Feature Extraction Techniques for Automatic Glaucoma Identification

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ABSTRACT

Nowadays, automatic glaucoma identification is done by feature extraction and classification techniques. In this paper, feature extraction in frequency domain technique is applied with the combination of wavelet transform with Harr functions and the concept of directional filter bank from contourlet transform are exclusively used for automatic Glaucoma identification. The feature extraction techniques achieve higher accuracy than those of the normal frequency domain methods, and traditional neural network-based classification algorithms used for better classification.

Keywords: *Glaucoma, Wavelet transform, contourlet transform, Support Vector Machines.*

Introduction

Glaucoma is an eye disease normally caused by the variations of Intra-Ocular Pressure in the eye, and it leads to blindness [1]. If the disease is not found in the early stage, the affected person may lose his vision. The anterior chamber of the eye is filled with liquid. If there is no proper drainage, it leads to blindness. So, it should be identified in the early stages to cure the patient. Glaucoma is the second leading cause of peripheral blindness worldwide and results in the neuro-degeneration of the optic nerve, when the damage to the optic nerve fibers occurs, blind spots develop and blind spots usually go undetected until optic nerve is significantly damaged [2]. Early detection and treatment are keys to prevent vision loss from glaucoma. It is useful to identify efficient methods by research to detect glaucoma in the initial stages. The proposed system is used to reduce the processing time taken by the existing techniques of manual-based algorithm without compromising on speed, accuracy, sensitivity, cost and compatibility of the product with relevance to image processing concepts.

Glaucoma affects retinal nerve fiber, due to high intra-ocular pressure in the retina. Retinal nerve fiber is one which carries information from the eye to the brain. Glaucoma affects mainly peripheral vision [3]. Texture-based analysis plays a pivotal role for the diagnosis of glaucoma from fundus image [4]. A number of diagnostic tools and algorithms are being developed by the researchers to identify this disease. But developing an automatic diagnosing tool with accurate identification is quite challenging. This is because these tools need more accuracy and response compared to the diagnostic tools used for other diseases [5]. A system was developed to diagnose glaucoma by automatically using the texture and higher-order features in the fundus images. The extracted features are classified using Support Vector Machines (SVM), Random forest and Naïve Bayesian classifiers. The three classifiers were compared and evaluated using some performance indices. Another system is proposed to find the fundus images in the optic disc boundary of the retinal images of the patients. The system is used to find Diabetic Retinopathy and Risk of Macular Edema from edge detection and optic disc detection techniques [6]. Gabor wavelet function is implemented for feature extraction using both time and frequency domains. The wavelet transform with Gabor filter bank function has got better result than other time domain functions [7]. Texture features are taken using frequency domain techniques such as Harr function, DWT transform and directional filter bank application using Contourlet transform [8,9].

In this paper the proposed system, which automatically and accurately detects the early stage of glaucoma from the set of fundus eye images and extract the image features using Discrete Wavelet transform with Harr functions and Contourlet Transform. Then the classification is done using Support Vector Machine (SVM) and Linear Discriminant Analysis (LDA)

Preprocessing

The preprocessed fundus image is retrieved after Region of Interest and high intensity point detection. ROI selection has a number of advantages which do not select the unwanted region of the image so that it reduces image size and the time consumption of the processing algorithms. Further, the fundus image contains brightness, and it is extracted by high intensity point selection. The unwanted noise is also removed by using this preprocessing technique.

Methodology

The block diagram of the proposed enhanced feature extraction and classification techniques of the system shown in Figure.1.The real fundus image database with and without glaucoma is collected from a nearby eye hospital. In the pre-processing stage, green plane extraction, highest intensity point detection, and region of interest detection are taken from the fundus images.

The spatial-based feature extraction techniques applied to the fundus images may not give better performance for automatic detection of diseases. Hence the texture features are extracted using frequency domain techniques such as Discrete Wavelet Transform and the Contourlet transform individually.

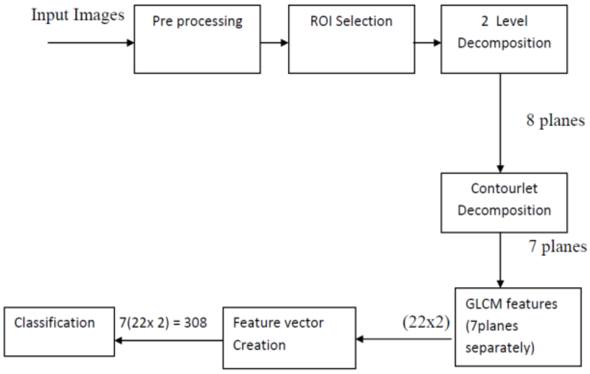

Figure. 1 Block diagram of the proposed system

i) Feature Extraction Using Wavelet Transform

Texture features using wavelet transforms in image processing are often employed to overcome the generalization of features. In DWT, the image is represented in terms of the frequency of content of local regions over a range of scales. This representation provides a framework for the analysis of image features, which are independent in size and can often be characterized by their frequency domain properties [10]. The aim of this work is to automatically classify normal eye images and glaucoma eye images based on the distribution of average texture features obtained from three prominent wavelet families of equations (1),(2) and (3).

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

$$\text{Average } Dv1 = \frac{1}{p \times q} \sum_{x=\{p\}} \sum_{y=\{q\}} |Dv1(x,y)| \qquad (2)$$

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

The fundus image is fed into high pass filter banks in row ways and fed to the down sampler. Then, the image is fed to low pass filter banks in column ways and also to own sampler.

Thus, DWT is applied to image to get an approximate clean and detail information. Thus, the approximation of the image is found with clear details using multi frequency bands by applying low pass and high pass filter banks row-and column-wise. The image is subdivided into four sub bands using wavelet transform which are HH, LH, HL and LL (approximation), and Wavelet transform decomposes a signal into a set of basis functions (wavelets).

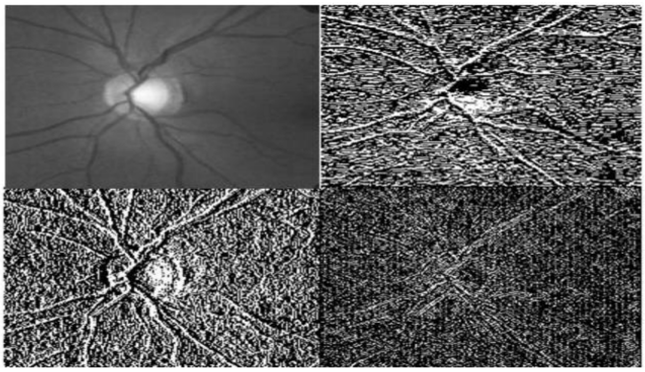

Figure. 2 Output of Discrete wavelet with Harr LL, HH, HL and LH component

ii) Feature Extraction Using Contourlet Transform

The Contourlet Transform is one of the recent transforms in image processing for feature extraction applications. In this transform, the given input images are directed to various orientations in multiple scales with flexible aspect ratios. The dominant features in the given input image are easily captured by this transform using image contours. In this transform, different and multi-scale directional systems are used compared to other transforms. It allows different and flexible number of directions at each scale. It has a large number of filter banks which make this transform computationally more efficient. Classification involves the segregation of the extracted features into the relevant assigned classes.The real skill is to study the geometry in images derived from the discrete signals. The technique is fully developed with the discrete domain so that we can elaborately explore the images. Here, we have built the image with multiresolution and multi direction using cavities which are discrete in nature. The contourlet consists of two steps, namely multiscale decomposition and directional decomposition. Only directional decomposition is applied here by directional filter bank. The output of the directional filter bank contains the Hue moment feature, GLCM feature and energy feature. These features are used for classification of glaucoma.

Classification

The extracted features are loaded as dataset, and these datasets are used for classification of glaucoma fundus images. In this paper The Support vector machines,Linear Discriminant Analysis (LDA) are used. The classifier which produces the best result is used for classification in the final automatic glaucoma identification system.

SVM classification

SVM is an efficient classifier for the classification of complex data. It can be used for the classification of linearly separable and non-separable data. The classes in the training data are separated by a decision line or margin. The data points touched by this decision line are called support vectors. Based on the majority of the support vectors, the class is assigned to the unknown query under analysis. Here, glaucoma and non-glaucoma are classified effectively with TPR and FPR. The ROC curve is drawn between TPR and FPR as shown in Figure.3.

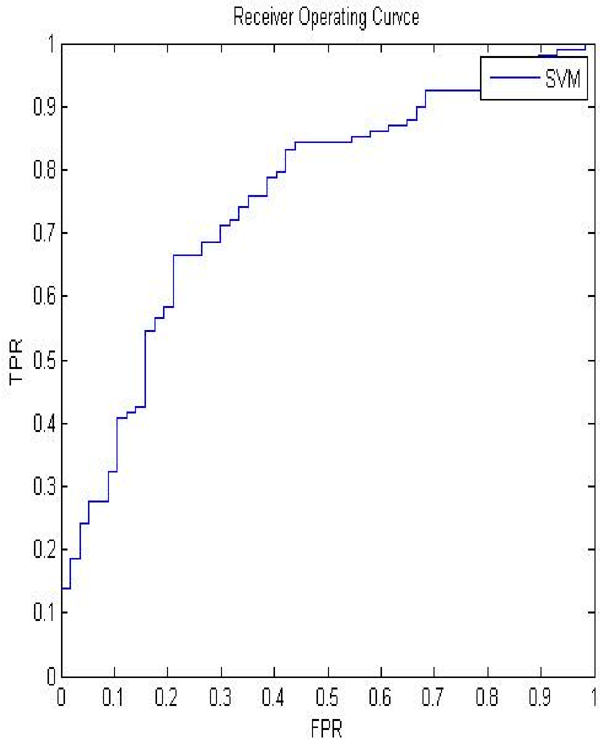

Figure. 3 ROC for Glaucoma classification using SVM

ii) LDA

Linear Discriminant Analysis (LDA) is a traditional method used for data classification applications. This method handles the data easily where the frequencies of data in a class are unequal, and their performance are evaluated and tested by generating random test data. This method finds the ratio of between-class variance to the within-class variance in any particular dataset using maximization and there by guaranteeing maximal reparability. Linear Discriminant Analysis is mostly used for data classification for speech recognition. This method is also used for feature data classification. Here, Glaucoma and Non-glaucoma are classified with TPR and FPR. The ROC curve is drawn between TPR and FPR is shown in figure.4

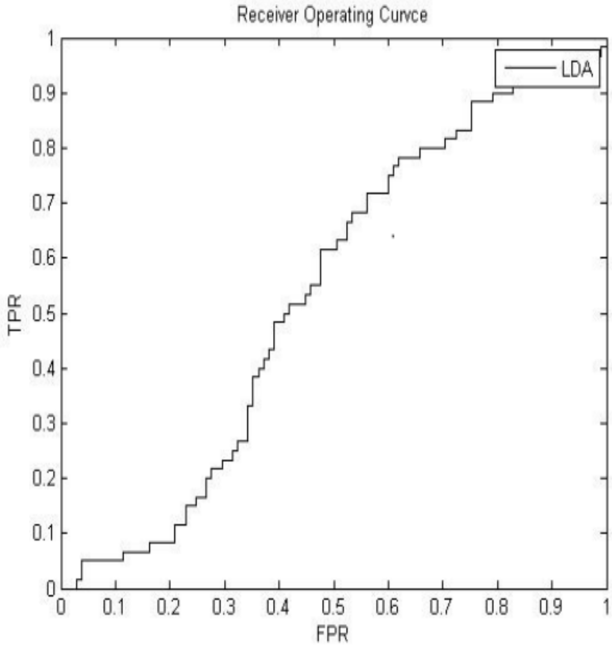

Figure. 4 ROC for Glaucoma disease classification using LDA

Conclusion

The objective of this research paper is to develop a system which automatically identifies extracts and classifies glaucoma and non-glaucoma sets of fundus images. The image is preprocessed, extracted and classified. By applying frequency methods, a computer-based system is developed to automatically detect Glaucoma. Here, an Enhanced Feature Extraction technique is done by combining wavelet and contourlet transforms, and the classification is done by Support Vector Machine. The extracted features are taken efficiently and effectively by the proposed technique.

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