Image Processing Based Automatic Diagnosis of Glaucoma using Wavelet Features of Segmented Optic Disc from Fundus Image

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Abstract

Glaucoma is a disease of the retina which is one of the most common causes of permanent blindness worldwide. This paper presents an automatic image processing based method for glaucoma diagnosis from the digital fundus image. In this paper wavelet feature extraction has been followed by optimized genetic feature selection combined with several learning algorithms and various parameter settings. Unlike the existing research works where the features are considered from the complete fundus or a sub image of the fundus, this work is based on feature extraction from the segmented and blood vessel removed optic disc to improve the accuracy of identification. The experimental results presented in this paper indicate that the wavelet features of the segmented optic disc image are clinically more significant in comparison to features of the whole or sub fundus image in the detection of glaucoma from fundus image. Accuracy of glaucoma identification achieved in this work is 94.7 % and a comparison with existing methods of glaucoma detection from fundus image indicates that the proposed approach has improved accuracy of classification.

Proposed Algorithm

The proposed method of glaucoma detection involves analysis of wavelet feature of segmented optic disc image. This glaucoma detection algorithm does not require any manual intervention to take decision whether the input fundus image is normal or glaucomatous. A flow diagram of the proposed method is presented in Fig. 1.

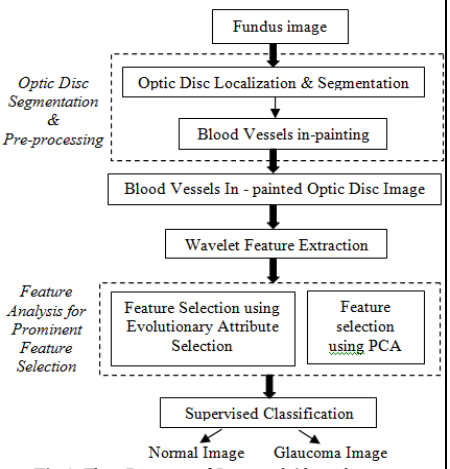

Fig.1. Flow Diagram of Proposed Algorithm

Optic disc Segmentation and Blood vessel Removal:

In the proposed method, Optic Disc is segmented from fundus image using a bit plane technique. OD is segmented using logical combination of bit planes for three higher most significant bits (MSB's). In this paper data base images used has 8 bit representation, hence 6th, 7th & 8th bit planes of red channel of fundus image are considered for optic disc segmentation.

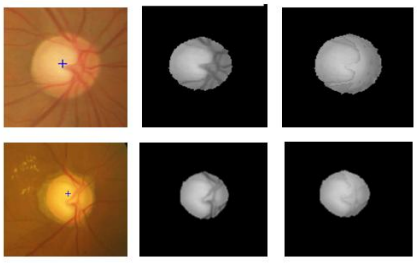

Fig. 2: (a) OD containing sub-image (b) Segmented OD image (c) OD image after blood vessels in-painted.

Removal of blood vessels is done using an algorithm based on the fact that pixel intensity is a function of the distance from the centre of optic disc. The gray level pixel values decrease as the distance from the optic disc centre increases outwards. Fig. 2 shows OD containing sub-image, Segmented OD image and OD image after blood vessels in-painted.

Wavelet Feature Extraction from segmented optic disc image:

In the proposed method, blood vessel in-painted optic disc image is transformed in wavelet domain for feature extraction. On the basis of experiments, it was found that there are enough discriminatory features for glaucoma detection in first level DWT decomposition. Hence first level DWT feature are used in the proposed method as discriminatory features for glaucoma detection system making it computationally cheap and suitable for real time applications. Higher order decomposition may make the computational cost more and not required in this case as the first order decomposition provides enough discriminatory variation. Fig. 3 represents two samples of optic disc image used for feature extraction.

Fig. 3: Two samples of blood vessels in-painted optic disc image used for feature extraction

Prominent Feature Selection:

In this proposed work two different techniques are used for prominent feature selection. In the first method prominent features are selected using evolutionary attribute selection method and then only selected prominent features are considered for further classification. Another technique tried was based on the feature reduction using principal component analysis (PCA) and then only two main principle components of compressed feature set which are more discriminatory are selected for glaucoma image classification. This technique of feature selection is less complex and efficient to select more discriminatory features for classification.

Glaucoma Image Classification:

Considering the prominent features, the performance of most popular classification algorithms Decision Tree, *k*-NN, Random Forest, K-star, Support vector machine (SVM), Artificial Neural Network (ANN) with various parameter configuration are measured and then the classifier which has the best accuracy are finally considered for glaucoma detection

Experimental Results

Experiments have been carried out in a local data base of 63 fundus images and results of the experiments are presented below.

Table 1
Accuracy of Classification (%) For Different Classifiers with Prominent Feature Selection using Evolutionary Attribute Selection

Classification Method	Feature Selection Method	Feature Normalization Method	Accuracy
Random Forest	**Evolutionary attribute Selection**	**Not used**	**94.75 %**
Naïve Byes	Evolutionary attribute Selection	Not used	89.48 %
k-NN	Evolutionary attribute Selection	Not used	89.48 %
ANN	**Evolutionary attribute Selection**	**Not used**	**94.75 %**
SVM	Evolutionary attribute Selection	Not used	84.21 %

Table 2
Accuracy of Classification (%) For Different Classifiers with Prominent Feature Reduction using PCA

Classification Method	Feature Reduction Technique	Feature Normalization Method	Accuracy
Random Forest	PCA	Z-Score Normalization	89.48 %
Naïve Byes	PCA	Z-Score Normalization	84.21 %
***k*-NN**	**PCA**	**Z-Score Normalization**	**94.75 %**
ANN	PCA	Z-Score Normalization	89.48 %
SVM	**PCA**	**Z-Score Normalization**	**94.75 %**

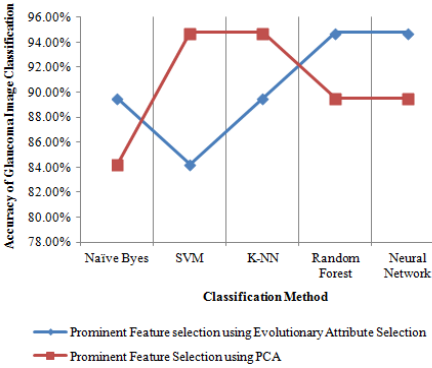

Fig. 4: Accuracy of Glaucoma Image Classification

Table 1 represents that Random forest and Neural Network classifier provides the best accuracy which is 94.7 % for the feature set selected using attribute selection method and Table 2 shows that K-NN and SVM classifier provides the best performance for the feature vector compressed using PCA. Fig. 4 shows the accuracy of glaucoma image classification using different classification algorithms.

Experimental results indicate that proposed method of glaucoma detection using attribute selection technique with Neural Network & Random Forest classifier and using PCA with K-NN & SVM classifier can be considered significant contribution in glaucoma identification having high levels of accuracy.

Conclusions

In this work, an automatic image analysis based system is proposed for diagnosis of glaucoma from the digital fundus image using wavelet features from the segmented optic disc. Performance of glaucoma image classification were measured for five supervised classifiers using prominent feature selected using evolutionary attribute selection and principal component analysis. It is observed that all the five classifiers present accuracy more that 85%. Random forest & Artificial Neural Network classifiers can identify the presence of glaucoma with 94.7% accuracy for feature set selected using evolutionary attribute selection whereas SVM & *k*-NN presents 94.7% accuracy for feature selected using principal component analysis. This proposed study is clinically significant, as the accuracy obtained is comparable to the accuracy achieved by existing methods. Some future work in this direction may be use of other feature selection methods and different classification approaches to improve accuracy and efficiency.

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