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Identification of Vessels from Retinal Image Analysis

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ABSTRACT - Retinal Blood vessel morphology can be an important indicator for many diseases such as diabetes mellitus, hypertension and arteriosclerosis. The measurement of geometrical changes in retinal veins and arteries can be applied to a variety of clinical studies. The spotlight of this paper is developing the screening system with the aim of highly accurate and automated analysing tool for the ophthalmologists and the retinal researchers. Segmentation of the retinal blood vessels is an assistance to understand more about its morphology and will provide a better source of information for studying the various related diseases. Analysis is implicated with automated vessel tracing and registration of sub pixel accuracy. The correct identification of blood vessels will lead to the best diagnosis. The two problems addressed in this scheme are; the automatic vessel extraction which means the segmentation of the vessels with good accuracy and the identification of all vessels from the segmented vascular structure as finding the optimal vessel forest in the graph given a set of constraints. It could be the lay concrete on the future screening services of the ophthalmologic amenities.

KEYWORDS - Ophthalmology, Geometrical, Retinal image analysis, Morphology, Vascular Structure.

I.INTRODUCTION

Retinal image is a unique one and also screen to indicate the diseases. Retina is a thin layer that is the posterior part of the eye. The image is acquired while looking through the pupil by ophthalmoscope. This part contains the multifarious structure of capillaries that furnish the retinal with blood.

Retinal image of human plays an important role in detection and diagnosis of many eye diseases for ophthalmologist. This part can be varying from each person to person and also eye to eye that's why used as a biometric identifier but it is substantiation for a pessimistic bang on the human health. In this point of view iris is differing from the retina and iris is one of the emerging trend in biometric identification field. The work of this paper is developing the screening system for detecting the vascular diseases which is happened on the retinal. The diabetic retinopathy is one of the most foremost ophthalmic pathological grounds of blindness among the world. Hypertension, Stroke, Diabetic retinopathy, Cardio vascular disease etc., are screened based on the vessel damages, the primary aim of my project is identifying the minute vessel damages using the DIP techniques and secondarily it can detect the vascular diseases based on the features of the image. This will be the useful tool for the automatic screening and helpful for the ophthalmologist. Diabetic retinopathy damages the tiny blood vessels inside the retina and this will be affect the blood vessels in the entire body. There is no sign of disease at its early stages but as the time of passes the disease turns into severe and it will cause the vision loss. The most of the vessel damages will kill the rest of the human life.

Fig. 1 Digital colour fundus photograph

During the acquisition process, images are habitually of meager quality that encumbers further analysis too. So, preprocessing of digital fundus images is a major concern in automatic screening system. Through the study of [7] viewed the performance of various methods and that evaluation studies are not weigh up on any large publicly available datasets. Our system protract on these survey of the preprocessing methods for enhancing the quality of the digital fundus image. Taken as a whole, the preprocessing methods for an image can be pigeonholed into mask generation, illumination equalization and color normalization. Optic disc detection is an efficient task in the retinal image analysis system. It appears as a bright spot of circular or elliptical shape, interrupted by the outgoing vessels. It can be seen that optic nerve heads and vessels emerge in to the retina through optic disc. It is situated on the nasal side of the macula and it does not contain any photoreceptor. Therefore it is also called the blind spot. User interactions are required for the marking of OD [9].The starting point detection by using matched Gaussian filter [4]. Qiangfeng et al., proposed the method which requires the scoring function for the starting point detection [14]. In the part of vessel tracking, optic disc plays the role as starting point.

Vasculatures are the effective tool for the optimization as well as screening the diseases. And the part of vessel extraction from the retinal image is mixed up in the segmentation process. The extraction of the vessel part is involved with the comparative study of the segmentation methods. The blood vessels are estimated by using the combined kalman filter and Gaussian filter which seems to produce the less error rates [4]. Azegrouz and E. Trucco suggested that the dijistra's for finding the minimal path and maximizing the merit function of all the selected candidates which these can be used to detect the vein in the retinal image [3].The Gaussian derivative operators are used to extract the blood vessels in [9]. Meindert Niemeijer et al., examined the vasculature forming by the candidate extraction methods with the comparison of morphological candidate extraction and kNN classification based candidate extraction [8].Segmented vasculature can precede the further analysis for the purpose of identification. In order to measure and quantify the geometrical and topological properties of continuous trees , the multiscale analysis required [8]. B. Al Diri et al proposed the low pass filtering technique to resolve the geometry of retinal junction and assign segment ends to local sets based on position and alignment and it chooses the most geometrically plausible configuration using SOFM neural networks [2].Each vessel is identified based on the nodal point fixing. The bifurcation and crossover are the points at which blood vessels break into secondary and tertiary vessels. Those intersections are detected based on the several techniques such as SCN (Simple Crosspoint Numbering), MCN (Modified Crosspoint Numbering).

II.SYSTEM MODEL

A screening system for vascular disease identification is full of the subsequent stages which are described below. First, in this arena, the image is superior to progress the defining the zone of interest, non uniformity correction and channel wise equalizing. The second arena is the segmentation; here it just carried out for the vessel extraction. After that all the vessels are branded by means of image processing methods.

A.Preprocessing

The preprocessing of fundus image is a major issue in automatic screening system. This part is involved with the following checkmarks such as mask generation, illumination equalization and colour normalization.

1) *Mask generation:* The fundus images may restrain the variations in the background athwart the image. Mask generation is the process of selecting the region of interest. It labels the pixels of the circular retinal fundus, Region of Interest in the entire image and excludes the background of the image. The method used the mean+4*std. deviation [1].

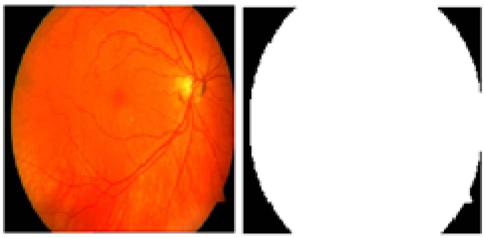

Fig. 2 Mask generation

The binary mask is created for defining the zone of interest with the help of binarization and thresholding methods. In that the background pixels are darker than the ROI shows in Fig.2.

2) *Illumination equalization:* The illumination means non- uniformity of the imaging system. The main drawback of uneven illumination is the inability to simply analyze the OD [1].To overcome that non-uniformity, each pixel is adjusted that is equalized by smoothing. The non-uniform illumination is overcome through adjusting the each pixel as follows,

$$I_{eq}(r, c) = I(r, c) + m - \overline{I_w}(r, c)$$

m is the desired average intensity and $\overline{I_w}(r,c)$ is the mean intensity value of the pixel within a window W of size NxN. The r,c are the row and column pixels. W is the window sliding. I_{eq} is the equalized image with regarding the pixels r,c.

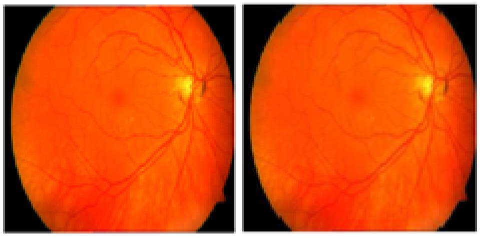

Fig. 3 Illumination equalized image through the mean based method

The Fig.3 describes how the illuminations equalized by mean intensities which is useful for the further processing such as optic disc detection and the other parts of retinal image. Each is corrected for equalizing the illuminations through this technique.

3) *Colour normalization:* Histogram of the image equalization is used to normalise the colour of the retinal image. The chromaticity coordinates were used to evaluate the effects of applying color normalization method to retinal images. The clusters of values were measured before and after applying the histogram equalization method with clearest separation of retinal clusters [7].Colour information is the potentially useful in classification given that colour measurements of lesions in retinal images show significant differences. Colour normalization plays an important role in this system which is used to enlighten the vessels that going to process. This can be implemented by the corrected mean technique [1].

$$d_m = \text{mean (Red)+mean(Green)+mean(Blue)}$$

$$R_{correct} = \frac{R_m}{d_m}, \quad G_{correct} = \frac{G_m}{d_m}, \quad B_{correct} = \frac{B_m}{d_m}$$

$$C_{RGB} = \text{Combine } (R_{correct}, G_{correct}, B_{correct})$$

d_m is the Desired Mean, R_m is the Red Mean, G_m is the Green Mean, B_m is the Blue Mean and C_{RGB} is the Corrected RGB. The desired mean is calculated based on the each planes separate extracted mean value. The separate mean values are the corresponding R_m,G_m and B_m. Each plane is corrected with its desired mean value. Because each planes is varied in its mean values. Those corrected planes are $R_{correct}$, $G_{correct}$ and $B_{correct}$. Based upon combining the corrected planes the corrected RGB image is evaluated.

*Input: Pre-processed image matrix **A***
Output: Segmented(Vessel Extracted) image
Step 1: Consider **A** matrix with window sizing
Step 2: Consider elements in window as 3x3 mask
Step 3: Find the **x, y** derivatives
Step 4: Find the Gradients such as S_x^2 and S_y^2
Step 5: Calculate the gradient magnitude **G**
Step 6: Repeat step 2-5 done for the whole image

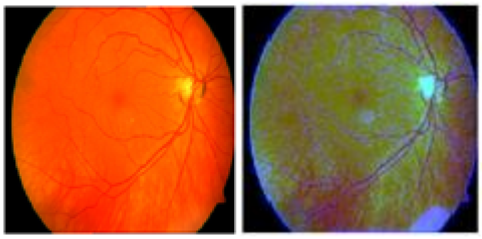

Fig. 4 Colour normalization for image in the set

In fig.4 the colour normalization is described which the illuminant equalized image and its corresponding colour normalized image. The normalization is kept by the each planes.

4) *Optic Disc detection:* Next is detecting the Optic Disc (OD)in that branch considers the noiseless retinal image. Optic disc is the area of retina which blood vessels of retina enters and leaves from this optic nerve head. Final step to pre-processing is the Optic Disc Detection (ODD) in the whole retinal image can gather for further analysis. The RGB to gray conversion is the most significant step in the pre-processing. This will provide to continue the ODD process.

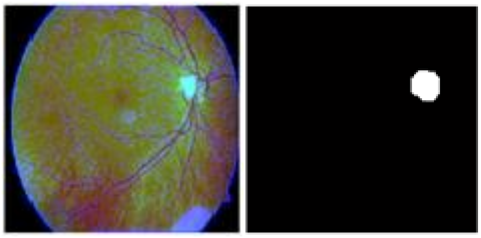

Fig. 5 Localized the optic disc in the normalized image

The grayscale image is used for this part. The morphological based optic disc localization is shown in the figure 5.

B. Segmentation (Vessel Extraction)

The pre-processed retinal image is taken for the purpose of vessel subtraction. Vessel structure alone extracted from the input for the consideration of the further analysis.

1) *Sobel method:* The Sobel edge detection method is the important and initial for the edge based segmentation. Sobel operator was deliberated and employed to find edges in images. Finding edges could also be used as aids by other image segmentation algorithms for refinement of segmentation results. The Sobel filter is a discrete differentiation operator. It is computing an approximation of the gradient of the image intensity function. For image segmentation, Sobel method finds edges using the Sobel approximation to the derivative. Therefore, it precedes the edges at related points where the gradient is highest.

Algorithm for sobel method:

The Sobel kernels can be thought of as 3x3 approximations to first-derivative of Gaussian kernels. Sobel mask generation is the main part of this method. It can be derived on behalf of the 3x3 windowing size. For enhancing the image, the gradient magnitude is added with its.

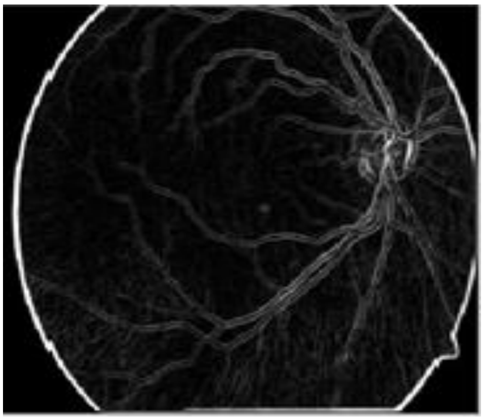

Fig .6 Vessel extracted by the sobel edge detection method

The fig.6 is the part which shows the extracted vasculature by using the sobel edge detection method. This method is implemented with the sobel operator and the gradient magnitude.

2) Kirsch's method: The kirsch's method for edge detection where the edge image (i.e., detected edges) can be regarded as the space gradient. The Kirsch operator can adjust the related threshold value automatically due to the image characteristics. Therefore, the Kirsch gradient operator is chosen to extract the contour of the object(s). The Kirsch edge detection uses eight filters that are applied to given image to detect edges. The eight masks is for relating eight main directions. It computes the gradient by convolution the image with eight template impulse response arrays $M_1 \sim M_8$.Those arrays are depicted as follows,

$$M_0=\begin{bmatrix}5 & 5 & 5\\ -3 & 0 & -3\\ -3 & -3 & -3\end{bmatrix} \quad M_1=\begin{bmatrix}5 & 5 & -3\\ 5 & 0 & -3\\ -3 & -3 & -3\end{bmatrix}$$

$$M_2=\begin{bmatrix}5 & -3 & -3\\ 5 & 0 & -3\\ 5 & -3 & -3\end{bmatrix} \quad M_3=\begin{bmatrix}-3 & -3 & -3\\ 5 & 0 & -3\\ 5 & 5 & -3\end{bmatrix}$$

$$M_4=\begin{bmatrix}-3 & -3 & -3\\ -3 & 0 & -3\\ 5 & 5 & 5\end{bmatrix} \quad M_5=\begin{bmatrix}-3 & -3 & -3\\ -3 & 0 & 5\\ -3 & 5 & 5\end{bmatrix}$$

$$M_6=\begin{bmatrix}-3 & -3 & 5\\ -3 & 0 & 5\\ -3 & -3 & 5\end{bmatrix} \quad M_7=\begin{bmatrix}-3 & 5 & 5\\ -3 & 0 & 5\\ -3 & -3 & -3\end{bmatrix}$$

The templates are evolved with the scaling factor of 1/15.Except the outermost row and the outermost column, every pixel and its eight neighbourhoods' in a given image are convolved with these eight templates, respectively. Every pixel has eight outputs. Also, the maximum output of the eight templates is chosen to be the value in given position. This is defined as the edge magnitude. The vessel from retinal image extracted based on the following algorithm.

Algorithm for the kirsch's method:

Input: Pre-processed image matrix A
Output: Segmented image
Step 1: Define the eight template filter with 3x3 mask
Step 2: Fix the scale factor as 1/15
Step 3: Gradient convolution is calculated for all these templates
Step 4: Choose the maximum of them and apply it
Step 5: Response of the double edge

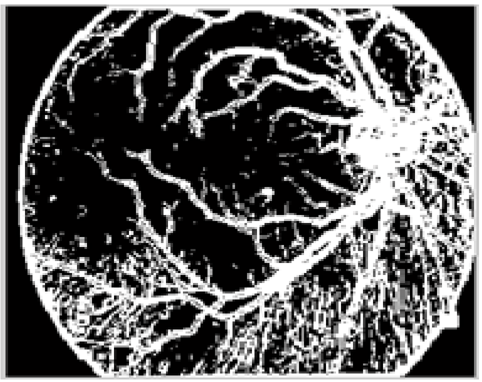

Fig.7 Vessel extracted by the Kirsch's template method

Fig.7 depicts the extracted vessels by using the kirsch's template. This can be producing the better edge continuity with the background noises.

3)Novel detection: This method used to trace edge of the boundary on the image with certain angular orientation and diameter. The boundary tracing is the part of the tracking by the threshold value and those values are corresponding to the intensity of an image. Those tracking area will lead to the dynamic process of pixel tracing with the predermined edge diameter as well as the directional flow of neighbouring pixel. This is known to be poise matrix, will be used for the further scheming. The scheme can be endowed with generation of the credence for each neighbours and the tracing will select the pixel if it have the greater also cross the predetermination. Those values can be chosen for iterating early pixels. The constraints can fix in this scheming based on the truth values such as detection happen if pixel meets the one for marking others assign to be zeros. The process is iterated till the end of the tracking area. The efficient scheming can differentiate small blood vessels as against the background. This automatic method based on confidence matrix and tracking strategy was proposed for producing the best resultant map.

Algorithm for the novel method:

Input: Pre-processed image matrix A
Output: Segmented image
Step 1: Determine the tracking area which to be tracked by the threshold value
Step 2: Initialize the neighbouring pixel and predetermine the diameter
Step 3: Calculate the weight for neighbouring pixel if it exceeds the threshold value then selected or repeat step2
Step 4: Otherwise assign the trust value as 1 for the selected pixels others 0
Step 5: Repeat 2-4 till the end of tracking area.

The subtracted vascular structure considered for the vessel identification.

Fig.8 Vessel extracted by the novel method

The fig.8 shows how well the vessels are extracted using the by using the novel method. This method is producing the better result comparing than the other two methods.

C. Vessel Identification

The vessel structure is considered as the graph. Each starting point is the root node. Each individual vessel tracing is done with global information of bifurcations and crossovers. This identification is part of the binary tree and each binary tree is the individual vessel. The graph tracer algorithm is used for this identification of vessels [13].Here the starting point is the single one for the simultaneous vessel tracing that is the point of the optic disc. The vessels have the complex structure with network effect and it leads to the resultant with ambiguity in vessel identification. So that vessel identification is focused with simultaneous vessel tracing as well as optimal vessel forest finding.

1) *Quantizing:* The process of mapping some large set of values to a smaller set such as rounding values to some unit of precision are known to be the quantizing. It is a many to few mapping and an inherently non-linear and irreversible process. The set of possible input values may be infinitely large and may possibly be continuous and therefore uncountable. The set of possible output values may be finite (or) accountably infinite. The input and output sets involved in quantization can be defined in a rather general way.

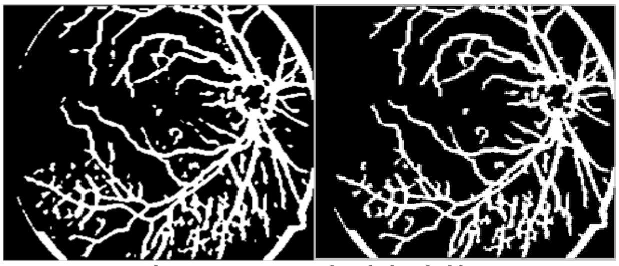

Fig. 9 Vasculature noises removal with thresholding

The background noise removal is the main part in this vessel identification. This noise removal is defined by using the fixed thresholding. Here the non continuity pixels were removed.

2) *Thinning:* The edge pixels make the process into lengthy and tedious in order to make it easy and the edge pixels are made into the single pixels with the morphological parameters. Similarly the inverse process is also involved with this thinning step.

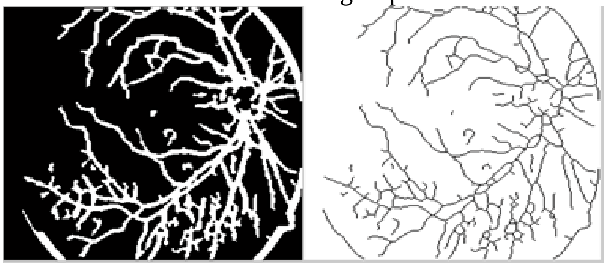

Fig. 10 Vessel thinning for ease of tracing

The Fig.10 shows the segmented image which produces the thinned image for the purpose of the proceeding steps. This thinning is done with the marking of the center pixels in between the edges.

3) *Nodal point fixing:* The computerized algorithm, this provides the temporal and spatial analysis for detecting the patterns and characteristics. The anatomical landmarks are terminals, bifurcations, crossovers. The modified cross point numbering is the method for detecting those landmarks and this part also joint with the simultaneous tracing from the starting point which means from the OD.

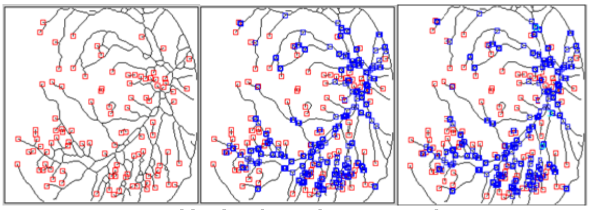

Fig. 11 Anatomical landmarks marking via simultaneous tracing obtained by MCN method

In Fig.11, the certain keynotes are depicted that is the initial terminal end marking, the bifurcation point marking and finally the crossover marking. Terminals are the end pixels of the each blood vessel. Bifurcations are the split point of the same blood vessels. Crossovers are the joining of different blood vessels. The simultaneous vessel tracing as well as the marking of anatomical landmarks marking are done with the modified cross point numbering. The landmarks are used for the analysis of the diseases.

III.Result Analysis

In the pre-processing parts the colour normalization method has the result as follows which the channel wise mean values are shown in the table and the pictorial views also describes the normalization.

TABLE: 1
MEAN VALUE TABLE FOR CERTAIN IMAGES IN SET

Images	Red Channel	Green Channel	Blue Channel	Corrected Mean
IMG_01	88.2	55.2	34.6	59.3
IMG_02	153.9	124.6	116.9	131.8
IMG_03	160.3	86.6	42.4	96.5
IMG_04	184.1	73.0	22.9	93.3
IMG_05	219.3	69.6	1.4	96.8

The Tab:1 is the table which describes the colour normalization with the separate planes mean values and its corrected mean value for the corresponding images based on its desired mean. Normalization is used for enhancing the part of vessels which is present in an image.

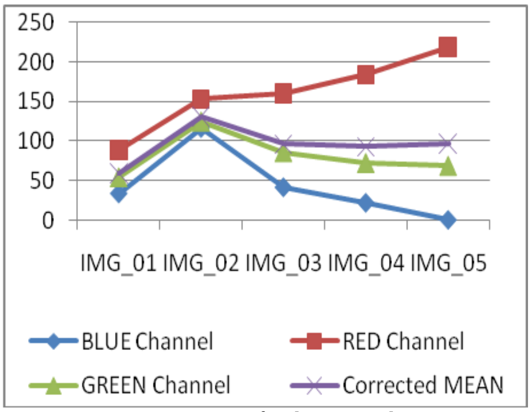

Fig. 12 Representation of Colour normalization

Fig.11 and 12 depicts the mean value for the each channel and the corrected mean value of the images. Desired mean is calculated depends on channel wise mean

Methods	Noise In Background	Edge Continuity	Accuracy	Elapsed Time
Sobel gradient	**Accepted**	**Good**	**Low**	**30sec**
Kirsch's template	**Not accepted**	**Bad**	**Low**	**40sec**
Novel	**Accepted**	**Very Good**	**High**	**15sec**

and that can be used for the correction.

Fig. 13 Comparison of the various segmentation methods

Fig.13 is used to describe the comparisons among the three methods with certain parameters such as accuracy for showing the efficiency, edge continuity on vessels, noises which is also extracted from image and execution time.

TABLE: 2
PERFORMANCE EVALUATIONS OF SEGMENTATION METHODS

The table 2 shows the performance of each method by

Methods	Sensitivity	Specificity
Sobel	**74%**	**93%**
Kirsch's	**73%**	**91%**
Novel method	**80%**	**96%**

the sensitivity and specificity parameter. Results can be quantified by comparing the segmented part against the hand labelled reference images. Sensitivity is the measurement of matching between the different regions in the same image.

IV.Conclusion

Our developed system that could be used by non experts to filtrate cases of patients not affected by disease would reduce the specialist's workload and increase the effectiveness of preventive protocols and easy therapeutic treatments. It results in economic benefits for public health systems since cost effective treatments associated to early illness detection lead to remarkable cost savings. The system which covers the step such as pre-processing for denoising the acquired image, segmentation for vessel extraction with the robust novel technique and vessel identification with the nodal point fixing based on the nodal point fixing. Our proposed methods provide robust vessel identification and also the scalable. The future work will be extend with disease detection on the vasculature parts and also the types of the diseases.

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