Processing of Retinal Images for the Detection of Vascular Diseases

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***Abstract*— Ocular fundus image can provide information on pathological changes caused by local ocular diseases and early signs of certain systemic diseases. Automated analysis and interpretation of fundus images has become a necessary and important diagnostic procedure in ophthalmology. Among the features in ocular fundus image are the optic disc, fovea (central vision area), lesions, and retinal vessels. These features are useful in revealing the states of diseases in the form of measurable abnormalities such as length of diameter, change in color, and degree of tortuosity in the vessels. In addition, retinal vessels can also serve as landmarks for image-guided laser treatment of choroidal neovascularization. Thus, reliable methods for blood vessel detection that preserve various vessel measurements are needed. In this paper, we will examine the pathological issues in the analysis of retinal vessels in digital fundus images and give a survey of current image processing methods for extracting vessels in retinal images with a view to categorize them and highlight their differences and similarities. We have also implemented two major approaches using matched filter and mathematical morphology respectively and compared their performances. Some prospective research directions are identified.**

***Keywords*— Component; Formatting; Style; Styling; Insert**

I. INTRODUCTION

The retina is a layered structure with several layers of neurons interconnected by synapses. The only neurons that are directly sensitive to light are the photoreceptor cells. For vision, these are of two types: the rods and cones. Rods function mainly in dim light and provide black-and-white vision while cones support the perception of colour. A third type of photoreceptor, the photosensitive ganglion cells, is important for entrainment and reflexive responses to the brightness of light. Neural signals from the rods and cones undergo processing by other neurons of the retina. The output takes the form of action potentials in retinal ganglion cells whose axons form the optic nerve. Several important features of visual perception can be traced to the retinal encoding and processing of light.

Retinal images are influenced by all the factors that affect the body vasculature in general. The human eye is a unique region of the human body where the vascular condition can be directly observed. In addition to fovea and optic disc, the blood vessels contributes as one of the main features of retinal fundus image and several of its properties are noticeably affected by worldwide major diseases such as diabetes, hypertension, and arteriosclerosis. Further, certain eye diseases such as choroidal neovascularization and retinal artery occlusion also make changes in the retinal vasculature. Therefore, the segmentation of blood vessels in retinal images can be a valuable aid for the detection of vascular diseases along with diseases directly related to eye.

An automated segmentation and inspection of retinal blood vessel features such as diameter, color and tortuosity as well as the optic disc morphology allows ophthalmologist and eye care specialists to perform mass vision screening exams for early detection of retinal diseases and treatment evaluation. This could prevent and reduce vision impairments; age related diseases and many cardiovascular diseases as well as reducing the cost of the screening. Over the past few years, several segmentation techniques have been employed for the segmentation of retinal structures such as blood vessels and optic disc and diseases like lesions in fundus retinal images.

II. LITERATURE SURVEY

V.Jayalakshmi T,Saranyalakshmi D, Kokila et al.[1] have proposed Detection of Macula Edema in Color Retinal Images, In the first set they going to start with preprocessing by using
(i) Denoising, (ii) Median Filter .After the preprocessing they going to mask the optic disk from this they got the motion patterns. In the Feature Extraction step extract the features such as locale, area, direction and solidity, are derived. Texture features are extracted according to the information of gray- level co-occurrence matrix (GLCM). Texture Feature are extracted from the GLCM classifier and got the result as,
Severity=2.375
Accuracy=96.6667.
ANFIS classifier and got the result as,
Severity=2.375
Accuracy=98.3333.

Deepashri. K M, and Santhosh .K V et al.[2] have proposed Glaucoma Detection by Image Fusion from Funds Color Retinal Images, here they have to use Image fusion techniques and carried out the radius of the optic disk and optic cup, and also height of the optic nerves and neuroretinal rim. They got the result as,
average sensitivity of 78%,
average specificity of 97.99%
average accuracy of 99.6% in the retinal fundus images.
Benson et al.[3] have proposed line-shape concavity measuring model to remove dark lesions which have an intensity structure different from the line-shaped vessels in a

retina. This method has achieved 95.67% of an average accuracy for the blood vessel detection with respect to ground truth images in DRIVE database, while provided 95.56 % of an average accuracy for the blood vessel detection with respect to ground truth images in STARE database.

Kanika Verma, Prakash Deep and A. G. Ramakrishna et al.[4] have proposed Detection and Classification of Diabetic Retinopathy using Retinal Images In this method have used Adaptive histogram equalization was used to enhances the contrast of the features of interest against background .six features are extracted from the retinal images they are are and perimeter in each of the RGB components of the blood vessels , area in the num of white pixels present within the vessels and premiter was determined by the num of pixel present on they got the result as,
TP=14,FP=0,TN=9,FN=2
Sensitivity=0.875
Specificity=1
Positivity predicted value=1(PPV)
Negative predicted value=0.8181(NPV)

L.R.Sudha, S.Thirupurasundari et al.[5] have proposed Analysis and detection of hemorrhages and exudates in retinal images in this method Automated system for classifying the type of retinal diseases by using KNN classifiers. In this method main intension is to find out the Hemorrhages and exudates diseases. In this work mesoderm database are used, in feature extraction texture analysis used to extract features values. Rough smooth and silkily as a function of spatial variation are shown in the pixel intensities.
Entropy=4.6133
Entropy filter=2.6296
Gray level-co-occurrences matrices, range filter=17.6331
Standard deviation =6.5250A
CCR=96%, specificity=90, sensitivity=100%.

Snehal B. Akhade, V. U. Deshmukh and S. B. Deosarkar et al.[6] have proposed Automatic Optic Disc Detection in Digital Fundus Images Using Image Processing In this method they have to use the Principal component analysis are used to preprocessing of an images and mathematical morphology for further work Watershed Transform are used to image segmentation problems. In this work they got the result as ,
Sensitivity of 78%, average specificity of 97.99% and an average accuracy of 99.6%

Srikanth Prabhu et al [7] have done a study of image segmentation techniques on retinal images for health care management with fast computing. This study indicates that segmentation of retinal images can give lot of insight into the extraction of artifacts and diseased features of retina specially the diabetic features. It has been seen through the classification methods that images with artifacts only gives good classification accuracy when compared with those with diseased features because artifacts and diseased features have different styles of extraction. Image processing techniques can classify different diseases like hypertension, glaucoma, diabetic retinopathy, diabetic uropathy and diabetic neuropathy. The main concentration has been on general classification into normal and abnormal patterns. More has been be done in specific diseases where in clearly it can be understood what is the difference between artifact, micro-aneurysms, hemorrhages, exudates, where micro-aneurysms, hemorrhages, exudates are diabetic features. Likewise there are different sets of features for glaucoma, hypertension and other disease. In non repeating classification accuracies is 74% and KNN is 71%.In Repeating feature classification accuracies is 43% and KNN is 41%.

S. Manoj, Muralidharan et al [8] have used neural network based classifier for retinal blood vessel segmentation. They have presented an effective retinal vessel segmentation technique based on supervised classification using Neural Network classifiers. Have used a 9-D feature vector which consists of the vessel map obtained from the orientation analysis of the gradient vector field. The morphological transformation, line strength measures and the Gabor filter response which encodes the information to successfully handle both normal and pathological retinas has been used. These features have been extracted and given as the input to the Neural Network classifiers like FFBNN, MLP, and RBF. By using the appropriate activation function and the training algorithms every pixels which are characterized by the feature vector and which is in feature space has been classified by the neural classifiers and vessel and non-vessel are detected. The images from DRIVE, STARE, and MESSIDOR are evaluated and the performance measures are calculated to evaluate the proposed method and compared with the existing method. The demonstrated performance, effectiveness and robustness, along with its simplicity and speed in training as well as in classification, make this supervised classification method for blood vessel segmentation a suitable tool to be integrated into a complete retinal image analysis system for clinical purposes.

Bin Fang ,Wynne Hsu ,Mong Li Lee , et al [9] have proposed On the Detection of Retinal Vessels in Fundus Images .They have presented Matched filter Method and also Mathematical Morphology. They have present an algorithm that combines Morphological filters and cross-curvature evaluation to segment blood vessels in retinal angiographies. Vessel-like patterns are bright features defined by morphological properties: linearity, connectivity, width and by a specific Gaussian-like profile whose curvature varies smoothly along the crest line. Mathematical Morphology is very well adapted to this description and is used to highlight vessels with respect to their morphological properties. . Accuracy has been found to be 0.9429 for normal images and in abnormal images, it is 0.849.

D.Siva Sundhara Raja et al.[10] have proposed performance analysis of retinal image blood vessel segmentation the proposed vessel segmentation method is compared to its corresponding round truth images. The performance of proposed vessel detected image is experimentally validated with ground truth images. The blood vessel detection and segmentation is important for diabetic retinopathy diagnosis at earlier stage.

The local binary pattern and GLCM features are extracted from the morphologically processed image and the images have been classified using support vector machine classifier. The proposed method has detected blood vessels with an average sensitivity of 78%, average specificity of 97.99% and an average accuracy of 99.6% in the retinal funds images.

III. OBJECTIVES

The objectives of the work are as below

1. Segmentation of blood vessels of retinal images accurately.
2. Detection of vascular abnormality in order to help early treatment for vascular diseases.

IV . METHODOLOGY

The block diagram of the proposed system is shown below and it consist of three important steps. First step consists of preprocessing of retinal image with suitable method in order to help proper segmentation. In the second step, retinal vasculature in the retinal images is segmented and important features of the image are extracted. In the third step, classification will be done using Support Vector Method in order to differentiate between normal and abnormal vessels.

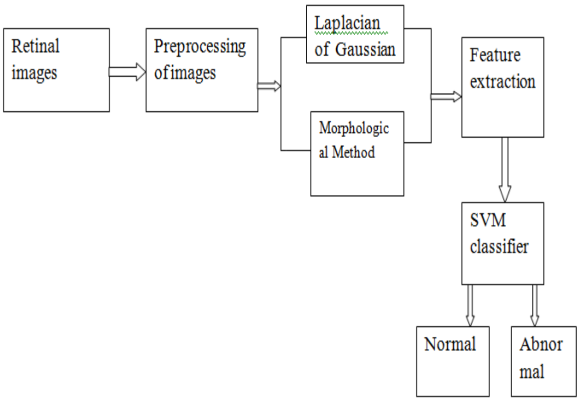


Figure. 1 .Proposed blood vessel segmentation system

1. DETECTION OF BLOOD VESSELS USING LAPLACIAN OF GAUSSIAN FILTER

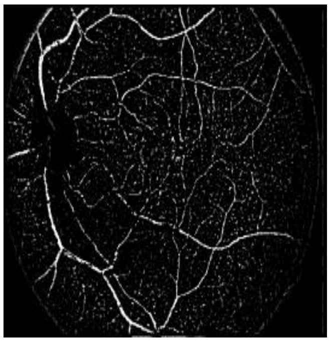
The vessels are extracted using local maxima and local minima . For example the local maxima for is The LOG function as shown in Eqs. Below

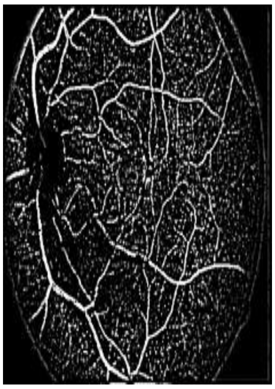
$$g(x,y,t)=\frac{1}{2\pi t^2}e^{(x^2+y^2)/(2t^2)}\ ,$$

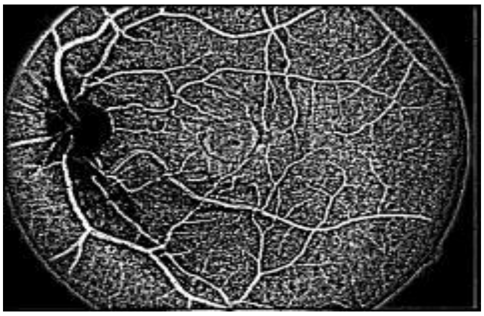
$$\Rightarrow L(x,y,t)=g(x,y,t)*f(x,y)$$

$$\Rightarrow \text{Laplacian Operator} = \nabla^2 L = L_{xx}+L_{yy}$$

where, $f(x, y)$ is the image. The results are shown in Fig.1.







V . FEATURES EXTRACTION

1. Contrast:

$$f_2 = \sum_{n=0}^{N_g-1} n^2 \left\{ \sum_{\substack{i=1 \\ |i-j|=n}}^{N_g} \sum_{j=1}^{N_g} p(i,j) \right\} .$$

2. Correlation:

$$f_3 = \frac{\sum_i \sum_j (ij)p(i,j) - \mu_x\mu_y}{\sigma_x\sigma_y}$$

where p,u, py, c., and ay are the means and standard deviations of px and py.

3. Sum of Squares: Variance

$$f_4 = \sum_i \sum_j (i - \mu)^2 p(i,j).$$

4. Sum Average:

$$f_6 = \sum_{i=2}^{2N_g} i p_{x+y}(i).$$

5. Entropy:

$$f_9 = -\sum_i \sum_j p(i,j) \log(p(i,j)).$$

6. Homogeneity:Dimensional homogeneity is the quality of an equation having quantities of same units on both sides.

$$E_k = \frac{1}{2}mv^2; \; E = mc^2; \; E = pv; \; E = hc/\lambda$$

7. Smoothness :In mathematical analysis, the smoothness of a function is a property measured by the number of derivatives it has which are continuous. A **smooth function** is a function that has derivatives of all orders everywhere in its domain.

$$f(x) = \begin{cases} x & \text{if } x \geq 0, \\ 0 & \text{if } x < 0 \end{cases}$$

8. Skewness:In probability theory and statistics, **skewness** is a measure of the asymmetry of the probability distribution of a real-valued random variable about its mean. The skewness value can be positive or negative, or even undefined.

$$\gamma_1 = \mathrm{E}\left[\left(\frac{X-\mu}{\sigma}\right)^3\right] = \frac{\mu_3}{\sigma^3} = \frac{\mathrm{E}[(X-\mu)^3]}{(\mathrm{E}[(X-\mu)^2])^{3/2}} = \frac{\kappa_3}{\kappa_2^{3/2}}$$

9. Vessel Thickness: It depends on the size of the blood vessels on the fundus image.Ex. 3.2187

1	contrast	0.0577
2	correlation	0.1088
3	variances	0.0033
4	averages	0.97
5	Entropy	0.9077
6	Homogeneity	0.9756
7	Smoothness	0.9569
8	Skewness	0.5993
9	Vessel Thickness	3.2187
10	Kurtosis	9.7178
11	RMS	0.0574

normal
accuracy=95.00%
confusion matrix for benign and malignant:

11	1
0	8

VI . RESULTS

1. Accurate segmentation of blood vessels in Retinal fundus Images.
2. Detection of clinically important abnormalities in retinal vasculature.
3. Detection of Vascular related diseases.

VII. APPLICATION

1. The Algorithm that will be developed can help in detection of ocular diseases from retinal images.

2. The Algorithms can be used for Processing Mammographic images with further processing.

VIII. REFERENCES

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