Biomedical Research and Therapy **2015, 2(10): 385-388**
ISSN 2198-4093
www.bmrat.org

DOI 10.7603/s40730-015-0025-x

ORIGINAL RESEARCH

Diagnosing Hypertensive Retinopathy through Retinal Images

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Received: 09 Oct 2015 / **Accepted**: 20 Oct 2015 / **Published online**: 30 Oct 2015

Abstract— The diagnoses of Hypertensive Retinopathy (HR) through retinal images become most important issue today, because HR is rapidly increasing disease that is found in eyes. HR occurs due to the highness of the blood pressure. The most important measurement that is used to diagnose HR through retinal images is arteriovenous ratio (AVR). This paper describe a method to determine AVR by first segment the vessels using match filtering technique and then detect the optic disk in order to determine the Region of Interest. Once the region of Interest is found, it classifies the blood vessels into arteries and veins using Neural Network to determine the AVR. The proposed work is implemented using MATLAB R2014a. This paper is divided into four sections. Section 1 will describe the Introduction. Section 2 will describe the method/techniques to determine AVR. Section 3 will describe the comparison of results with some previous results. Section 4 will describe the conclusion.

Keywords— Retinal Image Reconstruction, Vessels Enhancement, Vessels Segmentation, Neural Network Classification and Blood Vessels Width.

INTRODUCTION

Hypertension is the disease that spread in human body in various forms. It occurs due to the high blood pressure and causes damage to the retina of the eye. The damage of retina due to hypertension is known as hypertensive retinopathy. Retina is the major part of the eye which converts the incoming objects into nerve signal and then sends it to the brain. The damage of retina will lead towards the loss of vision or even blindness. So to overcome this problem many automated system have been introduced which helps the ophthalmologist in examining the eye patients. The literature review of previous work is described below.

G. C. Manikis et al.(G. C. Manikis, 2011)developed a system for diagnosing HR at early stages. It's developed system segment the blood vessels by multiscale filtering. The system measure the width of vessels in the region of interest. After measuring the width of vessels, the system calculated the AVR in order to diagnose HR. The proposed system is tested on the two publicly available databases DRIVE and STARE. By testing on STARE and DRIVE databases system will get the accuracy of 93.1% and 93.7%.

Ruggeri et al.(A Ruggeri, 2007) proposed a system which detects HR by evaluating AVR. The proposed system segment the blood vessels by Fuzzy C approach. After segmenting it uses the colour feature to classify vessels as artery or veins within the Region of Interest. As the system gets the classification of vessel, it finally calculated the AVR. The proposed system is tested on fundus images which gives the 81.6% accuracy.

Muramatsu et al. (C. Muramatsu, 2010) developed the approach which gives 75% accuracy in result after testing on the DRIVE database. Their proposed approach segmented the vessels by morphological operators and then used color based feature extraction to classify the major blood vessels as vein and artery.

SamraIrshad et al. (Samra Irshad) find the Cotton Wool Spot (CWS) which is the symptom of detecting hypertensive retinopathy (HR). Their developed tech-

Published online: 30 October 2015

nique determines the CWS regions by applying the global threshold on the enhanced vessels. The developed system is tested on locally retinal images dataset, which gives the accuracy of 81.3%.

PROPOSED METHOD

The following figure shows the steps of proposed method/ technique. The system first takes the retinal image as input. Then perform the preprocessing step and remove the noise from the image. Then segment the blood vessels using match filtering technique and classified the blood vessels as veins and arteries using neural network. Finally, the major step is performed, that is to find region of interest. After finding region of interest AVR is calculated and determine whether HR is found or not.

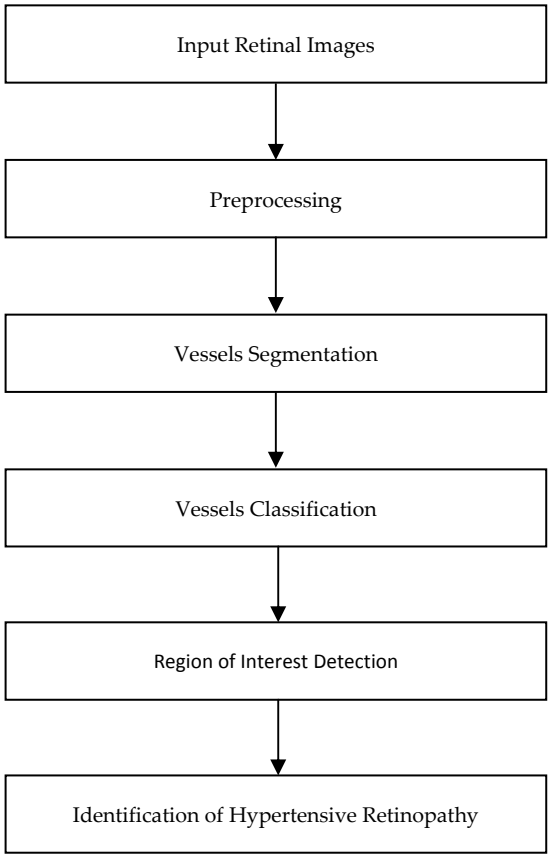

Figure 1. Steps of Proposed Method/ Technique.

Retinal Image Preprocessing

In preprocessing step input retinal image is converted into gray level image. Then enhanced the gray level image using morphological top-hat transformation. As a result of enhancement the noise and unnecessary pixels from background will remove which makes the system to easily segment the vessels and find the region of interest.

Blood Vessels Segmentation

Once the vessels are enhanced, the next step is to segment the vessels. There are many techniques/ methods available for vessels segmentation. The vessels can be segmented by using canny operator, sobel operator, perwitt operator, and match filtering (Basavaprasad B) etc. The proposed method segments the vessels using match filtering technique. The proposed method/technique uses the thresholding in order to get the high accuracy of segmented vessels (M. U. Akram, 2013). The following figure shows the preprocessing and segmentation of blood vessels.

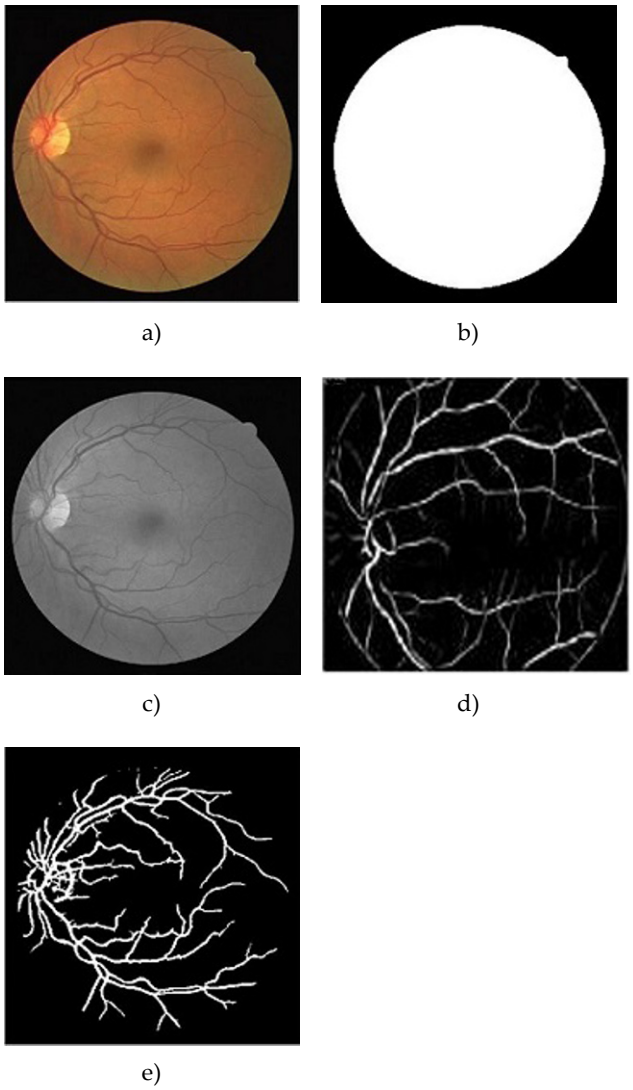

Figure 2. Shows the preprocessing and segmentation of blood vessels: a) Input Retinal Image b) Background Mask c) Gray Level Image d) Enhancement of vessels e) Segmentation of Vessels.

Vessels Classification as arteries and veins

There are supervised and unsupervised techniques available for vessels classification. All the supervised methods/techniques performed the classification based on the pixels. The best supervised techniques are neural network and support vector machines (SVM) (C. Sinthanayothin, 1999; Perfetti, Oct. 2007

). The proposed methodology uses the neural network for classification of vessels which is the supervised technique. The adopted method first train the set of training images from drive database and then test the images to classify/ determine vessels as arteries or veins. Neural network classifier uses the feature vector based on Hu moment invariants and local gray-level information to get the pixel of training images. Then it tests the pixel-by-pixel classification of vessels to determine which one are arteries or which one are veins.

Region of Interest Detection

In diagnosing HR, one of the major steps is to detect Optic disk. The nerves which are entering and leaving the retina to brain and from brain to retina, all are passes through the optic disk. Hence optic disk acts as an entry mark and exist mark. The developed system uses the Circular Hough transform to find optic disk (S. Bindu; Viranee Thongnuch). When applying the circular Hough transform with radius as an input then the edge points and centre of the optic disk is highlighted. Once we determine the centre of optic disk, then the next step is to set region of interest (ROI) three times to the radius of optic disk which gives the middle area of the optic disk as shown in the following figure (Figure 3). After doing this we separate the arteries and veins within the region of interest, so that it's easy to measure the vessels width.

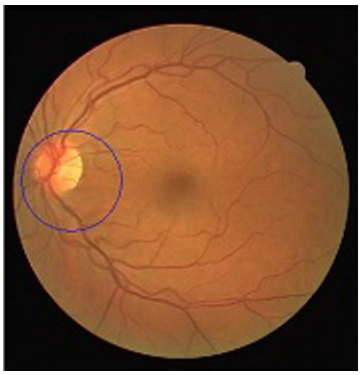

Figure 3. Optic Disk Detection.

Measurement of Blood Vessels Width

Once the arteries and veins are separated within the region of interest, the next step is to measure the width of arteries and veins. To measure the width, first of all take the complement of separated arteries and veins. By taking the complement it converts the 0 pixel into1 and 1pixel into 0. Then find the distance by using two-dimensional Euclidean transform to get the distance map for both arteries and veins (B. Heinz, 1995). After getting the distance, the next step is to determine the centre line of both arteries and veins by using morphological thinning operation. Then take the product of distance transform and thinned vessels for both arteries and veins separately. Finally the last step is to multiply 2 with output of previous step in order to get the actual width of veins and arteries.

Calculation and Grading of AVR

Once the vessels width is measured, the next step is to determine AVR. AVR is found by using Parr-Hubbar formulas (Spears, 1974). There are two formulas according to Parr-Hubbar which are as follows: One is the Central Retinal Artery Equivalent that is used to calculate the width of arteries. Other one is the Central Retinal Vein equivalent that is used to calculate the width of veins. The Central Retinal Artery Equivalent formula is as follows:

$$CRAE = \sqrt{(0.87W_a^2 + 1.01W_b^2 - 0.22W_aW_b - 10.73)}$$

In this formula Wa is the width of small artery and Wb is the width of large artery. The Central Retinal Vein Equivalent formula is as follows:

$$CRVE = \sqrt{(0.72W_a^2 + 0.91W_b^2 + 450.02)}$$

In this formula Wa is the width of small vein and Wb is the width of large vein. After determining the CRAE and CRVE, AVR is easily calculated by dividing CRAE by CRVE which is shown as below:

$$AVR = \frac{CRAE}{CRVE}$$

After determining AVR, the final step is to determine the grade/ stage of Hypertensive retinopathy. Keith Wagener Barker gives the 4 grades for various stages of HR along with their symptoms (A. Garner, 1979). The grading of HR is shown in the following table.

Table 1. Grades of HR on different Stages

Degree of HR	AVR	Symptoms
normal retina	0.667-0.75	None
grade 1	0.5-0.666	mild compression of venules
grade 2	0.33-0.4	compression of elevation of venules
grade 3	0.25-0.32	right angled crossing of vessels
grade 4	< 0.2	all above symptoms along with papilledema

COMPARISON OF RESULTS

The system that is proposed used DRIVE database which is publicly available database in order to diagnose HR. The system is applied on 20 images of DRIVE database. The practical implementation is done in MATLAB R 2014a. The comparison of result with some previous results is given in a **Table 2** below:

Table 2. Shows the comparison of Results based on methodology used

Name of Author	Method Used	Images Dataset	Accuracy (%)
G. C. Manikis	Multiscale Filtering	DRIVE	93.7
A Ruggeri	Color Based Feature Extraction	Local dataset	81.6
C. Muramatsu	Ring Filter	DRIVE	75
SamraIrshad	Feature Set	Local dataset	81.3
Proposed System	Neural Network	DRIVE	93.9

CONCLUSION

This proposed method/ technique gives the assistance of diagnosing hypertensive retinopathy automatically. By automatically means that proposed technique accepts the retinal image and determine whether hypertensive retinopathy is found or not by estimation of AVR. The proposed methodology/ technique comprise of five steps i.e. preprocessing, segmentation of vessels, classification of vessels, region of interest detection and finally last step is to determine HR is found or not. However, comparison of result with some previous results shows that using neural network results are little bit better.

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Cite this article as:

Faheem, M., & Din, M. (2015). Diagnosing Hypertensive Retinopathy through Retinal Images. *Biomedical Research And Therapy*, 2(10):385-388.