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Bayesian Network Based Classification of Optical Coherence Tomography Images for Diagnosis of Glaucoma using Discrete Wavelet Transform Compression

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Abstract: In worldwide, Glaucoma is a second major retinal disease which results permanent blindness. Loss of Retinal Nerve Fiber Layer (RNFL) is the result of glaucoma disease. RNFL thickness is evaluated from Optical Coherence Tomography (OCT) images is an important diagnostics indicator for glaucoma disease. At the same time in medical field they were maintaining large volume of medical image data with low quality of image contrast, speckle noise, exact compression of OCT is difficult. To solve above issues, Discrete Wavelet Transform (DWT) based OCT and image compression is proposed in this work. In this work speckle noise are removed by using radar improved frost filter, secondly the RNFL features are extracted by using Improved Linear Discriminant Analysis. Then the OCT image is segmented by using K-mean clustering algorithm. Hence the severity of Glaucoma is classified by using Bayesian network. Finally Discrete Wavelet Transform (DWT) is used to compress the image without any significant loss in the diagonsability of the real image. Experimental result shows that the proposed Bayesian network is efficient for detecting the severity of the Glaucoma.

Keywords: Optical Coherence Tomography, RNFL, Radar improved frost filter, Discrete Wavelet Transform, K-mean clustering algorithm, Bayesian Network.

I. INTRODUCTION

Glaucoma is a condition which affects the optic nerve that carries information from the eye to the brain. It is mainly associated with increase in the intra ocular pressure (IOP) of the eye. Most important issue is it has no symptom.[1]If glaucoma is not finding at right time then it may lead to permanent blindness. The severity depends on the RNFL thickness layer. The mean occurrence of 2.5% for all the ages and above 65 years ages of mean occurrence is 4.7%. Glaucoma society of India released the latest survey that, it is the second leading cause of blindness in India. 12 million people are affected accounting for 13.8% of the countries blindness. It is estimated that by year 2020, it would be 16 million in India. Statistics says that one in seven persons above the age of 40 years in India is either affecting from Glaucoma or is at the risk of the disease. Mainly 90% of Glaucoma in community is undiagnosed. The risk of developing Glaucoma increases by five times if parent have and almost nine time if a sibling have Glaucoma. Also hypertension and diabetes are other risk factors. There are two major types of Glaucoma are Open-Angle Glaucoma and Angle-closure Glaucoma. Open-Angle Glaucoma is caused by slow clogging of the drainage canals which results in increase eye pressure. Angle-closure Glaucoma affects the drainage canals get blocked or covered over, like a sink with something covering the drain. An “angle” defines that the drainage angle is fixed inside the eye that organizes the outflow of watery fluid, aqueous humor which is normally found inside the eye. There are other different types of Glaucoma are secondary Glaucoma, Normal-tension Glaucoma, Pigmentary Glaucoma, Neovascular Glaucoma, Exfoliative Glaucoma and Traumatic Glaucoma. In Glaucoma the retinal ganglion cell, does not die in the beginning stage of the disease so early detection is vital to stopping the progress of the disease.

Optical Coherence Tomography is actually an imaging method at first evolved for providing the function and quantitative estimates with respect to the RNFL thickness. The OCT based RNFL. measurements can be reproduced and had been depicted in the cross-sectional studies to be capable of discriminating the glaucomatous from healthful eyes.[2] To improve clinical analysis, ophthalmologists regularly require large field-of-view and high spatial resolution OCT images. However, storage and transmission of such temporal and high spatial resolution OCT data consumes a vast amount of memory and communication bandwidth, which exceeds the boundaries of present clinical data archiving methods and generates a heavy burden for remote consultation and diagnosis. Hence, development of competent image compression strategies is the key to managing such large amounts of data.

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In this paper we will discuss about the proposed methodology for diagnosing the Glaucoma in section II, then the experimental results in section III. Finally section IV concludes the work.

II. PROPOSED METHODOLOGY

A. Image Preprocessing

Preprocessing is an important part which is used to remove the speckle noise by using radar improved frost filter and to avoid the redundancy images. Speckle noise is a signal-dependent form of noise whose magnitude is related to the value of the real pixel. The simple derivative expression for a multiplicative noise model is defined by

f ’[m, n] = f[m, n] + ŋ [m, n] f [m, n] (1)

f ’[m, n]= f[m, n] +[1+ ŋ [m, n]] (2)

Radar improved frost filter is used to remove the speckle noise without removing the edges or sharp features in the OCT image. In standardized areas, speckles are removed by using a low filter. At the same time, the filter are conserved by the verified value. In diverse areas, speckles are minimized by convolving the OCT image with a circular kernel. The output of the gray-level value (R) for the smoothed pixel is defined as:

R = Im for Ci <= Cu (3)

R = Rf for Cu < Ci < Cmax (4)

R = Ic for Ci >= Cmax (5)

Where Rf is the output of convolve the image with a circularly regular filter whose weighting values (M) for individual pixel is calculated as:

M = exp(- A * T) (6)

B. Image Enhancement

Image enhancement is the process of adjusting OCT images without affecting the image quality and it is used for determining the image analysis. It is used to remove noise, sharpen and enhance the image. So that the output obtained from image enhancement produce high quality than the original image for RNFL thickness. By using MATLAB image adjustment function is used to develop the OCT image quality. It is used to inherent originality of the image and also it increases the dynamic range of the OCT image. Hence enhancement distorts the original digital values; therefore enhancement is not done until the restoration processes are completed. This is entire with the aid of effectively spreading out the most frequent intensity values.

C. Feature Extraction using Improved Linear Discriminant Analysis

Improved LDA is mainly used to reducing the large data dimensionality. OCT image recognition is used to get the individuality of a test image on their memory. To find the feature vector used an image recognizer which is most comparable to a test image given. It begins from an initial set of calculated data and builds derived values intended to be useful and non-redundant assessments. It is the process of minimizing the number of chance variables under consideration is used to find a set of particular values. It is used to distinguish two or many classes of objects. Improved LDA works on the calculations made on autonomous variables for each scrutiny are unremitting quantities. When dealing with categorical self-determining variables, it has been widely used for classification because the principle is to minimize the error of misclassification other than the detachment between samples. The concept is to derive from so called within the class, between the class and total-class scattering matrices as measured that the total-class scattering matrix is the sum of within the class and between the class scattering matrixes. When we reduce within the class distance, it will automatically increase the between-class distance. In this case, we can rewrite the Raleigh quotient as

$$J(W) = \frac{W^T S_T W}{W^T S_Z W} Over W \quad (7)$$

$$S_W^{-1} S_T V_i = \lambda_i v_i \quad (8)$$

Hence the OCT pixel features are extracted by improved LDA are the eigenvectors of the total-class and within the class are measured by training samples, as long as we have number of training samples more than number of bands, the rank of will most likely be full rank. By this way, since we have more features than the number of class, the linear combination problem can also be resolved.

D. RNFL Segmentation using K-mean clustering algorithm

Once the feature is extracted then by using K-mean clustering algorithm RNFL boundaries are clustered without any loss of image quality. It is an unsupervised clustering technique that the input image is spitted into many classes based on their inherent distance from one another. It is used to identify and group the affected pixels in the OCT image. Generally K-mean clustering is used to find the partition and group the objects as possible. It requires the particular number of groups to be separated and it shows difference between how close to the other objects.

Let us consider an OCT image with resolution of X*Y and the image has to be grouped into k multiples of cluster. Let f(x, y)be an input pixels to be grouped and gk be the cluster centers of the pixels. The fitness value the cluster centers are segmented easily. The algorithametic step of K-mean clustering is defined below:

1. Initialize the k number of cluster and centre of the pixel.
2. For every individual pixel of an OCT image, is used to calculate the center of the pixel as Euclidean distance d, for every individual image by using the mentioned relation below as

d = □ f(x, y) − gk □ (9)

3. Allocate all the pixels to the adjacent centre based on Euclidean distance d.

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4. Once all the pixels have been arranged, again recalculate from the new position of the centre pixel using the relation as

$$C_k = \frac{1}{k}\sum_{y\in c_k}\sum_{x\in c_k} f(x,y) \quad (10)$$

5. Repeat the entire process until it satisfies all conditions.
6. Restructure the cluster pixels into OCT image.

E. Classification using Bayesian classifier network

Once the OCT images are segmented then by using Bayesian classifier the OCT images are classified into normal, medium and severe for detecting the Glaucoma. Here, individual examination has an connected class prospect or initial rate, p(k), which denotes the preceding prospect that one will view a affiliate of class k. It is used to specify the chance distribution for every variable. It lay up a discrete distribution for every individual attribute. Each p(k) term determines the chance of value, given an case of class k. In numeric domains, one must describes a continuous probability distribution for individual attribute in terms of mean and variance. Using Bayes rule we calculate the posterior to weight the prediction of classification.

p(k|D) = p(k)p(D|k)/p(D) (11)

p(ti|xi,D)=KXk=1p(ti,k|xi,D)=KXk=1p(ti|xi,k,D)p(k|D) (12)

where xi represents a novel input data point and ti the forecasted class label linked with data point i. The enter element of this well-known process is that the prognostic allocation of each classifier is linearly weighted by its posterior probability. Hence from the Bayesian classifiers decision shows the ensemble at last combined by a majority voting.

F. OCT image Compression using Discrete Wavelet Transform

In this work OCT images are compressed by using Discrete Wavelet Transform without affecting the quality of the original image.

The wavelet transform has gained common acceptance in image compression. It decomposes a signal into a set of basic tasks. Here, first decomposes an OCT image into coefficients called sub-bands and then the output coefficients are contrasted with a threshold value as zero. Then the coefficients mentioned above the threshold assessment are indoctrination with a loss less compression technique. The compression attributes of a given wavelet basis are primarily combined to the relative scarceness of the wavelet domain representation for the signal.

The algorithmic steps of DWT are mentioned below as:

1. Select a wavelet and level as N.
2. Compute the wavelet and decompose into signals at level N.
3. For every level from1 to N, threshold value is assigned as zero.
4. After that manipulate the wavelet reconstruction using the real coefficient level as N.
5. Finally reconstruct the OCT image.

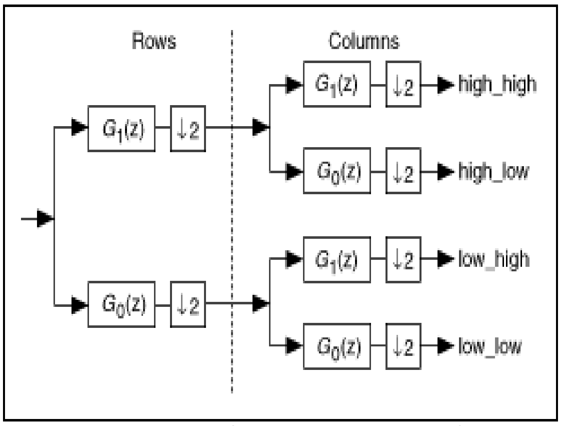

Fig1: Process of Discrete Wavelet Transform

III. EXPERIMENTAL RESULTS

All paragraphs must be indented. All paragraphs must be justified, i.e. In this paper, the Improved LDA,K-mean clustering algorithm, Bayesian classifier and DWT compression method performance is assessed and the results is compared with the existing algorithms. Performance results are calculated using MATLAB 12.Results has been evaluated from real time data set as 50 OCT images. The OCT images in the database are RGB JPEG format images of size is 689×329 pixels, these are converted into gray scale for this work.

The performance of vessel segmentation is analyzed with the following parameters:

Sensitivity =TP/(TP+FN))

Specificity =TN/(TN+FP))

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

Where, TP denotes true positive, FP denotes false positive, FN is false negative and TN is true negative. True Positive refers to the correctly identified disease, True Negative refers to the wrongly identified disease, False Positive refers to the correctly identified background pixels and False Negative refers to the wrongly identified background pixels.

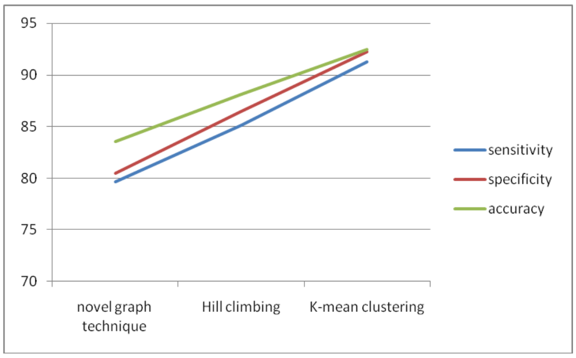

Fig2: Graphical representation of performance evaluation of segmentation methods

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In figure 2 the proposed K-mean clustering algorithm shows 91.25% sensitivity, 90.25% specificity, 91.65% accuracy rate which is higher than the other existing methods.

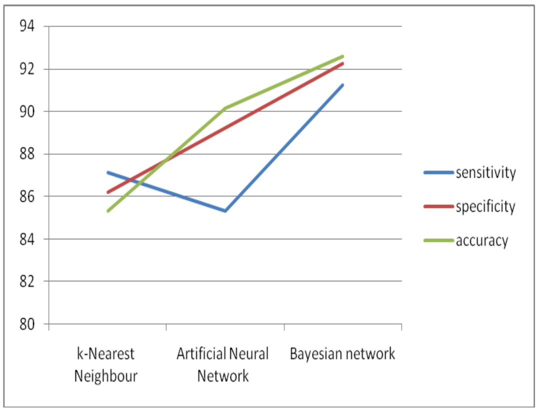

Fig 3: Graphical representation of performance evaluation of classification methods

In figure 3 the proposed Bayesian network shows 92.45% sensitivity, 90.65% specificity, 93.15% accuracy rate which is higher than the other existing methods. The overall result indicates that the proposed DWT work gives the high compression ration and also it exhibit the purity of the retrieved image.

IV. CONCLUSION

In this work, DWT based OCT image compression is proposed. Initially the OCT image is pre-processed by using radar improved frost filter for removing the speckle noise. Then the image is enhanced and the RNFL based features are extracted by using Improved LDA. Then, RNFL in OCT is segmented by K-mean clustering algorithm. After that the glaucoma is classified by using Bayesian network. Finally, DWT is used to compress the OCT image. The experimental results show that the proposed work attained 93.5% of high accuracy for glaucoma detection. The compression ratio is also raised in proposed method. In future, different types of compression method will be focused.

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