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Glaucoma Detection And Segmentation Using Retinal Images

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***Abstract*— Glaucoma is an eye disease .It is detected from retinal images using some classifiers like Support vector machine, random forest, Dual sequential minimal optimization, Naïve bayes and artificial neural networks. Some features are obtained from retinal images using 2D-DWT. These features are used for classification. Different wavelet features are obtained from the three filters symlets (sym3), daubechies (db3) and biorthogonal (bio 3.3,bio 3.5,bio 3.7) wavelet filters. These features are used for classifying and detecting normal and glaucomatous retinal images.The glaucomated retinal image is then threshold based segmented to highlight the affected portion.**

***Index Terms*— DWT, Feature extraction, Glaucoma, Segmentation**

I. INTRODUCTION

Glaucoma is a leading cause of blindness in the world .It occurs due to damage of eye's optic nerve. The damage to the optic nerve is due to the increased pressure inside the eye. The optic nerve carry the information from retina to brain. The intraocular pressure is due to malfunction of the drainage system of the eye. A clear liquid flow in and out of the eye is essential. The liquid is called acqueous humour, if it cannot drain properly immense pressure arise inside the eye. This pressure damages the optic nerve. The goal of the paper is to develop an algorithm that automatically classify normal eye images and diseased glaucoma eye images and also segment the affected portion[1]-[4].

Features extracted from retinal images are used for classification. Here discrete wavelet transform using daubechies, symlets and biorthogonal wavelets are used to extract features.Wavelet energy signatures are calculated from these extracted features. SVM, SMO, Random forest, Naïve bayes and ANN classifiers are used to classify images as normal or abnormal eye images. Then find out which classifier is good in accuracy for finding out the glaucomatous or normal retinal images.And finally segmentation is done on each glaucomated retinal image.

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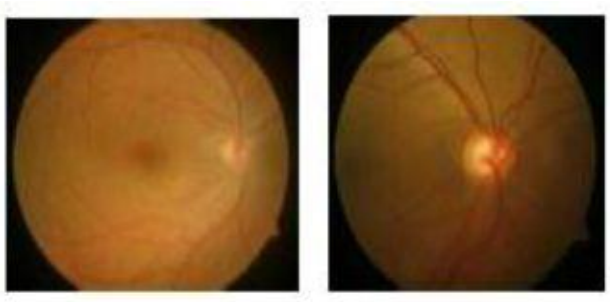


(a) (b)

Fig 1. (a) Normal retinal image and (b) Glaucomated retinal image

II. MATERIAL USED

The retinal images were collected from the web database, which manually curated the images based on the quality and usability of samples. The images grouped in to a set of normal retina images and a set of images diagnosed with glaucoma. All images were taken with a resolution of 560x720 pixel and stored in JPEG format. The dataset contains 30 fundus retinal images. The 30 retinal images consist of 15 normal and 15 glaucomatous images collected from database. The fundus camera, a microscope and a light source are used to captutre the retinal images to diagnose diseases.

III. METHODOLOGY

Retina image classification is based on these methods. They are using different tech- niques to classify image and then predict as glaucomated or normal retina images.

- Image capture
- Feature extraction
- Image classification

A. Image Capture

The first stage is image capture i.e, download the retinal image from the image database. This is normally captured by a fundal camera having back-mounted digital camera. Image was stored in 560x720 pixel JPEG format

B. Feature Extraction

Different features of the retinal image are extracted using 2D-DWT. Here DWT uses the daubechies(db3), the symlets

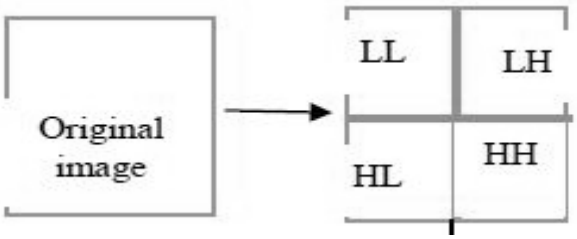


Fig 2.2D-DWT applied on an image

and the biorthogonal(bio3.3,bio3.5 and bio3.7) three wavelet filters is used to extract features. The process will decompose the input image in to a series of subband images. The wavelet features of an image are obtained by wavelet decomposition. Let each image be represented as a pxq gray scale matrix I[I,j],where each element of the matrix represents the gray scale intensity of one pixel of the image. On applying first level 2D-DWT to the image then four transform coefficient sets like LL,HL,LH and HH are created. Such decomposition is performed recursively on LL approximation coefficients obtained at each level, until necessary iterations are reached[5]. This decomposition process can be represented in the square scheme as shown in Fig 2.

The 2-D DWT is used to extract the energy features. The DWT is applied to three different filters daubechies (db3), symlets (sym3) and biorthogonal (bio3.3, bio3.5, bio3.7). With the help of these filters, obtain the wavelet coefficients.Since the number of elements in the matrices is high, and only need a single number as a feature, we employ averaging methods to determine single valued features.The definitions of three features that determined using DWT coefficients are in order. Equation (1) and (2) determine the averages of corresponding intensity values, whereas (3) is an averaging of energy of intensity values[6]. Thus wavelet coefficients which are subject to average and energy calculation results in feature extraction.

$$\text{Average Dv1} = \frac{1}{p \times q} \sum_{x=\{p\}} \sum_{y=\{q\}} |Dv1(x,y)| \quad (1)$$

$$\text{Average Dh1} = \frac{1}{p \times q} \sum_{x=\{p\}} \sum_{y=\{q\}} |Dh1(x,y)| \quad (2)$$

$$\text{Energy} = \frac{1}{p^2 \times q^2} \sum_{x=\{p\}} \sum_{y=\{q\}} (Dv1(x,y))^2 \quad (3)$$

C. Image Classification

Using the classified values obtained the energy signature values obtained after feature extraction were used to classify the retinal images which falls in glaucomatous and normal image values. For training the data set with the values available, classifiers like SVM, naïve bayes, random forest, SMO and ANN are used.

Support vector machine (SVM) is a large-margin classifier that comes under machine learning. That contain an algorithm and using that checks the data and finds some patterns existing in between.

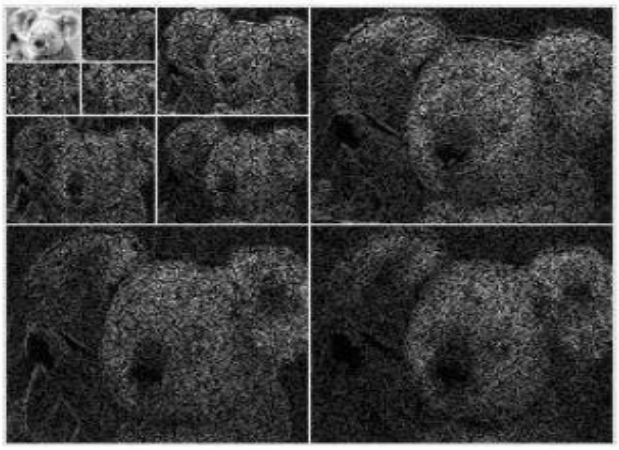


Fig 3.Three level decomposition for 2D-DWT

SVM training algorithm constructs a model that assigns the new training example into one of the classes. i.e. glaucomated or normal image.

Dual sequential minimal optimization (SMO) is an algorithm finding a linear separator by changing the weights of misclassified examples. Dual SMO performs far better than normal SMO in computational time.

Random forests classification technique, it make use of large number of decision trees at the time of training. For a new training example it constructs a group of decision trees using the training data and outputs the class which comes most often in the outputs retained by all trees.

Naive bayes classifier, it use bayes theorem for finding conditional probability that train the available data set. It assumes that existence or absence of any feature of class is not related to the existence or absence of any other feature.

Artificial neural networks (ANNs), it is a simple mathematical neural network model which comes under machine learning. A set of learning algorithms are used to evaluate functions which depends on many inputs that are unknown. Artificial neural networks are a collection of connected neurons. Mainly used in pattern recognition and classification.In artificial neural network, image classification and training for classifying whether the retinal image is glaucomatous or not, is defined with a collection of input neurons which are activated by the pixels of the input retinal image. Then it is weighted and transformed by a function changing the weights and parameters (number of neurons) involved. By that finds the members of the class obtained. Finally it finds in which class the function belong to. This determines whether the image belong to glaucoma affected or not glaucoma affected.

IV. PERFORMANCE MEASUREMENT

After training the classifiers each retinal image is fed to each classifier SVM, random forest, naïve bayes, SMO and ANN. Finding which classifier detects the galucomated and normal retinal image accurately using performance measures like accuracy, precision, sensitivity and specificity[8].

True positive (TP): Number of glaucomated retinal images correctly diagnosed as glaucomated.

False positive (FP): Number of normal (i.e. not glaucoma affected) retinal images incorrectly identified as glaucomated.

True negative (TN): Number of normal retinal images correctly identified as normal.

False negative (FN): Number of glaucomated retinal images incorrectly identified as normal.

Sensitivity or true positive rate
(TPR)=TP/ (TP+FN)

Specificity (SPC) or true negative rate
SPC=TN/ (FP+TN)

Precision or positive predictive value (PPV)
PPV=TP/ (TP+FP)

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

V. SEGMENTATION

Segmentation partitions an image into distinct regions containing each pixels with similar attributes. To be meaningful and useful for image analysis and interpretation, the regions should strongly relate to depicted objects or features of interest.

One of the simplest way of image segmentation is called the thresholding method. This method is based on the threshold value to turn a gray-scale image to a binary image. The key is to select the threshold value.The design steps of threshold segmentation is mentioned below

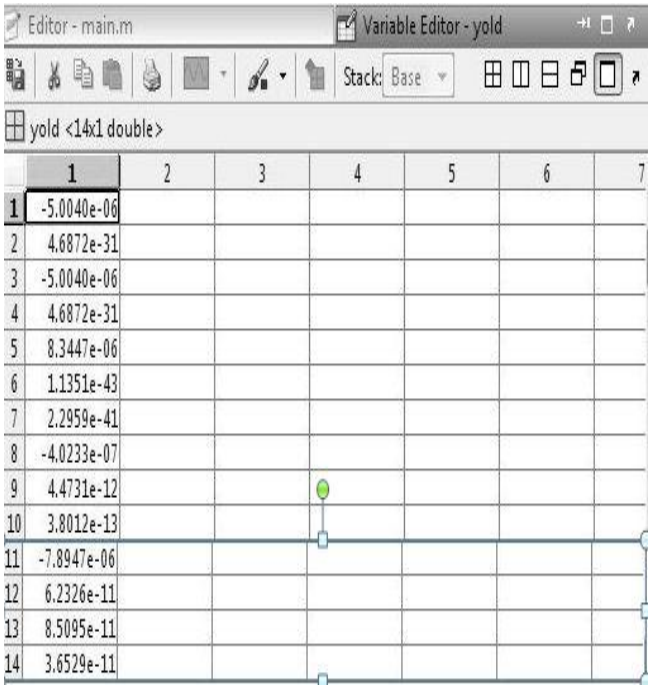
- Set the initial threshold T= (the maximum value of the image brightness + the minimum value of the image brightness)/2.
- Using T segment image to get two sets of pixels B (all the pixel values are less than T) and N (all the pixel values are greater than T).
- The N values obtained are used to highlight the segmented portion by gray to binary conversion and an edge detection algorithm is used.

VI. RESULTS

The following section provides the results obtained from feature extraction, Classification, performance measurement and segmentation

D. Feature Extraction Results

Feature extraction using 2-D DWT a total of 30 retinal images were used out of which 15 glaucomated images and 15 normal images. The values got for features sym3, db3, bio3.3, bio3.5, and bio3.7 for each classifier were recorded



	1	2	3	4	5	6	7
1	-5.0040e-06						
2	4.6872e-31						
3	-5.0040e-06						
4	4.6872e-31						
5	8.3447e-06						
6	1.1351e-43						
7	2.2959e-41						
8	-4.0233e-07						
9	4.4731e-12						
10	3.8012e-13						
11	-7.8947e-06						
12	6.2326e-11						
13	8.5095e-11						
14	3.6529e-11						

Figure4.14 Feature extracted for a single image

and it is used for classification.Fig 4 shows the screenshot of the workspace obtained after feature extraction of an image.

E. Classification Results

The extracted features are used for training the system that is the classifiers like SMO, random forest, naïve bayes, SVM and ANN. Fig 5 & Fig 6 shows classification result for the retinal images are classified as "glaucoma detected" or "glaucoma not detected"

Fig 5. Glaucoma detected for a retinal image

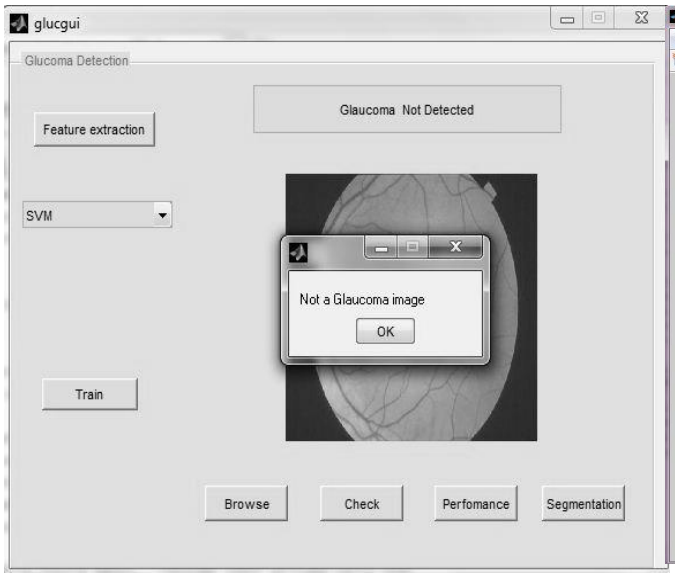


Fig 6. Glaucoma not detected for a retinal image

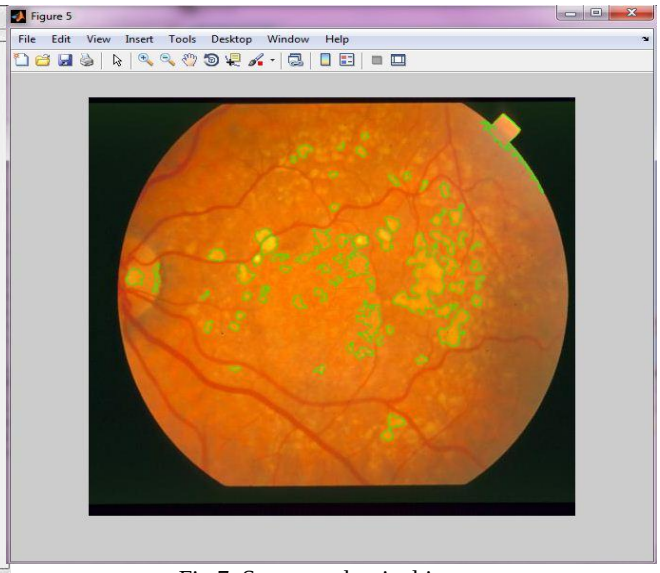


Fig 7. Segmented retinal image

F. *Performance Results*

In this approach, we have considered 30 retinal images both normal and glaucoma eye.Out of that 15 were normal retinal images and the remaining 15 were glaucomatous images. Results are presented in Table 1.

G. *Segmentation Results*

The glaucoma affected portion in the retinal image is threshold based segmented and shown in Fig 7. On clicking segmentation button in gui ,segmented image is obtained for glaucomated retinal image.

Table 1.Performance table

Classifier	Sensitivity	Specificity	PPV	Accuracy
SVM	86.66	85.66	85.6	85.66
SMO	85.66	85	85	85
Random forest	88.8	87.6	87.6	86
Naïve bayes	86.66	80	80	81
ANN	91.1	90.1	90.1	91.1

VII. CONCLUSION

In this paper, a wavelet-based texture feature set has been used. The texture feature set is made up of the energy of sub images. Wavelet transform is an efficient tool for feature extraction and they are successfully used in biomedical image processing. Classification technique is developed to detect whether glaucoma is present or not. Segmentation is done to highlight the glaucoma affected portion. If more powerful classifiers used, classification accuracy may further be improved.

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