A REVIEW ON DETECTION OF GLAUCOMA USING VARIOUS IMAGE PROCESSING ALGORITHMS

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ABSTRACT

Large number of people suffers from eye diseases in rural and semi urban areas all over the world. This paper presents a succinct of different types of image processing methods employed for the detection of Glaucoma. Glaucoma, an eye disease, caused due to neuro degeneration of the optic nerve. The damage done by glaucoma is irreversible. Glaucoma affects the optic nerve as a consequence of which loss of ganglia cells in retina of the eye come about and this loss eventually leads to loss of vision. As it cannot be cured, detecting the disease in time is important. A review of automated glaucoma detection techniques is presented in this paper. The existing techniques mentioned in the present review have certain advantages and disadvantages. Based on this study, one can determine which technique provides an optimum result.

Keywords: Glaucoma Detection, Comparison, Image processing Algorithms.

INTRODUCTION

The word glaucoma emanates from ancient Greek word, meaning 'clouded or blue-green hue ostensibly which describes a person with a dilated cornea or who is rapidly developing a cataract, both of which may be effected by chronic (long-term) increase in the intraocular pressure of the eye [1]. Glaucoma is a disease that progresses damaging the optic nerve with loss of retinal neurons and the nerve fiber layer, resulting in blindness if not treated on time. It is caused by elevated Intraocular Pressure (IOP) [2]. Blind spots develop due to damage to the optic nerve fibers which usually go undetected until optic nerve is significantly damaged. Thus early detection followed by the treatment is the key to preventing vision loss from glaucoma. Glaucoma is the leading cause of blindness in the world with around 80 million likely to be afflicted with glaucoma by the year 2020 [3].

The need for early glaucoma detection is due to the facts: 1) No noticeable symptoms in its early stages 2) Damage caused by it is irreversible 3) Leads to permanent loss of vision if not treated on time.

Although damage caused by glaucoma is irreversible, detection at early stage and subsequent treatment helps in slowing down the progression of the disease. If this damage left untreated, may lead to total blindness. Therefore, the early detection of glaucoma [4] is necessary. Glaucoma largely occurs in adults over age of 40, but it can also happen in young adults, children, and even infants. Increased risk of glaucoma is there in above 40 years of age, having family history of glaucoma, poor vision, diabetes and having trauma to the eyes [5].

A. Types of Glaucoma

There are two main types of Glaucoma:

a) *Open angle glaucoma*: This is the most common type of glaucoma, also called wide-angle glaucoma. It occurs due to partial blockage of drainage canal in which pressure increases slowly as fluid does not drain properly as shown in Fig 1. Symptoms arise from peripheral loss of vision and may not notice until central vision is affected. There is no visible abnormality of the trabecular meshwork [5].

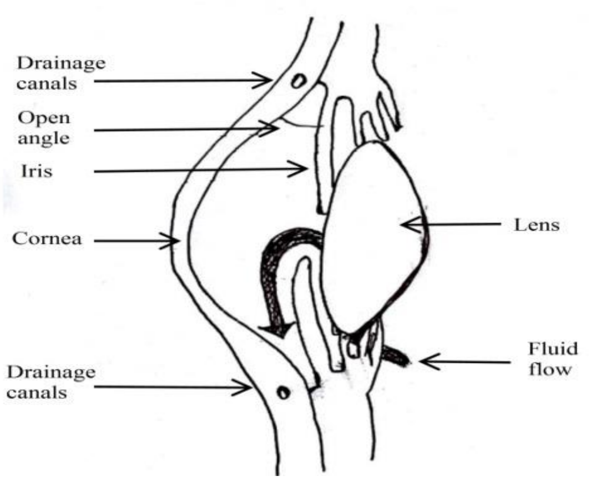


Fig 1. Open angle glaucoma

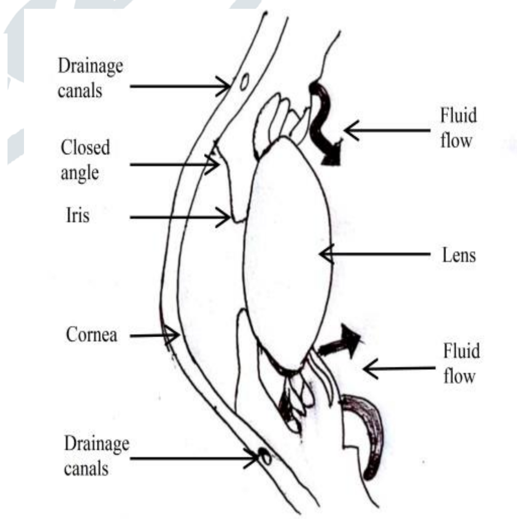


Fig 2. Angle-closure glaucoma

b) *Angle-closure glaucoma:* It is also called acute glaucoma caused due to sudden and complete blockage of aqueous drainage shown in Fig 2. The pressure rises rapidly leading to loss of vision quickly. It is developed due to narrow drainage angle, thin and droopy iris. The iris (coloured part of the eye) is pushed against the trabecular mesh network (drainage channels) within the angle of anterior of the eye, leads to blockage and bulges the iris forward [5].

B. Symptoms of Glaucoma

The foremost sign of glaucoma is often the loss of side vision, which may not notice as the disease prolongs [5]. This is why glaucoma is often called the “sneak thief of vision” [6]. In the case of severe levels in intraocular pressure, sudden eye pain, headache, blurred vision, or the appearance of halos around lights may occur. Seeing halos around lights.

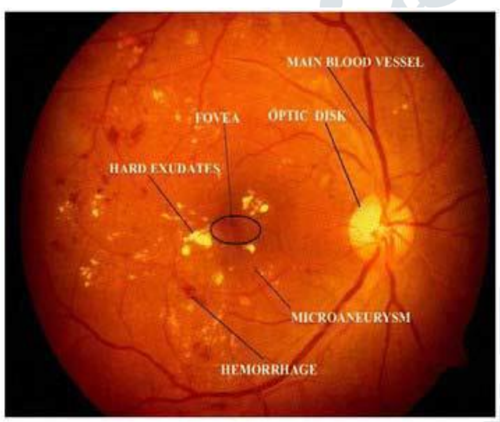
• Vision loss.
• Redness in the eye.
• Eye that looks hazy (particularly in infants).
• Nausea or vomiting.
• Narrowing of vision (tunnel vision).

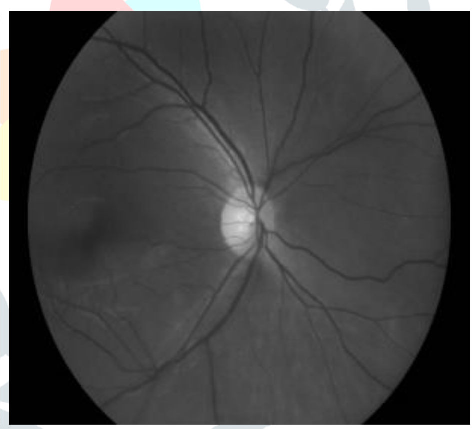
II. GLAUCOMA DETECTION

The important invention of ophthalmoscope by von Helmholtz in 1850 made it possible to diagnose glaucomatous changes in the fundus. Further improvement in identification of glaucoma was made by the diagnostic tools such as tonometer, Heidelberg edge perimeter technology, and the use of cocaine from the last few decades ginormous efforts have been done on detection and prediction of glaucoma using several Machine Learning techniques. Some of the techniques which have been used are neural networks, decision tree based on ID3 algorithms, Support Vector Machine, Naive Bayesian classifier, k- nearest neighbour, Canny edge detector, active contour model, linear regression, Fuzzy min-max neural network, KMeans Clustering, Thresholding, CDR, and ISNT.

A. Glaucoma Detection Process

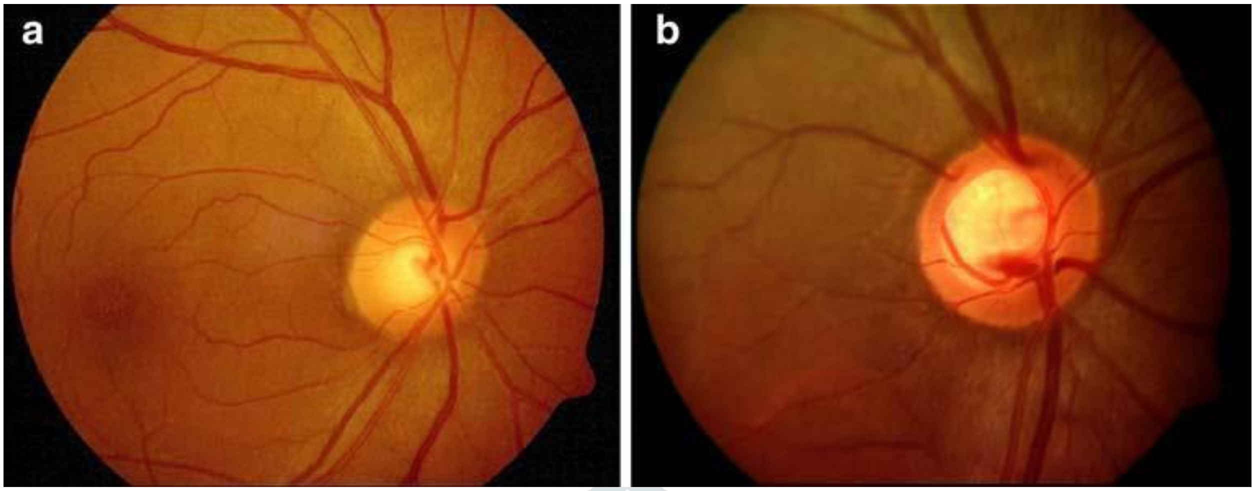
For glaucoma detection, first, retinal images are obtained using digital capture devices for image content. Then pre-processing is performed for equalizing the irregularities on the images. In pre-processing, blood vessels are segmented and in painted to gain a vessel-free image. Then, Feature extraction is performed to reduce the dimensions effectively to represent the interested parts of an image as a concise feature vector for describing the large data set precisely. Pixel intensity values, textures, FFT coefficients and Histogram model are the methods used in feature extraction. Image Classification is performed which analysis the numerical properties of an image and organizes the data. Depending on the results obtained, the set of data is divided into discrete classes' i.e. normal eye or glaucomatous eye. The general glaucoma detection process [7] is illustrated in Flowchart 1.





Labelled Retina fundus image Binary image

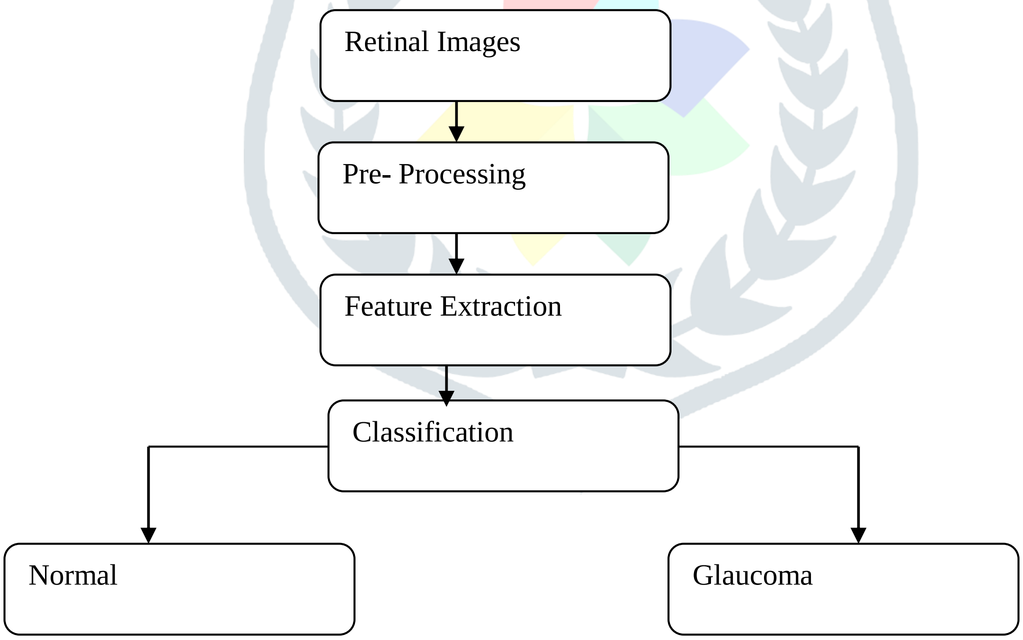
Fig.3



Normal Retina Fundus image Glaucomatous Eye fundus image

Fig.4

The inputs for the automated glaucoma detection process are Retinal fundus images which are shown above in fig.3 & 4.



Flowchart I: Generic process for glaucoma detection [7]

III. LITERATURE REVIEW

In [7], the authors presented a novel depth discontinuity approach for cup segmentation from multi retinal images. The proposed method is applicable for a range of images acquired sequentially. Initially the author experimented on a set of two images acquired sequentially and later used three set of images acquired sequentially. Addition of one more view enriched the information about the cup boundary which was more close to the cup boundary marked by the glaucoma expert. The system comprises Pre-processing, Region of Interest (ROI) Extraction, Feature Extraction stage, Calculation of CDR, Classification and Performance analysis stage. The system takes input as fundus image. In the pre-processing stage, illumination correction and blood vessel removal has been performed. After analysis of the entire image, a small square having 360 X 360 pixels taken around the brightest region denoted as ROI. Features have been extracted from optic disc and optic cup and CDR is calculated. The accuracy of classifiers namely SVM, Back Propagation Neural Network, ANFIS obtained are 98.12%, 97.35% and 97.77%. From above six stages and by suitable classifier, one might get good accuracy in glaucoma detection.

In [8], the authors exploited the CDR feature as well as ISNT rule to automatically detect glaucoma. To calculate CDR, Mean Threshold Morphological method has been used. And to find the neuro-retinal rim thickness to validate ISNT rule, AND operation is performed on the resultant images of optic disk and optic cup. The proposed method achieved an average accuracy of 97.5% when tested on three different databases.

In [9], the authors used super pixels clustering algorithm; simple linear iterative clustering (SLIC) and a feed-forward neural network classifier to calculate the CDR value. The proposed approach extracts features from super pixels and utilizes neural network classifiers to estimate the boundary of the optic disk and optic cup. The sensitivity and specificity achieved by the proposed approach is 92.3% and 88% respectively.

In [10], the authors used CDR, Neuro-retinal rim thickness (NRR) and Neuro-retinal rim area features to assess glaucoma. The feature extraction technique used by the authors is Pearson-R Correlation Filter. The optic disk and optic cup are segmented using Pearson-R coefficients followed by the CDR calculation. The NRR thickness is calculated from the segmented OD and OC by using Euclidean distance measurement technique. The proposed technique was tested against various datasets collected from hospitals, online database. The overall efficiency was found to be 97% which is very promising.

In [11], the authors made a review on different machine learning classifiers and compared their performance accuracy. It summarized various feature extraction techniques like pixel intensity value, moment, histogram, textures, FFT coefficients, p-tile threshold, macular cube methods. Among different machine learning classifiers, linear regression and Fuzzy min-max neural network based on Data-core (DCFMN) techniques tops the list with 99% and 97% accuracy respectively.

In [12], the authors proposed an algorithm for automatic glaucoma detection and classification by grouping the pixels using super pixel segmentation. The method extracted features such as RNFL thickness, blood vessels, RNFL reflectivity from the OCT image and combined them to obtain a feature map. The feature map is then segmented into 100 parts using super pixel segmentation. Histogram distribution, mean, standard deviation, 3rd and 4th moment of each super pixel was calculated to extract a feature vector. The proposed method accuracy statistically improved compared to the then current method.

In [13] , the author performed a work, "Enhancement of retinal fundus Image to highlight the features for detection of abnormal eyes". This work specifies the methods used to detect main features of retinal fundus images such as optic disk, fovea, and exudates and blood vessels using different techniques. To determine the optic Disk and its centre author find the brightest part of the fundus and apply Hough transform.

In [14], author performed a work, "Validation of Retinal Image Registration Algorithms by a Projective Imaging Distortion Model". A variety of methods for retinal image registration have been proposed. Authors also present the validation tool for any retinal image registration method by tracing back the distortion path and accessing the geometric misalignment from the coordinate system of reference standard.

In [15], author performed a work," Automated localization of retinal optic disk using hough transform". The retinal fundus image is widely used in the diagnosis and treatment of various eye diseases such as diabetic retinopathy and glaucoma. The proposed methodology consists of two steps: in the first step, region of interest (ROI) is found by image by means of morphological processing, and in the second step, optic disk is detected using the Hough transform.

In [16], author performed a work," ORIGA-light: An Online Retinal Fundus Image Database for Glaucoma Analysis and Research". Author present an online dataset, ORIGA-light, which aims to share clinical retinal images with the public. Author had updated the system continuously with more clinical ground-truth images. The proposed method focuses on optic disk and cup segmentation.

In [17], author proposed," The new approach to Automatic detection of Optic Disc from non-dilated retinal, images". Author describes a new filtering approach like Sobel edge detection, Texture Analysis, Intensity and, Template matching to detect Optic Disc. The proposed algorithm is applied in wavelet domain on 150 images of, Messidor dataset.

In [18], author performed a work," Retinal Blood Vessel Segmentation Using Gabor Filter and Tophat Transform". In this, Author gave a method for retinal blood vessels segmentation by applying firstly Gabor filter to enhance blood vessels and then applying top-hat transform. Later on, the output is converted to binary image with p-tile thresholding.

In [19], author performed a work," Optical Cup to Disc Ratio Measurement for Glaucoma Diagnosis Using Harris Corner". In this paper, CDR is determined using Harris Corner. Harris comer detector measures the local changes of the signal with patches shifted in different directions by a small amount. It is based on the local auto-correlation function of a signal.

In [20], author performed a work," Automatic Prediction of Diabetic Retinopathy and Glaucoma through Retinal Image Analysis and Data Mining Techniques". This paper proposed a novel approach for automatic disease detection. Retinal image analysis and data mining techniques are used to accurately categorize the retinal images as either Normal, Diabetic Retinopathy and Glaucoma affected.

In [21], author proposed, " Review of Image Processing Techniques for Automatic Detection of Eye Diseases". The review paper provides information about the application of image processing techniques for automatic detection of eye diseases. The key image processing techniques to detect eye diseases include image registration, fusion, segmentation, feature extraction, enhancement, pattern matching, image classification, analysis and statistical measurements.

In [22], author proposed Another method developed as an automated glaucoma detection system by combining the texture and higher order spectra (HOS) features obtained from fundus images. Naive Bayesian, support vector machine, random- forest classifiers, and sequential minimal optimization have been used to perform the classification. After z-score normalization and feature selection, the result gives the texture and HOS-based features. When these features are combined with a random-forest classifier, it performed better than the other classifiers. This method has diagnosed the images of glaucoma with an accuracy of 91% using HOS technique and with the help of random-forest classifiers.

This method [23] involves developing a glaucoma screening technique using super pixel classification on the optic disc and optic cup segmentation. In this method, first, each optic disc image is over-segmented into super-pixels; then, from each super pixel, mean intensities, center, surround locations, and features of the location have been extracted in order to classify whether it is a cup or non-cup. In optic disc segmentation, histograms have been used to differentiate each super-pixel as disc or non-disc. In the database of 650 images was used with boundaries of optic disc and optic cup. The result showed an overlapping error of 9.5% and 24% in the optic disc and optic cup.

The author presented [24] only the first step of the pipeline i.e., fast and robust OD segmentation in retinal images. This correction paper presents the remaining steps of Glaucoma detection processing pipeline. The segmented OD is preprocessed to highlight the NRR and OC area. A multi-layer perceptron with 12-D feature vector is used for pixel classification based OC segmentation. Cup-to-disc ratio and other contextual features are extracted from the segmented OD and OC. A decision tree-based random subspace ensemble classifier is used to classify the

Glaucomatous and non-Glaucomatous images. Experimental evaluation shows that the proposed methodology can be reliably utilized in screening programs for early glaucoma detection.

The author [25] introduces a new method to improve the precision of the ILM-layer extraction. It also employs a novel technique to refine contour of an ILM layer. The novel method has outperformed interpolation and Bezier curve fitting in term of outliers' removal and surface refinement. In the disc-diameter-calculation process, the retinal-pigment-epithelium (RPE) layer end points have been used to define disc margin. Prior to RPE-layer extraction, ILM-Layer removal has been done by an innovative strategy to locate and remove ILM-layer. Finally, precise RPE-layer extraction has been done based on the novel thickness-value (TV) estimation method. Furthermore, a new criterion for cup edges determination, based on the mean value of RPE-layer end points, is proposed. The proposed system has shown a clear precedence over its contemporary systems in terms of accuracy and handling of acute cases. Satisfactory results have been obtained when compared with the clinical results.

IMAGE PROCESSING TECHNIQUES USED FOR GLAUCOMA DETECTION

S.No	Method	Database	Classification accuracy%	Sensitivity %	Accuracy%	Specificity%
1.	Detection of RNFL Defects Using Gabor Filtering	52 fundus images	Not reported	Not reported	71 %	71 %
2.	Texture Analysis of Nerve Fiber Layer in Images	28 fundus images	2.85 % (class A-B) 0.55 % (class B-C) 10.88 % (class A-C)	Not reported	Not reported	Not reported
3.	Nerve Fiber Layer via Markov	28 fundus images	0.55 % (class C-B) 3.05 % (class	Not reported	Not reported	Not reported

	Random Fields Texture Modeling		A-B) 11.7 % (class A-C) 9.88 % (class C-B-A)			
4.	Neuro Retinal Optic Cup Detection	71 fundus images	Not reported	97.2 %	97.2 %	97.2 %
5.	Close Angle Glaucoma Detection in RetCam Images	1866 fundus images	Not reported	86.7 % 97.8 %	Not reported	83.3 % 92.6 %
6.	Enhancement of Optic cup to Disc Ratio Detection	Few fundus images	Not reported	Not reported	97.5 %	Not reported
7.	A Computer based Diagnosis System for Early Glaucoma Screening	128 fundus images	Not reported	96.2 %	Not reported	96. 6 %
8.	Automated Diagnosis of Glaucoma Using Texture and Higher Order Spectra Features	60 fundus images	91 %	Not reported	91 %	91 %

V. CONCLUSION

Through this review paper we have studied different techniques which were involved in detecting glaucoma. Glaucoma is one of the major disease which is contributing to majority of blindness worldwide. With the help of these techniques, we need to develop some less expensive automated technique in order to detect glaucoma disease accurately. These techniques would be helpful for less developed countries where there is a shortage of ophthalmologists. In future, accurate detection with less cost effectiveness, it may be beneficial to the poor people. Once glaucoma is correctly diagnosed there is a probability of avoiding total blindness.

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