



## Analysis of Various Techniques Used for Optic Disc and Optic Cup Segmentation for Glaucoma Diagnosis

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**Abstract**— *Glaucoma is a disease in which damage to the optic nerve causes progressive, irreversible vision loss. It is the second leading cause of blindness that can damage the eye's optic nerve, causing loss of vision and thereby permanent blindness. It is caused due to increase eye pressure which enlarges the size of optic cup blocking the flow of fluid to the optic nerve and deteriorating the vision. The ratio of the size of optic cup to optic disc, also known as the cup-to-disc ratio (CDR), is one of the measure indicators of glaucoma. More is the value of CDR, more is the chance of glaucoma. The aim of this analysis is to highlight various techniques used for segmentation of optic disc and optic cup used by different researches.*

**Keywords**— *Glaucoma, Segmentation, optic cup, optic disc, cup to disc ratio (CDR).*

### I. INTRODUCTION

Glaucoma is one of the major leading causes of permanent blindness worldwide. It involves mechanical compression and/or decreased blood flow of the optic nerve. It is caused by enlarging the size of optic cup present in the optic disc. The optic disc or optic nerve head is the location where ganglion cell axon exits the eye to form the optic nerve. The optic disc represents the beginning of the optic nerve and is the point where the axons of retinal ganglion cells come together. The optic disc is the entry point for the major blood vessels that supply the blood to retina. Central depression of variable size present on optic disc is called the optic cup. Normal optic disc is orange to pink in colour. A pale disc is an optic disc which varies in colour from a pale pink or orange colour to white. A pale disc is an indication of a disease condition.

Early detection of glaucoma can limit the disease progression. According to World Health Organization (WHO), glaucoma is the second leading cause of blindness. It is responsible for approximately 5.2 million cases of blindness all over the world (15% of the total burden of world blindness and is expected to increase till 11.2 million people by 2020) [1]. In Thailand, glaucoma is found to be prevalent in 2.5-3.8% of the total Thai population or approximately 1.7-2.4 million people of the country [2]. Hence, a timely and precisely early detection of glaucoma can play a major role for preventing irreversible damage in eyes due to this disease.

Currently, an important indicator of glaucoma is Cup-to-disc ratio (CDR), defined as the ratio of the vertical height of the optic cup to the vertical height of the optic disc. CDR, is one of the important clinical indicators of glaucoma, and is determined after the segmentation of optic disc and optic cup [3].

As a researcher we can detect the glaucoma by segmenting the optic disc and optic cup and then calculating the ratios of their vertical diameters for diagnosis of glaucoma. This ratio is known as Cup to Disc Ratio (CDR). CDR for Normal patient is expected to be less than 0.5 and that for Glaucomatous patient to be more than 0.5.

### II. SURVEY OF METHODOLOGIES USED FOR OPTIC DISC AND OPTIC CUP SEGMENTATION

To calculate the vertical cup to disc ratio (CDR), the optic cup and optic disc first have to be segmented from the retinal images. Its segmentation is carried out only in retinal fundus images.

Optic disc segmentation is generally carried out in red channel due to higher contrast between optic disc region and non disc region. Region of interest is mostly located in many cases as it reduces the size of image and makes the computation fast and accurate. Problems in the disc segmentation are mainly due to vessels present and are overcome by pre-processing image using morphological operations such as opening and closing.

Optic cup segmentation is more difficult as compared to optic disc segmentation due to cup's interweavement with blood vessels and surrounding tissues. Optic cup segmentation is usually carried out in green channel due to less visibility of vessels in this channel.

Some of the approaches used so far for optic disc and optic cup segmentation are as follows:

Liu et.al [4] proposed a method which used variational level set approach derived from level set approach that use re-initialization to avoid changes in contour after extracting region of interest (ROI). It used green channel for segmentation of optic cup. It used thresholding, level set approach and color intensity based approach for optic disc segmentation in red channel. Later it used some functions to eliminate problem of re-initialization. It was analysed that thresholding based approach is better than color intensity based approach.

Wong et.al [5] proposed a method which used level set approach for segmentation of optic cup in green channel due to clear visibility of cup in this region.

Wong et.al [6] proposed a method which used variational level-set approach for optic cup segmentation. Also it applied variational level-set approach on the extracted region of interest (ROI) in the red channel of retinal fundus image to segment the optic disc. Later for smoothing the boundary it used ellipse fitting. It used support vector machine (SVM) for classification and regression to improve the tolerance or outlier's rejection. It then determined Cup to disc ratio (CDR) using different component method one by one and then merging all of them using adaptive neural network.

Arturo Aquino et.al [7] proposed a method which used morphological operations to remove the outliers present in the retinal image for optic disc detection. To detect the edge boundaries it used the edge detection techniques followed by circular hough transform. This approach improved the quality and success rate as compared to elliptical and deformable models.

Tan et.al [8] on the extracted region of interest used k component gaussian distribution with some mixing coefficient. Expectation maximization (EM) algorithm does optimization in gaussian mixture model. It applied ellipse fitting to smoothen the boundary of optic cup and optic disc. This method improved the segmentation as compared to ARGALI (automated computer-aided diagnosis system designed for glaucoma detection via optic cup-to-disc ratio assessment).

Joshi et.al [9] proposed a method which used morphological opening for optic cup extraction. It then transformed intensity values and used thresholding in nasal and temporal regions of cup. It used the regional information for detection of optic disc. For detection of optic disc it transformed the image to a particular range and extracted the pixels above certain range. It then applied bottom red hat transform to remove vessels and applied region based active contour for extraction of disc in red channel.

Kavitha et.al [10] proposed a method which used erosion and dilation as morphological operations for processing of optic cup and optic disc segmentation. It extracted the region of interest (ROI) and used labelling plot method on contour of the image. It was analysed that the component analysis method provided better cup to disc ratio (CDR).

Joshi et.al [11] proposed a method which used region based active contour modelling in red color channel for optic disc segmentation. The results of the proposed method is compared with gradient vector flow (GVF) and chan-vese model (C-V model). It is analysed that the proposed method improved the boundary measure. It applied the concept of r-bends (vessel bends) information which use dynamic region of support (ROS) for corners detection followed by 2-D spline interpolation for non uniform r-bends. The result after comparing with thresholding and ellipse fitting realize that proposed approach improved the result as compared with other approaches.

Muramatsu et.al [12] proposed a method which used localization of the image by extracting the region of interest. It used otsu method for removal of vessels and finally for optic disc extraction used active contour modelling (ACM), fuzzy c-means clustering (FCM) and artificial neural network (ANN) segmentation techniques. It was determined that ACM and ANN gave better results as compared to that of FCM.

Murthi et.al [13] proposed a method which on extracted region of interest used histogram equalization and thresholding. Noise is removed by component labelling (neighbourhood connecting pixels) finally the disc boundaries are extracted by optimal color channel histogram, ellipse fitting and optimization. It then used optimal color channel histogram, ellipse fitting and optimization for detection of the cup boundary. This approach improved the result as compared to other approaches.

Rama Krishnan et.al [14] proposed a method which for pre processing used contrast limited adaptive histogram equalization (CLAHE). It then for localization of optic disc used thresholding and column wise neighbourhood operations (CWNO). It used Intuitionistic fuzzy (A-IFS) for segmentation of optic disc. The proposed approach improved the result as compared to that of gradient vector flow (GVF) and Otsu thresholding with achieved accuracy of 93.4%.

Sandra Morales et.al [15] proposed a method which analyzed each of the R, G, and B components individually using principal component analysis (PCA). It then applied Impainting algorithm to preserve structure continuity followed by morphological operations such as opening and closing. It used centroid calculation, stochastic watershed and region discrimination methods for segmentation. It used Circular approximation for post processing. This method improved the result by increasing the mean overlap area as compared with that of standard defined.

Cheng et.al [16] proposed a method which for segmenting optic cup and optic disc used simple linear iterative clustering (SLIC). For different color maps it initially generated the super pixels followed by histogram equalization of each component to get centre surround statistics (CSS). It then used histogram equalized centre surround statistics component and finally classified optic disc using support vector machine (SVM) classifier.

Noor et.al [17] proposed a method which for segmentation of optic cup and optic disc used the extracted region of interest. It analysed different color channels to identify the threshold value for optic disc by calculating the minimum, maximum and mean values. For detection of threshold values for optic disc it analysed red, green and blue channels. On the basis of threshold, retinal image was divided into first, second and background classes. Finally post processing was carried out using receiver operating characteristics (ROC). This method improved the parameters such as sensitivity, specificity and precision of cup to disc ratio (CDR).

M.Malini et.al [18] proposed a method which on extracted region of interest used thresholding and simple linear iterative clustering (SLIC) algorithm to generate the super pixels. For segmentation of optic disc it used K-means clustering in red channel due to clear visibility of disc region in this channel. For the segmentation of optic cup it used green channel. It then defined the contours by zero crossing of laplacian of gaussian filtered image. For edge detection of the cup region it used canny edge detection algorithm. Finally for smoothing the cup boundaries it used ellipse fitting.

Priyadharshini et.al [19] proposed a method which for pre processing used histogram equalization. For blood vessels extraction and removal it used morphological operations and smoothing median filters. For segmentation it then used region growing by seed point selection. This method improved the results as compared to thresholding techniques.

K.Padmanaban et.al [20] proposed a method which used median filtering in green plane for pre-processing, For segmentation it used fuzzy c mean clustering on extracted region of interest and morphological operations for post processing.

Hemanth et.al [21] proposed a method which used contrast limited adaptive histogram equalization and Gaussian filtering for enhancement of the image on gray scaled green plane. It then for locating the disc region used kirsch operator and segmented the disc region using combination of level set approach and fuzzy c mean clustering. This approach improved the result by increasing the efficiency of disc segmentation. For cup segmentation it used morphological operations and thresholding methods.

Vimala et.al [22] proposed a method which used median filtering and contrast limited adaptive histogram equalization on I component of HSI image transformed from RGB image for pre-processing. For segmentation of disc region it then used line operator and fuzzy c means clustering.

Noor Elaiza Abdul Khalid et.al [23] proposed a method which for pre-processing used extracted region of interest, color channel analysis and morphological operations. It then for segmentation of optic cup and optic disc used fuzzy c mean clustering (FCM). Finally it calculated the CDR values and compared this method with others by calculating receiver operating characteristics (ROC).

### III. CONCLUSION

In this analysis study, we presented a list of various existing techniques proposed by different researchers from time to time for optic disc and optic cup segmentation for glaucoma diagnosis. Most of these techniques follow the steps such as region of interest extraction, thresholding, morphological operations etc. The performances of all these approaches vary depending upon the different techniques used by them. All these methods have their own importance depending upon the type of images taken. It has gained a great attention in recent years due to the growth of glaucoma rapidly and commonly. As a researcher we can detect glaucoma is by calculating the CDR values which is the ratio of optic cup to optic disc diameter. This ratio is achieved after segmenting the optic disc and optic cup. From the analysis it can be realized that optic disc detection is more appropriate in red channel and that of optic cup in green channel. It's segmentation is done only in retinal fundus images. The segmentation problems due to presence of exudates and blood vessels in the retinal fundus images are generally overcome by using various filters and morphological approaches.

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