ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

Image Processing Techniques for Glaucoma Detection: A Survey

Abdul Rehaman.K
Department of Electronic and Communication,
BMS College of Engineering,
Bangalore, India.

Rashmi Ravi
Department of Electronic and Communication,
BMS College of Engineering,
Bangalore, India.

Vishwas M Shetty
Department of Electronic and Communication,
BMS College of Engineering,
Bangalore, India.

Vivek Hegde
Department of Electronic and Communication,
BMS College of Engineering,
Bangalore, India.

Abstract:

Glaucoma is a chronic eye disease that leads to vision loss. As it cannot be cured, detecting the disease in time is important. Current tests using intraocular pressure (IOP) are not sensitive enough for population based glaucoma screening. Optic nerve head assessment in retinal fundus images is both more promising and superior. This paper proposes image processing techniques for the early detection of glaucoma. Glaucoma is one of the major causes which cause blindness but it was hard to diagnose it in early stages [21]. In this paper, we propose various image processing techniques for cup to disc ratio (CDR) assessment using 2-D retinal fundus images. In this paper various images processing techniques like sparse dissimilarity constrained coding (SDC), Observing local binary patterns, Adaptive threshold techniques, observing image based features etc., are discussed.

Keywords:

SDC, Glaucoma, CDR, Fundus and Optic disk.

I.INTRODUCTION:

Glaucoma is a condition that causes damage to the optic nerves that carry information from the eye to the brain. It is always associated with increase in the intra ocular pressure (IOP) of the eye. Usually glaucoma is inherited and has few or no symptom. If left untreated or uncontrolled glaucoma may lead to peripheral vision loss initially and eventually lead to permanent blindness. Survey by glaucoma society of India] have revealed that glaucoma is the third leading cause of blindness in India.12 million people are affected accounting for 12.8% of the countries blindness. Population based studies a prevalence between 2% to 13%.Two major categories of glaucoma are open angle glaucoma and narrow angle glaucoma. By “angle” we refer to the drainage angle inside the eye that controls the outflow of watery fluid, aqueous humor that is normally produced inside the eye. If the aqueous access the drainage angle, then the glaucoma is known as open angle glaucoma and if the drainage angle is blocked and the aqueous cannot reach it, the glaucoma is known as narrow angle glaucoma. Variations in open angle glaucoma include: primary open angle glaucoma (POAG), normal tension glaucoma (NTG), pigmentary glaucoma, pseudo exfoliation glaucoma, secondary glaucoma and congenital glaucoma. Variations in narrow angle glaucoma include acute angle closure glaucoma, chronic angle closure glaucoma and neo vascular glaucoma.

A tonometer is used to measure the intra ocular pressure (IOP). An abnormally high IOP reading indicates a problem with the amount of fluid (aqueous humor) in the eye i.e. either eye is producing too much fluid or it is not draining properly. Normally IOP should be below 21mm hg. Other methods of monitoring glaucoma involve the use of sophisticated imaging technology like Scanning Laser Polarimetry (SLP), Optical Coherence Tomography (OCT) and Confocal Scanning Laser Ophthalmoscopy. These methods are used to create the baseline images and measurements of the eye optic nerve and internal structures. Then at specified intervals images and measurements are taken to make sure n changes have occurred over time. Visual field testing is a method to determine if the patient is experiencing vision loss from glaucoma. Gonioscopy can also be performed to make sure aqueous humor can drain freely from the human eye. But it has been observed that the methods involving measuring of IOP are less accurate and the methods involving visual field examination involves sophisticated equipment only available in specialized hospitals. Hence these methods are not useful when a population has to be screened for glaucoma. Also, manual assessment is subjective, time consuming and expensive. Hence, we look forward to an easy, inexpensive and efficient method for glaucoma diagnosis. 2-D retinal fundus images can be easily obtained at a lower cost since fundus cameras are widely available in hospitals, polyclinics, eye centers, and especially in optical shops. Sing these 2-D fundus images and applying various image processing techniques we can easily identify glaucomatous fundus images. Therefore, there is little additional hardware cost to build a glaucoma screening program using existing fundus cameras. In this paper we discuss various such image processing techniques that can be implemented for a population based glaucoma screening.

II.IMAGE PROCESSING TECHNIQUES FOR GLAUCOMA DETECTION.

1. SPARSE DISSIMILARITY CONSTRAINED CODING.

It has been observed that the methods involving measuring of IOP are less accurate and the methods involving visual field examination involves sophisticated equipment only available in specialized hospitals. Hence these methods are not useful when a population has to be screened for glaucoma. Also, manual assessment is subjective, time consuming and expensive. Hence, we look forward to an easy, inexpensive and efficient method for glaucoma diagnosis. 2-D retinal fundus images can be easily obtained at a lower cost since fundus cameras are widely available in hospitals, polyclinics, eye centers, and especially in optical shops. Sing these 2-D fundus images and applying various image processing techniques we can easily identify glaucomatous fundus images. Therefore, there is little additional hardware cost to build a glaucoma screening program using existing fundus cameras. In their paperJun Cheng ,Fengshou Yin, Damon Wing Kee Wong, Dacheng Tao, Jiang Liu discuss Sparse Dissimilarity-Constrained Coding techniques that can be implemented for a population based glaucoma screening [1].Disc localization: The first step in order to calculate Cup to Disc Ratio using Sparse Dissimilarity Constrained Coding technique is to locate and segment the disc. The approximate location of the disc is found out by disc localization. Disc localization can be achieved using various factors like brightness, anatomical structures among the disc, macula and retinal blood vessels. Jun Cheng , Fengshou Yin, Damon Wing Kee Wong, Dacheng Tao, Jiang Liuin their paper followed brightness based method for disc localization.

Disc Segmentation: Segmentation is applied to locate the disc boundary. Algorithms proposed for segmentation are template-based approaches, deformable model-based approaches, and classification-based approaches. Here a combination of the above three approaches known as self-assessed is followed. Usually, one method of segmentation may work on a particular image but the same method may fail when used on some other image. That is the reason why here self- assessed disc segmentation is proposed which uses one result among the outputs of the three segmentation methods. It is the best result among the three results that is chosen [1].

Disc Normalization: Past studies have revealed that the green channel representation of a colour image is the best suited for CDR computation. The images of the right eye are flipped horizontally t avid the difference between the right eye and the left eye. Two major operations done in this stage are: Blood vessel removal: The distribution of blood vessels varies from one individual to another. They highly affect the disc reconstruction and dissimilarity computation between two disc images.

Hence it is important that we remove them. Any one among the many automated blood vessel detection techniques can be used for blood vessel removal. Within Disc Uneven Illumination Correction: Disc reconstruction and dissimilarity computation are affected by uneven illumination across the image. Uneven illumination varies from image to image. Here in this method linear mapping is used to even out the unbalanced illumination.

SPARSE DISSIMILARITY-CONSTRAINED CODING:

Let n reference disc images be $X=[x_1,x_2,\dots x_n]$, the corresponding CDRs as r $[r_1, r_2, \dots, r_n]^T$ and x_i denotes the ith balance corrected disc computed above. Inspired from the reconstruction based method, we want to compute a linear reconstruction coefficient $w = [w_1, \dots, w_n]^T$for a new testing disc image y while minimizing the reconstruction error $|y - X_w|^2$. Once the co-efficient w is calculated the best value of the CDR can be obtained using the equation:

$$\hat{r} = \frac{1}{1_w^T w} r^T w$$

Calculation of CDR using SDC involves:

Data set evaluation criteria:In the method proposed [Paper number] images 2326 images from 2326 different subjects was acquired using two different retinal cameras (say A and B). The Intra Ocular Pressure of these subjects was measured. The CDR's of the images taken using the camera A were manually computed by the professionals. These CDR values are used as "ground truth". The camera B images are collected in a screening study. Out of the 2326 images, 168 A and 46 SCES images were diagnosed as glaucomatous by the ophthalmologists. These results are used as "Gold ground truth". Now the accuracy of the automated CDR values calculated by applying the above mentioned techniques i.e. localization, segmentation and normalization is checked using these manually calculated values. The CDR assessment accuracy criteria is as follows:

1) CDR error, computed as $\delta = |CDR_m - CDR|$, where CDR_mdenotes the manual CDR.
2) The correlation with the manual CDR's is calculated. In this method Pearson's Co-efficient was used.
3) Based on the correlation coefficient value, the accuracy of the CDR value calculated is measured.

Performance Evaluation under Different Settings: In order to check the robustness of the method proposed, it is checked under different settings i.e. varying the different parameters and also changing the reference images.Comparison with other methods: This method was then compared with two state of the art methods i.e. using super pixel and LLC.Effect of Reference Manual CDRs r: Manual assessment of CDR's is very subjective. Hence it is very likely that each person may calculate a different CDR value for the same image. Hence it is important to make a note of how different CDR values affect the calculation of r. This method of calculating CDR's using SDC achieves accuracy equivalent to that of the ones calculated manually. Hence this method can be used in place of time consuming and expensive manual CDR assessment techniques.

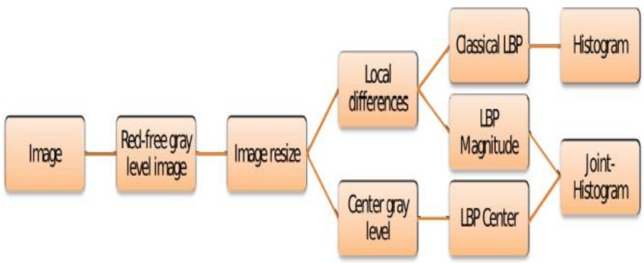
2.OBSERVING LOCAL BINARY PATTERNS OF THE FUNDUS IMAGES:

The major drawback in the method involving calculation of CDR is that, while applying segmentation even a small error in localization will lead to major errors in measurement and hence we end up with faulty diagnosis. Also the existing methods involve several complex preprocessing stages, which are intended to remove variations that are not required for the diagnosis but in the process they end up eliminating the blood vessels, which can also be affected by glaucoma. In case of a patient suffering from glaucoma, the location of his/her blood vessels changes due to dying tissue structure. These factors are not taken into consideration while calculating CDR. Hence these methods involving calculation of CDR are found not to be that effective.

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

Maya Alsheh Ali, Thomas Hurtut, Timoth_eeFaucon, Farida Cherietin their paper propose a method of analyzing the texture using Local Binary Pattern in order to study glaucoma. Unlike CDR calculation, here the information from the entire image is considered and not a specific region. Three operators are used to classify each local region. The factors being: the central pixel (LBPC), the sign (LBP) and the magnitude (LBPM) Distribution of LBP and joint distribution of LBPM and LBPC together capture the discriminative textural information [3].

Framework of the proposed method



Preprocessing: Initially the green- blue channel mean of the fundus image is considered. This is because, it has been observed that the red channel free fundus images have better contrast among the retinal structures like blood vessels and retinal nerve fiber layer.

Local Binary Pattern: The local binary pattern operator is a powerful and simple gray scale invariant method of analyzing textures. It combines the structural textural analysis and statistical characteristics. With the given central pixel value, the pattern number is calculated by comparing its value with those in its circular neighborhood:

$$LBP_{P,R} = \sum_{p=0}^{P-1} s(g_p - g_c) \times 2^p, \quad s(x) = \begin{cases} 1 & \text{if } x \geq 0 \\ 0 & \text{otherwise} \end{cases}$$

Here gc is the central pixel gray level value and gp is the Pth neighbor among P neighbors within the radius R. After identifying the LBP pattern of each pixel (i, j), the whole texture image is represented by a histogram of LBPs:

$$H(k) = \sum_{i=1}^{N} \sum_{j=1}^{M} f(LBP_{P,R}(i,j), k), \quad k \in [1, K]$$

$$f(x,y) = \begin{cases} 1 & \text{if } x = y \\ 0 & \text{otherwise} \end{cases}$$

Here K is the maximum LBP value. When the value of P increases, it is observed that the value of K increases rapidly. To avoid this problem, texture information is mostly contained in patternswhich have at most two binary transitions in the circular representation, called uniform patterns. These uniform patterns while retaining most of the information of the image, reduce the feature dimension from 2^P to P(P-1) +3.

$$U(LBP_{P,R}) = |s(g_{P-1} - g_c) - s(g_0 - g_c)| + \sum_{P=1}^{P-1} |s(g_P - g_c) - s(g_{P-1} - g_c)|$$

Completed modeling of LBP: In order to expand the magnitude component (LBPM) and central pixel intensity (LPBC) f the conventional LPB, completed model of LPB was proposed.

$$LBPM_{P,R} = \sum_{p=0}^{P-1} t(g_p - g_c, T) \times 2^p, \quad t(x,T) = \begin{cases} 1 & \text{if } x \geq T \\ 0 & \text{otherwise} \end{cases}$$

$$LBPC_{P,R} = t(g_c, T_I)$$

Here T is a threshold set to the mean value of (gp − gc) from the whole image and TI is the average gray level of the whole image. The distribution of LPB and joint distribution of LPBM and LPBC, gives us the needed image features.

LPB parameters:

1) The number of neighbors P
2) The neighborhood radius R:
3) The image resolution

Classification: Leave-one-out validation method with a k-nearest neighbor classification method is used to deal with the limited size of the data base. The simplest of all machine learning algorithms is the k-nearest neighbor algorithm. According to this algorithm, an object is classified by a majority vote of its neighbors, with the object being assigned to the class most

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

common amongst its k nearest neighbors.Hellinger f-divergence metric is used to measure the inter-feature distance. For two discrete probability distributions P = (p1 . . . pk) and Q = (q1 . . . qk), their Hellinger distance is defined as:

$$H(P,Q) = \frac{1}{\sqrt{2}} \sqrt{\sum_{i=1}^{k} (\sqrt{p_i} - \sqrt{q_i})^2}$$

This method is a glaucoma detection method based on textural features. The various attractive properties of these features are that: they are invariant to monotonic gray scale variations, low complexity, few parameters to be fixed before the feature extraction and satisfactory discriminating power. This method is effective even in the case of varying imaging and lighting conditions. It also enables very fast feature extraction. It does not target a specific disease symptom; hence it is found effect even in case of detection of diabetic retinopathy.

3. USING ADAPTIVE THRESHOLD BASED TECHNIQUE

In this paper, the digital fundus images are used to detect glaucoma by using a technique based on histogram of the image wherein the statistical features of the image are studied. The main aim is to lower the computation cost and obtain efficient results. Ayushi Agarwal, ShradhaGulia, Somal Chaudhary, Malay Kishore Dutta, RadimBurget and KamilRiha propose a technique in which glaucoma is detected by localizing the optic disk and optic cup automatically from the digital fundus images using the image adaptive thresholding technique making the proposed method individualistic of image quality and invariant to noise.

Statistical features like mean and standard deviation of the image histogram are used to track the threshold value that depends on the relationship between the statistical features. The threshold values are used to detect the optic disk and optic cup and finally the CDR is calculated for glaucoma detection [23].

PROPOSED METHOD

Image feature extraction: The local features, mean and variance are extracted in order to make the method adaptive of image quality.

Mean and Variance are obtained as:

$$X = 1/N \sum x_i$$

$$\sigma^2 = 1/N \sum (x_i - X)^2$$

Standard deviation is defined as the square root of variance and is given as:

$$\sigma = \sqrt{\sigma^2}$$

Histogram Analysis: The histogram of green channel image is examined and the graphical representation of number of pixels with respect to gray levels are obtained. The 8-bit grayscale image contains 255 gray levels, for which the probability distribution function of the image is given as

$$P(r_k) = n_k/n$$

Where r_k is the kthgray level, n_k is the number of pixels corresponding to k^{th}gray level and n is the total number of pixels in the grayscale image. The segmentation of the optic disk and optic cup is done by providing a threshold value that has a high intensity in the histogram as observed from the fundus image which show the optic disk and optic cup regions are brighter. Determination of the intensity level at which the optic disk lies is given byT_{disc}= 1.2x sum(mean, standard deviation)The threshold for optic cup is obtained in an experimental manner given as:

T_{cup}= 1.25 x (threshold$_{optic\ disk}$) + diff(mean, standard deviation). Adaptive image thresholding: The robust and effective method of thresholding is used to segment objects from the image where in the particular intensity value of the image is thresholded in the following way. If f(x,y) is the image and I is the threshold value then the output image g(x,y) is obtained as:

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

$$g(x,y) = \begin{cases} 1 & \text{if } f(x,y) \geq I \\ 0 & \text{otherwise} \end{cases}$$

An 8-bit green channel image is converted to binary image to obtain the cup and disk from the given threshold value.

Cup to disk ratio:

The noise in the form of extraneous information are removed from the segmented optic disc and optic cup for accurate results. The cup to disc ratio is obtained by calculating the total number of white pixels individually for the segmented disc and cup and further the cup to disc ratio is obtained.The method of adaptive threshold for automated segmentation of optic disk and optic cup helps in early detection of glaucoma. The major positive point of this technique is that, it is independent of the image quality and invariant to noises. This method has given 90% accurate result which might be the drawback since many other methods provide higher accurate results.Further work may include the revival of low number of pixels that were lost from the disk and cup during the removal of noise.

4.USING HISTOGRAM FEATURES

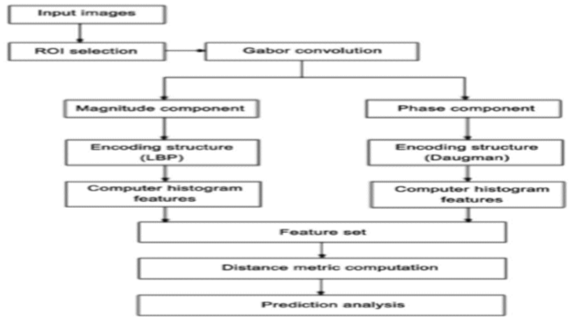
This paper mainly aims at detecting glaucoma at an early stage by combining the magnitude and phase features of the digital fundus image. The method of

$$\max_{(g,a_0,b_0)} \left| G_\sigma(g) \times \frac{\partial}{\partial r_{g,a_0,b_0}} \oint \frac{I(a,b)}{2\pi r} ds \right|$$

feature set extraction is done by Local binary patterns and Daugman's algorithm. The histogram features are computed for both the magnitude and phase components and glaucoma is predicted by analysing the Euclidean distance between the feature vectors.The

system proposed by Karthikeyan Sakthivel and Rengarajan Narayan is compared with the performance of the higher order spectra (HOS) features in terms of specificity, sensitivity, classification, accuracy and execution time.

This method promises an output of 95.54% for sensitivity, specificity and classification. Also, since the execution time is less than the HOS this system is more robust, reliable and accurate.



Region of interest selection: In this method, the ROI is found in order to detect the optical disk.The ROI is estimated by mathematical morphology like dilation, erosion techniques wherein the small holes in the image get filled and the smoothening of the object boundary takes place.The output after erosion is a smooth image without any blood vessels and the minimum pixel value is set as the threshold to extract the optic disk boundary.Gabor Convolution: In this paper, 2D gabor filter is applied which is basically a gaussian kernel function regulated by a sinusoidal plane which extracts the edges of the optic disk.

The 2D Gabor filter is expressed as:

$$f(m,n,\omega,\theta,\sigma_m,\sigma_n) = \frac{1}{2\pi\sigma_m\sigma_n}\left\{\frac{-1}{2}\left[\left(\frac{m}{\sigma_m}\right)^2 + \left(\frac{n}{\sigma_n}\right)^2\right] + j\omega(m\cos\theta + n\sin\theta)\right\}$$

Local Binary Patterns (LBP):To obtain local binary pattern feature vector the image is divided into cells and each pixels of neighbouring cells are compared. According to the centre pixel value normalization and concatenation of histogram is done of all the cells.Daugman's Algorithm:For the calculation of the iris and the pupil contour daugman's algorithm depends on the integral differential operator. It is estimated based on the following equation

Performance analysis: This paper evaluated the results based on sensitivity, time consumption, specificty and receiver operation characteristics classification. The sensitivity and specificity are calculated based on the following equations:

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

$$Sensitivity = \frac{Number\ of\ true\ positives}{Number\ of\ true\ postives + number\ of\ false\ negatives}$$

$$Specificty = \frac{Number\ of\ true\ negatives}{Number\ of\ true\ negatives + number\ of\ false\ positives}$$

$$Accuracy = \frac{Number\ of\ true\ positive + number\ of\ true\ negative}{TOTAL}$$

Accuracy is given by:

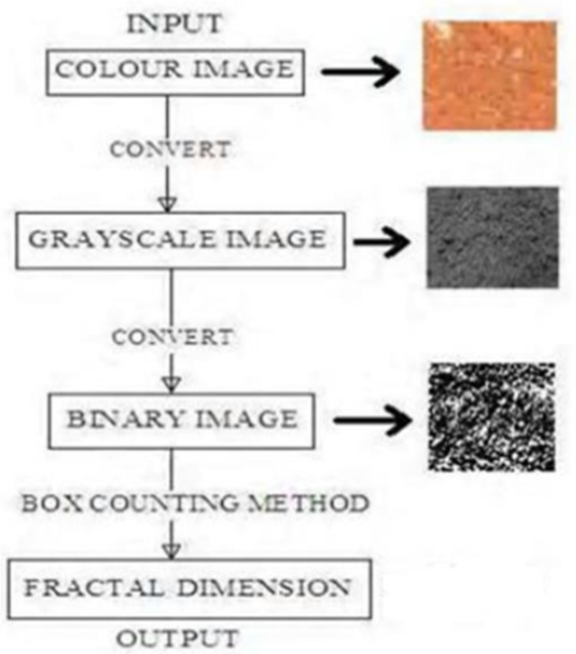
It was observed that the time consumption is more in HOS to extract the feature vectors. Also, the Receiver Operating Characteristics id formed by plotting the fraction of two positives out of the actual total and the fraction of the false positives out of the total actual negatives.The proposed method results above 95% results for classification which makes the system stable to detect the glaucoma disease. Also, the time taken for detection also takes lesser time. Clinically it is very efficient and cost effective. Further ideas implanted in this paper is to feature detection schemes and identify the best algorithms [15].

5.TEXTURE FEATURE METHODS

DharmannaLamani, T. C. Manjunath, Mahesh M, Y. S. Nijagunarya have proposed in their paper a solution for calculation of retinal nerve fiber layer loss with fractal dimension & texture feature methods, to detect glaucoma in early stages. This paper explains an efficient way to categorize the severity of RNFL loss using fractal dimension and texture feature methods. It varies from other methodologies which are based on cup to disk ratio (CDR) where the value changes by large amount within normal. The detailed analysis of retinal nerve fiber can be achieved which in turn contributes to glaucoma detection using RNFL loss calculation.

Pre-Processing: To get a new brightness value in the output image pre-processing techniques can be used to appreciably enhance dependability of surrounding of a pixel in an input image. This can be achieved through normalization of the image. In the next step, red channel component of the image is stressed as retinal images with RNFL loss are darker when compared to a healthy image.

Extracting Image Features:



Fractal Dimension (FD): This method enables to evaluate the complexity of an entity.Only the image intensity can specify fractal dimension. Since the study through FD is effective in characterizing complex systems that are hard to describe using conventional Euclidean geometry it is appropriate for objective quantification of spatial heterogeneity.

Box Counting Method: Box counting method is one of the most accepted algorithms to find fractal dimension of an image. Following example describes the box counting method. Image was transformed to a gray scale image and was converted into a binary image by bw technique and then square boxes are created, To measure the length in number of pixels of a power of 2 binary image was resized to a nxn, this contributes for the square image to be equally divided into four parts and again each sub-part is further divided in to four subparts and so on. N(s) is then recorded as the number of pixels which have white pixels which acts as a function of the box size, length of box. The inverse of box size, also noted as 1/r, this method is carried on for all the binary images obtained by various threshold values from 0.2 to 0.5 with interval 0.1 of an average binary retinal image.

Algorithm for BCM: Retinal images use box counting method to exhibit a fractal structure. The image was resized to (256 × 256) and turned into gray scale. These became binary images with a threshold of 0.2 to 0.5 with interval of 0.1, denoting that if the pixel had a binary value more than threshold value the pixel has assigned the value of 0, otherwise a value of 1 is given.

For texture classification texture methods & statistical based techniques are common mathematical tools. Hence these tools are employed for RNFL analysis. There are mainly three categories of statistical techniques: first order, second order, and higher order statistics. First order statistics is adopted in the referred paper, which depends on individual pixel intensity values, but not on the inter relationship. Parameters' interpretation is simple & gives a view on textural properties and its appearance. The different parameters of first order statistics are skewness, average, kurtoses, standard deviation, etc. Mean and standard deviation parameters out of these parameters are computed from intensity probability distribution (IPD), which is obtained using histogram of ROI.

The equations for parameters used are:

Mean:

$$u = \sum_{i=0}^{N} iH(i)$$

Standard deviation:

$$\sigma = \sum_{i=0}^{N-1} (i-\mu)^2 H(i)$$

Where H(i) indicates a PDF and is obtained from histogram. H(i)=ni/N, where ni is ith pixel for i=0,1,2….L-1, and N is total number pixels. L is 255 (Gray levels). This method is a glaucoma detection method based on using fractal dimension and texture feature methods. The suggested features can be used as a part of feature vector in glaucoma risk. These may also be used in the glaucoma screening along with other parameters such as RNFL thickness, CDR, and ISNT ratio, etc. based on various methods [18].

III. CONCLUSION:

Glaucoma is a disease that affects the optic nerve. It causes blindness if it is left untreated. This has made glaucoma detection as one of the main research topics in the field of medicine. This has led to invention of various medical devices for early detection of glaucoma. But the tests conducted by these devices are found to be very expensive. Given the number of people suffering from this disease worldwide today, we can't solely rely on these medical devices. So, extensive research is being carried out to apply various image processing techniques for early detection of glaucoma.

In this survey paper, the various image processing techniques used for detection and diagnosis of glaucoma have been compiled. The main aim here is to highlight the extensive research being carried out in this domain and to stress on the severity of this disease.

Further in future, the techniques mentioned in this survey paper can be checked for their effectiveness by applying and testing them on a large data sample. It has been observed that various factors like neuro-retinal rim area, cup to disc ratio etc are found to indicate the severity of glaucoma. So it's the need of the hour that we come up with an efficient image processing technique to calculate the various factors that are the indicators of the severity of glaucoma.

IV. ACKNOWLEDGEMENT:

Our sincere gratitude to Dr. D. Seshachalam, Head of the Department, Electronics and Communication Engineering for encouraging and providing this opportunity to carry out the project in the department.
We would like to thank our guide, Dr. A Meera Professor, Department of ECE who helped us in all the ways to carry out the project work. She stood beside

and guided us in every step. We are thankful to Mr.Siddappaji associate professor, Department of ECE, for guiding us with his valuable inputs. We also thank our group mates and friends for their constant help and support.

V. REFERRENCES:

[1] Jun Cheng , Fengshou Yin, Damon Wing Kee Wong, Dacheng Tao, Jiang Liu, "Sparse Dissimilarity-Constrained Coding for Glaucoma Screening", ieee transactions on biomedical engineering, vol. 62, no. 5, may 2015

[2] Husandeep Kaur,Amandeep Kaur, "Early Stage Glaucoma Detection in Diabetic Patients: A Review", International Journal of Advanced Research in Computer Science and Software Engineering, Volume 4, Issue 5, May 2014

[3] Maya Alsheh Ali, Thomas Hurtut, TimotheeFaucon, Farida Cheriet, "Glaucoma Detection based on Local Binary Patterns in Fundus Photographs", SPIE Medical Imaging, Feb 2014,

United States.

[4]R¨udiger Bock, J¨org Meier, Georg Michelson, L´aszl´o G. Ny´ul, and Joachim Hornegger,"Classifying Glaucoma with Image-based Features from Fundus Photographs"

[5] Padmasinh M. Deshmukh, "Segmentation of Retinal Images for Glaucoma Detection"International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181www.ijert.orgIJERTV4IS060897, Vol. 4 Issue 06, June-2015

[6] Gogila Devi and Vasanthi, "Segmentation Of Optic Disc And Macula In Retinal Images"International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-0181, Vol.2 Issue 4, April – 2013.

[7] PadmasinhM.Deshmukh, Anjali C.Pise, And S.V.Survase "Segmentation Of Optic DiskAnd Optic Cup From Retinal Image" Proceedings of 27th IRF International Conference, 14thJune 2015, Chennai, India, ISBN: 978-93-85465-35-2.

[8] J.MariaJeyaSujitha and P. Shiny Guna "Cup to Disc Ratio(CDR) Assessment for DetectingGlaucoma Using 2-D Retinal Images" International Journal of Advanced Research in Biology,Ecology,Science and Technology(IJARBEST),Vol. 1, Issue 5, August 2015.

[9] Preeti, JyotikaPruthi "Review of Image Processing Technique for Glaucoma Detection"International Journal of Computer Science and Mobile Computing, A Monthly Journal ofComputer Science and Information Technology, IJCSMC, Vol. 2, Issue. 11, November 2013,pg.99 – 105.

[10] Adria Perez-Rovira and EmanueleTrucco "Robust Optic Disc Location via Combination ofWeak Detectors".

[11]K.Kavitha, M.Malathi"Optic Disc and Optic Cup Segmentation forGlaucomaClassification" Vol. 2 Issue Special 1 Jan-March 2014, International Journal of AdvancedResearch in Computer Science & Technology (IJARCST 2014).

[12] HanungAdiNugroho, K.Z. WidhiaOktoeberza, TeguhBharataAdji, Faisal Najamuddin"Detection of exudates on color fundus images using texture based feature extractrin"International Journal of Technology (2015) 2: 121-129 ISSN 2086-9614.

[13] MeghanaThodaskar N R, "Segmentation and Detection of Text in Natural Scene Images"International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181

[14] K.Narasimhan, Dr. K.Vijayarekha, "An efficient automated system for glaucomadetection using fundus image", Journal of theoretical and applied information technology15th november 2011. vol. 33 no.1

[15] KarthikeyenSakthivel, Rengerajan Narayanan, "An automated detection of glaucoma using histogram features" ,Int J opthalmol, Vol. 8, No. 1, Feb 18 2015

[16] SobiaNaz ,Sheela N Rao, " Glaucoma Detection in Color Fundus Images Using Cup to Disc Ratio", The International Journal Of Engineering And Science (IJES), Volume, 3, Issue , 6 Pages, 51-58, 2014

[17] JyotikaPruthi, Dr.Saurabh Mukherjee, "Computer Based Early Diagnosis of Glaucoma in Biomedical Data Using Image Processing and Automated Early

Nerve Fiber Layer Defects Detection using Feature Extraction in Retinal Colored Stereo Fundus Images", International Journal of Scientific & Engineering Research, Volume 4, Issue 4, April-2013

[18] DharmannaLamani, T. C. Manjunath, Mahesh M, Y. S. Nijagunarya, "Early detection of glaucoma through retinal nerve fiber layer analysis using fractal dimension and texture feature", IJRET: International Journal of Research in Engineering and Technology

[19] A.G.Praveena, Mr.P.Kumar, "Glaucoma screening using super pixel classification based on optic disc and optic cup segmentation", International Journal of Engineering Research and General Science Volume 3, Issue 1, January-February, 2015

[20] A. R. McIntyre1, M. I. Heywood1, P. H. Artes2, S. S. R. Abidi ,"Toward Glaucoma Classification with Moment Methods", Proceedings of the First Canadian Conference on Computer and Robot Vision

[21]Imran Qureshi, "Glaucoma Detection in Retinal Images Using Image Processing Techniques: A Survey", Int. J. Advanced Networking and Applications

[22] Jost B Jonas, Wido M Budde, Peter Lang, "Neuroretinal rim width ratios in morphologicalglaucoma diagnosis", Downloaded from http://bjo.bmj.com/ on April 16, 2016 - Published by group.bmj.com

[23]Ayushi Agarwal, ShradhaGulia, Somal Chaudhary, Malay Kishore Dutta, RadimBurget, and KamilRiha, "Automatic Glaucoma Detection using Adaptive Threshold based Technique in Fundus Image".