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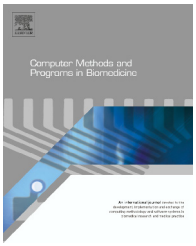

# Image processing based automatic diagnosis of glaucoma using wavelet features of segmented optic disc from fundus image

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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.



## 1. Introduction

Glaucoma is a disease of retina in which the optic nerve undergoes a damage caused by the increase in the intraocular pressure (IOP) of the eye. There is a fluid called aqueous humor that flows through the pupil and is absorbed by the blood-stream. In case of glaucoma the flow of this fluid becomes clogged. This results more intraocular pressure in the eye which damages the highly sensitive optic nerve causing vision impairment. It mainly affects the portion inside the optic disk where the size of the optic cup increases resulting in a high cup-to-disk ratio. It causes the successive narrowing of the field of view of affected patients.

After diabetic retinopathy, glaucoma is the second highest cause of blindness across the world. Glaucoma is not curable and the loss of vision cannot be regained but with early diagnosis it is possible to prevent further loss of vision by proper medication and surgery.

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One serious threat and cause of concern for glaucoma is unlike many other diseases the signs and symptoms of glaucoma are not immediately felt and experienced [1] by the patient. By the time the patient experiences the signs and symptoms of glaucoma, the damage in the retina is done. According to data available [1] it is estimated that more than 2.2 million Americans have glaucoma but unfortunately 50% of them are not aware that they have it. The situation is even worse in developing countries of Asia and Africa where there is a shortage of trained ophthalmologist for diagnosis of glaucoma. Hence, there is a need to develop automatic and efficient computer based methods for diagnosis of such diseases.

Some work has been reported in computer vision based identification of glaucoma from digital fundus image. An image processing based glaucoma identification process [2] was presented in which several image based features were analyzed and combined to capture signs of glaucoma. Wavelet-Fourier analysis was used [3] for characterization of neuroanatomic changes in glaucoma images. The results reported in this work are encouraging and may attract more work using wavelet for identification of glaucoma from digital fundus images.

There are many studies where segmentation of the optic cup and optic disc from the color fundus image is done for calculation of the optic cup to disk ratio (CDR) to identify symptoms of glaucoma. An optic disc segmentation technique is presented [4] which use the local image information around some points of interest in multi-dimensional feature space and it seems to provide robustness against some variants around the optic disk region.

A statistical model based method [5] for the segmentation of the optic disc and optic cup from digital color fundus images is presented where knowledge based circular Hough Transform is used. A CDR calculation based method is presented [6] where a double threshold based approach is used, one for removing blood vessels and background and second threshold for segmenting the super intensity pixels contained by the optic disc and optic cup.

Multiple features such as area of blood vessels in Inferior, Superior, Nasal and Temporal side near to optic disk (ISNT ratio), neuroretinal rim analysis, distance between optic disc center and optic nerve head [7] has been used for identification of glaucomatous eyes.

Proper orthogonal decomposition (POD) is a technique [8] that uses structural features to identify glaucomatous progression. The use of texture features and higher order spectra (HOS) features were proposed [9,10] by for glaucomatous image classification. The use of wavelet-Fourier analysis (WFA) for the characterization of neuroanatomic disruption in glaucoma [11,12] was proposed and the results are encouraging. Discrete wavelet based features of fundus image are used [13] to identify glaucomatous images.

Some high dimensional feature vectors from the fundus images are compressed and combined [14] and is classified using SVM classifiers. A super-pixel based classification method [16] for glaucoma screening from fundus images is presented where in optic disc segmentation, histograms and some statistical parameters are used to classify each super-pixel as disc or non-disc.

In all these methods of glaucoma detection, features are extracted from the whole fundus image or a sub-image containing optic disc. The features from the image portions outside the optic disc do not carry any significant information about glaucoma and are redundant and may also adversely affect the automatic classification. Keeping this in mind this paper presents a method where the optic disc is first automatically segmented from the fundus image and then the features are extracted from the segmented optic disc.

The main contribution of this paper is a novel method that achieves 94.7% accuracy in classification of glaucoma from fundus images. This outperforms accuracy of comparable works [7,9,12–14,16]. Detailed comparative information is provided in Section 5. The idea behind this paper is an automatic glaucoma identification algorithm from digital fundus images where feature extraction and classification is done from the segmented region of optic disc. Unlike the existing method where the features have been extracted from the complete fundus image or a sub-image this method has the advantage of reducing the redundant features which do not contribute to glaucoma identification. In this way only features from the glaucoma informative regions are considered which will improve the accuracy of identification. There may be a possibility that the features from non-informative regions may adversely affect the classifiers during training and testing stages and this method prevents such situation to arise.

Another important contribution of this work is removal of the blood vessels from the segmented optic disc before features are extracted from the segmented optic disc. Blood vessel pixels are considered as noisy pixels in the case of glaucoma identification and the removal of the blood vessels before feature extraction may improve the accuracy of classification. First level wavelet features from segmented and blood vessel in-painted optic disc image are extracted. These features are more prominent in comparison to spatial domain features for classification which will enhance sensitivity and specificity of glaucoma image classification. To improve the performance of glaucoma image classification, extracted features from this blood vessel removed image are subjected to feature selection scheme and then prominent features are considered for further classification.

Another highlight of this work is to improve the performance of classifiers used for glaucoma image classification where evolutionary attribute selection algorithm is used to select the most prominent features. Genetic algorithm with operator optimized selection (evolutionary) is employed for feature selection to reduce the dimensionality of feature vector which enhances the performance efficiency of the classifiers.

The rest of the paper is organized as follows. Section 2 includes the explanation of the fundus image data base used in this paper. The next section describes the justification of feature selection from segmented optic disc. Section 4 describes the proposed methodology of glaucoma detection including optic disc segmentation, feature extraction, feature selection and description of the classifiers and classifier parameters employed for our experiments. Section 5 includes experimental results obtained using proposed method. Finally Section 6 provides conclusion to the paper.