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Review on: Blood Vessel Extraction and Eye Retinopathy Detection

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***Abstract*— Diabetic retinopathy eye disease which is harmful; cuases pressure in eye nerve fiber. It is essential to diagnose it earlier. And this paper we have process on images of retina with the help of Digital Image Processing (DIP) tool. Therefore in which images are getting detected and then processed. At last we distinguish the problem of detecting edges in images as a diabetic retinopathy (DR), macular degeneration and glaucoma. The edge detection problem can be separated into three stages: filtering; detection; and tracing. And images separated with the application of different algorithm based on local pixel characteristics which can control the degree of Gaussian smoothing [1]. Filtered images are then applied to a simple edge detection algorithm which evaluates the edge fuzzy association value for each pixel; based on local image characteristics.**

***Keywords:-* Diabetic Retinopathy, Digital Image Processing, DR, macular degeneration and Blood vessel.**

I. Introduction to blood Vessel Segmentation

Blood vessel segmentation is the basic foundation while developing retinal screening systems, since vessel serve as one of the main retinal landmark features. Previous works on blood vessel detection and segmentation can be mainly divided into 3 categories: window based, classifier based and tracking based. Important application of automatic retinal vessel segmentation is in the registration of retinal images of the same patient taken at different times.

Segmentation involves dividing images into subsections such as defining areas of an image that are appropriate to be subsequently analyzed, or finding circles, lines or other shapes of interest. And segmentation can stop when such objects of interest have been isolated. Automating the segmentation process provides several benefits including minimizing subjectivity and eliminating a painstaking; tedious task. And segmentation of retinal vasculature from the retinal images is used in many medicine disciplines, e.g., disease identification, biometrics or image registration [5,6].

Fovea segmentation is also important because some specialized cells that provide central vision lie in it. The severity of a lesion partially depends on its distance to the fovea.

OD(Optic Disc) segmentation provides a great medical importance in helping other retina image analysis tasks such as vessel tracking, fovea localization, recognition of left and right eyes and finally image registration.

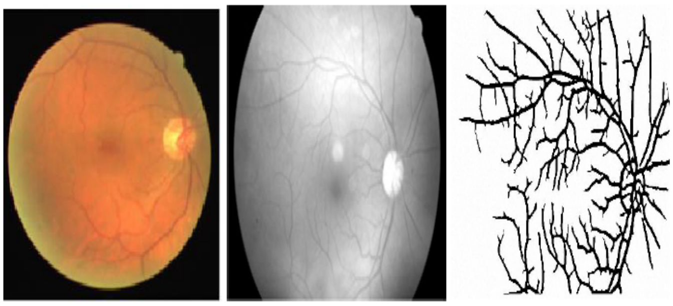

Figure 1: Blood vessel extraction

Segmentation of blood vessel in retinal images allows early diagnosis of disease; automating this process provides several benefits including minimizing subjectivity and eliminating a painstaking; tedious task. Manual detection and analysis of the retinal images is a time consuming and unreliable task; and as the number of images increases; the study becomes very difficult. Thus; it is necessary to use automated algorithms for analysis of images.

According to The vessel detection techniques fall into three main categories: kernel-based, tracking-based and classifier based. Kernel-based methods convolve kernels with different sizes and orientations with the main image based on a specific model. The proposed method in uses Gaussian matched filters for detection of blood vessels in human retina digital images. However it is relatively time consuming when the kernels become quite large and need to be applied repeatedly with different orientations. Tracking-based methods utilize a certain model to track the vessels. They work by first locating some seed points and then trace the vasculature recursively according to that model[2,3]. These seed points may be set manually by simple thresholding or automatically by morphological operations. In classifier-based methods, first, a features vector is extracted for each pixel of retina image and then a classifier uses the vectors and classifies the pixels to vessels and non-vessels[4].

We discuss some of the current techniques used to automatically detect the important clinical features of retinal image, such as the blood vessels, optic disc and macula. The quantitative analysis and measurements of these features can be used to better understand the relationship between various diseases and the retinal features

II. EYE

The human eye these gives the sensation of vision including color differentiation and perception of depth due to the presence of rods and cones in the retina (sensor tunic). Neural layer present in the retina plays a direct role in vision and visual processing. The most important parts of the retina are optic disc (OD), macula, fovea and blood vessels. OD is the brightest region having elliptical shape which appears bright orange pink with a pale center. OD is called blind-spot as it lacks photoreceptors. The blood vessels are emanating out from the OD. Lateral to the blind spot of the eye a hazy dark region having oval shape with a diameter of nearly 0.4mm is present. It is called macula lutea (yellow spot). The center of the macula is called fovea (having size of a pin head), which contains only the cones and helps in acuity vision. Macula contains mostly the cones and its density declines gradually from the edge of macula to retinal periphery. The neural retina is nourished by the blood circulation in the central artery and central vein, which leave the eye through the center of the OD. These vessels give rise to a rich vascular network, which clearly visible non-invasively by the help of ophthalmoscope [9].

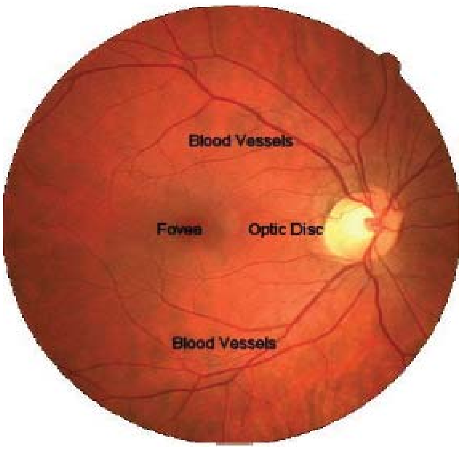

Figure 2: EYE

A. BLOOD VESSEL: The retinal blood vessels are usually referred to; arteries and veins. Then artery and central vein normally appear near each other in the nasal side of the optical disc center. Blood vessels are clearer in the green component. Information about the structure of the blood vessels can help to classify the severity of the disease and may also serve as a reference during operation. And two strategies have been used for the detection of blood vessels in image. One is the detection of edges; and the other is monitoring that requires a priori knowledge of the position from the image. Information about blood vessels can be used in grading disease severity or as part of process of automated diagnosis of diseases with ocular manifestations. Blood vessels can act as landmarks for localizing the optic nerve, the fovea (central vision area), and lesions. As a result of systematic or local ocular disease; the blood vessels can have measurable abnormalities in diameter and color. For example, central retinal artery occlusion usually causes generalized constriction of retinal arteries; hypertension may result in focal constriction of retinal arteries, central retinal vein occlusion typically produces dilated tortuous veins, arteriosclerosis can cause the arteries to acquire a copper or silver color, and diabetes can generate new blood vessels (neovascularization). Thus, a reliable method of vessel detection is needed, which preserves various vessel measurements [6].

B. OPTIC DISC: The location of optic disc (OD) is of critical importance in retinal image analysis. In normal images, the OD is brighter than any part of the retina and is normally circular in shape. This is also the entry and exit point for nerves entering and leaving the retina to and from the brain. A typical retina image, the bright OD. OD detection helps the ophthalmologists to find whether the patient is affected by diabetic retinopathy or not[10,15].

III. VESSEL SEGMENTATION TECHNIQUE

Vessel segmentation algorithms are the critical components of circulatory blood vessel analysis systems. Thus we present a survey of vessel extraction techniques and algorithms. Put the various vessel extraction approaches and techniques in perspective by means of a classification of the existing research. We have mainly targeted the extraction of blood vessels; neurosvascular structure in particular; we have also reviewed some of the segmentation methods for the tubular objects that show similar characteristics to vessels. Thus we have divided vessel segmentation algorithms and techniques into six main categories:
(1) pattern recognition techniques,
(2) model-based approaches,
(3) tracking-based approaches,
(4) artificial intelligence-based approaches,
(5) neural network-based approaches; and
(6) miscellaneous tube-like object detection approaches[13].

A. Pattern Recognition Techniques

Pattern recognition techniques deal with the automatic detection or classification of objects or features. For vessel extraction, pattern recognition techniques are concerned with the automatic detection of vessel structures and features. We divide pattern recognition techniques into seven categories: (1) multi-scale approaches, (2) skeleton-based (centerline) approaches, (3) region growing approaches, (4) ridge-based approaches, (5) differential Geometry-based approaches, (6) matching filters approaches, and (7) mathematical morphology schemes.

A.1 Multi-scale Approaches (MSA): Multi-scale approaches perform segmentation at varying image resolutions. The main advantage of this technique is increased processing speed. Major structures (large vessels in our application domain) are extracted from low resolution images while fine structures are extracted at high resolution. Another advantage is increased robustness. Thus after segmenting the strong structures at the low resolution;

weak structures; such as branches; in the neighborhood of the strong structures can be segmented at higher resolution.

A.2 Skeleton-based Approaches (SBA): Skeleton-based methods extract blood vessel centerlines. Then vessel tree is created by connecting these centerlines. And different approaches are used to extract the centerline structure. Variously these methods apply thresholding and then object connectivity; thresholding followed by thinning procedure; and extraction based on graph description. Then resulting centerline structure is used for 3D reconstruction.

A.3 Ridge-based Approaches (RBA): Ridge-based methods treat grayscale images as 3D elevation maps in which intensity ridges approximate the skeleton of the tubular objects. Ridge points are local peaks in the direction of maximal surface gradient; and can be obtained by tracing the intensity map from an arbitrary point along the steepest ascent direction. The Ridges are invariant to affine transformations and can be detected in different imagemodalities. These properties are exploited in medical image registration. Since RBA detect skeleton of tubular objects; it can be thought of as a specialized SBA.

A.4 Region Growing Approaches: Starting from some seed point, region growing (RG) techniques segment images by incrementally recruiting pixels to a region based on some predefined criteria. Two important segmentation criteria are value similarity and spatial proximity. It is assumed that pixels that are close to each other and have similar intensity values are likely to belong to the same object. The main disadvantage of region growing approach is that it often requires user-supplied seed points. Due to the variations in image intensities and noise, RG can result in holes and oversegmentation. Thus, it requires postprocessing of the segmentation result.

A.5 Differential Geometry-based Approaches: Differential geometry (DG) based methods treat images as hypersurfaces and extracts features using the curvature and the crest lines of the surface. The crest points of the hypersurface correspond to the center lines of the vessel structure. Then 2D and 3D images are treated similarly, being modeled as 3D and 4D hypersurfaces respectively. In DG a 3D surface can be described by two principal curvatures and by their corresponding orthogonal directions, called principal directions. These features are also invariant under affine transformations and therefore well-suited to medical image registration. The principal curvatures correspond to the eigenvalues of the Weingarten matrix and the principal directions are the eigenvectors. The Crest points; which are the intrinsic properties of the surfaces; are the local maxima of the maximum curvature on the hypersurface. Center-lines are obtained by linking the crest-points.

A.6 Matching Filters Approaches: Matching filters (MF) approach convolves the image with multiple matched filters for the extraction of objects of interest. Thus in extracting vessel contours; designing different filters to detect the vessels with different orientation and size plays a crucial role. The convolution kernel size affects the computational load. The MF are usually followed with some other image processing operations like thresholding and CCA to get the final vessel contours. CCA is preceded by a thinning process to detect vessel centerlines.

A.7 Mathematical Morphology Schemes: Morphology relates to the study of object forms or shapes. Morphological operators (MO) apply structuring elements (SE) to images; and are typically applied to binary images but can be extended to the gray-level images. Therefore Dilation and erosion are the two main MO. Dilation expands objects by a SE, filling holes, and connecting disjoint regions. Thus erosion shrinks objects by a SE. Closing; dilation followed by erosion; and opening; erosion followed by dilation, are two other operations. Two algorithms used in medical image segmentation and related to mathematical morphology are top hat and watershed transformations[7,11].

B. Model-Based (MB) Approaches

MB approaches apply explicit vessel models to extract the vasculature. We divide MB approaches into four categories: (1) Deformable models, (2) Parametric models, (3) Template matching, and (4) Generalized cylinders.

B.1 Deformable Models (DM): We divide DM into two categories: parametric DM and geometric DM. DM are MB techniques find object contours using parametric curves that deform under the influence of internal and external forces.

B.2 ParametricModels (PM): PM approaches define objects of interest parametrically. Thus in tubular object segmentation, objects are described as a set of overlapping ellipsoids. Some applications use a circular vessel model. The parameters of the model used are estimated from the image. While an elliptic PM can approximate healthy vessels and stenoses, it fails to approximate pathological irregular shapes and vessel bifurcations.

B.3 Template Matching: Template matching tries to recognize a structure model (template) in an image. The method uses the template as a context; which is a priori model. It is a contextual method and a top-down approach. In arterial extraction applications; the arterial tree template is usually represented in the form of a series of nodes connected in segments. Thus template is then deformed to fit the structures in the scene optimally. The stochastic deformation process described by a Hidden Markov Mode l (HMM) is a method to achieve template deformation. Thus dynamic programming is an effective method employed in recognition process.

B.4 Generalized Cylinders Model: Generalized cylinders (GC) are used to represent cylindrical objects. Technically GC are PM but we discuss them separately because there is a significant amount of work on this model and because of its prominence in the literature[14].

C. Tracking-Based Approaches

Tracking-based approaches apply local operators on a focus known to be a vessel and track it. On the other hand, patter recognition approaches apply local operators to the whole image. Vessel tracking (VT) approaches, starting from an initial point, detect vessel centerlines or boundaries by analyzing the pixels orthogonal to the tracking direction. Thus different methods are employed in determining vessel contours or centerlines. Edge detection operation followed by sequential tracing by incorporating connectivity information is a straightforward approach.

D. Artificial Intelligence-Based Approaches

Artificial Intelligence-based approaches (AIBA) utilize knowledge to guide the segmentation process and to delineate vessel structures. And different types of knowledge are employed in different systems from various sources. One knowledge source is the properties of the image acquisition technique, such as cine-angiography, DSA, computed tomography (CT), MRI, and MRA. Some applications utilize a general blood vessel model as a knowledge source [7].

E. Neural Network-Based Approaches

Neural networks (NN) are used to simulate biological learning and widely used in pattern recognition. Thus Neural nets are basically a classification approach. The network is a collection of elementary processor (nodes). Each node takes a number of inputs, performs elementary computations; and generates a single output. Therefore each node is assigned a weight and the output is a function of weighted sum of the inputs. These weights are learned through training and then used in the recognition. Back-propagation algorithm is a widely used learning algorithm. One of the advantages that make neural networks attractive in medical image segmentation is their ability to use nonlinear classification boundaries obtained during the training of the network. Another attractive feature of the neural nets is the ability to learn. The selection of a good training set which includes all possible features or objects; the network can learn the classification boundaries in its feature space. One of the disadvantages of NN is that they need to train every time a new feature is introduced the network. Another limitation is that it is difficult to debug the performance of the network [8].

F. Miscellaneous Tube-Like Object Detection

This class of research approaches deals with the extraction of tubular structures from images. This is actually a ”miscellaneous” class of approaches that may be applicable to vascular extraction in that vessels are tubular entities; but these approaches were not designed for vessel extraction[13].

IV. Conclusion

The different pathological conditions (diseases) of retina are: diabetic retinopathy (DR), macular degeneration and glaucoma.One of the serious complication in modern era is the Diabetic Retinopathy (DR) occurs due to progression of diabetes. It causes damage to the different parts of the retina and leads to vision loss. DR is a progressive disease which approaches from non-proliferative diabetic retinopathy (NPDR) to the proliferative diabetic retinopathy (PDR). Microaneurysms, the small red dots in the color photographs are the first clinical sign for the presence of DR. During the PDR stage the tiny blood vessels are blocked. So, new vessels grow to provide nutrients to the retina. These vessels are fragile and causes bleeding into the vitreous, which results cloud vision. The new vessels lead to retinal detachment and vision loss. Age related macular degeneration (AMD) occurs in the older group peoples, which affects the macula and the central vision. glaucoma is a specific optic nerve disease occurs due to the progressive break down of nerve fibers and causes an elevated pressure in the optic nerve head (ONH). ONH contains the optic nerve fibers, which carries the sight image information to the brain. There make algorithms
To overcome these problem.

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