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Glaucoma Detection Technique in Retina-A study

Shilpa Kaushal[1], Sunil Datt Sharma[2], Shruti Jain[3]

[1, 2, 3] Department of Electronics and Communication Engineering, Jaypee University of Information Technology, Solan, Himachal Pradesh, India

shilpakaushal1993@gmail.com[1], sunildatt.sharma@juit.ac.in [2], jain.shruti15@gmail.com [3]

Abstract- Glaucoma is a disease associated with retina of eye. Presently, millions of human being is suffering from this disease. Early detection of these diseases can save the people from blindness. Therefore, various methods have been developed for its detection. In this paper, we have studied the reported methods and summarized their performance in terms of accuracy of detection.

Keywords— Glaucoma, Intraocular Pressure(IOP) , fundus images, early detection, Cup-to-Disk Ratio(CDR).

1. INTRODUCTION

Glaucoma is disease related to optic nerve that arises due to deviation in fluid density inside the eye in addition harms the optic nerve [1, 2].Glaucoma, an optic nerve disease occurs due to variation – increase or decrease in fluid pressure within the eye. The pressure of the normal eye is 21 mm of Hg and when the pressure value is higher than 21 mmHg or 2.8 kPa, the optic nerve gets damaged leading to vision impairments and blindness. Diagnosis and treatment is based on elevation of Intraocular Pressure **(**IOP). Due to the buildup pressure in the eye, the nerve cells become compressed eventually leading to permanent vision loss. The anterior chamber of eye is bounded by cornea, iris, pupil and lens which is filled by fluid called aqueous humor. Aqueous humor nourishes the lens and cornea with nutrients, oxygen and provides optimal pressure called as IOP to maintain the shape of the eye. IOP is measured for detecting glaucoma and diagnosis is done by dilated eye examination showing an abnormal amount of cupping [3]. The post symptoms of Glaucoma are seeing halos around lights, vision loss, Redness in the eye, nausea or vomiting, eye pain and narrowed vision (tunnel vision) [4].

About 6 to 67 million people have glaucoma globally [5]. Every year more than 2 million people are affected by Glaucoma in USA. Glaucoma mostly occurs at the age of 40. Glaucoma has been referred to as the "silent thief of sight" because the loss of vision occurs slowly and gradually with no symptoms and warning signs. Worldwide, glaucoma is the second-leading cause of blindness after cataracts [6]. In 2010, 44.7 million people in the world suffered with open angle glaucoma. By 2020, the prevalence is projected to increase to 58.6 million worldwide [7]. Women are more prone to Closed-angle glaucoma. Bilateral vision loss can negatively affect mobility and interfere with driving. People with primary open angle glaucoma do *not* have increased mortality rates, or increased risk of cardiovascular death.

The different types of glaucoma are [8]: Normal Tension Glaucoma, Ocular Hypertension, Primary Open Angle Glaucoma, Primary Angle Closure Glaucoma, Secondary Glaucoma, Congenital Glaucoma, Acute Glaucoma, Pigmentary Glaucoma, and Exfoliation and Trauma- Related Glaucoma out of which we are concentrating on Open angle Glaucoma and Angle Closure Glaucoma because the value of IOP is highest in these two cases. Open angle glaucoma is very common among the individuals. Normal Tension Glaucoma is very painful comparative to other and is also termed as a type of Open angle Glaucoma. [9]. This type of glaucoma generally occurs which low IOP in the eye that's why it is termed as low pressure glaucoma**.** [10, 11, 12]

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2. LITERATURE REVIEW :

In this section, various methods proposed by different authors has been discussed. With this review, best method for early detection of Glaucoma can be chosen.

i. Agarwal *et al* [13], had proposed an adaptive thresholding method in which features like mean, standard deviation to segment the optic disk to optic cup are extracted from the images which make this method independent of the noise and image quality. This method gives the 90% accuracy.

ii. Pruthi *et al* [14] had given a method for Glaucoma detection by the cup to disk ratio (CDR) analysis. The methodology suggested by the author consists of 6 stages involving: pre-processing the data by illuminance correction, blood vessel removal. ROI extraction after pre-processing the images, followed by the feature extraction technique where optic disc extraction, optic cup extraction, morphological operations, ellipse fitting are some of the steps. The method discussed gives 98.12% accuracy.

iii. Virk *et al* [15] suggested a simple method i.e. CDR determination for the screening of Glaucoma. The author had specified one threshold value for CDR i.e. 0.5. If the CDR is greater than 0.5 then one can be suspected with Glaucoma. It gives 95% accuracy. The detection rate for CDR determination was 80% which needs more improvement.

iv. Gopalkrishnan *et al* [16] proposed a technique to segment the Optic Disc (OD) Segmentation using Circular Hough Transform and Curve Fitting boundary from the retinal images. It had used a circular Hough transform for the detection of Glaucoma in early stage. But the accuracy of the method was 68%. This method can be extended and improved using the OCT images.

v. Ayub *et al* [17] had proposed a method of Optic Disc and Cup Segmentation using K mean Clustering. Since for this method, firstly, ROI was being extracted which was further followed by the pre-processing technique which improves the image quality. In this techniques ellipse fitting was used for smoothening the boundary of OC and OD. Further using these techniques CDR was calculated and used for the early detection of Glaucoma. The advanced process gives the accuracy of 92% for Glaucoma detection.

vi. Sakthivel *et al* [19], suggested a technique for glaucoma detection using the Histogram Features Detection Technique. In these method different algorithms like Local Binary pattern (LBP) and Daugman's algorithm had been used for the feature extraction of the data. Histogram was performed for both magnitudes as well as phase components in the data. For the classification of the data, Euclidean distance between the feature vectors has been analyzed.

vii. Kolar *et al* [19] suggested a method depends on the fractal description which was followed by the classification process. For fractal dimensions estimation, two methods were given which explainsdifferent image information. Retinal nerve fibers was analyzed which were taken from the fundus color images. As losses in the retinal nerve fiber was the symptom of the glaucomatous eye, so it can be used as one of the feature for the detection of the Glaucoma.

viii. Acharya*et al* [20] presented a technique in which Glaucoma can be detected using combination of Higher Order Spectra (HOS) and texture features obtained from the retinal digital fundus images. These features after z-score normalization are fed to random-forest classifier which can be used clinically for detecting glaucoma accurately with the accuracy of 91%.

ix. Acharya *et al* [21] proposed a method in which Gabor transform was used where various features were extracted from the retinal fundus images. These features are mean, variance, skewness, kurtosis, energy and Shannon entropies. PCA was done to reduce the dimensionality of the features. This method gives the 93.1% accuracy. Author had also proposed a GRI which was developed using principal components to classify the 2 classes using 1 number only. This will reduce the complexity and reduce the classification time for the Glaucoma images.

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x. Shishir *et al* [22] developed a method for the detection of Glaucoma which consists of Empirical Wavelet Transform (EWT) using fundus images. EWT components were used to extract the correntropy features which were ranked depending upon *t*-value feature selection algorithm. 98.33% accuracy was obtained using Least SVM which decrease to 96.67% if 3 fold and 10-fold cross validation was used.
xi. Krishnan *et al* [23] proposed a method in which they used the texture features for the detection of Glaucoma. In this method, classification accuracy of 91.67% was obtained using the SVM classifier.
xii. Nyul *et al* [24] suggested a method in which author followed three steps process i.e. pre-processing, feature extraction and classification for the detection of the Glaucoma. In pre-processing, different methods i.e. illumination correction, vessel improvement and normalization were employed. Different features were extracted using generic method and these features were classified using SVM classifier in which classification accuracy comes to be 80%.
xiii. Bock *et al* [25] presented a method for the detection which used a standard pattern recognition pipeline with two stage classification. In this method, features extracted were termed as appearance based features which include pixel intensity values, spectral based, texture and histogram model values. In this approach of Glaucoma detection 86% accuracy was obtained using SVM classifier.
xiv. Mookiah *et al* [26] presented an automatic detection method for Glaucoma using the HOS and DWT features. These features with SVM classifier were able to detect Glaucoma with an accuracy of 95%. This method can be employed for the earlier detection of glaucoma.
xv. Dua *et al* [27] presented a method in which texture features like energy signatures were used as the exact and efficient approach for the detection of Glaucoma. In this method, author extracted energy signatures present within the images using 2D DWT feature extraction technique and different feature ranking and feature selection algorithms were followed. 93% accuracy was obtained using different classifiers like SVM and naïve Bayes classifier with tenfold validation.
xvi. Beaula *et al* [28] proposed a methodology for the early detection of the Glaucoma using empirical wavelet transform. In this method, author extracted the correntropy features from the EWT components obtained in the feature extraction process. These features were selected using *t*-test algorithm. 95% Classification accuracy was obtained with the SVM classifier.
xvii. Patil *et al* [29] proposed a methodology in which the diagnosis was done using the CDR method. In this method, the super pixel classification on the basis of the cup to disc ratio was done to identify Glaucoma. Color contrast improvement and image filtration were the preprocessing techniques used with the segmentation process for the glaucoma detection.
xviii. Dey *et al* [30] suggested automated glaucoma selection using support vector classification. In this method, images pre-processing techniques like noise removal and contrast enhancement were used. Principal Component Analysis (PCA) method was employed for feature extraction and SVM method for image classification. This method after cross validation gave accuracy rate 96%,
xix. Singh *et al* [31] suggested a method for glaucoma detection. This method employs various steps for the diagnosis which are pre-processing, feature extraction and classification. 97% accuracy was obtained when used with SVM classifier.

3. METHODOLOGY:

The general flow diagram for the detection process of glaucoma is shown in Figure 1.In this section; different steps involved in the detection of Glaucoma are discussed.

Step 1: First step is to collect the database which can be local (taken from the hospital) and online available database like Stare (maximum 400 images are present), Drones-DB (110 images are

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present). These images are known as retinal fundal images. Table 1 show the different Database used for detection of Glaucoma till yet.

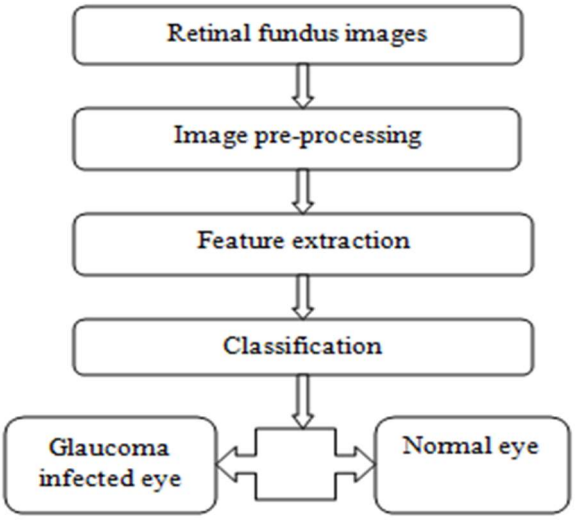

Figure 1: General process for the detection of Glaucoma

Table 1: Summary of different Database used for detection of Glaucoma

S.No.	Authors	No. of Images	Database
1)	Agarwal *et al* [13]	110 images	Local database (Venue Eye Research Centre, New Delhi)
2)	Pruthi*et al* [14]	10normal/10 Glaucoma	
3)	Virk*et al*[15]	50 images	Local Physician
4)	Gopalkrishan*et al* [16]	200 images	RIGA
5)	Ayub*et al* [17]	100 images	Local database (Armed forces institute of ophthalmology)
6)	Sakthivel*et al* [18]	44 images	Local database (Aravind Eye Hospital, Madurai, India.)
7)	Kolar *etal* [19]	30 images	NA
8)	Acharya *et al*.[20]	60 images	Local database (Kasturba Medical College, Manipal, India)
9)	Acharya*et al*[21]	510 images	Local database (Kasturba Medical College, Manipal, India)
10)	Shishir *etal* [22]	505 images (Public Database) and 60 images (Private database)	http://medimrg.webs.ull.es/. (Public Database) Kasturba Medical College, Manipal, India.(Private Database)
11)	Krishnan *et al* [23]	60 images	Kasturba Medical College, Manipal, India.(Private Database)
12)	Nyul *et al* [24]	NA	Erlangan Glaucoma Registry

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13)	Bock *et al* [25]	NA	NA
14)	Mookiah *et al* [26]	NA	NA
15)	Dua *et al* [27]	60 images	Kasturba Medical College, Manipal, India.(Private Database)
16)	Beaula *et al* [28]	NA	NA
17)	Patil *et al* [29]	NA	Atharva Eye Care Hospital, Pune
18)	Dey *et al* [30]	NA	NA
19)	Singh *et al* [31]	220 images	http://www.tf.fau.de/ (public database) and TechnischeFakultat (private database)

Step 2: Second step for the detection involves the pre-processing of the data i.e. noise removal and balancing other loopholes present in the image. The main motive of pre-processing is an improvement of the image data that suppresses unveiling distortions or enhances some image feature which are important for further processing steps, although geometric transforms of images (example rotation, scaling and translation) are classified among pre-processing methods. Different methods which are commonly used for this purpose are Histogram equalization, extraction of red, blue and green channel from the image, color enhancement, morphological operations, Fractal Analysis and much more. Histogram equalization is defined as a processor which was used for modifying image intensities to improve the contrast. Fractal analysis is a process where important parameter is the color of image. Fractal dimension is spontaneously determined for all levels of chosen channel of color information i.e. Red, Green, Blue, Hue, Saturation etc. Another method for the pre-processing is the extraction of color channels from the images. These channels are termed as Red channel, Blue channel, Green channel and Gray channel which were further used for the extraction of features from the image. Morphological can be explained as the set of image processing methods which characterize images on the basis of shapes [32, 33, 34, 35]. These methods use a structuring element as a mask in the input image which results in the same size output image. Basic morphological operations used are dilation and erosion [36, 37].

Table 2 shows the summary of different pre-processing techniques used for detection of Glaucoma till yet. Out of the different pre processing techniques the best method for preprocessing is extraction of Red, Blue, Green and Gray Channel Extraction. In fundus images, blood vessels in eye appeared like a network structure. So, to achieve success in detecting blood vessels accurately, different channels are extracted. Green channel gives highest accuracy when compared with other channels because it gives the finest results in the contrast for extracting the vessels which appear darker in light background [38].

Table 2: Summary of different pre-processing techniques used for Detection of Glaucoma

S.No.	Authors	Pre-processing techniques
1)	Agarwal *et al* [13]	Red ,Green and Blue channel extraction

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2)	Pruthi*et al* [14]	Anisotropic diffusion filter
3)	Virk*et al*[15]	NA
4)	Gopalkrishan*et al* [16]	Localized Gaussian Smoothing
5)	Ayub*et al* [17]	Morphological operations, Equalization , Color Enhancement
6)	Sakthivel*et al* [18]	Gabor filter
7)	Kolar *etal* [19]	Fractal Analysis
8)	Acharya *et al*.[20]	Radon Transform , Histogram Equalization
9)	Acharya*et al*[21]	Histogram Equalization
10)	Shishir *etal* [22]	Red ,Green and Blue channel extraction
11)	Krishnan *et al* [23]	Histogram equalization , Radon transformation
12)	Nyul *et al* [24]	Illumination correction, Vessel removal, Papilla normalization
13)	Bock *et al* [25]	Normalization
14)	Mookiah *et al* [26]	NA
15)	Dua *et al* [27]	Histogram equalization
16)	Beaula *et al* [28]	Red ,Green and Blue channel extraction
17)	Patil *et al* [29]	Histogram equalization
18)	Dey *et al* [30]	NA
19)	Singh *et al* [31]	NA

Step 3: Third step can be termed as the Feature extraction step which involves different techniques like wavelet methods [37, 38, 39, 40], filters, pixel intensity values and histogram models. Feature extraction is defined as method which is used to convert the visually extractable and non-extractable features into respective mathematical expressions. These expression ns, if based on shape then known as morphological features and if they are based on intensity distribution then termed as texture features. Methods based on the intensity distribution are (i) Statistical methods (ii) Signal Processing based Techniques, (EWT is the best example of this technique) and (iii) Transform based methods. Discrete transform, Fourier transform are some of the common transform based techniques used in the detection process. Different features are extracted like CDR, correntropy features, mean, standard deviation and open-angle parameters. Many proposed method uses change in CDR value as a feature for the detection of Glaucoma at early stage. The best extraction technique is EWT based correntropy features on the accuracy value.EWT, a signal decomposition technique can be defined as the signal-dependent method which does not require any predefined basis function like Fourier and Wavelet transform. It acts as a band pass filter. The empirical scaling function $\xi_m(W)$ and the empirical wavelets ς_m (W) are predefined. Correntropy are termed as a nonlinear kernelized

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similarity measure. This feature excellently captured the restrained variations in the pixel intensitiesand gives high classification accuracy.

Step 4: Last step or image classification (whether normal or glaucoma) is the analysis done using different features and consolidate the data for the classification. Classification is the techniques of combining the testing samples with similar features into same levels, where these levels are termed as classes. There are two categories of classification viz. supervised classification and unsupervised classification. Supervised classification is one in which training set is predefined else it is termed as unsupervised classification [38, 39, 40]. There are different types of classifications like SVM classifier, Bayes classifier, K-mean clustering classifier and many more depending upon the data used for the analysis. SVM gives the highest classification accuracy when used. Based on all the steps discussed above, CAD system was designed for the detection of Glaucoma. These systems use various techniques for detection process which gives different percentage of accuracy. Table 3 shows the comparison of different techniques used for the Detection of Glaucoma. The different papers were reviewed on the detection of Glaucoma; CDR was termed as important feature for the detection. CDR was calculated using different classifiers like thresholding, SVM, Least square minimization, K-mean clustering which results in lessaccuracy. Later it was seen that when 2D EWT and correntropy method (feature extraction method) with Least-SVM (classifier) was used, gives more accuracy over the other methods.

Table 3:Comparison of different methods used for the Detection of Glaucoma

S.No.	Authors	Methods given by authors	Images Number	Features extracted	Classifier	Accuracy (%)
1.	Agarwal *et al* [13]	Adaptive thresholding	110 images	CDR, mean, standard deviation	Thresholding	90%
2.	Pruthi*et al* [14]	CDR Calculation	10normal/10 glaucoma	CDR	SVM	98.12%
3.	Virk*et al*[15]	CDR Determination	50 images	CDR	Thresholding	95%
4.	Gopalkrishan*et al* [16]	Segment OD boundary	200 images	CDR	Least square minimization	68%
5.	Ayub*et al* [17]	Optic disc and Cup segmentation using K-mean clustering	100 images	CDR	K-mean Clustering	92%
6.	Sakthivel*et al* [18]	Histogram	44 images	LBF	Euclidean Distance	95.45%
7.	Kolar *etal* [19]	Fractal Dimensions	30 images	Fractal and power spectral features	SVM	74%
8.	Acharya *et al*.[20]	Diagnosis using texture and HOS feature	60 images	HOS and texture	Random-forest	91%
9.	Acharya*et al*[21]	Using Gabor Transformations	510 images	Gabor features	SVM	93.1%
10.	Shishir *etal*	Using EWT and	505 images	Correntropy	LS-SVM	98.33%

	[22]	Correntropy features	(Public Database) and 60 images (Private database)	features		
11.	Krishnan *et al* [23]	Detection using texture , DWT energy and HOS features	60 images	HOS and energy features	SVM	91.67%
12.	Nyul *et al* [24]	Glaucoma detection	NA	PCA	SVM	80%
13.	Bock *et al* [25]	Texture analysis for detection	NA	Pixel intensity values, FFT coefficients	SVM	86%
14.	Mookiah *et al* [26]	NA	NA	HOS and wavelet	SVM	95%
15.	Dua *et al* [27]	Detection using texture features	60 images	Energy signatures	SVM	93.33%
16.	Beaula *et al* [28]	Detection using texture features	NA	Correntropy	SVM	74%
17.	Patil *et al* [29]	Using CDR	NA	CDR	SVM	NA
18.	Dey *et al* [30]	NA	NA	NA	SVM	96%
19.	Singh *et al* [31]	Detection of glaucoma	220 images	Red, Green and Blue values	SVM	97%

CONCLUSION AND FUTURE WORK

Glaucoma detection techniques have been studies thoroughly and it has been concluded that the accuracy of EWT with Correntropy features based method and CDR with SVM is better than other reported methods. In future, the performance of these methods can be tested on the same data set using same classifiers.

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