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Research Article

WAVELET BASED FEATURE EXTRACTION IN RETINAL IMAGES TO DETECT GLAUCOMA

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ABSTRACT

Glaucoma is the second leading cause of blindness and results in the neuro degeneration of the optic nerve and it is one of the most common causes of blindness. Because revitalization of the degenerated nerve fibers of the optic nerve is impossible early detection of the disease is essential. An early glaucoma diagnosis system is proposed using a combination of wavelet features. Wavelet based textural features specifically energy, entropy, skewness, kurtosis with first level decomposition method is extracted from retinal images. The extracted features are fed as input to SVM classifier. The proposed system achieves sensitivity of 90% and specificity of 92.2% in SVM. Furthermore, the impact of different features on the detection of retinal defects was compared and the performance was analyzed.

Keywords: Glaucoma Classification, Image Processing, Wavelets, Feature Extraction, LDA, SVM Classifier.

INTRODUCTION

Glaucoma is the second leading cause of peripheral blindness worldwide and results in the neuro degeneration of the optic nerve fibers. As the revitalization of the degenerated optic nerve fibers is not viable medically, glaucoma often goes undetected in its patients until later stages. The prevalent model estimates that approximately 11.1million patients worldwide will suffer from glaucoma induced bilateral blindness in 2020. Furthermore, in countries, like India, it is estimated that approximately 11.2 million people over the age of 40 suffer from glaucoma. It is believed that these numbers can be curtailed with effective detection and treatment options. Glaucoma is an eye disease in which the second cranial nerve is broken in a very characteristic pattern. This could permanently injury vision within the affected eye(s) and cause visual defect if left untreated. It is ordinarily related to inflated fluid pressure within the eye (Aqueous Humor)[1]. Conversely, the term 'normal tension' or 'low tension' eye disease is employed for those with second cranial nerve injury and associated visual field loss, however normal or low Intra Ocular Pressure (IOP). The nerve injury involves loss of retinal neural structure cells in a very characteristic pattern. The numerous completely different subtypes of eye disease will all be thought-about to be a sort of optic pathology[2]. Raised intraocular pressure (above 21 mmHg or 2.8 kPa) is that the most significant and solely modifiable risk issue for eye disease. However, some could have high eye pressure for years and never develop harm, whereas others will develop nerve harm at a comparatively depression. Untreated eye disease will cause permanent harm of the optic tract and resultant field of regard loss that over time will attain visual defect.

GLAUCOMA

Glaucoma causes harm to eye's second cranial nerve and gets worse over time. It's usually related to a buildup of pressure within the attention. Eye disease tends to be heritable and will not show up till later in life[3]. The inflated pressure, known as pressure level, will harm the optic tract that transmits pictures to the brain. If harm to the optic tract from high eye pressure continues, eye disease can cause permanent loss of vision. While not treatment, glaucoma will cause total permanent visual defect among a couple of years. Glaucoma typically happens once pressure in your eye will increase. This may happen once eye fluid is not circulating ordinarily within the front part of the eye. Normally, this fluid, known as humor, flows out of the attention through a mesh-like channel. If this channel becomes blocked, fluid builds up, inflicting eye disease. The direct explanation for this blockage is unknown, however doctors do understand that it will be heritable, which means it is passed from parents to kids[4]. Less common causes of eye disease embrace a blunt or chemical injury to the eye, severe eye infection, blockage of blood vessels within the eye, inflammatory conditions of the eye, and sometimes eye surgery to correct another condition. Eye disease happens in each eyes, however it's going to involve every eye to a distinct extent. Evacuation could also be poor as a result of the angle between the iris and also the membrane (where evacuation channel for the eye is located) is simply too slender. Fig 1& Fig 2 shows the normal and glaucoma affected retinal image.

To diagnose eye disease, an eye doctor can take a look at your vision and examine your eyes through expanded pupils. The eye pattern generally focuses on the optic tract that incorporates an explicit look in eye disease. In fact, pictures of the optic tract may also be useful to follow over time because the optic tract look changes as eye disease progresses. The doctor also will perform a procedure known as tonometry to examine for eye pressure and a visible test, if necessary, to see if there is loss of aspect vision. Glaucoma tests are painless and take little or no time[5].

Figure 1: Normal Image

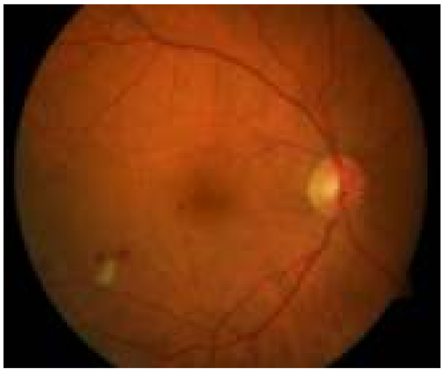


Figure 2: Abnormal Image

WAVELETS

A wavelet is a wave-like oscillation that is localized within the sense that it grows from zero, reaches most amplitude, and then decreases back to zero amplitude again. It thus includes a location wherever it maximizes, a characteristic oscillation amount, and conjointly a scale over that it amplifies and declines [6]. Wavelets may be employed in signal analysis, image processing and information compression. They are helpful for searching for scale information, whereas still maintaining some degree of time or space vicinity.

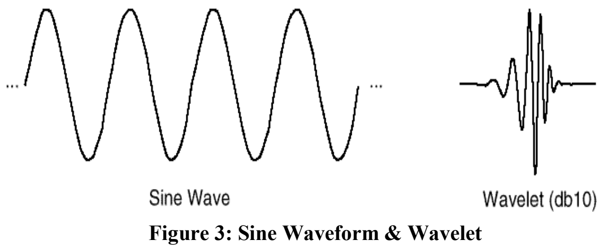


Figure 3: Sine Waveform & Wavelet

DISCRETE WAVELET TRANSFORM

Discrete wavelet transform (DWT), which transforms a discrete time signal to a discrete wavelet representation, it converts an input series x_0, x_1, x_m into one high-pass wavelet coefficient series and one low-pass wavelet coefficient series (of length n/2 each) given by:

$$Hi = \sum_{m-0}^{k-1} x_{2i-m}.s_m(z) ----------(1)$$

$$Li = \sum_{m-0}^{k-1} x_{2i-m}.t_m(z) ----------(2)$$

Where sm (Z) and tm (Z) are called *wavelet filters*, K is the length of the filter, and i=0, 1,..., [n/2]-1. In practice, such transformation will be applied recursively on the low-pass series until the desired number of iterations is reached[7].

WAVELET DECOMPOSITION METHOD

A wavelet is a wave shape of effectively limited length that has a median worth of zero. Wavelets are irregular and uneven [8]. They need varying frequency. Wavelet analysis is often applied to at least one dimensional data (signals) and two dimensional data (images). The most advantage of applying the wavelet transform to the detection of edges in a picture is that the risk of selecting the scale of the main points that may be detected. When process a 2D image, the wavelet analysis is performed individually for the horizontal and therefore the vertical directions. Thus, the vertical and the horizontal edges are detected separately. The 2D discrete wavelet transform (DWT) decomposes the images into sub-images, 3 details and 1 approximation. The approximation looks similar to the input image but only 1/4 of original size.

The 2-D DWT is an extension of the 1-D DWT in both the horizontal and the vertical direction. The resulting sub-images from an octave (a single iteration of the DWT) are labelled as A (the approximation or we say the smoothing image of the original image which contains the most information of the original image), H (preserves the horizontal edge details), V (preserves the vertical edge details), and D (preserves the diagonal details which are influenced by noise greatly), according to the filters used to generate the sub-image. The decomposition of image is shown in Fig. 2 This process can repeat continuously by putting the first octave's a sub-image through another set of low pass and high pass filters. These iterative procedures construct the multi-resolution analysis. Fig 5 shows the flow diagram of the glaucoma classification process[1,9].

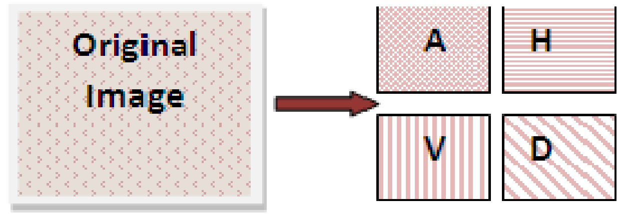
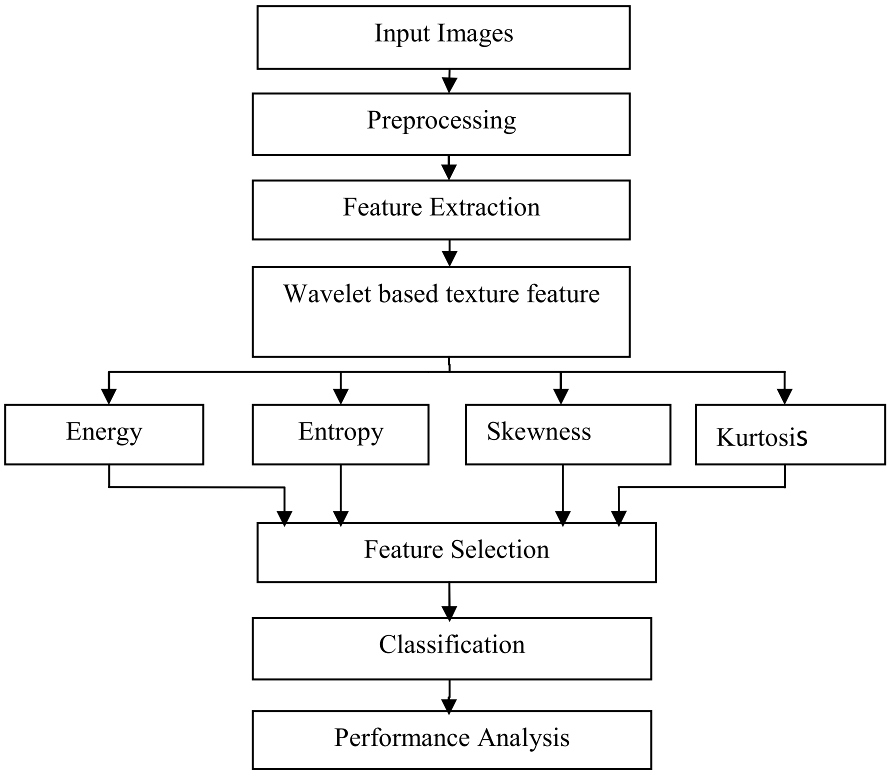


Figure 4: Wavelet decomposition of an image

FLOW DIAGRAM



PRE-PROCESSING

Pre-processing of retinal images is first step in the automatic diagnosis of retinal disease. If the quality of retinal image is not good, there is a necessary to improve the quality of retinal image the purpose of preprocessing is to improve the noisy area from retinal image[10]].

HISTOGRAM EQUALISATION OF AN IMAGE

Enhancing the fundus image contrast will aid the feature extraction process. In this work, colored (RGB) eye images are converted to gray scale image by forming weighted sum of R, G, and B.

I gray=0.2989*R+0.5870*G+0.1140*B

After the conversion of gray level, the histogram equalization is done to improve the quality of input images.

Preprocessing for Normal Image:

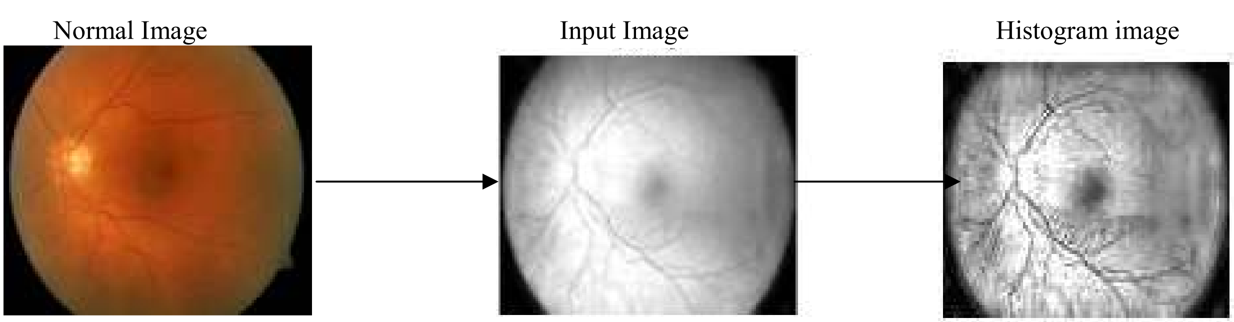


Figure 6: Preprocessed output image for Normal Image

Preprocessing for abnormal Image:

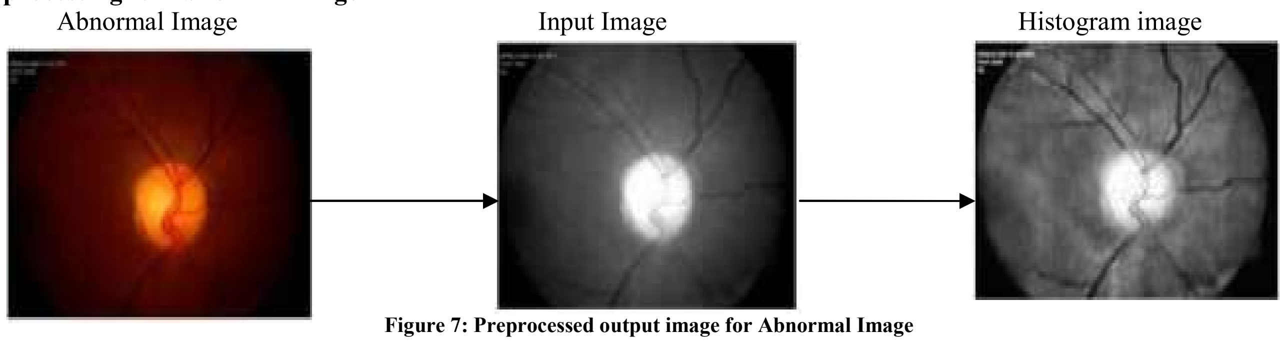


Figure 7: Preprocessed output image for Abnormal Image

FEATURE EXTRACTION FROM THE RETINAL IMAGE

Feature extraction is a special form of dimensionality reduction. The purpose of feature extraction is to reduce original data set by measuring certain features that distinguish one region of interest from another[11-13]. Wavelet based textural features namely energy, entropy, skewness, kurtosis which are extracted from retinal images. The analysis and characterization of textures present in the medical images can be done by using the combination of Wavelet Statistical Texture features (WST) obtained from 2-level Discrete Wavelet Transformed (DWT) low and high frequency sub bands. A feature extraction is the determination of a feature or a feature vector from a pattern vector. In order to make pattern processing problems solvable one needs to convert patterns into features, which become condensed representations of patterns, ideally containing only salient information. Feature extraction involves simplifying the amount of resources required to describe a large set of data accurately. Table 1 & Table 2 shows the feature values (energy, entropy, skewness and kurtosis) for the different type of wavelets.

Table 1: Feature values for Normal Images

Wavelet types/Features	Energy	Entropy	Skewness	Kurtosis
Haar	3.84e-004	0.298±0.141	-0.087±1.36	3.918±1.92
Db1	3.31e-001	0.316±0.163	-0.055±1.272	3.613±1.684
Db3	3.26e-001	0.331±0.148	-0.035±1.252	3.690±1.528
Sym2	3.02e-001	0.360±0.152	-0.077±1.301	3.718±1.726
Sym3	3.60e-001	0.396±0.139	-0.055±1.272	0.673±1.796
Coif1	2.96e-001	0.363±0.138	-0.140±1.308	3.581±1.629
Coif3	3.28e-001	0.480±0.120	0.005±1.122	3.110±1.350
Bior 1.3	2.71e-001	0.364±0.170	-0.067±1.545	3.543±1.545
Bior 1.5	2.99e-001	0.392±0.137	-0.044±1.868	3.321±1.389
Rbio 3.3	2.84e-001	0.399±0.150	-0.076±1.217	3.393±1.433
Rbio 3.7	3.28e-001	0.432±0.123	-0.030±1.121	3.088±1.254
Rbio 6.8	3.76e-001	0.458±1.68	-0.008±1.046	2.951±1.059

Table 2: Feature values for Abnormal Images

Wavelet types/Features	Energy	Entropy	Skewness	Kurtosis
Haar	1.88e-001	0.334±0.149	0.264± 1.132	3.082±2.173
Db3	1.90e-001	0.342±0.128	0.294 ±1.093	2.991±2.089
Db4	1.67e-001	0.344±0.145	0.314 ±1.085	2.988±2.130
Sym2	1.78e-001	0.316±0.152	0.272 ±1.09	2.992±2.037
Sym3	1.73e-001	0.352±0.136	0.294±1.09	2.991±2.08
Coif1	1.72e-001	0.333±0.131	0.287±1.08	2.977±2.090
Coif3	1.70e-001	0.380±0.152	0.379±1.032	1.897±0.422
Bior 1.3	1.54e-001	0.328±0.147	0.281± 2.048	2.954±0.432
Bior 1.5	1.80e-001	0.347±0.126	0.310±1.058	2.913±2.095
Rbio 3.3	1.83e-001	0.356±0.136	0.297±1.077	2.970±2.160
Rbio 3.7	1.97e-001	0.350±0.188	0.330±0.999	2.912±2.250
Rbio 6.8	1.78e-001	0.372±0.211	0.367±1.023	2.887±2.23

FEATURE SELECTION PROCESS

Feature selection is that the method of choosing a set of the terms occurring within the training set and victimization only this set as features in text classification. Feature selection serves 2 main functions. First, it makes training and applying a classifier more efficient by decreasing the dimensions of the effective vocabulary. This can be of specific importance for classifiers that are expensive to train. Second, feature selection usually will increase classification accuracy by eliminating noise features. The central assumption once employing a feature choice technique is that the information contains several redundant or impertinent features. Redundant options are those which offer no a lot of data than the presently elect options, and irrelevant features offer no helpful data in any context. Feature selection techniques are a set of general field of feature extraction [14].

LDA (Linear Discriminant Analysis)

Discriminant analysis is used just for classification (i.e., with a categorical target variable), not for regression. The target variable might have 2 or a lot of classes. LDA seeks to cut back dimensionality whereas conserving the maximum amount of the class discriminatory data as possible. Discriminant analysis[16] is one of the most popular solutions for the small sample learning problem. In the last twenty years, Fisher Linear Discriminant Analysis (LDA) has been successfully used in face recognition[11]. LDA was first used in CBIR for feature selection and extracts the most discriminant subset feature for image retrieval. The remaining images in the database were then projected onto the subspace and finally, some similarity or dissimilarity measures were used to sort these images. Fig 9 shows the LDA feature ranking. From the four set of features, 'Energy feature' took first place

SUPPORT VECTOR MACHINE CLASSIFIER

The ability of each image-based feature extraction method to separate glaucoma and non-glaucoma cases is quantified by the results of two classifiers. SVM is a supervised machine learning algorithm. It produces a linear boundary to achieve maximum separation between 2 classes of subject (cases and controls) by mathematical transformation of input feature for each subject. This linear classifier determines a maximum-margin and soft hyper plane that best separates the considered classes. The data is normalized and transformed via the non-linear radial basis kernel. Support vector machines (SVMs) have been a promising tool for data classification. Its basic idea is to map data into a high dimensional space and find a separating hyper plane with the maximal margin. Fig 10 shows the SVM Classification graph for Normal and Glaucomatous images.

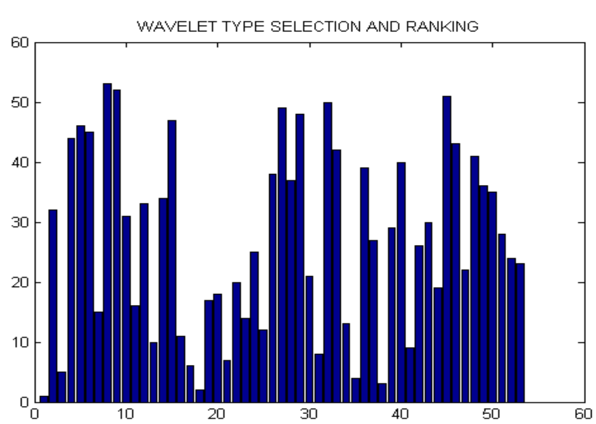


Figure 8: Feature ranking & selection using LDA for Wavelets

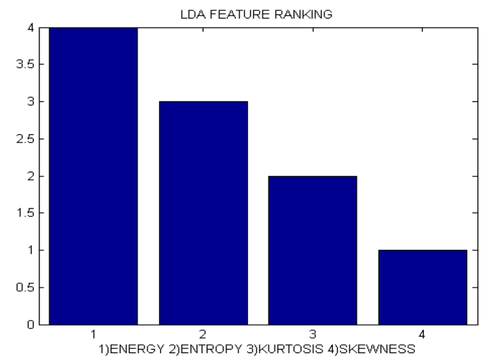


Figure 9: Feature Ranking using LDA

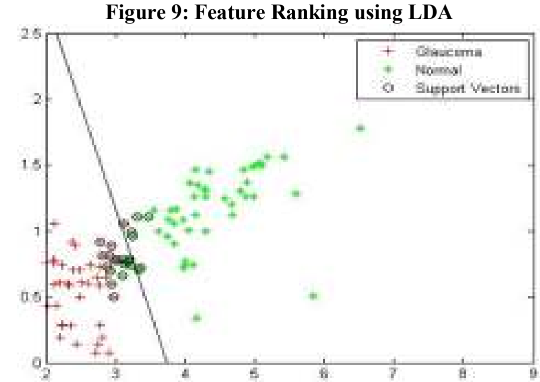


Figure 10: SVM Classification

PERFORMANCE ANALYSIS

Sensitivity and specificity are two main performance indicators for binary classification problem.

$$\text{Sensitivity}=100\{(TP/(TP+FN))\}$$

$$\text{Specificity}=100\{(TN/(TN+FP))\}$$

In the formula above, TP means true positive, FN false negative, TN true negative, FP false positive. Sensitivity represents the ratio of correctly identified SSVEP cases to all SSVEP cases, and Specificity refers to the ratio of correctly identified NC cases to all NC states.

ROC

A receiver operating characteristic (ROC), or just ROC curve, could be a graphical plot that represents the performance of a binary classifier system as its discrimination threshold is varied. The ROC graphs are a helpful technique for organizing classifiers and visualizing their performance. ROC graphs are usually employed in medical deciding. ROC approaches to the left-up corner, the higher the synthesis performance of each sensitivity and specificity[15-17].

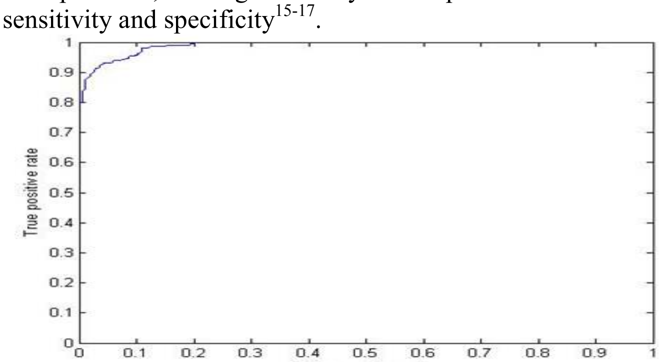


Figure 11: ROC Plot

CONCLUSION

An automated system has been successfully developed that is able to discover the eye disease from the retinal images with the performance approaching that of trained clinical observers. It's been found that the eye disease is detected regardless of the stages of its growth. The wavelet based textural options and SVM classification has been used to discover this complication caused owing to eye disease. This technique is found to cut back the manual effort needed for the detection and additionally accuracy gets accumulated. The performance of the system is analyzed by forming tables and plotting the graphs examination technique. SVM technique will offer help in making decision on glaucoma detection.

FUTURE WORK

The detection and classification of glaucoma is done by Wavelet based textural features, LDA feature ranking and SVM classification. These methods are computationally powerful to detect and diagnose the diseases from the retinal images. Very near this system can be implemented in hospital to reduce the visual loss by helping the human environment with low cost of finding the glaucoma.

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