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ARTERY/VEIN CLASSIFICATION AND DETECTION OF NEW VESSELS

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Abstract—The classification of retinal vessels into artery/vein (A/V) is an important phase for automating the detection of vascular changes. It is an automatic approach for A/V classification based on the analysis of the retinal vasculature. The proposed method classifies the entire vascular tree and assigning one of two labels to each vessel segment. Proliferative diabetic retinopathy is a rare condition likely to lead to severe visual impairment. It is characterized by the development of abnormal new retinal vessels. It also describe a method for automatically detecting new vessels on the optic disc using retinal photography. Vessel-like candidate segments are first detected using a method based on watershed lines and ridge strength measurement. Fifteen feature parameters associated with shape, position, orientation, brightness, contrast and line density are calculated for each candidate segment. Based on these features each segment is categorized as normal or abnormal using a support vector machine (SVM) classifier.

Keywords—Retinal Image, Fundus, Preprocessing, Vessel Segmentation, Classification

I. INTRODUCTION

Automated detection of retinopathy in eye fundus images using digital image analysis methods has huge potential benefits, allowing the examination of a large number of images in less time, with lower cost and reduced subjectivity than current observer-based techniques. Another advantage is the possibility to perform automated screening for pathological conditions, such as diabetic retinopathy, in order to reduce the workload required of trained manual graders. Retinal vessels are affected by several systemic diseases, namely diabetes, hypertension, and vascular disorders. In diabetic retinopathy, the blood vessels often show abnormalities at early stages , as well as vessel diameter alterations. Changes in retinal blood vessels, such as significant dilatation and elongation of main arteries, veins, and their branches, are also frequently associated with hypertension and other cardiovascular pathologies.

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Several characteristic signs associated with vascular changes are measured, aiming at assessing the stage and severity of some retinal conditions. Generalized arteriolar narrowing, which is inversely related to higher blood pressure levels, is usually expressed by the Arteriolar-to-Venular diameter Ratio (AVR). The Atherosclerosis Risk in Communities (ARIC) study previously showed that a smaller retinal AVR might be an independent predictor of incident stroke in middle-aged individuals. The AVR value can also be an indicator of other diseases, like diabetic retinopathy and retinopathy of prematurity. Among other image processing operations, the estimation of AVR requires vessel segmentation, accurate vessel width measurement, and artery/vein (A/V) classification. Automatic AVR measurement system must accurately identify which vessels are arteries and which are veins, since slight classification errors can have a large influence on the final value.

II. RELATED WORK

A. First Methodology for Artery and Vein Classification

Three main steps are introduced in "Automated characterization of blood vessels as arteries and veins in retinal images" .Image enhancement techniques are applied in the first step which is used to improve the images. To separate major arteries from veins specific feature extraction process is employed. Feature extraction and vessel classification are not applied to each vessel point .It is applied to each small vessel segment. The results obtained from the previous step are improved by applying a post processing step. The post processing step uses structural characteristics of the retinal vascular network. Some incorrectly labelled vessels are correctly labelled by this method. The vessels are labelled correctly based on the adjacent vessel .

- Stages of the method
- Image Enhancement
- Feature extraction and vessel classification
- Post-processing

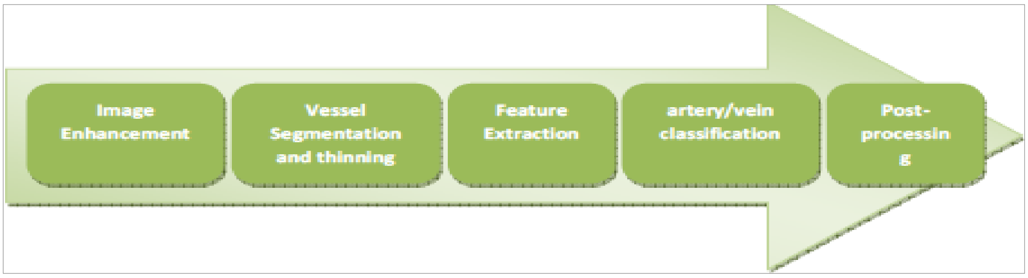


Figure 1.Stages of development

To enhance the contrast between arteries and veins in the retinal images ,Image enhancement is employed. Histogram matching algorithm is applied for normalizing the color through images. It takes two images as input. One is the source image C and the other is the reference image D and the image R is returned as output. Image C is transformed into Image R using the histogram matching algorithm. The histogram of resulted image R is approximately same as the histogram of the reference image D.

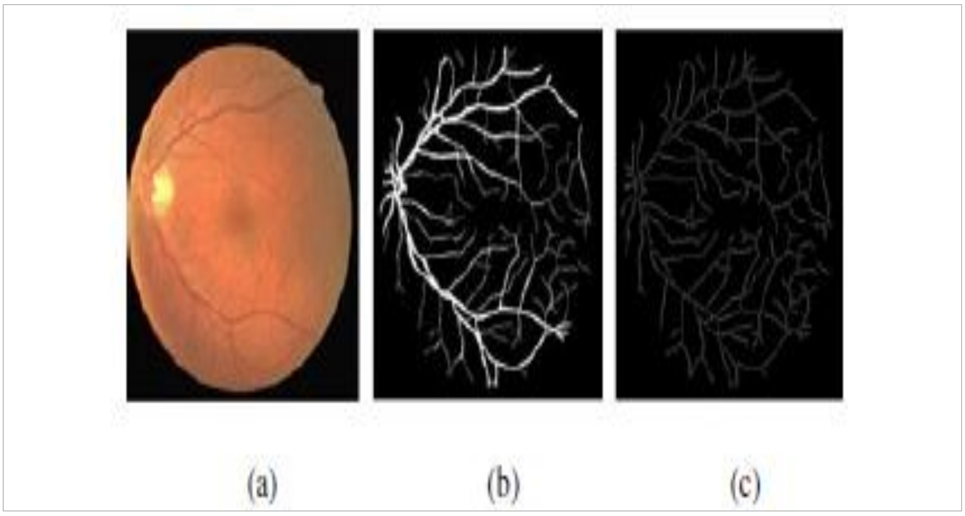


Figure 2. (a)Retinal image.(b)Vascular tree.(c)Skeleton of vascular tree

In the methodology author has used Gabor wavelets for feature extraction [8]. After the vessel is extracted, morphological structures is used to remove the vessel thinner than three pixels. Then for centerline points extraction, thinning algorithm [9,10] is applied. After extraction of centerline pixels of vessels bifurcation and cross-over points are discarded from vessel skeleton. Pixels in skeleton for which there are more than two adjacent pixels in the skeleton are cross over and bifurcation points. They indicate where two vessels pass each other or a vessel branches into two thinner vessels. Output of this step is a binary image of vessel segments.

B. Second Methodology for Artery and Vein Classification

The peculiarities of retinal images are exploited in a new algorithm for classifying the vessels. By applying a divide et impera approach a concentric zone around the optic disc are partitioned into quadrants. There by a more robust local classification analysis can be performed. Manual classification provided on a validation set were compared with the results obtained by this technique.

A previously developed algorithm is used in this methodology. This algorithm analyzes the background area of retinal image to detect changes of contrast and luminosity. Through an estimation of their local statistical properties derives a compensation for their drifts. The first task is to extract the vessel network in retinal fundus image. Vessel tracking procedure is used. To extract the vessel network Previously developed sparse tracking algorithm is used.

The retina is partitioned into four regions. Each region should

- Image preprocessing and vessel tracking
- Divide
- Feature Extraction
- Impera

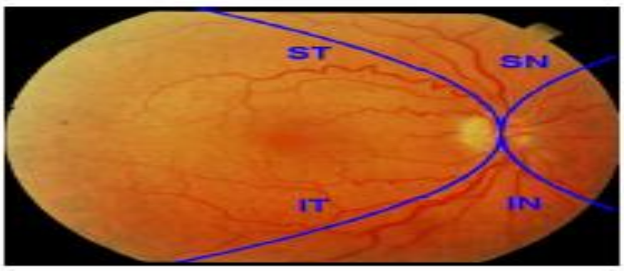


Figure 3. Principal arcades of the retinal vessel network

To find the most discriminant features for the A/V classification Author of this methodology [3] has performed an extensive statistical analysis. The best features to classify into an artery or vein is the mean of hue values and the variance of red values . The fact that the arteries and veins classes are differentiated by looking at their average homogeneity and hue of their red component is also in accordance with medical experience. When two vessels close to each other are compared for classification, the one having dark red is classified as vein. Then the one having lowest degree of uniformity is classified as artery.

After features extraction, vessels are labelled as arteries or veins based on the probability formulas and also by using fuzzy clustering algorithm .

C. Third Methodology for Artery and Vein Classification

"An automatic graph-based approach for artery/vein classification in retinal images" is an artery vein classification based on the graph extracted from the retinal vessel. The vascular tree based on the type of each intersection point this method classifies and assigning A/V label to each vessel segment. A vessel segment as A/V is labelled through the combination of a set of intensity features and graph based labelling.

- Overview of Methodology
- Graph Generation
- Vessel Segmentation
- Vessel Centerline Extraction
- Graph Extraction
- Graph Modification
- Graph Analysis
- A/V Classification
- Detection of Candidate New Vessels

The vascular network is represented as graph, in which each node represents an intersection point in the vascular tree, and each link between two intersection points corresponds to a vessel segment. Three-step algorithm is used by the author for generating the graph. First the vessel centrelines are extracted from the segmented images, then the graph needs to be generated from the centerline image, and finally some additional modifications are applied to the graph.

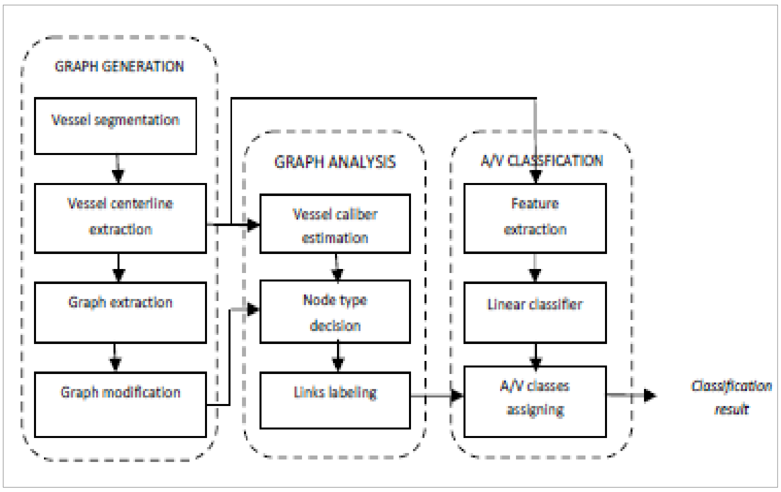


Figure 4.Block diagram for A/V classification

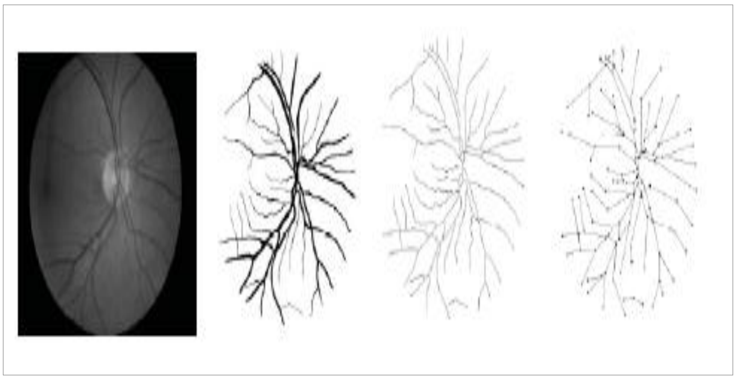


Figure 5.Graph generation

For extracting the graph, vessel segmentation result has to be used. The result is also used for estimating vessel calibers. To obtain the centerline image an iterative thinning algorithm has to be applied to the vessel segmentation result. This algorithm removes border pixels from the segmented image. It is removed until the object shrinks to a minimally connected stroke. The segmented image is shown in Figure 4(b) where as its centerline image is shown in Figure 4 (c).

The graph nodes have to be extracted from the centerline image. By finding the intersection points and the endpoints or terminal points it is extracted. Intersection points are the pixels having more than two neighbours. Terminal points are the pixels with only one neighbor. In order to find the links between nodes , all the intersection points and their neighbors are removed from the centerline image .As result is an image with separate components which are the vessel segments. Each vessel segment is represented by a link between two nodes. The graph extracted from the centreline image Figure 4(c) is shown in Figure 4(d).

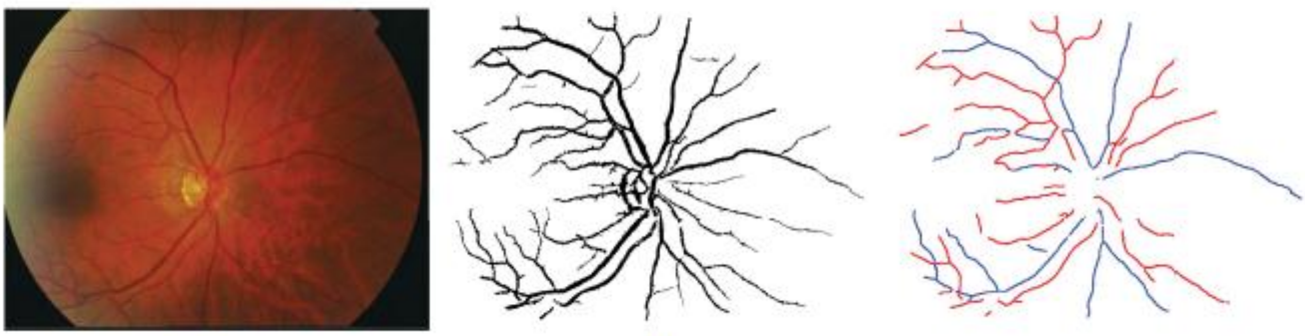
The extracted graph may include some misrepresentation of the vascular structure as a result of the segmentation and centerline extraction processes. The extracted graph should be altered when one of following errors is identified. The typical errors are

1. The splitting of one node into two nodes
2. Missing a link on one side of a node
3. False link.

A SVM was chosen as the classifier for its rapid training phase and good classification performance. The original SVM algorithm is a linear classifier which finds the best hyperplane separating two classes. A kernel function can be used to transform the features to a higher dimensional space. Although the SVM finds a linear hyperplane in the transformed space, the chosen hyperplane is likely to be nonlinear in the original feature space.

III. ARTERY/VEIN CLASSIFICATION IN RETINAL IMAGES

The centerline image is obtained by applying an iterative thinning algorithm to the vessel segmentation result. This algorithm removes border pixels until the object shrinks to a minimally connected stroke. The final goal is now to assign the artery class (A) to one of the labels, and the vein class (V) to the other. For this purpose add to the structural information, vessel intensity information in order to allow the final discrimination between A/V classes. The trained classifier is used for assigning the A/V classes to each one of the labels. Each centerline pixel is classified into A or V classes, then for each label (C ij , j =1, 2) in i , the probability of its being an artery is calculated based on the number of associated centerline pixels classified to be an artery or a vein. Fig



(a) (b) (c)

Fig 6 .A/V classification in retinal images

IV. DETECTION OF NEW VESSELS ON THE OPTIC DISC USING RETINAL PHOTOGRAPHS

Proliferative diabetic retinopathy is a rare condition likely to lead to severe visual impairment. It is characterized by the development of abnormal new retinal vessels. Here describe a method for automatically detecting new vessels on the optic disc using retinal photography. Vessel-like candidate segments are first detected using a method based on watershed lines and ridge strength measurement. Fifteen feature parameters, associated with shape, position, orientation, brightness, contrast and line density are calculated for each candidate segment. Based on these features, each segment is categorized as normal or abnormal using a support vector machine (SVM) classifier.

The green color plane was used in the analysis since it shows the best contrast between the vessels and the background retina.The grey levels were normalized by stretching the image contrast to cover the full pixel dynamic range, excluding the surrounding dark border pixels and any image labels.The diameter of a typical optic disc is approximately 1800 micrometer. All the images were resized to the same scale prior to analysis, so that the diameter of the optic disc was approximately 300 pixels, making each pixel approximately 6 micro meter square. The position of the optic disc was located using a method have described previously.

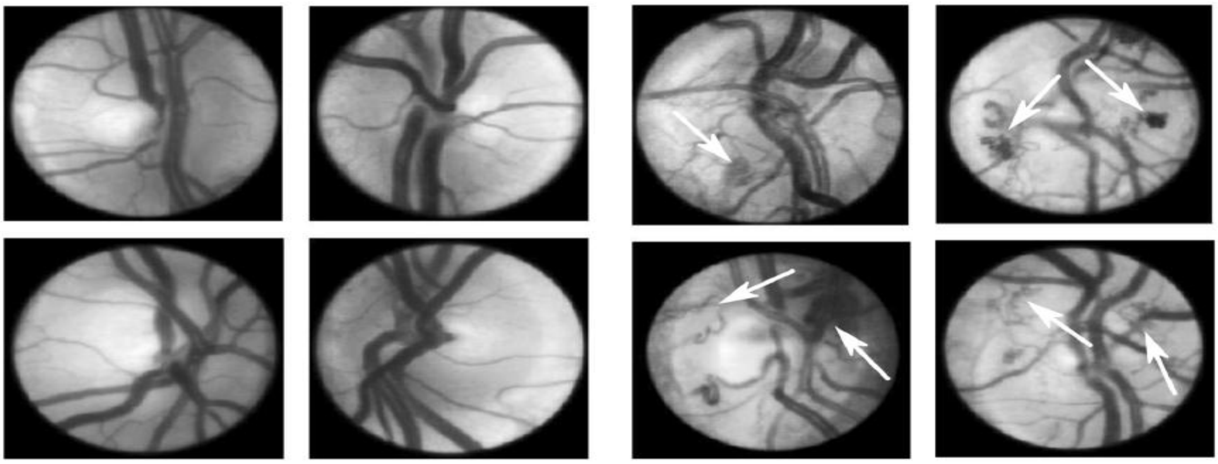


Fig 7.Vessel abnormality

Several methods have described for segmenting normal retinal vasculature. Compared with the normal vasculature abnormal disc vessels are smaller and more tortuous. However, detection is aided by the bright background of the lamina cribrosa, which gives greater vessel/background contrast on the disc, and the deep cup structure of the disc, which means any distractors tend to be out of the vessel focal plane. The dark ridges formed by the vessel center lines may be detected using the ridge strength.

The Watershed transform is a morphological region-based segmentation operation. It divides an image into regions based on a topographic map of the image grey level. The dividing lines between hypothetical topographical catchment areas are known as the watershed lines. In a retinal image the dark vessels form topographical valleys and hence the grey level is inverted so that the vessel center lines form the watershed ridges. The inverted image was filtered with a 2-D Gaussian function (with a standard deviation, , equal to 2 pixels) to prevent over-segmentation. The watershed regions are calculated using Meyer's algorithm, implemented in the MATLAB image processing toolbox. The watershed transform was also used by Walter et al. to detect vessels across the retina. The binary image of the watershed lines is thinned, such that only pixels at vessel bifurcations have more than two neighbors.

Fifteen segment features were proposed, based partly on observation of the characteristics human observers use to recognize abnormal vessels, such as their shape, position, orientation, brightness, contrast and line density.

A support vector machine (SVM) was chosen as the classifier for its rapid training phase and good classification performance. The original SVM algorithm is a linear classifier which finds the best hyperplane separating two classes. However, a kernel function can be used to transform the features to a higher dimensional space. Although the SVM finds a linear hyperplane in the transformed space, the chosen hyperplane is likely to be nonlinear in the original feature space.

V. CONCLUSION

Proliferative diabetic retinopathy is a rare condition that likely to lead to severe visual impairment. It is characterized by the development of abnormal new retinal vessels. Using retinal photograph analysis, vascular changes like new vessel detection is possible. Vessels are mainly of two types. One is artery and other is vein. So differentiating vessel into artery or vein is important for vascular change study. So it is great if possible for automatically detecting new vessels on the optic disc and the classification of arteries and veins in retinal images . Because various diseases affected to either artery or vein. So here an automated method for Artery/Vein classification and new vessel identification has been proposed. The AVR ratio(Arteriolar-to-Venular diameter Ratio) can be calculated by the identification of Artery/Vein after the detection of new vessels. So AVR calculation is the future work of the proposed work.

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