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Diabetic Macular Edema Detection by Artery/Vein Classification Using Neural Network

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***Abstract*— A thin layer of tissue that lines the back of the eye on the inside is known as retina. Retina plays an important role in visual recognition, as it converts the light focused by the lens into neural signals which is send to the brain for visualization. Retinal blood vessels are classified into two: arteries and veins. Any disease that effect retina leads to so many problems. Classifications of retinal vessels are essential for the early detection of diseases like Diabetic Retinopathy, Hypertension and other Cardiovascular diseases. Diabetic retinopathy is caused by changes in blood vessels of the retina. The damaged blood vessels due to Diabetic Retinopathy can lead to fluid leakage in the center of the macula causing it to swell, thus blurring the vision. In this condition is called Diabetic Macular Edema. This paper presents detection of Diabetic macular edema based on Neural Network by analyzing the graph extracted from the retinal vasculature. Segmented retinal vasculatures detects the type of intersection points (graph nodes), after that one of two labels is assigned into each vessel segment (graph links). Based on the set of intensity features vessels are divided into A/V. The parameters such as sensitivity, specificity and accuracy are calculated. Based on this value the stages of Diabetic Macular Edema (DME) effected to the Artery/Vein are analyzed. INSPIRE-AVR, DRIVE and VICAVR databases are used for the detection of retinal disease.**

***Index Terms*— Artery/Vein, Diabetic Macular Edema, Feature extraction, Retina, Vessel segmentation.**

I. INTRODUCTION

Eye is the one of the most important organ in our body, called as organs of vision. They detect light and convert into electrochemical impulses in neurons. It is a complex optical systems that collects light from the surroundings, regulate intensity through a diaphragm and focuses it by adjusting lenses to form an image. Its internal component is called retina. The light sensitive layer at the back of the eye, which serves same function as a film in the camera. The central part of retina is called macula, responsible for central vision and outside provides peripheral vision. So many diseases are affected by retina. They are diabetic retinopathy, hypertension and other cardio vascular conditions. In diabetic retinopathy, the blood vessels show abnormalities, as well as vessel diameter changes. Decrease the width of arteries and increase the width of veins and their branches are also associated with hypertension and other cardio vascular conditions. Retinal images play major role in several applications such as human recognition and disease diagnosis. Blood vessel is the most important features of retina, consisting of arteries and veins. Arteries transport oxygen rich blood from heart to the tissues of the body. Fig.1 shows the retinal image of an eye. The vein transport blood low in oxygen level. Arteries are bright red in colour but veins are darker. For identification of various diseases it is more essential to distinguish the vessels into veins and arteries. Automatic surgery on eye, biometrics etc are the main applications of retinal images. Retinal vessel segmentation and classification of artery/vein are the essential things for the detection of disease like diabetes, hypertension and other cardio vascular conditions. Several characteristic signs associated with vascular changes are measured, assessed each stage and severity of some retinal conditions. Diseases can alter the width of the portion, length of retinal vessels, increase their curvature and change the reflectance of light. Generally arteriolar narrowing is inversely related to high blood pressure level which is expressed as Arteriolar-to-Venular diameter Ratio (AVR). The AVR value is an indicator of other diseases, like diabetic retinopathy and retinopathy of prematurity. Among other image processing operations, calculations of AVR requires vessel segmentation, vessel width measurement and artery/vein (A/V) classification. Automatic AVR measurement systems accurately identify which vessels are arteries and which are veins, since small classification errors having large influence on the final value.

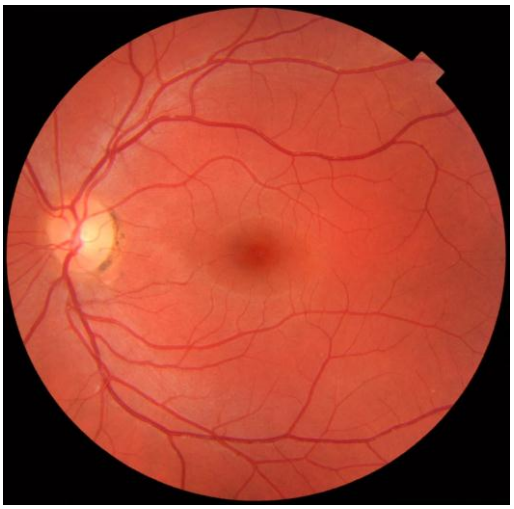

Fig.1. Retinal image.

There are many geometric and visual features that discriminate between arteries and veins. Bright colored arteries have thicker walls than dark colored veins and artery calibers are smaller than vein calibers. Important characteristics of retinal vessel is that at least in the region of optic disc, arteries rarely cross arteries and veins rarely cross veins but artery and vein bifurcate to narrower vessels and can cross each other.

Vazquez [3] described a vessel tracking method with a color based clustering algorithm. First the clustering approach

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divides the retinal image into four quadrants, then it separately classifies, and finally it combines the result. Then a tracking method based on a minimal path approach is applied to join the vessel segments. For analyzing retinal vascular trees, a semi automatic method was proposed by Martinez-Perez. [6] From the segmentation result, skeleton is extracted and points are detected. For labeling, root segment of the tree to be tracked by the user and algorithm will search for terminal point. A piece Gaussian model describes the intensity distribution of the vessel based central reflex [5]. The Minimum distance classifier based on the Mahalanobis distance was used to differentiate between the vessels using features derived from the parameters. Rothauset described a semi-automatic rule based constraint optimization approach depending on vessel segmentation classifies the vessels into Artery/Vein.

In recent years graph-based methods have been used for retinal vessel segmentation, retinal image registration, and retinal vessel classification. In this paper graph extracted from the retinal images and detect the graph nodes and graph links. Based on the set of intensity features finally vessels are divided into A/V. Here INSPIRE-AVR, DRIVE, VICAVR databases are used and detect disease likes Diabetic Macular Edema as moderate or severe by using Neural Network.

Diabetic Macular Edema is a complication of diabetes caused by fluid accumulation in the macula, or central portion of the eye. The macula is filled with cones, the nerve cells that are responsible for sensing light. When the macula begins to fill with fluid, the ability of those cells to sense light is impaired, causing blurred vision that can be severe. Diabetic Macular Edema affects up to 30% of people who had diabetes for 20 years or more, if it is untreated people had lead to moderate vision loss. Classification of retinal vessels is essential for the early detection of DME. This system having great potential benefits that screening more number of images in less time, low cost and reduced workload.

II. Design Methodology

In this paper a graph generation algorithm is proposed for Artery/Vein (A/V) classification, which targets the characteristics of retinal vascular network nearer to the optic disc (OD), vein rarely cross veins and arteries rarely cross arteries. Based on the assumption we define various number of intersection points like bifurcation, crossing, meeting, and connecting points. Bifurcation point is an intersection point where a vessel bifurcates into narrower vessels [1]. In meeting point different types of vessels meet each other without crossing. In crossing point two different types of vessel cross each other. Where vessels never cross or bifurcate and are a continuation point connecting different segment of the same vessel called connecting point. The decision regarding the type of point is totally based on geometrical vascular tree analysis of graphical network.

The first part describes graph generation, graph analysis and A/V classification and second part is the disease identification on the A/V classification, it provides easier analysis of several stages in human retinal disease diagnosis. Fig. 2 shows block diagram of the proposed model. It consists of: 1) Graph generation 2) Graph Analysis 3) A/V classification 4) Disease Identification.

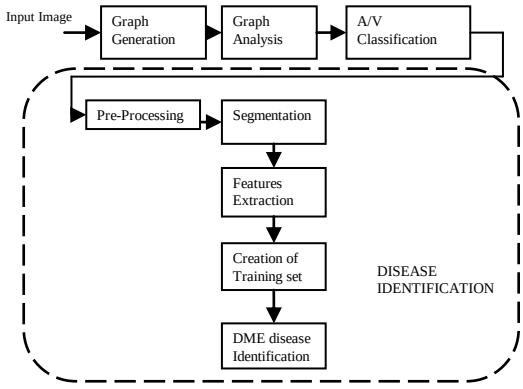

Fig.2. Block Diagram of A/V Classification for Disease Identification.

A. Graph Generation

Vascular network is represented as graph in which each node gives an intersection point and each link is associated with the vessel segment [4]. Graph generation include the following sections: a) Vessel Segmentation b) Vessel centerline extraction c) A/V classification.

(a) Vessel Segmentation: Segmentation is the process of assigning a label to every pixel in an image such that pixels with same label share certain characteristics. It is used to locate boundaries in an image. Graph extracting from the vessel segmentation is used for the calculation of vessel calibers. Fig. 3(b) shows vessel segmentation result [2].

(b) Vessel Centerline Extraction: Thinning algorithm is applied to the segmentation result to obtain the centerline image [7]. Fig. 3(c) shows centerline extracted image. That remove thicker pixels and provide a minimally connected centerline vessel graph.

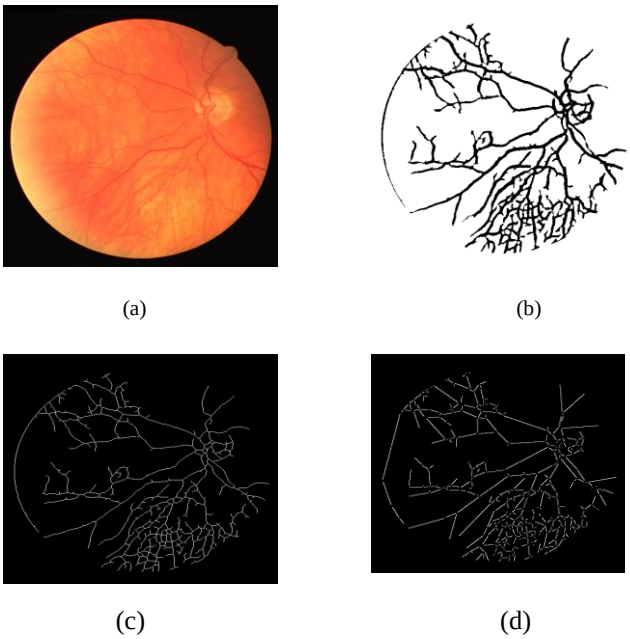

Fig.3. Graph Generation. (a) Orginal image. (b) Vessel segmentation. (c) Centerline image. (d) Extracted graph.

(c) Graph Extraction: From the centerline graph image graph nodes are extracted by finding the intersection points and terminal points. Intersection points are pixels having more than two neighbours. Terminal points are pixels having

only one neighbour. Fig. 3(d) shows extracted graph image. Then all the intersection points and their neighbours are removed from the vessel centerline graph the resulting vessel segment is represented as link.

(d) Graph Modification: Result of the segmentation and centerline extraction process the extracted graph may include some misrepresentation. They are i) Node splitting ii) Missing a link and iii) False link. The graph should be modified when one these errors is identified.

The extracted centerline pixels in a single intersection, having two graph nodes instead of only one is known as node splitting. The lost link between two nodes is known as missing link. It can be corrected by setting threshold value, after finding the distance between the nodes. An incorrect detection of a link between the two nodes is known as false link. This will happen when the two vessels are close to each other but they do not cross. These false nodes will affect the correctness of the final result. Before initiating the graph analysis phase, all vessels around the optic disc (OD) are removed. The optic disc area usually contains many vessels and the graph in that area is not reliable.

B. Graph Analysis

It analyzes various numbers of intersection points (nodes) like bifurcation, crossing, meeting and connecting points. Node classification extracting node information like number of links connected to each node, the orientation of each link, the angle between the links, the vessel caliber at each link, and the degree of adjacent nodes. Vessel caliber assign to each link by vessel caliber estimation. Generally vein calibers are larger than artery calibers. Based on this assumption locate the centre of optic disc (OD) with the help of vascular entropy directions. Labeling is carried out for every subgraph. Once for each subgraph, labeling is assigned with suitable algorithm then we cover the whole retinal image, now we having graph with various labeling to its each disjoint subgraph.

C. A/V Classification

Labeling stage in the graphical representation is embedded with vessel structural information stage. Fig. 4 (a) & (b) shows graph analysis and A/V classification result. Depending upon the label the next class is assigned as which is artery and which is vein class.

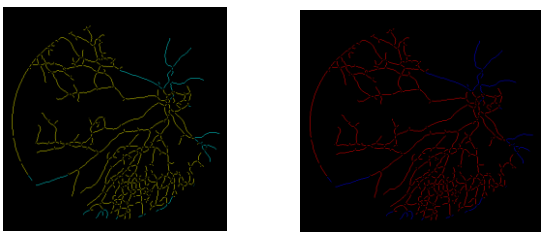

Fig.4. (a) Graph analysis (b) A/V classification.

D. Disease Identification

Feed forward neural network (FFN) is used to detect disease likes Diabetic Macular Edema as moderate or severe. It calculates pairs of pixel with specific values and in a specified spatial relationship occur in an image. For feature extraction, the features of Gabor are Entropy, Correlation, Energy, and Homogeneity. Additional features are Mean and Standard deviation of Red, Blue, Hue, Green and Intensities in the vessel. A FFN is an artificial neural network where information moves only in one direction i.e. forward from input node. There are hidden nodes in between input nodes and output nodes. The reason for Diabetic Macular Edema is an accumulation of fluid in the macula-part of the retina. Diabetic Retinopathy is a disease that damages blood vessels in the retina, resulting in vision impairment. If it is untreated, these blood vessels begin to build up pressure in the eye and leak fluid, causing DME. Common symptoms of DME are blurry vision, floaters, double vision, and eventually blindness.

III. RESULTS

Three databases, DRIVE [8], INSPIRE-AVR [9], and VICAVR [10] are used. DRIVE dataset were captured with 768 × 584 pixels and INSPIRE-AVR database have resolution of 2392 2048 pixels and are optic disc-centered. The 58 images of the VICAVR database were acquired using a TopCon non-mydriatic camera NW-100 model and are also optic disc-centered. Automatic vessel segmentation results were available for three datasets, and a manual artery/vein was performed by using 20 images of the DRIVE data set and 40 images of the INSPIRE database. The VICAVR database includes the caliber of the vessels measured at different radii from the optic disc as well as the vessel type labeled. The accuracy values are obtained for centerline, vessel pixels in the entire image and pixels inside the region of interest (ROI). Fig. 5 shows (a) Input Image (b) Red (c) Green (d) Blue (e) Gaussian Filter (f) Median Filter (g) Image after adjust Intensity (h) Imclose - to remove blood vessels (i) Image after colfilt (j) Image after image segmentation (k) ROI image (l) Gabor Features. The features of Gabor are Entropy, Correlation, Energy, and Homogeneity, additional features are Mean and Standard deviation of Red, Blue, Hue, Green and Intensities in the vessels taken for the feature extraction. After feature calculation Feed forward neural network classify the DME as moderate or severe based on the sensitivity, specificity and accuracy values. Table I shows feature values of the input images.

TABLE I. FEATURE VALUES OF INPUT IMAGES

Features	Severe	Moderate
Energy	0.33	0.35
Standard Deviation	0.31	0.32
Covariance	0.41	0.38

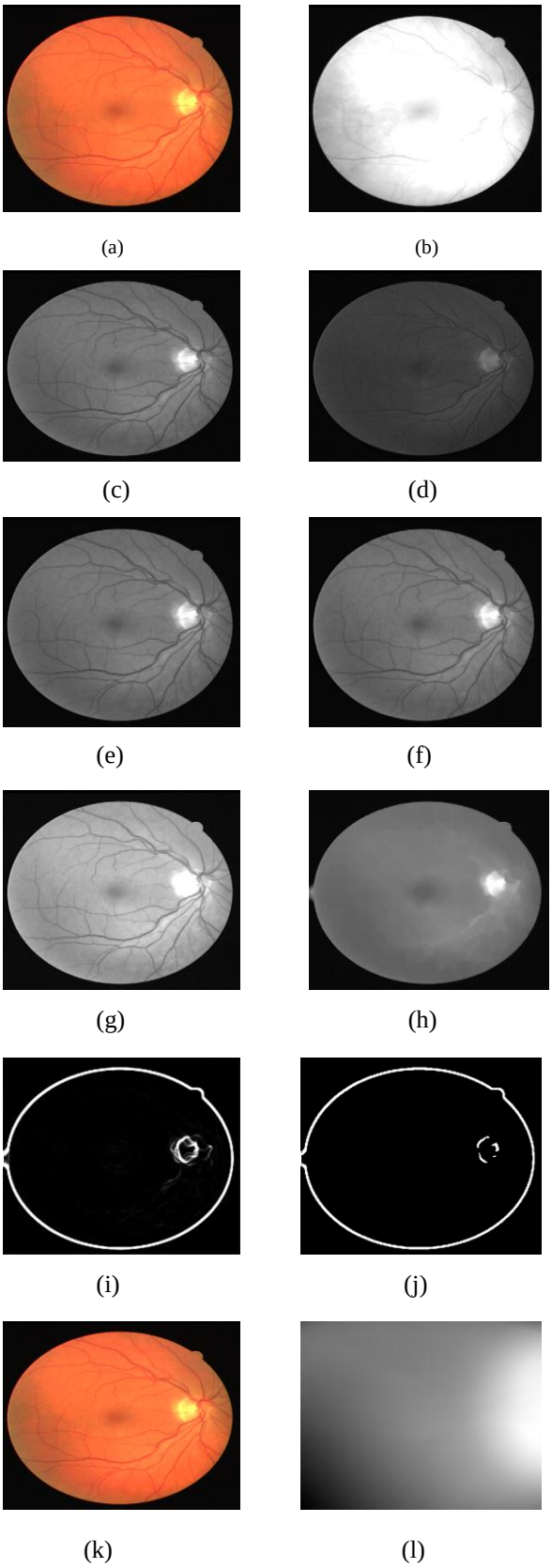

Fig.5. (a) Input Image. (b) Red. (c) Green. (d) Blue. (e) Gaussian Filter. (f) Median Filter. (g) Image after adjust Intensity. (h) Imclose - to remove blood vessels. (i) Image after colfilt. (j) Image after image segmentation. (k) ROI image. (l) Gabor Features.

Accuracy values of 98%, 90%, and 92% are obtained for the images of the INSPIRE-AVR, DRIVE and VICAVR databases, respectively. This system classifies the retinal images with sensitivity≥0.80, specificity≥0.993 and accuracy≥0.965 as severe and with sensitivity≥0.802, specificity≥0.992 and accuracy ≥0.966 as moderate.

IV. Conclusion

The automatic Artery/Vein classifications of retinal images are essential for the estimation of vascular changes. This method use intensity features and additional information extracted from the graph for the discrimination of Artery/Vein. Feed forward neural network is used to detect disease like Diabetic Macular Edema as moderate or severe. This proposed system has better accuracy, speed and good performance.

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References

[1] Behdad Dashtbozorg, Ana Maria Mendonca, *Senior Member, IEEE*, and Aurelio Campilho, Member, *IEEE* An Automatic Graph-Based Approach for Artery/Vein Classification in Retinal Images, *vol*. 23, NO. 3, March 2014.

[2] A. Mendonca, B. Dashtbozorg, and A. Campilho, "Segmentation of the vascular network of the retina," in *Image Analysis and Modeling in Opthalmology*, E. Y. K. Ng, U. R. Acharya, J. S. Suri, and A. Campilho, Eds. Boca Raton, FL, USA: CRC Press, 2013.

[3] S. Vazquez, B. Cancela, N. Barreira, M. Saez, "On the automatic computation of the arterio-venous ratio in retinal images: Using minimal paths for the artery/vein classification,"in *Proc. Int. Conf. Digital Image Comput., Tech.Appl*., 2010, pp. 599-604.

[4] A. Mendonca and A. Campilho, "Segmentation of retinal blood vessels by combining the detection of centerlines and morphological reconstruction," *IEEE Trans. Med. Imag.*, vol. 25, no. 9, pp. 1200-1213, Sep. 2006.

[5] H. Li, W. Hsu, M. Lee, and H. Wang, "A piecewise Gaussian model for profiling and differentiating retinal vessels, "in *Proc. Int. Conf. Image Process*., vol. 1. Sep. 2003, pp. 1069-1072.

[6] M. E. Martinez-Perez, A. D. Hughes, A. V. Stanton, S. A. Thom, N. Chapman, A. A. Bharath, and K. H. Parker, "Retinal vascular tree morphology: A semi-automatic quantification," *IEEE Trans. Biomed. Eng*., vol. 49, no. 8, pp. 912-917, Aug. 2002.

[7] Z. Guo and R. W. Hall, "Parallel thinning with two-subiteration algorithms*," Commum. ACM*, vol. 2, no. 3, pp. 359-373, 1989.

[8] M. Niemeijer, J. Staal, B. Ginneken, M. Loog, and M. Abramoff. (2004). *DRIVE: Digital Retinal Images for Vessel Extraction* [Online]. Available: http://www.isi.uu.nl/Research/Databases/DRIVE.

[9] M. Niemeijer, X. Xu, A. Dumitrescu, P. Gupta, B. van Ginneken, J. Folk, and M. Abramoff. (2011). *INSPIRE-AVR: Iowa Normative Set for Processing Images of the Retina-Artery Vein Ratio* [Online]. Available: http://webye.ophth.uiowa.edu/component/k2/items/270.

[10] *VICAVR: VARPA Images for the Computation of the Arterio/Venular Ratio* [Online]. Available: http://www.varpa.es/vicavr.html.

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