A Retinal Image Enhancement Technique for Blood Vessel Segmentation Algorithm

Chesti Altaff Hussain [1],K.V.Mahendra[2],K.Reddy Koushik[3], K. Bala Venkaiah[4], K.Sai Krishna[5]

[1]Assistant Professor, Department of Electronics and Communication Engineering, Bapatla Engineering College, chestialtaff@gmail.com

[2]Scholar, Department of Electronics and Communication Engineering, Bapatla Engineering College, mk9959953487@gmail.com

[3]Scholar, Department of Electronics and Communication Engineering, Bapatla Engineering College, koushikkalangi@gmail.com

[4]Scholar, Department of Electronics and Communication Engineering, Bapatla Engineering College, balavenkaiah123@gmail.com

[5]Scholar, Department of Electronics and Communication Engineering, Bapatla Engineering College, ksai07251@gmail.com

Abstract: *The structure of blood vessels interior within the eye may be a significant source of indicator for several diseases if exist in a human body. The extraction of vasculature network of blood vessels which plays a vital role in the study and diagnosis of many eye related diseases like diabetic retinopathy, glaucoma, and many cardiovascular diseases is a challenging task. In this paper, a new method to derive tree-shaped vasculature from retinal fundus RGB images is proposed. This proposed algorithm is performed in two stages: Pre-processing stage involves PCA which is then contrast enhanced with CLAHE. Post-processing stage is carried out working on the contrast enhanced gray image for attaining better accuracy of retinal blood vessel segmentation by using Thresholding as well as morphological operator. The performance measures of proposed method are evaluated on STARE database and obtained best results with an average accuracy of 96.44% and proven to be an outstanding method compared to other existing retina vessel segmentation algorithms.*

Keywords: **Retinal Vessel segmentation, STARE database, CLAHE, Tyler Coye algorithm, Thresholding**

1. INTRODUCTION

The diabetic retinopathy is the most well-known cause for impairment of vision it causes loss of blood supply inside the retina by the broadly spread diabetes which leads to diabetic retinopathy. The division of veins in the pictures of retina is a significant feature in diagnosis and treatment of diabetic retinopathy. There are numerous different illnesses that are frequently analyzed dependent on their progressions. Retinal veins division is additionally the center stage in robotized enlistment of two retinal veins pictures of a specific patient to pursue and analyze his malady advance at various occasions The classification issue of retinal veins division of each pixel in the field of retina is classified as vessel-like or non-vessel. The division of retinal vein is an extended monotonous assignment, in which the retinal veins division is a great deal of research in the satisfying picture handling territory since it is the basic segment of circulatory vein investigation systems. The variation in the segmentation process of blood vessels and the quantitative measurement of retinal blood vessel plays a crucial role in many research efforts that are associated with vascular structures. Many clinical researchers proved that retinal blood vessels are significant structures of retinal images. in some cases, retinal blood vessel must be omitted for easy recognition of pathological lesions (exudates or micro aneurysms).

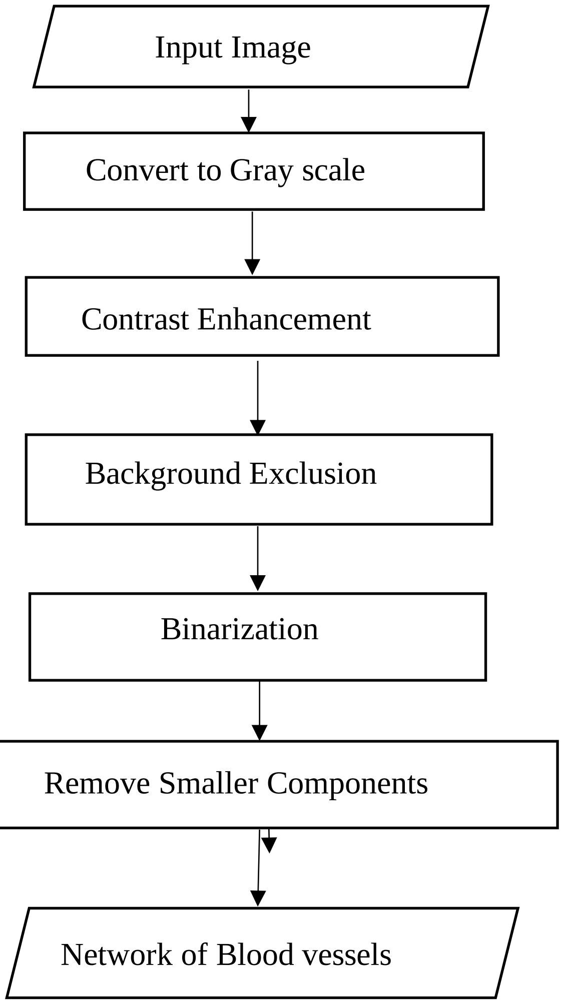


Figure-1: Block Diagram of Retinal Vessel segmentation

The process of retinal blood vessel extraction practices few complications : "(i) The retinal blood vessels have a wide scope of widths from (15 pixels) to (3 pixels) and different tortuosity. (ii) Various structures show up in retinal picture, as well as the optic plate, fovea, exudates and shade epithelium variations, which extremely disturb the programmed vessel extraction. (iii) The thin vessels with unlike surroundings may seem to be lengthened and disconnect spots, which are generally lost. (iv) The vessel power differentiate is feasible and variant, the tiny vessel is particularly overpowered. The figure-1 the diabetic retinopathy is identified by the clots of blood vessels in retina it causes when diabetic detects the tiny blood vessels inside the retina. Figure-1 gives an idea of the process of segmentation. The remaining paper is arranged as follows: The section 2 illustrates literature review i.e., the work done by different authors by using different optimization techniques. Section 3 gives proposed work followed experimental results and discussions in Section 4. Section 5 concludes the work followed by list of references.

2. LITERATURE REVIEW

Sumathi[1] stated that extraction of retinal vessels is done as it is most important task in the field of medical image processing to diagnose various retinal and non-retinal diseases. This paper presents an automated method for segmentation of retinal vasculature using morphological process and the random forest classifier. Random forest classifiers utilizing 21-D feature vector is used to extract the major vessels. Thin vessels are extracted using morphological process. The final segmented image is obtained by combining both the major vessels and thin vessels. The performance of this method was evaluated and tested using the retinal images in the available retinal Databases namely DRIVE, STARE and CHASE-DBI.

Yun Jiang [2] stated that most of the methods of retinal vessel segmentation still have problems such as poor accuracy and low generalization ability. This is because of the symmetrical and asymmetrical patterns between blood vessels are complicated and the contrast between the vessel and the background is relatively low due to illumination and pathology.It is an end-to-end frame work that automatically and efficiently performs retinal vessel segmentation.

FI scores: 0.8321, 0.8531, 0.8243 } DRIVE, STARE, CHASE-DBI
Accuracy: 0.9706, 0.9777, 0.9773 }

Negar Hassan pour [3] shows that in this we can locate the blood vasculature in images. This is done using DRIVE-database. Accuracy is 93.96%.It is sample but accuracy is comparable to that reported by the most accurate to that reported by the most accurate methods.

Shuang ling wang [4] it is the combination of convolution Neural Networks and Random forest. In this method CNN performs as a trainable hierarchical feature extractor and ensemble RF's work as a trainable classifier.The proposed method is able to automatically learn features from the raw images and predict the pattern. Uses DRIVE & STARE database.

Priya C[5] proposed Image segmentation model based on hierarchical pixel is preferred to obtain blood vessels from fundus images of the eye.

T.S. Sasikala[6] presented a unimodal biometric system which relies on the retina of the human eye. In this DRIVE & VARIA datasets were used.

Lan-Yan Xue[7] stated that we use color and texture as the saliency features for vessel extraction combined with region optimization. Optimization can be obtained through the gray histogram thresholding method to segment the vessel. Accuracy was 94%.

Zhun Fan[8] states it is based on integral channel features and random forest.

Accuracy: 0.9614, 0.9588

Sensitivity: 0.7191, 0.6996 } DRIVE, STARE

Specificity: 0.9849, 0.9787

C.Gunaselvi [9] stated ten different features based on shape, color, contrast & brightness are extracted. Based on the values of these feature vector each patient is categorized as mild, moderate and severe using Random forest classifier. Area under receiver operating curve was 0.87.Average computational time was 6.38sec.

3. RELATED WORK

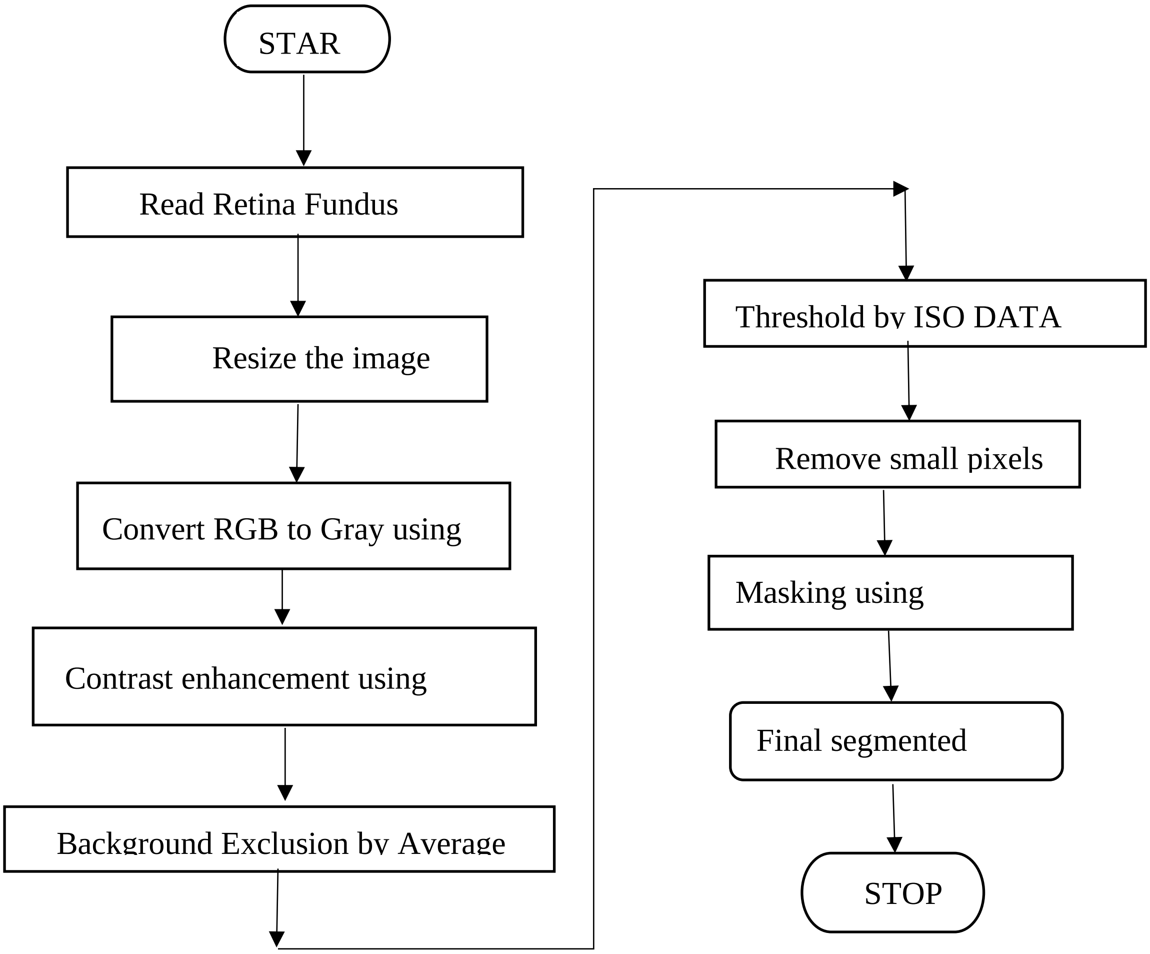


Figure2: Flowchart of Tyler Coye Algorithm

Tyler Coye Algorithm: Fig. 2 shows the flow chart of the Tyler Coye algorithm for vessel segmentation in retinal images. The principle component analysis (PCA) of weighted Lab color model is employed for converting the image into grayscale. The contrast enhancement is completed by adaptive histogram equalization. Following the contrast enhancement step, it excludes the background by subtracting the average filtered image. Isodata is employed for extracting a good intensity for the binarization process and eventually, the smaller components are removed by considering the dimensions of every connected components.

Algorithm:

Step1: Read the Image using ‘imread’.

Step2: Resize the Image for easier computation using ‘imresize’.

Step3: Read the resized Image.

Step4: Now convert this RGB image into GRAY image via PCA(empty matrix).

Step5: Enhancing the contrast of gray image using CLAHE(Contrast Limited Adaptive Histogram Equilisation).

Step6: Now apply average filter.

Step7: Now take the difference between gray image and average filter.

Step8: Now thresholding of the image is done using ISODATA method.

Thresholding: It is the portion of the image into foreground and background.

- By knowing the thresholding level we can convert the gray image to a binary image.
- This method was developed by Ridler and Calvard.

Thresholding level is a normalized value lies between 0&1.

- Initially histogram image in step5 is divided into 2 parts.
- Now a new threshold value is computed with the average of these two sample means.
- The process is repeated until the threshold value does not change any more.

Step9: Now remove all the small pixels.

Step10: Now do the overlay.

Overlay creates a mask-based image overlay. It takes input image and a binary mask and it produces an output image whose masked pixels are replaced by a specified color.

4. RESULT ANALYSIS

The outputs of the proposed work and their ground truth measures are the typical manual annotations that are mentioned by different ophthalmologists. These are specific for a particular database that evaluates the segmentation performances of the automated retinal image investigation values by means of sensitivity, specificity, precision accuracy and the f1- score which are based on the following aspects. 1. true positive (TP gives pixels which are correctly identified), 2. false positive (FP gives pixels which are incorrectly identified), 3. true negative (TN gives pixels which are correctly rejected), and 4. false negative (FN gives pixels which are incorrectly rejected)

where one can derive the following measures:

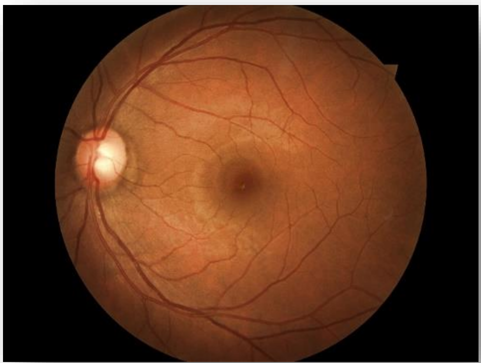
Sensitivity = TP/(TP+FN)

Specificity = TP/(TP+FP)

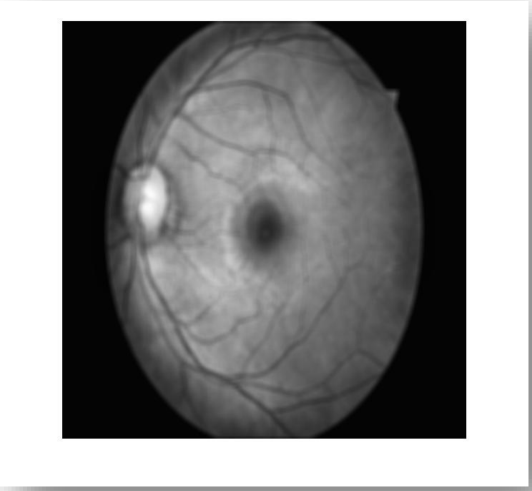
Precision = (TP+TN)/(TP+FP+TN+FN)

Accuracy = 2TP/(2TP+FP+FN)

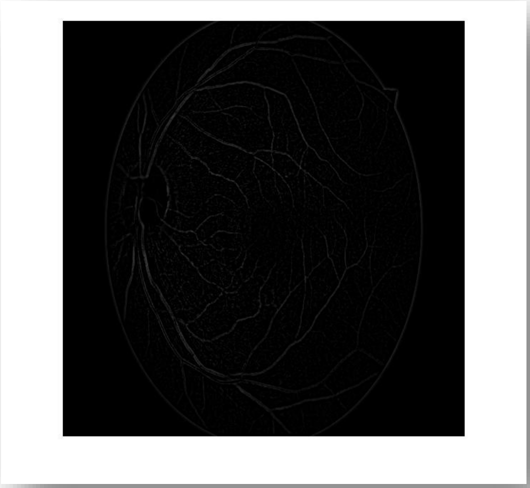
The results disclosed in this section which are arranged in three columns for three images show the process of the method leading to effective segmentation. Also, Table 2 describes the performance measures which are calculated to make evident that the proposed method is quite near reachable to the ground truth segmentation and is outstanding with: i. an average sensitivity of 69.03%(sensitivity is inversely proportional to better segmentation of blood vessels) ii. an average specificity of 98.10% (the more value of sensitivity, the higher segmentation of blood vessels) iii. an average accuracy of 97.96% (the more value of accuracy, the better segmentation of blood vessels)



(a) Input test image(left eye)



(b) RGB to gray scale image



(c) Background excluded image

(d) Final segmented image

Fig-3: (a), (b), (c), (d) images during simulation

5. CONCLUSION

The effectiveness of using Tyler Coye Algorithm is witnessed in this paper which gave an outstanding accuracy of the segmentation process. Also the CLAHE method served a better purpose in increasing the contrast of the gray retinal images. The result analysis being done proves that this approach which used STARE database gives better segmentation accuracy of 95%. The results of both qualitative and quantitative chemical analysis showed the prevalence of CLAHE in enhancing the retinal images for vessel segmentation, hence we will conclude that CLAHE is not only suitable for this application but also out performs all other enhancement techniques which are used in the comparison. Further works can be directed to tune up the parameters detect the other possible components in retinal images such as fovea, optical disc and retinal lesions.

6. REFERENCES

[1] Sumathi, "Automated retinal vessel segmentation based on morphology and random forest classifier", in Mar 2018.

[2] Yun Jiang, "Automated retinal vessel segmentation based on fully convolutional neural networks", in Aug 2019.

[3] Negar Hassan pour, "Retinal vascular segmentation using random forest classifier", in Jul 2017.

[4] Shuang Ling Wang, "Hierarchical retinal blood vessel segmentation based on feature and ensemble learning", in Nov 2018.

[5] C. Priya, "Blood vessel segmentation in fundus images", in Jun 2019.

[6] T. S. Sasikala, "Unimodal biometric based security application by exploiting retina", in Dec 2018.

[7] Lan-Yan Xue, "Retinal blood vessel segmentation using detection model and region optimization", in Feb 2017.

[8] Zhun Fan, " Automated blood vessel segmentation in fundus images based on integral channel features and random forest classifier", in Jun 2016.

[9] C. Gunaselvi, "White and red lesions detection for Diabetic retinopathy", in Mar 2018.

[10] P. Furtado, C. Travassos, R. Monteiro, S. Oliveira, C. Baptista, and F. Carrilho, "Segmentation of Eye Fundus Images by density clustering in diabetic retinopathy," in Biomedical & Health Informatics (BHI), 2017 IEEE EMBS International Conference on, 2017, pp. 25–28.

[11] S. W. Franklin and S. E. Rajan, "Computerized screening of diabetic retinopathy employing blood vessel segmentation in retinal images," Biocybern. Biomed. Eng., vol. 34, no. 2, pp. 117–124, 2014.

[12] T. Intaramanee, S. Rasmequan, K. Chinnasarn, B. Jantarakongkul, and A. Rodtook, "Optic disc detection via blood vessels origin using Morphological end point," in Advanced Informatics: Concepts, Theory And Application (ICAICTA), 2016 International Conference On, 2016, pp. 1–6.

[13] A. Salazar-Gonzalez, D. Kaba, Y. Li, and X. Liu, "Segmentation of the blood vessels and optic disk in retinal images," IEEE J. Biomed. Health Inform., vol. 18, no. 6, pp. 1874–1886, 2014.

[14] M. Saranya and A. G. Selvarani, "Fundus Image Screening for Diabetic Retinopathy," Indian J. Sci. Technol., vol. 9, no. 25, 2016.

[15] J. H. Yoon and Y. M. Ro, "Enhancement of the contrast in mammographic images using the homomorphic filter method," IEICE Trans. Inf. Syst., vol. 85, no. 1, pp. 298–303, 2002.

[16] A. W. Setiawan, T. R. Mengko, O. S. Santoso, and A. B. Suksmono, "Color retinal image enhancement using CLAHE," in ICT for Smart Society (ICISS), 2013 International Conference on, 2013, pp. 1–3.

[17] J. Staal, M. D. Abràmoff, M. Niemeijer, M. A. Viergever, and B. Van Ginneken, "Ridge-based vessel segmentation in color images of the retina," IEEE Trans. Med. Imaging, vol. 23, no. 4, pp. 501–509, 2004.

[18] R. Bandara, H. Kulathilake, M. P. Giragama, "Super-Efficient Spatially Adaptive Contrast Enhancement Algorithm for Superficial Vein Imaging," in 2017 IEEE 12th International Conference on Industrial and Information Systems (ICIIS) (ICIIS'2017), Peradeniya, Sri Lanka, 2017.

[19] C. Tyler, "A Novel Retinal Blood Vessel Segmentation Algorithm for Fundus Images," MATLAB Cent. File Exch., 2016.

[20] P. Saponaro et al., "Three-Dimensional Segmentation of Vesicular Networks of Fungal Hyphae in Macroscopic Microscopy Image Stacks," ArXiv Prepr. ArXiv170402356, 2017.

[21] J. Matas, C. Galambos, and J. Kittler, "Robust detection of lines using the progressive probabilistic hough transform," Comput. Vis. Image Underst., vol. 78, no. 1, pp. 119–137, 2000.

[22] M. Niemeijer, J. Staal, B. van Ginneken, M. Loog, M. D. Abramoff, and others, "Comparative study of retinal vessel segmentation methods on a new publicly available database," in SPIE medical imaging, 2004, vol. 5370, pp. 648–656.

[23] J. Fu, J. Chai, and S. T. Wong, "Wavelet-based enhancement for detection of left ventricular myocardial boundaries in magnetic resonance images," Magn. Reson. Imaging, vol. 18, no. 9, pp. 1135– 1141, 2000.

[24] A. El-Zaart, "Images thresholding using ISODATA technique with gamma distribution," Pattern Recognit. Image Anal., vol. 20, no. 1, pp. 29–41, 2010.

[25] P. Feng, Y. Pan, B. Wei, W. Jin, and D. Mi, "Enhancing retinal image by the Contourlet transform," Pattern Recognition. Lett., vol. 28, no. 4, pp. 516–522, 2007.