Segmentation of Blood Vessel in Retinal Images and Detection of Glaucoma using BWAREA and SVM

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ABSTRACT

Segmentation is one of the most important processes in Digital Image Processing. Segmentation means divide or partition an image into multiple parts. Image segmentation is used to segment the parts of the image for processing. The glaucoma disease directly affects the optic nerve, and it becomes blindness. Blindness is an increasing disease of all over the world. If this eye diseases were detected earlier mean the blindness can be avoided at the earliest stage. Blood vessel segmentation can perform an important role in the diagnosis and treatment of different cardiovascular and ophthalmologist diseases. The main aim of this work is detection of glaucoma. In this research work, the segmentation of blood vessels and detection of glaucoma is done by using Black and White Area (BWAREA) method. The experimental results are evaluated such as accuracy, sensitivity and specificity.

Keywords: Segmentation, Mean filter, Morphological operation, BWAREA and SVM.

I. INTRODUCTION

Images are a way of recording and presenting information in a visual form. Image processing is a collection of techniques for handling the digital images by computers. A digital image is collection of limited number of elements called pixels. Each pixel has a particular location and value. Image processing is normally used in different fields like communication, medicine, remote sensing, forensics, automobiles, satellite television, research and technology and so on. The different components of an image processing system include image acquisition, image storage, image compression, image enhancement, image processing and display.The blood vessels in the retinal image should be segmented and analyzed to get an idea of the disease affecting the eye like glaucoma and diabetic retinopathy. Glaucoma is a complicated disease. Glaucoma patients have an elevated Intra Ocular Pressure (IOP). Normal Intra Ocular Pressure (IOP) is considered in millimeters of mercury and can range from 10-21 mm Hg. An elevated Intra Ocular Pressure (IOP) is the most important risk problem for the development of glaucoma. The glaucoma disease directly affects the optic nerve, and it becomes blindness. Blindness is an

increasing disease of all over the world. If this eye diseases were detected earlier mean the blindness can be avoided at the earliest stage. Segmentation of blood vessel can perform an important role in the diagnosis and treatment of different cardiovascular and ophthalmologist diseases. In this research work image segmentation techniques are used to detect the blood vessel and glaucoma disease. The first step, preprocessing is used to extract the green channel. Then the morphological operation is used to find blood vessels and mean filter is used to remove the noise from the image. And BWAREA (Black and White Area) method is used to calculate the area of blood vessels. Finally Support Vector Machine (SVM) classifier is used to detect the glaucoma or normal eye and achieve the performance evaluation for accuracy, sensitivity and specificity.

II. SYSTEM ARCHITECTURE

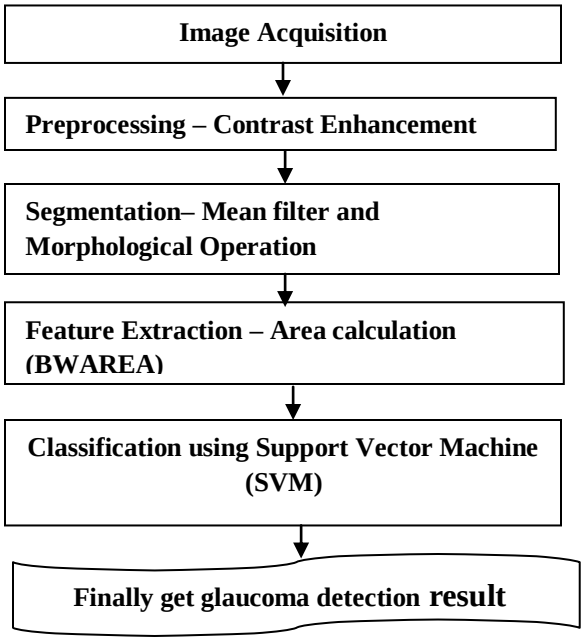

Figure 3.1 System Architecture

CONTRAST ENHANCEMENT

The preprocessing step is used to extract the green channel from the test image. After the green channel is extracted, image enhancement is performed. Image enhancement involve contrast enhancement. Contrast is the difference between the maximum and minimum pixel intensities. Contrast enhancement increases the visibility of the image. Contrast adjustment is done by scaling all the pixels of the image by a constant k. it is given by

$$g[m, n] = f[m, n] * k \quad ①$$

Changing the contrast of an image, changes the range of luminance values present in the image. Specifying a value above 1 will increase the contrast by making bright samples brighter and dark samples darker, thus expanding on the range used. A value below 1 will do the opposite and reduce a smaller range of sample values.

MORPHOLOGICAL OPENING

In segmentation the optic disk is removed from enhanced retinal image by using morphological operation. Finally binarization method is explored for segment the blood vessels and small noises are removed by morphological open process. Opening is based on the morphological operations, erosion and dilation. The opening operation is used to remove noise and charge-coupled devices (CCD) defects in the images. The opening process can be mathematically represented as

$$X \circ B = (X \ominus B) \oplus B \quad ②$$

Where X is an input image and B is a structuring element.

MEAN FILTER

The mean filter is also known as averaging filter. The mean filter replaces each pixel by the average of all the values in the local neighborhood. The size of the neighborhood controls the amount of filtering. In a spatial averaging operation, each pixel is replaced by a weighted average of its neighborhood pixels. The 3 by 3 spatial mask which can perform the averaging operation is given below,

$$3 \text{ by } 3 \text{ mask} = 1/9 \times \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

The mean filter preserves the smooth region in the image and it removes the sharp variations leading to blurring effect. The mean filter is used for remove the noise in image that increases the segmentation accuracy.

BLACK AND WHITE AREA (BWAREA)

In feature selection method that is calculate the area of blood vessels for total segmented image using math calculation Black and White Area (BWAREA).

Area = bwarea ((bw1))

Syntax

Total = bwarea (bw)

BW estimates the area of the objects in binary image.

Total is a scalar whose value corresponds roughly to the total number of on pixels in the image, but might not be exactly the same because different shapes of pixels are weighted differently. There are six different shapes, each representing a different area,

- Shapes with zero on pixels (area = 0)
- Shapes with one on pixel (area = 1/4)
- Shapes with two adjacent on pixels (area = 1/2)
- Shapes with two diagonal on pixels (area = 3/4)
- Shapes with three on pixels (area = 7/8)
- Shapes with all four on pixels (area = 1)

SUPPORT VECTOR MACHINE (SVM)

The Support Vector Machine (SVM) classifier is used for find the given input image is glaucoma or normal eye and it is used to calculate the total segmented area to provide a better accuracy, sensitivity and specificity values the given image. The purpose of SVM is used to improve the performance evaluation for the segmentation of blood vessels in retinal images and detection of glaucoma.

III. EXPERIMENTAL RESULTS

PERFORMANCE EVALUATION

In the evaluation metrics, Confusion matrix is evaluated to make decision that can be made by classifier. Consider a confusion matrix illustrated in Table 1.1.

Table 1.1 Confusion Matrix

Actual	**Predicted Eye**	
	Normal	Glaucoma
Normal	TP	FN
Glaucoma	FP	TN

- TP (True Positive) represents the number of normal eye are correctly classified.
- FN (False Negative) refers to the number of glaucoma eye are misclassified as normal eye.
- FP (False Positive) expresses the number of normal eye misclassified as glaucoma eye.
- TN (True Negative) refers the number of glaucoma eye are correctly classified.

EVALUATION METRICS

To measure the accuracy and specificity values. The confusion matrix of existing and proposed work, the accuracy and specificity are calculated which is shown in the Table 1.2.

Table 1.2 Evaluation Metrics

Measure	Description
Accuracy	(TP+TN)/(TP+TN+FP+FN)
Sensitivity	TN/(TN+FP)
Specificity	TP/(TP+FN)

Nearly 50 normal and glaucoma retinal images are collected from High-Resolution Fund us (HRF). Figure 1.1 shows the sample images in the database.

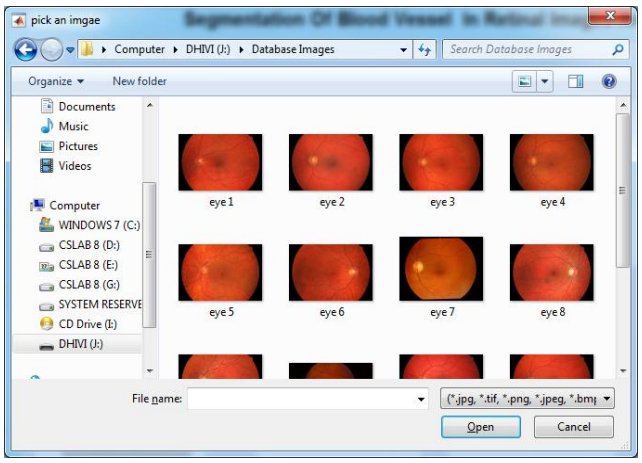

Figure 1.1 Retinal Image Database

The second step is preprocessing. It is used to extract the green channel and contrast enhanced image. Figure 1.2 shows the preprocessed image.

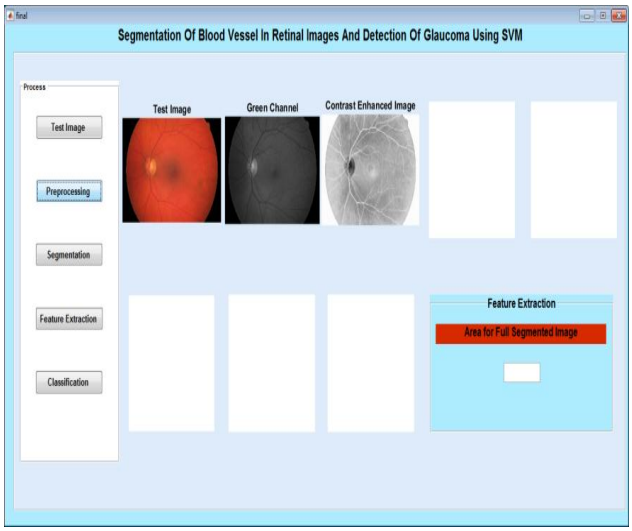

Figure 1.2 Preprocessing Image

The next level is segmentation. Segmentation is used to morphological operation and mean filter are to segment the blood vessels. Figure 1.3 shows the segmented image.

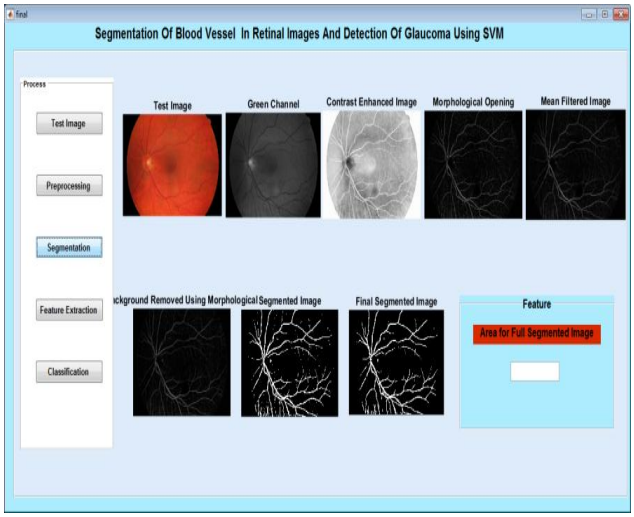

Figure 1.3 Segmentation Image

The feature extraction is another step. The feature extraction is used to calculate the full segmented area for using Black and White area (BWAREA) method. Figure 1.4 shows the feature area calculation.

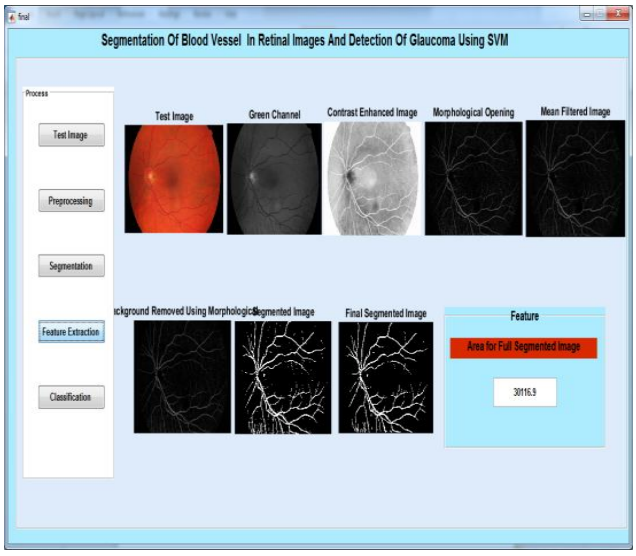

Figure 1.4 Featuer Area Calculation

The final step is SVM classification using performance evaluation for accuracy, sensitivity, and specificity. Figure 1.5 shows the performence evaluation.

Figure 1.5 Classification

RESULT ANALYSIS

The Inferior Superior Nasal Temporal (ISNT) method is used to calculate the area for segmented blood vessels. The ISNT ratio values are calculated using ten retinal images. Table 1.3 shows the ISNT ratio values. The experimental result shows ISNT ratio for normal eye is 1.9 ± 2.4 and for glaucoma eye is 1.6 ± 1.8.

Table 1.3 ISNT Ratio Values

S.No	Image	ISNT- Ratio	Detected Eye
1	Image 1	1.61284	Glaucoma Eye
2	Image 2	1.85949	Glaucoma Eye
3	Image 3	1.8544	Glaucoma Eye
4	Image 4	1.67907	Glaucoma Eye
5	Image 5	1.64486	Glaucoma Eye
6	Image 6	1.93839	Normal Eye
7	Image 7	1.97705	Normal Eye
8	Image 8	2.32681	Normal Eye
9	Image 9	2.14572	Normal Eye
10	Image 10	2.1629	Normal Eye

TheBWAREA (Black and White Area) method is used to calculate the area for total segmented blood vessels. The BWAREA values are calculated using ten retinal images. Table 1.4 shows the BWAREA values. The experimental result shows BWAREA method used for normal eye is 3.1 ± 4.4 and for glaucoma eye is 2.6 ± 3.0.

Table 1.4 BWAREA Values

SNO	Image	BWAREA	Detected Eye
1	Image 1	26321.3	Glaucoma Eye
2	Image 2	26570.9	Glaucoma Eye
3	Image 3	24339.3	Glaucoma Eye
4	Image 4	25050.3	Glaucoma Eye
5	Image 5	28859.1	Glaucoma Eye
6	Image 6	30116.9	Normal Eye
7	Image 7	31793.9	Normal Eye
8	Image 8	44886.5	Normal Eye
9	Image 9	30788	Normal Eye
10	Image10	29901.4	Normal Eye

The comparison between the Inferior Superior Nasal Temporal (ISNT) method and BWAREA (Black and White Area) method is used area calculation for segmented blood vessels. The table 1.5 shows the ISNT and BWAREA comparison values.

Table 1.5 ISNT and BWAREA Comparison Values

SNO	Image	ISNT-Ratio	BWAREA	Detected Eye
1	Image 1	1.61284	30116.9	Glaucoma Eye
2	Image 2	1.85949	26570.9	Glaucoma Eye
3	Image 3	1.8544	24339.3	Glaucoma Eye
4	Image 4	1.67907	25050.3	Glaucoma Eye
5	Image 5	1.64486	29859.1	Glaucoma Eye
6	Image 6	1.73839	26321.3	Normal Eye
7	Image 7	1.87705	31793.9	Normal Eye
8	Image 8	2.32681	44886.5	Normal Eye
9	Image 9	2.14572	30788	Normal Eye
10	Image 10	2.1629	29901.4	Normal Eye

Result analysis is based on the confusion matrix of ISNT and BWAREA method, the accuracy, sensitivity and specificity are calculated which is shown in the Table 1.6

Table 1.6 Performance Evaluation Metrics

Method	**Accuracy**	**Sensitivity**	**Specificity**
ISNT	85.7143	79	92.8571
BWAREA	92.8571	85.7143	100

In the figure 1.6 the accuracy, sensitivity and specificity values for ISNT are plotted based on Table 1.6.

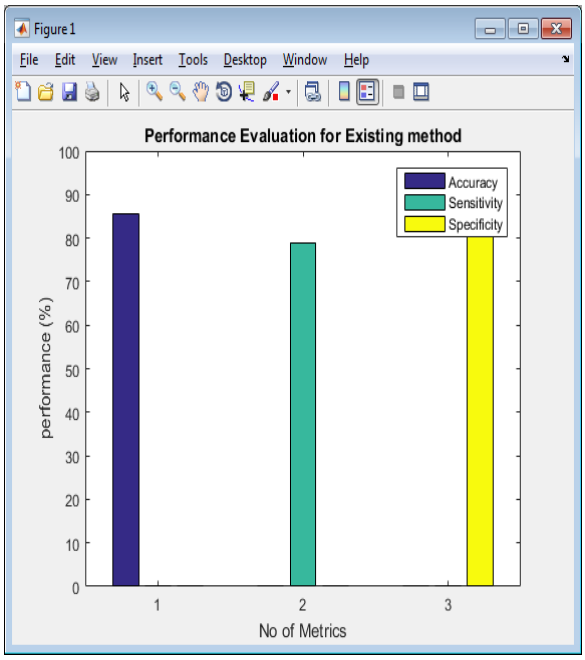

Figure 1.6 Performance Evaluation for (ISNT) Using SVM

In the figure 1.7 the accuracy, sensitivity and specificity values for BWAREA algorithm are plotted based on Table 1.6.

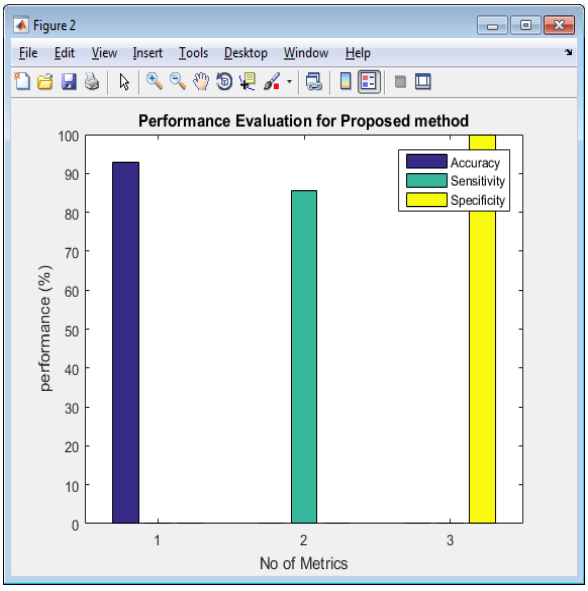

Figure 1.7 Performance Evaluations for BWAREA Using SVM

IV. CONCLUSION AND FUTURE WORK

The retinal images are used for the proposed method is collected from High-Resolution Fund us (HRF) database. Glaucoma is a chronic eye disease which is the cause of irrevocable blindness. So it is important to detect glaucoma at the earliest to control it to a certain extent. In order to detect glaucoma, the first step is preprocessing is used to extract the green channel. And then segmentation of blood vessels is another step for using mean filter and morphological operation. The experimental results show that the BWAREA method will be in the range 3.1± 4.4 for normal persons and 2.6 ± 3.0 for glaucoma affected patients. Finally SVM provides to distinguish Glaucoma from normal eye and also achieve accuracy, sensitivity, specificity is better than existing method. In this research BWAREA method provides better result than the ISNT.

This research work can be enhanced in the future with the following scopes:

- Artificial Neural Network (ANN) classification method can be implemented to enhance the prediction accuracy.
- Threshold based segmentation methods can be implemented to enhance the segmentation accuracy.

V. REFERENCES

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