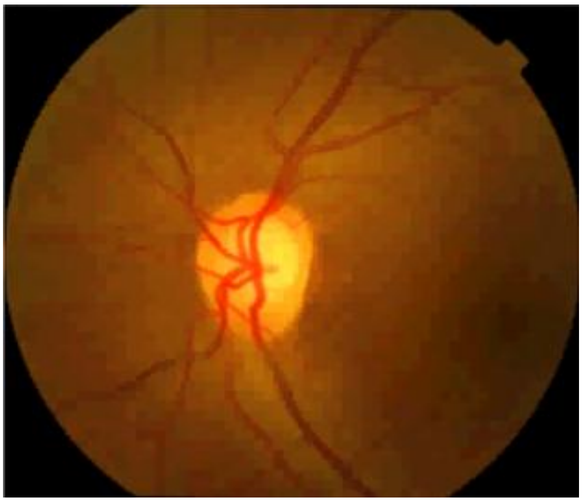

Fig 1. Fundus image

Vessel segmentation approach uses supervised and unsupervised method to segment the blood vessel features. The unsupervised method sub divided into techniques based on the morphological processing, matched filter, multi scale analysis and vessel tracking.

The supervised segmentation approach uses ground truth data for the classification of vessels based on given features. Diabetic retinopathy is one of the major causes of blindness. The presence of the diabetic retinopathy is identified by the Vector quantization [10] method. They proposed novel method of detection of the diabetic retinopathy using Gaussian Intensity feature input to a VQ classifier. They achieved 90% diagnostic performance by using vector quantization approach. Few methods uses pure intensity based pattern recognition approaches such as thresholding followed by connected component analysis (CCA). I. Liu et al [23] proposed a method based on vessels tracking technique to obtain the vasculature structure, along with vessel diameters and branching points.

Retinal maps were automatically generated by retinal vascular pattern for the treatment of age related macular degeneration [19]. The characteristics points of the retinal vasculature [15] are extracted for multimodal image registration.

II. BLOOD VESSEL SEGMENTATION TECHNIQUES:

Retinal blood vessel segmentation is important in screening programs for the diabetic retinopathy.

Some of the blood vessel segmentation is discussed below.

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A. Morphological processing:

Morphology refers to the study of object forms or shapes. Ana et al [11] presented an automatic approach for segmentation of blood vessels in retinal images by considering morphological characteristics. This paper uses intensity and morphological features of vascular structures, such as linearity, connectivity, and width. In [7] the morphological processing helps in detecting the vessels. This paper describes two methods for identifying general vascular segments associate with two different strategies for classifying each pixel as belonging to vessel or not and these approaches were used for vasculature segmentation application as well. The methods utilized are pixel processing based and tracking approach. The pixel processing based method uses two step approaches. In the first step enhancement procedure happens, the main purpose of this procedure is to selecting an initial set of pixels to be validated as vessels in the second step. The next approach is tracking begin by locating vessel points used for tracing the vasculature, by measuring some image properties. This paper presents vessel segmentation method which has preprocessing phase, vessel centerline detection, vessel segmentation. Preprocessing phase includes background normalization, vessel enhancement. Vessel centerline detection phase includes selection of vessel centerline candidates by using directional information provided by offset Gaussians filter, the next procedure is to finding the connection of the candidate points and validating the centerline segment candidates. The horizontal and vertical blood vessel segments are shown in the figure 2. The vessel segmentation phase provides multiscale morphological vessel enhancement and reconstruction followed by vessel filling by a region growing process using as initial seeds the pixels within the centerlines obtained in the vessel centerline detection phase.

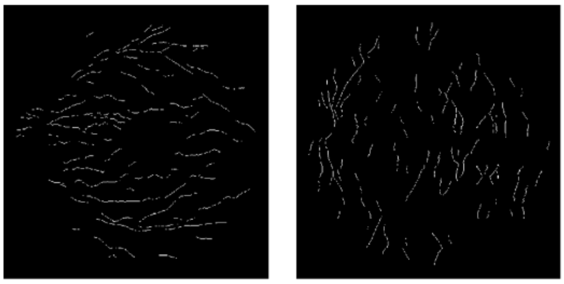

Fig 2. Horizontal and vertical vessel centerline segment.

M. Usman et al [9] describes their method of defining automated vessel segmentation method for colored retinal image. This paper uses 2D-Gabor wavelet to enhance the vascular pattern especially the thin and less visible vessels are enhanced using Gabor wavelet. The 2-D Gabor wavelet is used to enhance the vascular pattern and thin vessels [18]. The enhance retinal images were used for creating the vessels segmentation binary mask then the blood vessels are marked by one to all those pixels which belong to blood vessels and zero to non vessels pixels using masking procedure. Histogram for the enhanced retinal image is computed. In order to remove the noise the image the Gabor filter [22] were used, which acts as low level feature extractor. Pouya Nazari et al [3] employed 2D Gabor filter for extracting the vessels followed by thresholding based on the structural properties of the vessel candidates.

Verdonc et al [21] explains segmentation of blood vessels from 3D-images. This paper concentrated on the stenosis quantification which demands for accurate segmentation of blood vessels in order to accurately estimate the changes in the blood vessel diameter. The GC (Generalized Cylinder) is defined by a set of cross-sectional curves that are defined only at discrete points along the axis. The cross sectional contours are defined by 2-dimensional contours points that resides on specific pattern. Disadvantage of this method is that the initial axis estimate must be sufficiently precise as to guaranty that is positioned within the blood vessel anywhere. The positioning of GC is independent of position of blood vessels in the original voxel matrix. The discrete GC model [24] describes this feature as its contours are described with respect to the axis. The work discussed in this paper starts from a coarse approximation of the axis and then local reference systems are generated and a series of slices is resampled orthogonal to the axis. Counter candidates are selected at positions where the intensity gradient on a ray has a maximum and all the counter candidates are transferred to a selection matrix. The optimization happens slice by slice and finally, the closed path with lowest total cost is remained in each slice.

B. Matched filters:

Matching filters method involves the image with multiple matched filters for the extraction and segmentation of the object of interest. Zhu Hongqing et al [14] presents an automated segmentation of blood vessels in a retinal images using a set of directional basis filters based on dyadic wavelet transform. These filters are used to enhance the blood vessels. The proposed method composed of two steps: retinal image enhancement and entropy based thresholding. The first step uses the linear combination of the wavelet transforms to fix on the blood vessel directional information in the retinal images. Entropy-based thresholding process is an automatic

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technique for thresholding the digital image based on gray level-gradient co-occurrence matrix and the maximum entropy principle. Their proposed maximum entropy thresholding algorithm not only uses the grey level information but also gradient information as well, results in accurate segmentation. The retinal image and segmentation result is shown in the figure 3.

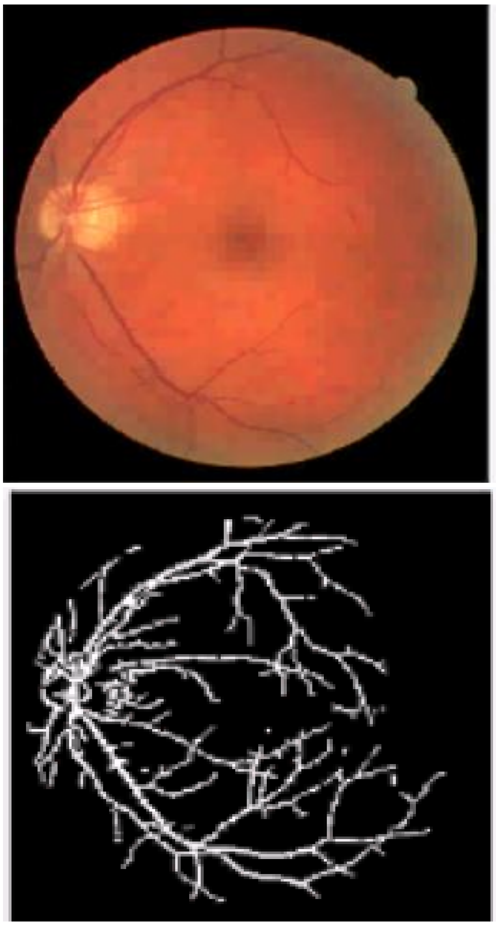

Fig 3. Retinal image and the blood vessels enhancement using steerable filters based wavelet transforms and segmentation result

R.V.Prasanna et al [2] described Kirsch edge-detection algorithm for segmentation of blood vessels. Digital image processing refers to processing of 2-Dimensional image by digital computer. A digital image is represented as real or complex numbers by a finite number of bits. They proposed supervised segmentation method using ground truth data for the classification of vessels based on the given features. The process involved in segmentation is: divide the input retinal image into non overlapping segments, extract the RGB components from the original image, and then use histogram equalization to improve the quality of image and to enhance the contrast and lastly use large median filter to remove the noise from the retinal image. The proposed system is shown in the below diagram.

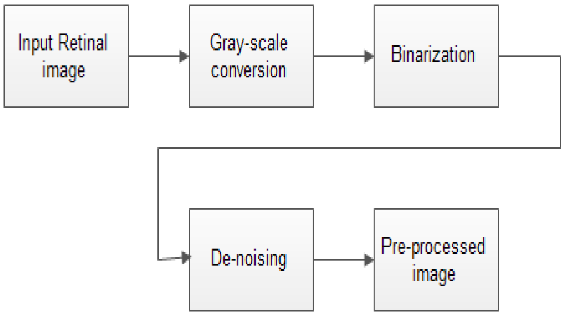

Fig 4. Preprocessing

Maruthusivarani et al [4] presents comparison works of blood vessel segmentation such as entropy based thresholding and morphological operation. The entropy based thresholding method comprises following steps: preprocessing, matched filtering and local entropy thresholding. The preprocessing stage removes all the noise, lighting variations and enhances the contrast. The color channels such as red, green and blue are extracted from the original color image. Histogram equalization is applied to increase the contrast. Matched filter is template matching algorithm which is used to enhance the blood vessel. The matched filter is depends on spatial properties of the object to be recognized and its kernel is defined to convolve with the retinal image. The gray level co-occurrence matrix is made by comparing the gray levels in specific pixel and adjacent pixels and contains information about the spatial distribution of gray levels. Morphological operation analyzes image based on the set coordinate points called as structuring elements which may be of any shape and size. Morphological operation involves separation of three channels in which green channel provides better vessel background contrast. Green channel is used for further processing. Greyscale image is enhanced using histogram equalization. Next stage, is morphological opening which smoothens the object. Lastly thresholding is used for automatic segmentation that selects an optimal gray-level threshold value for separating objects of interest in a retinal image from the background based on their gray-level distribution.

C. Multi-scale Analysis

Multi-scale analysis approache performs segmentation at varying image resolutions. The advantage of multi-scale analysis is increase in speed. Yoshiki et al [20] their aim is to show the abnormality in blood vessel using 3-D images,

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so that doctors can easily identify the defected place. The abnormal part and normal part are differentiated by using surface representation method. The surface representation provides magnitude of curvature, surface normal direction, minimal and maximum principal directions and surface types. The surface types are detected based on an aneurysm like a blob and on a stenosis. The surface representation of blood vessels is given below.

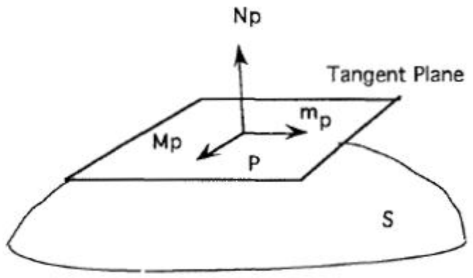

Fig 5. Surface representation blood vessel

Chwialkowski et al [17] used multi resolution analysis based on wavelet transform. Their work aims at automated analysis of arterial flow employing velocity-sensitive, phase contrast MR images. The segmentation process is give to the magnitude image and the velocity information from the phase difference image is integrated on the resulting vessel area to get the blood flow measurement.

III. OPTIC DISC SEGMENTATION:

Segmentation of the optic disc is the essential to developing the screening system for eye diseases such as glaucoma, diabetic retinopathy.

H. Yu et al [5] discussed optic disc segmentation. Optic disc detection is difficult due to the variability in its appearance and confounding bright pathologies. Many techniques have been developed in order to detect the optic disc. The intensity and shape have been the main properties used to locate the position of the optic disc. Other approach is template matching with adaptive template size design in CIELab lightness image to select OD candidates. After identification of the Optic disc location, active counters have been used for optic disc segmentation. The proposed work uses the gradient vector flow (GVF) active contour to segment the disc with an interactively initialized curve, which is set close to the true contour of the OD.

Li et al [16] proposed a modified active shape model to segment the optic disc. The algorithm successfully detected the optic disc boundary in 33 of 35 images. Lydia et al [13] represented work on segmentation of optic disc which helps in diagnosis of Gluacoma. Glaucoma is the one of the important ophthalmic pathologies and is the second most cause of blindness worldwide. They detected the optic disc position by normalizing the luminosity and adaptive histogram equalization methods and is shown in the below diagram. Their proposed work uses DRIVE and STARE dataset images. The first process is preprocessing, in which all the irrelevant information was removed and eliminate the borders from the image. In order to segment the optic disc, blood vessels are extracted and removed. To do this extraction morphological operations are done. They used region based segmentation to segment the optic disc based on the candidate set of pixels.

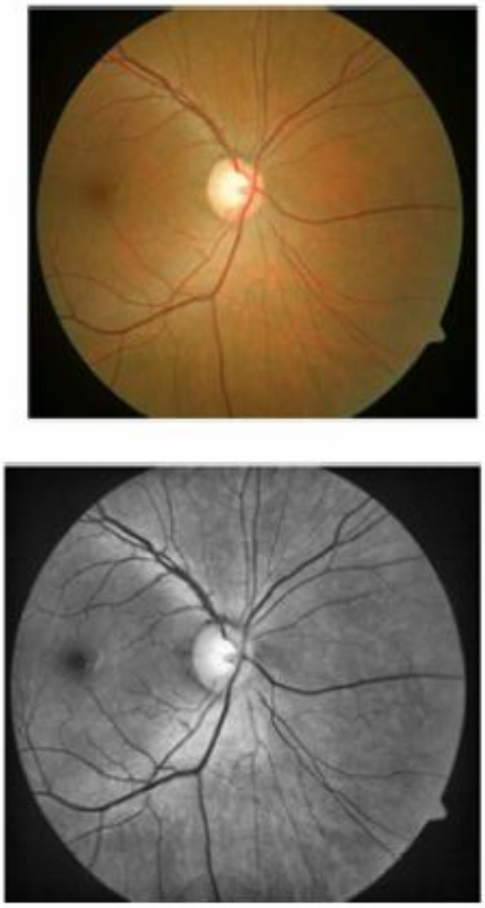

Fig 6. Input image and Adaptive Histogram Equalization

Anushikha [1] proposed method for automatic optic disc segmentation based on the region growing technique. The process of optic disc segmentation is divided into three subsections which deals with image processing, detection of center of optic disc and segmentation o optic disc based on region growing technique. The retinal image processing includes adjusting the intensity of the retinal image and removing the noisy parameters by using the large window size. The center of optic disc is detected by extracting the

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green channel from the color retinal image then, row of center of optic disc is detected by window of dimension, another window of dimension is passed through the detected row for all columns and center of optic disc is identified by selecting the maxima. The segmentation of optic disc using region growing method starts from the some pixels representing distinct image regions and to grow them until they cover complete image. Predicate describing growth mechanism and predicate checking the homogeneity techniques are used for the region growing method. The pixel (seed) point is selected using the double windowing technique and is shown in the below diagram 5, after pixel point selection, a predefined predicate is used to grow the region to segment the optic disc. Optic disc segmentation is done by considering the average intensity as predicate to grow the region.

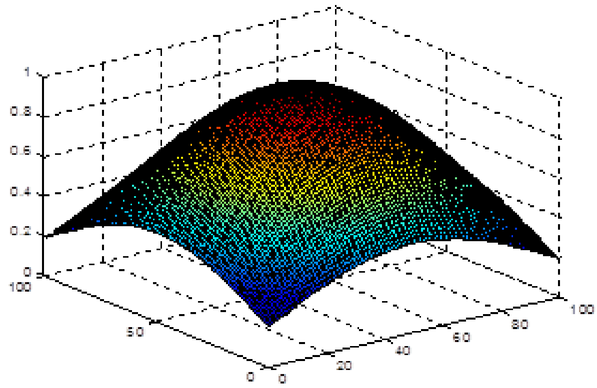

Fig 7. Optic disc detection using double windowing system.

In [12] identification of the optic disc position retinal image mosaic synthesis was employed and localization fovea is explained in [17]. Optic disc Segmentation using edge detection methods proposed in [6]. Joshi et al [8] proposed a method to segment the OD in the presence of atrophy. The initial attempts they made are with shape-based template based in which OD is modeled as circular or elliptical object. This mapping is done on an edge map extracted from the underlying image. The disadvantage is extracting the vessel edges present in and around the OD region; hence circular template is improved by considering the intensity information within and out of the OD region. The first step in segmentation is localizing OD region and extract the region of interest.

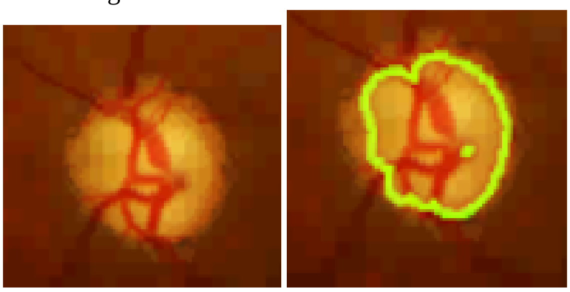

Fig 8. (a) retinal color image and circular shaped template of OD, (b) retinal image and irregular shaped template of OD

They performed localization of OD region and initialization of contour together. A number of active contours are used to better capture the shape irregularity in the optic disc region. The accuracy in segmentation is due to the sensitivity of contour initialization. The vessel segments are recognized by curvature based technique. To improve the segmentation, they employed region based active contour model. The scope of region based active contour model is improved by including the retinal image information at a support domain around each of interest in the OD region.

IV. CONCLUSION

This literature survey proposed various approaches for identifying and segmenting the blood vessels and optic disc. We have tried to cover recent and early literature related to segmentation algorithms and techniques. Faster segmentation can be achieved through the multi-scale image processing method. The most important application of segmentation is radiological diagnostic system. Advances in radiological imaging system result in large number of patient images. Processing of these images, fast segmentation algorithms required. One way to do fast segmentation is by developing parallel algorithms.

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