Detection of Diabetic Retinopathy by Iterative Vessel Segmentation from Fundus Images

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Abstract - *Computerized systems helped in identification of retinal damages related with Diabetic Retinopathy (DR) offers numerous potential advantages. In a screening setting, it permits the examination of substantial number of pictures in not so much time but rather more equitably than conventional observer driven procedures. In a clinical setting, it can be a critical analytic guide by lessening the workload of prepared graders and different expenses. Howsoever, the segmentation of major therapeutic structures and their consequential follow-ups are difficult because of various artifacts for example, existence of anatomical structures with exceptionally correlated pixels with that of injury, illumination changeability and movement of the eye amid various visits by the patient. This paper introduces a novel system for examination of color retinal images obtained through advanced fundus cameras from patients treated for DR. The proposed system utilizes an iterative vessel segmentation to identify vessels and extract useful imaging features from detected vessel for the purpose of classification of retinal images. The system has been useful in analyzing images obtained from standard fundus image databases.*

***Key Words*: fundus images, iterative algorithm, morphological reconstruction, vessel segmentation, ophthalmic, diabetic retinopathy.**

1. INTRODUCTION

The human eyes are most significant part of individual body and diseases like diabetic retinopathy glaucoma and macular degeneration and can irreversible damage person vision. According to modern survey, 4% of the nation populace has been diagnosed of diabetes disease only and it have been known and accepted as major root of blindness in the nation if not appropriately treated and managed.

Diabetic retinopathy is a complexity of diabetes, caused by rich blood sugar grades injurious for the backside of eye. It will cause sightlessness if left undiagnosed and unprocessed. However, it always takes many years for diabetic retinopathy to attain a phase wherever it might threaten your vision. Early discovery and diagnosis have been known as one of the way to achieve a drop in the percentage of visual injury caused by diabetes. Patient's retinal picture must be examined for identification of illness like a diabetic retinopathy.

Many automatic blood vessel detection algorithms have been projected in decades of study. A blood vessel chart is the basis of many applications. Many diseases such as diabetic retinopathy, arteriosclerosis and hypertension, are linked with irregularities of blood vascular. By observing the variation in diameter, position and tortuosities of blood vessels, strict diseases may be predicted in the early time and thus raise the prospect of a cure. Many techniques are preferred for segmentation of blood vessels, which can be separated into the following major categories: supervised and unsupervised methods.

Supervised method requires a feature vector for every pixel and hand labeled retinal images to classify between veins and non-veins pixels. This method uses thresholding and generates binary image with large vessels including some tiny vessels in to it. These extracted vessels are being tracked and classified by help of Support Vector Machine (SVM). Matched filter responses, morphology based methods, combination of edge pixels and vessel tracking are the examples of unsupervised techniques. The centreline pixels by vessel resulting features are being classified using this method. The final segmentation of the picture is being done by iterative vessel segmentation of binary image. This requires special types of filters. The image is next reconstructed so as to obtain the disorders and diagnose the diseases.

This paper determines the vein segmentation of fundus photographs by utilizing novel iterative vessel segmentation method. Different features are extracted from segmented blood vascular and support vector machine (SVM) is used to classify it for detection of Diabetic Retinopathy.

2. LITERATURE SURVEY

Digital images have the potential to be processed by automated examination systems. Fundus image examination is a difficult job, as the inconsistency of the retinal images in terms of colour/gray levels, the morphology of the anatomical structures of the retina and the existence of certain features in different patients that may direct to a wrong understanding. There have been few examine investigations to identify retinal mechanism such as optic disk, blood vessels, fovea and retinal lesions with micro-aneurysms, exudates and hemorrhages [1-3]. S.

Roychowdhury et al. [4] describes an unsupervised iterative veins segmentation algorithm utilizing fundus images. This method of segmentation is computationally proficient and reliable in vein segmentation performance for fundus images with varieties.

The strategy offered by Chaudhuri et al. [5] was premise on directional two dimensional matched filter. Two-dimensional matched filter kernel was considered to convolve with the first fundus photo to acquire unequaled retinal veins. The kernel was pivoted into either 8 or 12 introductions to fit into blood veins of various configurations. An amount of kernel shapes have been investigated. Gaussian kernels were used in [5-7]. Lines based kernels [8] and partial Gaussian kernels [9] were also used.

Chanwimaluang et al. [10] projected thresholding method based on local entropy. The tracking methods seem for a continuous blood veins portion starting from a point specified either by hand or automatically, depending on definite local information [11-13]. These methods usually attempt to get the path which finest matches a vessel outline model. Gradient operators, matched filters and sobel edge detectors were applied to find the vascular direction and edge. Fang et al. [14] describes a two step scheme to segment veins. Firstly, statistical morphology filtering joined with curvature progression was utilized to improve the vascular in retinal images. The main restriction of this technique was that important features such as bifurcation and intersection points may be missed. To progress the complete vessel arrangement a reconstruction process employing dynamic local region growing was performed. Multi-scale approaches in vascular segmentation were performed by unreliable image resolutions [15-17]. The key benefit of using these approaches was their well-organized processing rate. In these techniques finer veins were divided from areas having high resolution and bigger veins were sectioned from regions having low determination.

The vein network was segmented by Softka et al. [18] based on the response of multi-scale matched filters, gradient at the edge of veins, the edge quality at the limit and vein certainty measure. A number of supervised methods [19-21] focusing on two dimensional retinal images were explored to get better results. Two vein recognition techniques in computerized retinal images on line operators were produced by Perfetti et al. [19]. The reaction of the line detector was threshold to accomplish pixel characterization which was unsupervised in the primary segmentation technique. In the second segment technique, a feature component including two orthogonal line identifiers and target pixels gray level was used for supervised order.

3. SYSTEM DESCRIPTION

3.1 Fundus Images

Fundus photography is done by taking a photograph at the backside of the eye. Retinal digital pictures are typically known as Fundus images taken by digital fundus camera. These images have frequently red tint due to rich blood supply. Fundus picture contains several significant parts as macula, blood vessels and optical disk, which are important for appropriate diagnosis by ophthalmologist. Figure 1 shows different fundus images.

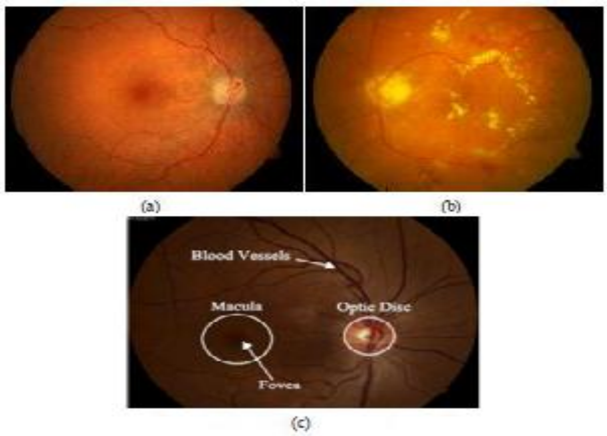


Fig -1: Fundus images: (a) normal fundus;

(b) abnormal fundus and (c) color fundus photo with main anatomical structures

3.2 Proposed Method

System block diagram of the proposed work shown in figure 2. In which retinal color image is pre-processed to extract green channel and applied for segmentation. Unsupervised iterative vessel segmentation algorithm is applied to detect blood veins. Various features are extracted from segmented image and by help of support vector machine (SVM) classified it to discover disease diabetic retinopathy.

The basic steps involved are:

I. Pre-processing of retinal image
II. Blood vessel segmentation
III. Feature extraction and detection

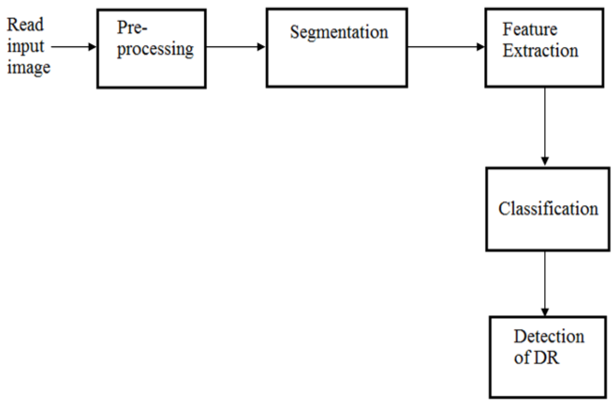


Fig -2: Schematic of automatic analysis of diabetic retinopathy

4. METHODOLGY

4.1 Pre-processing of Retinal Images

Input: The input given is the fundus image that consists of Red, Green and Blue region in the fundus images. The vessels are in the form RGB.

Select green plane: The green channel is high sensitive to blood vessel. Hence it is consider for segmentation.

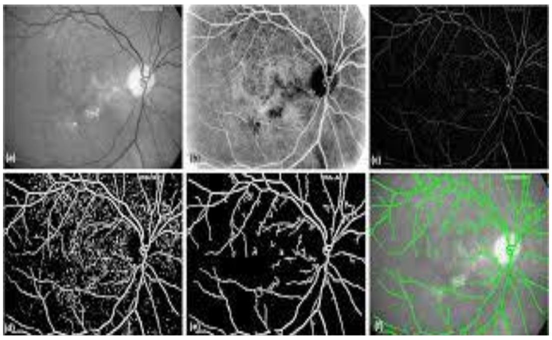


Fig -3: Green channel extract [4]

Create mask image: A mask is used to remove the dark background region from the photographs to focus concentration on the retinal region only.

Image inversion followed by superposition of the mask: In green plane image, the red regions corresponding to the blood veins come out as dark pixels with intensities close to 0. To focus interest on the blood vein regions, image green plane is inverted and make the red regions appear the brightest, followed by superposition of the mask image.

Contrast enhancement and Top-hat transformation: Contrast adjustment followed by morphological tophat transformation is applied. 12 linear structuring elements each of length 21 pixels are used to generate top-hat reconstructions from contrast enhanced image. To approximately fit the diameter of the biggest vessels the length of pixels is selected in the images. For each pixel location, the reconstructed pixel with the highest intensity is selected, thereby resulting in tophat reconstructed vessel enhanced image.

4.2 Blood Vessels Extraction

For every fundus image, a vein enhanced image is created by top-hat reconstruction of the extracted green channel image. By using global thresholding vein estimation is extracted. After that adaptive thresholding is applied to recognize new vein pixels. Next new pixels are region grown into the presented vessel, thus gives an iterative enhancement of the segmented vessel formation. The iterative addition of the newly identified vessel regions to the accessible vessel estimate is continued till a best vessel estimate with highest accuracy is occurs.

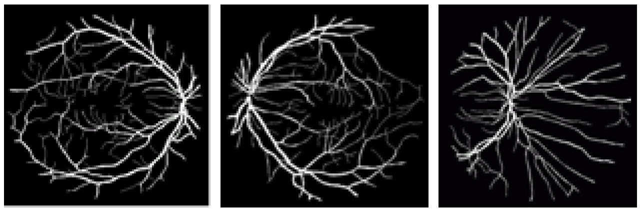


Fig -4: Required extracted vessels from DRIVE database

4.3 Feature extraction and Detection of DR

Feature extraction plays a central role in various image processing tasks including object classification, pattern recognition and image segmentation. Features offer relevant information and descriptions of objects limited in a given subject. Hence, feature extraction techniques basically analyze image attributes to extract the most important features that are delegate of the different classes of objects. From segmented vein image different 28 features are obtained. Some of them are; Shape features such as Bounding box, area, perimeter, convex area, major axis length and minor axis length etc. Intensity features such as standard deviation, Skewness, mean etc. Texture features like contrast, correlation, entropy, energy, homogeneity.

In figure 5 the graphical illustration of fundus photo shows various regions of retina. This helps to identify the diseases.

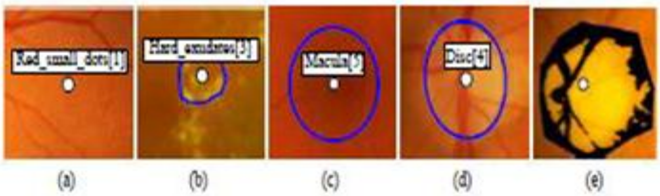


Fig -5: Graphical orders for denoting the visual discoveries. (a) centroid; (b) polygon region; and (c) circle region; d) semi-automatic region cropping tool and representative point [22]

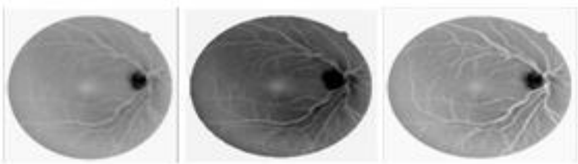
Features are act as input to classifiers that assign them to the class that they characterize. This is completed by applying Support Vector Machine (SVM) classifier. The SVM classifier is organized with 40 fundus pictures which display typical levels of DR. The output of classifier divided into 4 classes, 0 & 1 for normal, 2 for mild and 3 for severe DR stage.

5. RESULTS AND DISCUSSION

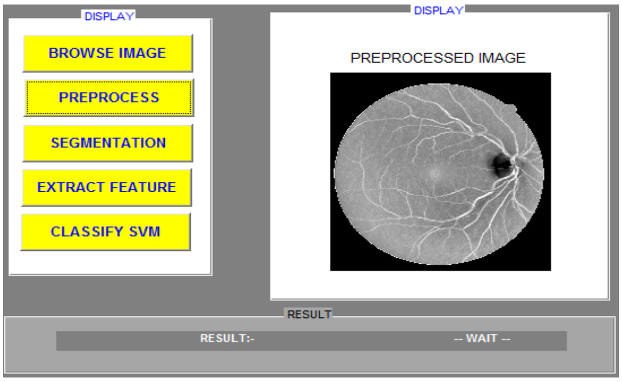
Pre-processing results-

In this work, general experimentations are performed on publicly accessible retinal image databases. There are namely three types of databases, DRIVE, STARE and CHASE. These outputs are achieved on mainly DRIVE database. Figure no. 6 shows the output of preprocessing stage.

(a) (b) (c)



(d) (e) (f)



(g)

Fig -6: Output of pre-processing stage: (a) input fundus image; (b) green plane; (c) inverted image; (d) superposition with mask; (e) contrast adjusted image; (f) tophat reconstructed image and (g) GUI output of preprocessed image

Blood vessel detection results-

Applied threshold value and iterative addition of new identified vessel regions into existing vessel estimate is continued till we get best vessel estimate shows in figure 7. Blood vessels segmentation results are obtained for DRIVE database.

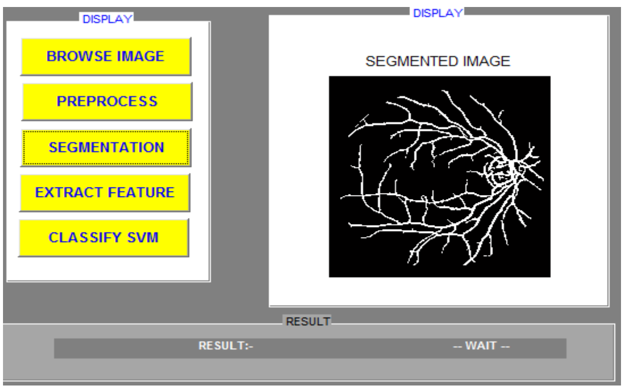


Fig -7: output of extracted vessels

Feature extraction and detection of DR-

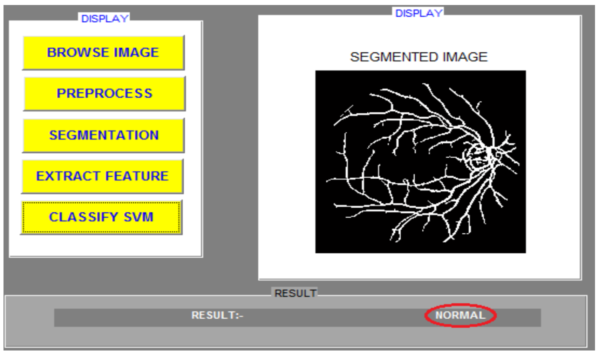
The detection of various diseases is being done by using various classifiers. Here SVM classifier is used to detect the DR disease. Different 28 features are extracted and Diabetic Retinopathy classified into four classes. Thus we can achieve the disease of retina that is DR. Figure 7 shows different feature values extracted from segmented image.

FV_Stat <1x1 struct>

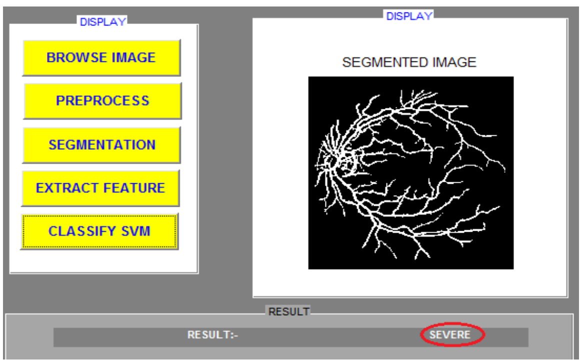
Field	Value	Min	Max
Contrast	1.5271	1.5271	1.5271
Correlation	0.8596	0.8596	0.8596
Energy	0.7479	0.7479	0.7479
Homogeneity	0.9727	0.9727	0.9727

Fig -8: Features extracted from detected vessel image

Here we get the disease of diabetic retinopathy. The output of detection shown in figure 9. It gives the different classes of DR.



(a)



(b)

Fig -9: Output of DR detection; (a) No DR output; (b) DR at severe stage.

Evaluating Parameters-

The performance of proposed work is evaluated using the standard parameters sensitivity, accuracy and specificity. Specificity is the percentage of normal fundus images classified as normal by the method. Sensitivity is the percentage of abnormal fundus images classified as abnormal by the method. Parameters can be calculated as follows,

Sensitivity= TP/(TP+FN)

Specificity= TN/(TN+FP)

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

Where TP, FP, TN and FN mean true positive, true negative, false positive, and false negative, respectively. A screened fundus is considered as a true positive if the fundus is really abnormal and if the screening process also classified it as abnormal. Similarly, a true negative means that the fundus is really normal and the method also classified it as normal. A false positive means that the fundus is really normal, but the method classified it as abnormal. A false negative means that the method classified the screened fundus as normal, but it really is abnormal. Performance parameters of proposed work are shown in table 1.

Table -1: Performance Parameters

Database	Sensitivity	Specificity	Accuracy
DRIVE database	95.83%	62.5%	82.5%

6. CONCLUSION

A picture database framework was proposed for assessing and comparing techniques for automatic recognition of diabetic retinopathy. It gives an integrated system to benchmarking the strategies, it also indicate apparent deficiencies in the retina. It is observed that study of retinal pictures is the key contribution to distinguish DR Since its early discovery is possible it helps to treat consequently and thus the vision loss can be avoided**.**

REFERENCES

[1] M. Goldbaum, S. Moezzi, A. Taylor and S. Chatterjee. "Automated Diagnosis and Image Understanding with Object Extraction, Object Classification, and Inferencing in Retinal Images", Proc. of IEEE International Conference of Image Processing, vol. 3, 1996, pp.695-698.

[2] C. Sinthanayothin, J. Boyce, H. Cook and T. Williamson. Automated localisation of the optic disc, fovea, and retinal blood vessels from digital colour fundus images, British Journal of Ophthalmology, vol. 3, 1999, pp.902-910.

[3] A. Frame, P. Undrill, M. Cree, et al. "A Comparison of Computer Classification Methods Applied to Detection of Microaneurysms in Ophthalmic Fluorescein Angiograms", Computers in Biology and Medicine, vol. 28, 1998, pp.225-238.

[4] S. Roychowdhury et al., "Iterative Vessel Segmentation of Fundus Images," IEEE Trans. Biomed. Eng., vol. 62,no. 7, Jul. 2015.

[5] S. Chaudhuri, S. Chatterjee, N. Katz, M. Nelson, and M. Goldbaum, "Detection of Blood Vessels in Retinal Images using Two-Dimensional Matched Filters", IEEE Transactions on Medical Imaging, vol. 8, 1989, pp. 263-269.

[6] M. Goldbaum, N. Katz, S. Chatterjee, and M. Nelson, "Image Understanding for Automated Retinal Diagnoses", IEEE Symposium for computer applications in clinical medicine, 1989, pp. 756-760.

[7] Hoover, V. Kouznestova, and M. Goldbaum, "Locating Blood Vessels in Retinal Images by Piece-Wise Threshold Probing of a Matched Filter Response", IEEE Transactions on Medical Imaging, vol. 19, 2000, pp.203-210.

[8] Y. Wang and S. C. Lee, "A Fast Method for Automated Detection of Blood Vessels in Retinal Images", Proceedings of the 31st Asilomar Conference on Signal, System, and Computers, vol.2, 1997, pp.1700-1704.

[9] A. Can, H. Shen, J. N. Turner, H. L. Tanenbaum and B. Roysam, "Rapid Automated Tracing and Feature Extraction from Retinal Fundus Images using Direct Exploratory Algorithms", IEEE Transactions on Information Technology in Biomedicine, vol. 3, 1999, pp.125-138.

[10] Thitiporn Chanwimaluang and Guoliang Fan, "An Efficient Blood Vessel Detection Algorithm for Retinal Images using Local Entropy Thresholding", in Proc. of the IEEE International Symposium on Circuits and Systems, Bangkok, Thailand, vol.5, 2003, pp.21-24.

[11] H. Li, W. Hsu, M. L. Lee and H. Wang, "Automatic Grading of Retinal Vessel Calibre", IEEE Transactions on Biomedical Engineering, vol. 52, 2005, pp.1352-1355.

[12] Y. A. Tolias and S. M. Panas, "A Fuzzy Vessel Tracking Algorithm for Retinal Images Based on Fuzzy Clustering", IEEE Transactions on Medical Imaging, vol. 17, 1998, pp. 263-273.

[13] Chutatape, L. Zheng and S. M. Krishnan, "Retinal Blood Vessel Detection and Tracking by Matched Gaussian and Kalman Filters", In Proc. of the 20th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, vol. 20, 1998, pp. 3144-3149.

[14] Fang, B., Hsu, W., Lee, M., "Reconstruction of Vascular Structures in Retinal Images", Proc. ICIP‟03, 2003, pp. 157–160.

[15] N. Armande, P. Montesinos, and O. Monga, "Thin Nets Extraction using a Multi-Scale Approach", SCALE-SPACE ‟97: Proceedings of the First International Conference on Scale-Space Theory in Computer Vision, Springer-Verlag,1997, pp.361–364.

[16] A. Bhalerao and R. Wilson, "Estimating Local and Global Image Structure using a Gaussian Intensity Model", Medical Image Understanding and Analysis, 2001.

[17] M. P. Chwialkowski, H. L. Ibrahim, Y. M. Li, and R. Peshock, "A Method for Fully Automated Quantitative Analysis of Arterial Flow using Flow-Sensitized MR Images", Computerized Medical Imaging and Graphics, vol. 20, 1996, pp. 365–378.

[18] Michal Sofka, Charles V. Stewart, "Retinal Vessel Centerline Extraction using Multiscale Matched Filters, Confidence and Edge Measures", IEEE Transactions on Medical Imaging, vol. 25, 2006, pp. 1531-1546.

[19] Ricci, E., Perfetti, R., 2007. Retinal Blood Vessel Segmentation Using Line Operators and Support Vector Classification. IEEE Transactions on Medical imaging vol. 26, 2007, pp. 1357-1365.

[20] Joao V. B. Soares, Jorge J. G. Leandro, Roberto M. Cesar Jr., Herbert F. Jelinek, and Michael J.Cree, "Retinal Vessel Segmentation Using the 2-D Gabor Wavelet and Supervised Classification", IEEE Transactions on Medical imaging I, vol. 25, 2006, pp. 1214-1222.

[21] J. Staal, M Abramoff, M. Niemeijer, M. Viergever, and B. van Ginneken, "Ridge-Based Vessel Segmentation in Color Images of the Retina" IEEE Transactions on Medical Imaging, vol. 23, 2004, pp.501–509.

[22] A Review of Vessel Extraction Techniques and Algorithms–Cemil Kirbas and Francis Quek, Wright State University,Dayton, Ohio.