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Glaucoma Detection Based on Wavelet Transform using Fundus Images

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ABSTRACT: Glaucoma is detected in the early stage of the diseases by identifying the intensity variation in the Retinal Nerve Fiber Layer(RNFL).The variation in the intensity was evaluated by calculating the wavelet filters (namely db3,sym3,rbio3.3,rbio3.5 and rbio3.7) coefficient and is obtained by using 2-D Discrete Wavelet Transform(DWT). DWT is good reproducibility in normal fundus images and most popular transformation technique. The proposed system is used to extract different features (namely Average Dh1,Average Dv1 and Energy) for the identification of glaucoma by using the red-free fundus images.

KEYWORDS: Biomedical optical imaging, feature extraction, glaucoma, Retinal Nerve Fiber Layer (RNFL), Image texture, Wavelet Transforms (WT).

I. INTRODUCTION

Glaucoma is a group of eye disease that gradually steal eye sight without warning. In the early stages of the disease, there may be no symptoms and its estimated that half of the people affected by glaucoma may not know that they have it. Vision loss is caused by damage to the optic nerve and its acts like an electrical cable with over a million wires. It is responsible for carrying images from the eye to the brain.It is disease of the optic nerve involving loss of retinal ganglion cells then, Initially high pressure within the eye also known as Intraocular Eye Pressure (IOP). IOP is the main cause of this optic nerve damage. Although IOP is clearly a risk factor we now know that other factors must also be involved because even people with “normal” levels of pressure can experience vision loss from glaucoma.

To detect the glaucoma to extract energy signatures obtained using 2-D discrete wavelet transform , and subject these signatures to different features ranking and feature selection methods[1].To detect the glaucoma by using feature and Higher Order Spectra(HOS) features from digital fundus images and choosing better features and classifiers[2].In this paper, the dependence between features extracted from wavelet decomposition is investigated and incorporated into subband selection for classification[3]. Spectal domain – Optical coherence tomography(OCT) offers improved performance interms of reproducibility[4]. OCT provides structural information and is fast, requires no preparation of the patient, and the output is immediately available[5]. A larger dataset is required for validating the results in this preliminary study and is being collected[6]. Chi2 is a useful and reliable tool for discretization and feature selection of numeric attributes[7]. The concept of Discrete Wavelet Transform(DWT) is presented for applying to textured images for decomposing them into detail and approximation regions[8]. Detection of ocular glaucoma based on the characterization of global flash multifocal electro-retinography(mfERG) images and it can be useful in the detection of advanced stage glaucoma[9]. Further study is necessary to determine whether the unique strengths of the Proper Orthogonal Decomposition(POD) frame work can significantly improve the diagnostic accuracy of the method[10].

II. DATASET

The retinal images used for this study were collected from the Lotus Eye Care Hospital, Tamilnadu, India (http://www.eyelotusrsp.com). All the images were taken with a resolution of 2196 × 1958 The images were acquired using a Canon CR5 non-mydriatic 3CCD camera with a 45 degree field of view (FOV). The database contains 100 fundus images: 50 normal and 50 open angle glaucomatous images from 20 to 70 year-old

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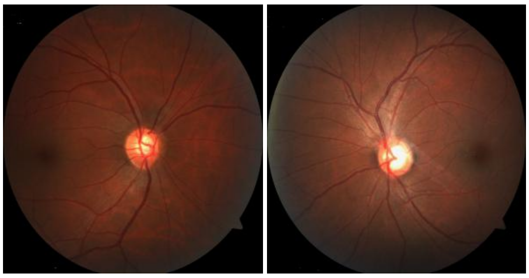
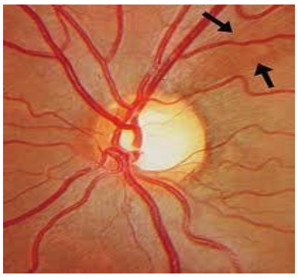
subjects. The fundus camera, a microscope, and a light source were used to acquire the retinal images to diagnose. Fig 1(a),1(b) and 1(c) presents typical normal, glaucoma and RNFL fundus images respectively.

All images in ZEISS database are digitized using a Cannon CR5 non-mydriatic 3CCD camera with a 45 degree field of view. Each image is captured using 24-bits per pixel.



(a) (b)



(c)

Fig.1. Typical fundus images (a) normal (b) glaucoma (c) rnfl image. In glaucoma, the pressure within the eye's vitreous chamber rises and compromises the blood vessels of the optic nerve head, leading to eventual permanent loss of axons of the vital ganglion cells.

III.METHODOLOGY

The images in the dataset were subjected to standard histogram equalization . The objective of applying histogram equalization was twofold: to assign the intensity values of pixels in the input

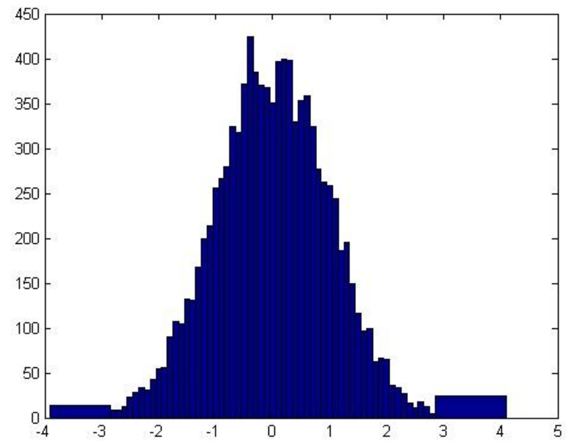


Fig.2. Histogram Equalization

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image, such that the output image contained a uniform distribution of intensities, and to increase the dynamic range of the histogram of an image. The following detailed procedure was then employed as the feature extraction procedure on all the images before proceeding to the feature ranking and feature selection schemes.

A) Wavelet Transform-Based Features

Wavelet transform to separate low and high frequency and its image is reprecented in terms of frequency .Decomposition method used by 2-D Discrete Wavelet Transform (DWT) and its find to extract low frequency.

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

$$\text{AverageDv1} = \frac{1}{p \times q} \sum_{x=\{p\}} \sum_{y=\{q\}} \left|\text{Dv1}(x, y)\right| \quad (2)$$

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

DWT is multiscale analysis method and its have two co-efficints

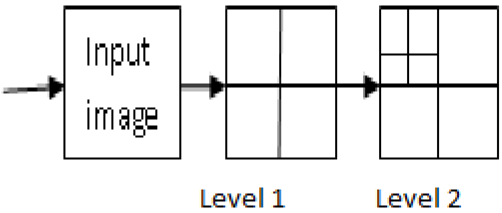

Fig 3.Multiscale analysis method

i) Detailed co-efficients
ii) Approximation co-efficients.

In the orthogonal wavelet decomposition procedure, the generic step splits the approximation coefficients into two parts. After splitting we obtain a vector of approximation coefficients and a vector of detail coefficients, both at a coarser scale. The information lost between two successive approximations is captured in the detail coefficients. Then the next step consists of splitting the new approximation coefficient vector, successive details are never reanalyzed.

In the corresponding wavelet packet situation, each detail coefficient vector is also decomposed into two parts using the same approach as in approximation vector splitting. This offers the richest analysis. The complete binary tree is produced in the one-dimensional case or a quaternary tree in the two-dimensional case.

B) Preprocessing of Features

Preprocessing step is done to enhance the fundus image. Color image processed to grey value (ie) RGB to grey level. The image is preprocessed to remove the noise and improve the accuracy.

The digital colour retinal images required for the development of automatic system for maculopathy detection are provided by the Department of opthamology and following different preprocesing techingues

i) Color enhancement
ii) Color normalization
iii) Fundus mask detection

Color normalization is necessary due to the significant inter and intra image variability in the colour of the retina in different patients. There can also be, differences in skin pigmentation, aging of the patient and iris colour between different patients that affect the colour of the retinal image. Colour normalization method is applied to make the images invariant with respect to the background pigmentation variation between individuals. The

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colour normalization is performed using histogram matching (Gonzalez and Woods 2004).

The color enhancement techniques are aimed at altering the visual appearance that makes an object distinguishable from other objects and the background. Usually retinal images acquired using standard clinical protocols often exhibit low contrast and may contain photographic artifacts. Also, it can be seen that retinal image contrast is decreased as the distance of a pixel from the centre of the image increases. In the current work this preprocessing step is applied to retinal images after the colour normalization.

The mask is a binary image with the same resolution as that of fundus image whose positive pixels correspond to the foreground area. It is important to separate the fundus from its background so that the further processing is only performed for the fundus and not interfered by pixels belonging to the background. In a fundus mask, pixels belonging to the fundus are marked with ones and the background of the fundus with zeros.

IV. WAVELET SEGMENTATION SYSTEM

The steps involved in wavelet segmentation and
The main objective of segmentation is to group the image into regions with same property or characteristics. It plays a major role in image analysis system by facilitating the description of anatomical structures and other regions of interest. shown in Fig. 4.Here, texture mosaic images of size N×N are considered. The analysis is carried out by considering sub-images (i.e., block) of size 32×32. Each 32×32 sub-image, taken from top left corner of the original image, is decomposed using one level DWT and co-occurrence matrices (C) are derived for sub-image and detail sub-bands (i.e., LH1,HL1 & HH1 sub-bands) of wavelet decomposed sub-image. In our implementation, the contrast feature values, calculated over all the blocks, are subjected to linear normalization in the scale of 0–255, while the cluster shade and cluster prominence features, which found to have very large dynamic ranges, are subjected to logarithmic normalization in the scale of 0–255 for computational simplicity, without affecting their original variations. A necessary initial step in applying shape analysis to retinal blood vessels is to segment the blood vessels from the background. A supervised approach for vessel segmentation based on the continuous wavelet transform (DWT) in which has been shown to outperform other state-of-the-art methods with respect to receiver-operating-characteristic (ROC) analysis on public retinal image databases.

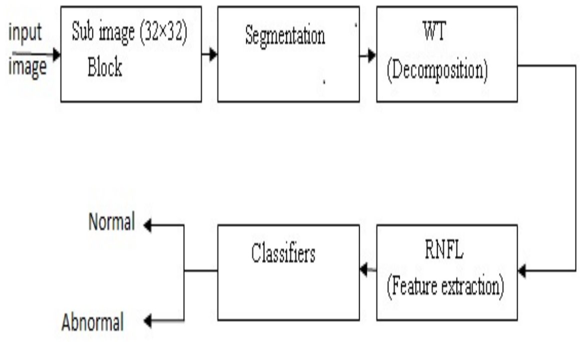

Fig.4. Wavelet segmentation system

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V. FEATURE EXTRACTION AND CLASSIFIERS

To extracted from RNFL images produced by very high accuracy and removed by the blurred image. The images are segmented and the features are extracted and features were proposed, based partly on observation of the characteristics human observers use to recognize abnormal vessels, such as their shape, position, orientation, brightness, contrast and line density.

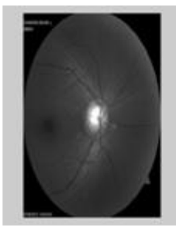
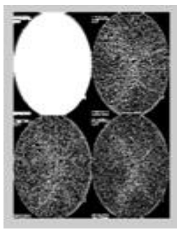
Two classifiers are
- i) Support Vector Machine
- ii)Artificial Neural Network

Using classification technique–classify image as normal or abnormal. Some of the classification techniques are Super Vector Machine(SVM) and Artificial Neural Network(ANN). A Support Vector Machine (SVM) performs classification by constructing an N-dimensional hyperplane that optimally separates the data into two categories. SVM models are closely related to neural networks. In fact, a SVM model using a sigmoid kernel function is equivalent to a two-layer, perceptron neural network. The neural network used for rotor fault diagnosis consists of one hidden layer and one output layer.

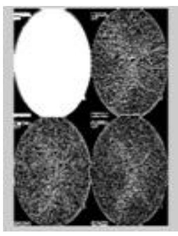
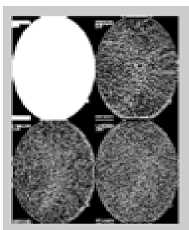
VI.EXPERIMENTAL RESULTS AND DISCUSSION

The segmentation technique discussed in the previous section is applied on five different wavelet filter co-efficients with features namely (diagonal horizontal dh1, diagonal vertical dv and energy) and in this techniques, new approaches of extracting features from the clinical scans have been proposed and used for classification. Its follows table no (1) and (2) different wavelet filter coefficients and features and plot the graphs between features and images. The classifier predicts the membership of each sample in the data set based on its feature vector and its classified into two images normal and abnormal.

This work can be implemented for finding the stages of glaucoma. More statistical features may be incorporate for the improvement of accuracy of the system. It is also adopted for the other diseases. The performance was analyzed using normal and abnormal images curve. In this curve the comparison is between the images and features. The area under this curve was detecting images with new vessels on the disc. The performance of this system is better than the existing system

(a) (b)

(c) (d)

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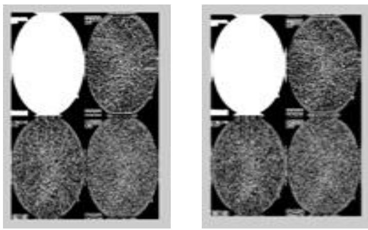

(e) (f)

Fig 5. Typical fundus images (a) normal input image (b) Db3 wavelet filter (c) Sym3 wavelet filter (d) Rbio3.3 wavelet filter (e) Rbio3.5 wavelet filter (f) Rbio3.7 wavelet filter

VII. CONCLUSION

This study illustrates the dependence between features extracted from RNFL that have been subjected to various feature ranking and feature selection methods. The ranked subsets of selected features have been fed to a set of classification algorithms to gauge the effectiveness of these features. From the accuracies obtained and contrasted, we can conclude that the energy obtained from the detailed coefficients can be used to distinguish between normal and glaucomatous images with very high accuracy. As observed the db3-h1_Average_l1_Norm and the rbio3.3-cD_Energy features are highly discriminatory. Furthermore,from Table I and II that both LibSVM_(1) and SMO_(2) .

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