**Research Article**

# Comparative Study of Glaucomatous Image Classification Using Optical Coherence Tomography

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**ABSTRACT**

Glaucoma is a condition that involves distinctive changes in the optic nerve and visual field. It is marked by functional and structural abnormalities in the eye in which optic nerve damage can ordinarily be alleviated and inhibited by sufficiently reducing intraocular pressure (IOP) by the direction of optic nerve damage may permit early detection of glaucoma. In this paper to detect the glaucoma, various image classification technique discussed based on Discrete Wavelet Transform (DWT) using Optical Coherence Tomography images (OCT). Texture features are extracted from OCT images and utilized for the accurate and efficient glaucoma classification. There are three classifiers are used in this paper that are Naive Bayes, K-Nearest Neighbour (KNN) and Support Vector Machine (SVM). The experimental result shows that the 83.98%, 90%, and 91.75% classification accuracy achieved by naive bayes, KNN and SVM classifier respectively. Sensitivity and specificity of the naive bayes, KNN and SVM classifier are 90.90% and 90.90%, 93.90% and 87.50%, 84.40%, 93.80%.

**Keywords:** Discrete Wavelet Transform, feature extraction, feature classification, optical coherence tomography.

## INTRODUCTION

DWT based glaucoma classification is explained using OCT images in [1]. Initially pre-processing is taken place using median filtering and thresholding approach, appropriate region obtained from OCT images. Then using DWT decomposition, significant wavelet co-efficient are selected using t-test class separability criteria and fed into the SVM classifier for automated diagnosis.

Principal Component Analysis (PCA) based glaucoma classification is explained using OCT images in [2]. Initially pre-processing is taken place using median filtering and Otsu thresholding approach, whereas appropriate region obtained from OCT images. Then PCA is applied to ROI selected images and obtained features are used for classifier training. On account to classify whether subjected image is normal or glaucomatous, SVM classifier is adopted. Wavelet transform based glaucomatous image classification is presented using retinal fundus images in [3]. Various wavelet families such as daubechies, symlet and reverse bi-orthogonal are taken into account for image decomposition. Mean and energy features are extracted from decomposed coefficients and then fed into the KNN classifier for image classification.

Optic nerve Head (ONH) segmentation based glaucoma diagnosis is presented in [4] using OCT images. In this paper based on the computed CDR, glaucoma is identified. Automatic anterior chamber angel assessment is implemented by using OCT images for glaucoma detection is presented in [5]. In this paper glaucoma diagnosis is made by using anterior chamber angle measurement.

Retinal nerve fiber layer (RNFL) thickness and macular volume is computed for glaucoma diagnosis using OCT images[6]. In this paper the early stage of glaucoma and advanced glaucoma is analysed.

The various parameter such as vertical integrated RIM area, disc area, RNFL thickness and ONH features, Cup to Disc Ratio (CDR), cup to disc horizontal ratio and cup to disc vertical ratio are extracted as feature[7] for glaucoma diagnosis.

The correlation among RNFL thickness along with visual field is analysed for glaucoma diagnosis in [8]. The correlation between visual field parameters like, mean defect, loss variance, mean sensitivity, RNFL thickness is computed using regression analysis and pearson correlation co-efficients. Multi thresholding approach based CDR determination is presented for glaucoma and normal analysis[9]. Glaucoma detection is introduced using machine learning classifiers in [10], whereas thirty eight parameters such as global mean macular thickness, vertical integrated rim area, horizontal integrated rim width, disc area, cup area, rim area, horizontal CDR, vertical CDR, cup area, global mean RNFL thickness, 4 quadrant mean thickness and 12 clock hour means. Among these parameters only eight highest correlations with visual field mean deviation are selected for classification.

Five various classifiers such as LDA, SVM, recursive partitioning and regression tree, generalized linear model and generalized additive model employed for glaucoma classification. Automatic determination of ONH and RNFL structure parameters such as optic disc area, cup area, rim area, CDR, RNFL thickness and RNFL temporal is discussed in [11].

From the overview of glaucoma detection using OCT images, it is observed that most algorithms are used for various measurement, and diagnosis of glaucoma. This measurement and calculation mainly depends on the RC boundary, cup disc and (CFR ratio), RNFL & RV & RC boundary. The misclassification occurs if they are not segmented properly. To avoid this, an OCT image classification approach for automated glaucoma diagnosis systems is used and compared with various classifiers like naive bayes, KNN and SVM.

## METHODOLOGY

The main aim of this work is to develop a computerized automated diagnosis system for early detection of glaucoma. It follows three important stages are (i) pre-processing stage (ii) feature extraction stage, (iii) classification stage. It shows in Figure 1.
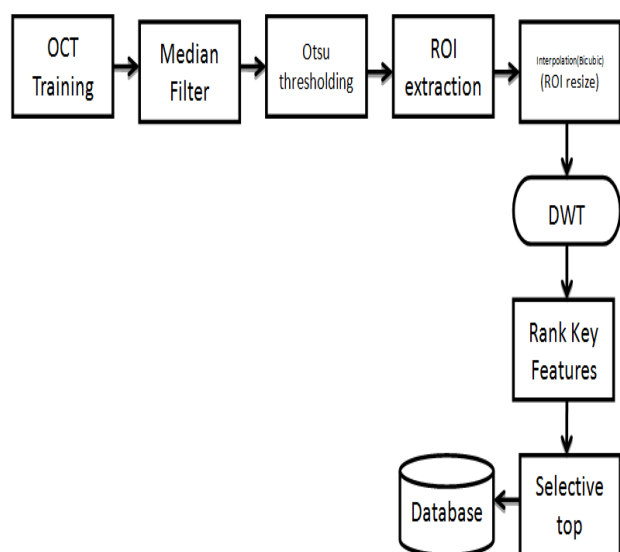


**Figure 1:** Proposed glaucoma diagnosis model using DWT

### Pre-processing stage

In the pre-processing stage, Region of Inertest (ROI) is extracted from the OCT image that contains only the retinal area. This is done by applying Otsu thresholding technique[12]. Before extracting the ROI region, the OCT image must be free from noise. Hence, median filtering is applied to de-noise the image.

### Feature Extraction

The important step of the proposed system is feature extraction. In the feature extraction stage, the extracted ROI image is decomposed by using DWT at predefined resolution level. This decomposition produces a group of low frequency and high frequency sub-bands. The size of the decomposed image is same as the size of the input OCT image. From the high dimensionality space, it is very difficult to select the features which contain plenty of information about the type of data. In order to reduce the dimension of the feature vector, the dominant wavelet coefficients to be selected first. For this purpose, a t-test class separability criterion is used. After ranking the wavelet coefficients, the significant wavelet

coefficients are selected as features and stored as Feature Database (FB) for classification.

## Classification

To classify an unknown OCT into glaucomatous or non-glaucomatous, the same kind of features is extracted as what have done for training OCT images. These features and the database FD are given to nearest neighbor classifier for classification. The classification performance of the proposed system is evaluated by using classification accuracy in percentage. The block diagram of proposed classification stage is shown in Figure 2.
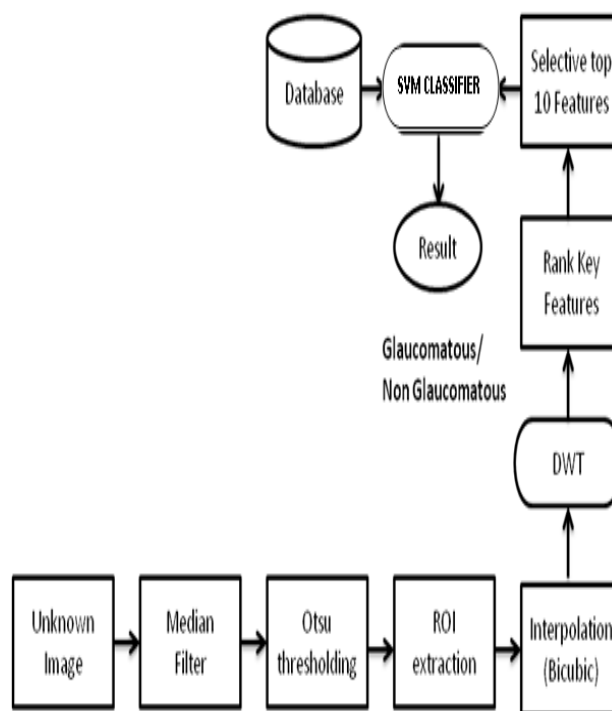


**Figure 2:** Block Diagram of Proposed Classification stage

## RESULTS AND DISCUSSION

This section discusses the performance of the glaucoma diagnostic system based on DWT and different classifiers like NB, KNN and SVM classifier. The assessment is carried on using 200 OCT images. Among them, 100 normal images & 100 Abnormal images from various patients. The images in the database are RGB images of size 689x329 pixels in the JPEG format, which is converted into gray scale for this work. Table 1 shows the accuracy of the KNN classifier for glaucoma diagnosis using cross validation process. R10 indicates that 10% of top ranked wavelet coefficients are used for classification process. The data set used for evaluation is divided into 1/3rd of samples 10 times randomly.

In Table 1 shows the comparison of accuracy, sensitivity and specificity using tenfold cross validation technique. The accuracy of Naive bayes classifier is 83.98% and accuracy of SVM classifier is 90.75%.

Sensitivity of NB, KNN, SVM classifier are 90.9%, 90.9%, 91.79% respectively and specificity of NB, KNN, SVM classifier are 87.5%, 84.4%, 89.7% respectively.

The performance of the different classifier is further analysed by confusion matrix and receiver operating characteristic (ROC) curve.

Figure 3 shows the confusion matrix and ROC curve corresponding to the features extracted at 6th level decomposition with selected R40 features for classification.

Confusion matrix and ROC plot for NB classifier from the ROC curve. It is observed that the area under the curve is 0.870 that shows the capability of the classifier performance for classifying OCT images into either normal or glaucoma.

Confusion matrix and ROC plot for KNN classifier from the ROC curve. It is observed that the area under the curve is 0.850 that shows in Figure 4, the capability of the classifier performance for classifying OCT images into either normal or glaucoma.

**Table 1:** Comparison of Accuracy, sensitivity and specificity using Tenfold cross validation

| Classifier | Best DWT level | Accuracy (%) | Sensitivity (%) | Specificity (%) |
|---|---|---|---|---|
| NB classifier | Level 5 | 83.98 | 90.9 | 87.5 |
| KNN (Euclidean measure) | Level 5 | 85.69 | 84.80 | 84.40 |
| KNN (City Block measure) | Level 6 | 86.68 | 90.9 | 84.4 |
| KNN (Correlation measure) | Level 6 | 83.80 | 81.80 | 90.60 |
| KNN (Cosine measure) | Level 6 | 83.71 | 81.80 | 90.60 |
| **SVM (Linear)** | **Level 6** | **90.75** | **93.90** | **93.80** |
| SVM (Qudratic) | Level 5 | 80.12 | 78.80 | 71.90 |
| SVM (Polynomial) | Level 5 | 83.82 | 81.80 | 81.30 |
| SVM (RBF) | Level 5 | 80.26 | 84.80 | 75.00 |
| SVM (MLP) | Level 5 | 76.32 | 84.80 | 71.90 |
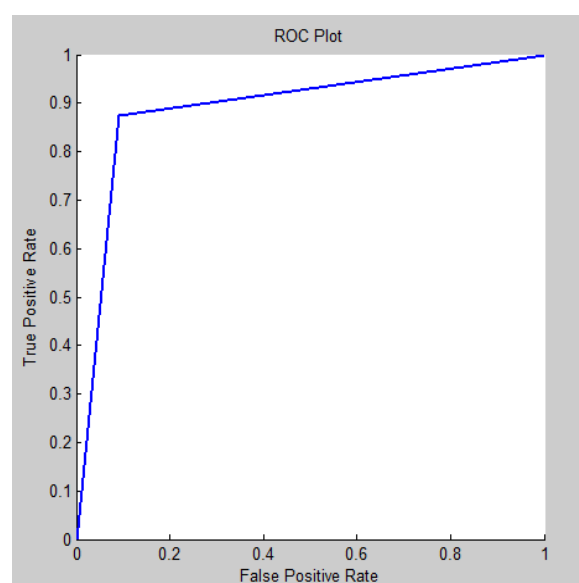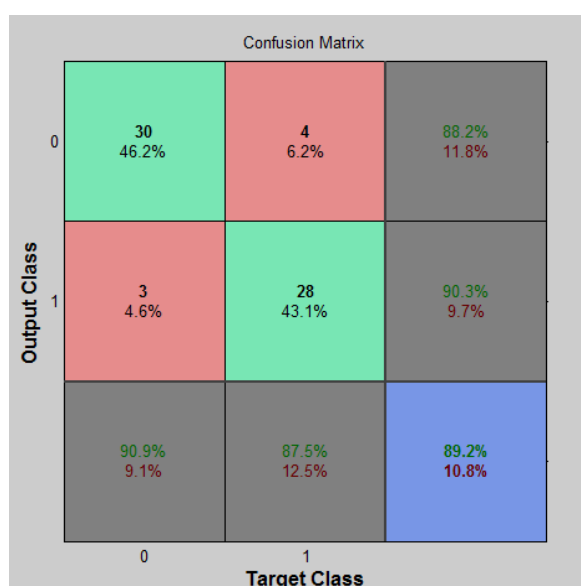


**Figure 3:** Confusion matrix and ROC plot for NB classifier
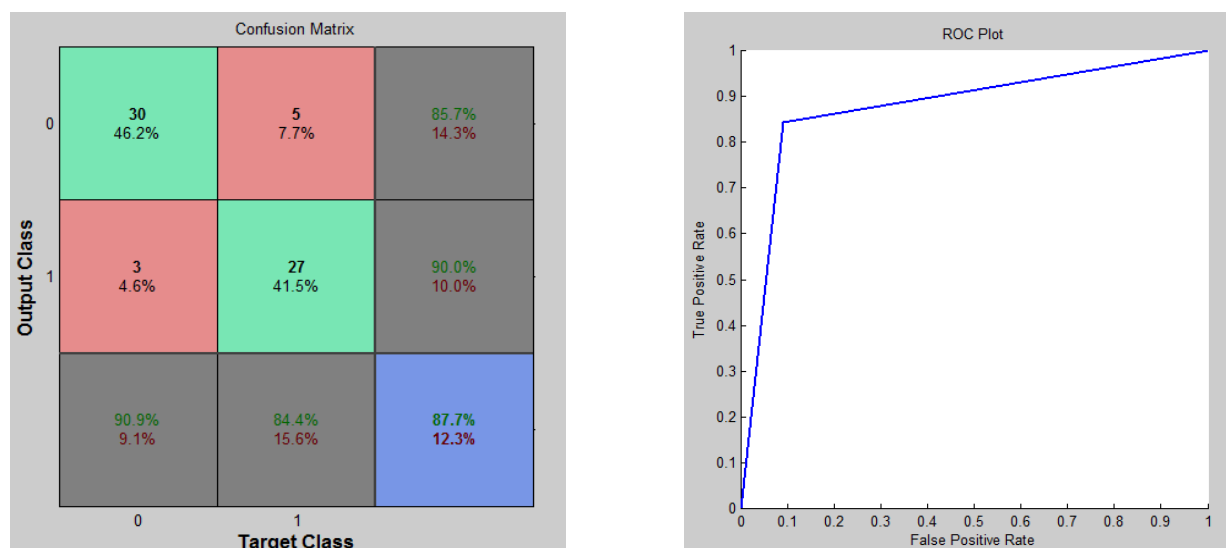
**Figure 4:** Confusion matrix and ROC plot for KNN classifier

## CONCLUSION

In this comparative study of glaucomatous image classification using optical coherence tomography an early glaucoma detection system is proposed in wavelet domain using OCT images to prevent the onset of blindness. At first, OCT images undergo pre-processing stage where de-noising and cropping of retinal region is performed. Then, wavelet coefficients are obtained by DWT decomposition of pre-processed OCT image and key features are selected using statistical significance test. Finally, Naive bayes, KNN and SVM classifier is employed for glaucomatous and healthy OCT image classification. It is observed from the experimental results that the proposed system using SVM classifier achieves satisfactory performance over NB, KNN and achieves maximum classification accuracy of 90.75%. Also the proposed approach yields sensitivity of 91.79%, and specificity of 89.71%.

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