Automatic Optic Disc Localization and Optic Cup Segmentation from Monocular Color Retinal Images for Glaucoma Assessment

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***Abstract*—In recent years, computer-aided screening and diagnosis of glaucoma have made considerable progress. Computer-aided retinal image analysis provides an instant detection of retinal features before specialist inspection. Eye disease of glaucoma is a significant globally is due to an increase in intraocular pressure. It causes permanent vision loss, and also early prognosis is complicated. The present work provides an image processing technique used to automatically detect the center of the optic disc and segment the optic cup for prediction of glaucoma by developing software algorithms in MATLAB. Three kinds of steps are used such as pre-processing, detection of optic disc center and optic cup. In the first step, green Chanel image and filtering methods used for removing noises. In the second step, Region localization using entropy is applied to locate Optic Disc center. In the third step, the Optic Cup has segmented by region growing technique. This subject to different retinal fundus image datasets such as DRIONS and DRIVE. Proposed algorithm is obtained 100% Accuracy rate(A), 98% Sensitivity(S), 99% Specificity(Sp), 95% Precision(P), 87% F-score(Fs), 94% G-mean(Gm) and trivial computation time.**

Keywords—Glaucoma, image processing, fundus images, optic disc, optic cup, MATLAB, localization, segmentation

I. INTRODUCTION

Retinal Image analysis and processing is very helpful for early detection of disease, screening, and treatment of retinal disease like Diabetic retinopathy and Glaucoma. Prior and accurate detection of retinal pathologies and timely treatment used to prevent vision loss. The Computer Assisted Diagnostic (CAD) systems used for early diagnosis and prognosis of eye diseases and also play a vital role in healthcare, in the developing countries with a limited number of ophthalmologists. Glaucoma is irreversible and asymptomatic eye disease [1].

The increased intraocular pressure in the retina leads to damage of optic nerve fibers, and change the cup orientation. It is an essential sign for diagnosis of glaucoma [2]. Cupping is enlargement of the OD due to glaucoma damage [3]. Identify the optic disc and cup is a primary step for diagnosis of glaucoma and it is the essential signs in treating patients with glaucoma. Usually Ophthalmologists, diagnose the glaucoma by determining Cup-to-Disc Ratio (CDR) and the Rim-to-Disc Ratio (RDR) [4].

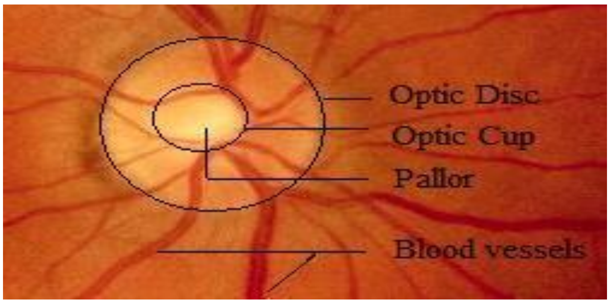


Fig. 1. The anatomical parts of a retina in fundus image

Fig. 1.shows the retinal anatomy with OD, OC, pallor and blood vessels.The diagnosis of glaucoma is related to the detection and tracking of changes in the optic cup which is a portion of the optical disc. Automated screening system used to segment an OD and OC region. However, localization of optic disc is an essential step in simplifying detection process.They have exploited some OD region features, such as its yellow color, having more brightness with high grey intensity pallor region, and also containing a network of convergence of millions of blood vessels.Usually experts measure the CDR/RDR by manually segment and outline the OD and OC for earlier diagnosis of glaucoma. A greater CDR or smaller RDR indicates a high risk of the glaucoma [5]. It is the time-consuming process, and also expensive. Now a day computer-aided glaucoma diagnosis from retinal image is essential for easy diagnosis. It is the simple and secured noninvasive test. Automated tools improve the accuracy of diagnosis and it reduce the workload of the expert. OC boundary detection contains the bright region of pallor with vessel bends [5].

In this paper, image processing technique is developed to locate the Optic Disc center and segment the Optic Cup in retinal images. The proposed method has two sections. The first section has localization: Entropy-based extracting OD region part of the image from the given dataset. Further, this image is used for image enhancement technique to accurately detecting the optic disc center. The second section has the segmentation of the optic cup. For proposed segmentation method utilizes yellow bright region of pallor along with blood vessel which has direct or indirect bends. It is a precursor step in the diagnosis of glaucoma.

II. RELATED WORKS

Optic disc localization and Optic Cup detection different methods discussed below

A. *Optic Disc localization*

The number of researchers tried various algorithms with different features to locate the optical disc in retinal images. Techniques used by their pros and cons of their algorithms given below:

S.A. Ramakanth et al. [6] proposed approximate nearest neighbor field based optic disk detection and the shape, color, brightness features are used to locate OD. Its performance is excellent and less computation time. But it has less accuracy and dislocation of the optic disc.

H. Yu et al. [7] proposed a template matching method and the size, shape and brightness features are used to locate OD. Its increase robustness and accuracy of Optic Disc detection. But this method Optic Disc detection is difficult.

S. Lu et al. [8] proposed method is a 2D circular convolution mask, and the image variation and brightness features are used to locate OD. This method detection speed is high, and retinal lesions tolerated. But its Poor Performance and various types of imaging artifacts cannot be handled.

A. Mahfouz et al. [9] proposed a model-based method and space; intensity features are used to locate OD. This method is less computation time and search space dimensionality reduced. But its robustness for localization of OD is difficult.

B. *Optic Cup segmentation*

Many researchers tried various algorithms with different databases to segment the optic cup in retinal images. Techniques used by them and the pros and cons of their algorithms given below:

T.D. Varsha Shree et al. [10] proposed a hybrid method and RIM-ONE Database used. In this paper is reduced manual process of OD and OC segmentation and CDR estimation improved. But this method, specific region of OC cannot be identified under eye disease effect. In case, region orientation changed that this method only circled the OC parts to detect some of the outer areas. It will reduce the effective screening of glaucoma.

J.R. Harish Kumar et al. [11] proposed a Kåsa's circle fitting technique. Drishti-GS, DRIONS, MESSIDOR datasets used. In this method, OC segmented automatically and accurately. But its achieved a moderate localization and also improve the segmentation performance to approximating the optic cup region by ellipse fit model.

Chananchida Jaikla et al. [12] proposed a maximally stable extremal regions technique. HRF Database used. In this research methodology automatically identifying the position of Optic Disc and Cup on low contrast Retinal Fundus images and achieved accuracy rate is 80%. But it's to improve the OD and OC segmentation methods to increase accuracy and decrease the computational time performance.

J. Ayub et al. [13] proposed a clustering technique. It assessed on 100 fundus images collected locally. This technique is a large-scale clinical evaluation, improved OC segmentation performance as compared to other published approaches. But this work has underestimates and overestimates cup of small and large sizes.

III. METHODOLOGY

The new technique is developed to locate Optic Disc automatically and identify the center and segment the Optic Cup accurately. This method consists of three main steps such as (i) Pre-processing, (ii) Localization of Optic Disc and (iii) Segmentation of Optic Cup. An overview of proposed methodology shown in Fig.2

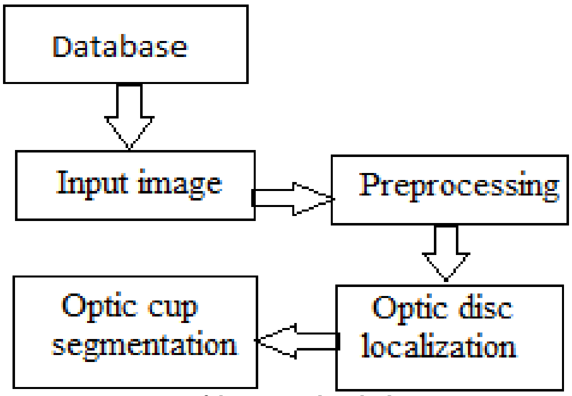


Fig. 2. An overview of the proposed method

A. *Preprocessing*

Fig. 3. Input image

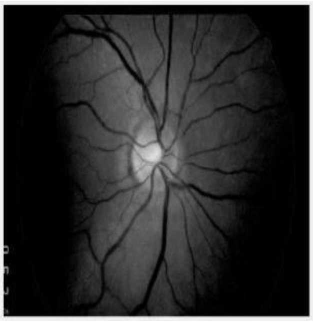
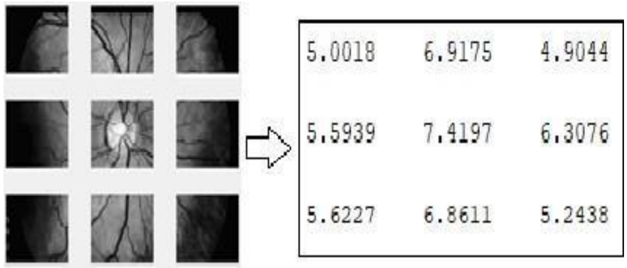


Fig. 4. Green channel image

The input RGB image takes from the databases shown in Fig.3. For a 24bit RGB image, each channel has 8 bits for red, green, and blue with conventional brightness intensities between 0 and 255. Each channel expresses each object characteristics in different concentration. For a Fundus image, the properties of the green channel are correctly distinguishing the disc from other components. So that green channel is extracted. In this, green channel image converted to the gray image shown in Fig.4. And then median filtering is applied to remove noise from photographs, and it preserves the edges. The preprocessing picture data used for further processing (Ip).

B. Localization of Optic Disc

The preprocessed image (Ip) is divided into (3x3) patches using non-overlap sliding window. The resultant image after application of the sliding window shown in Fig.5(a). The size of the nine split is the same. It is approximate to the size of optic disc area. Among the nine patches, any one of the image spots has OD which has high entropy value. Entropy can calculate by using the following formula (1).



$$E= -(sum(p.*log2(p))) \quad (1)$$

Where, p contains the normalized histogram counts. The patches are ranking by the entropy values. Entropy value for all the nine pieces shown in Fig. 5(b).

(a) Green image patches. (b) Entropy values for pieces.

Fig. 5. Image patches with its entropies

Entropy value in the optic disc area is significant. One of the searching technique Greedy method is applied to find the maximum entropy value the maximum amount of entropy image considered for further processing. Remain patches parts are disabled. The histogram plot for the maximum entropy image.The x-axis is the pixel intensity, and the y-axis is pixel count. From the Histogram, the high-intensity pixel founded and it has marked as a center of the optic disc. High-intensity pixel point marked with "+" symbol in the green color shown in Fig 6. used. This point considered as the optical disc center point

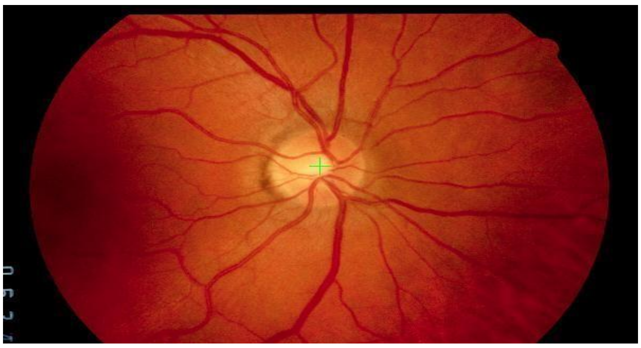


Fig. 6. Optic disc center located image.

C. Segmentation of Optic Cup

Optic cup is the region placed on inside of the OD. Optic Cup contains the direct or indirect bend of a blood vessel with the brighter part of yellow color pallor part. OC region segmented by region growing technique. The seed-based region growing is partitioning of an image into similar areas of connected pixels through the application of similarity criteria among candidate set of pixels. In this method, located optic disc center pixel value considered as an initial seed point of the proposed segmentation technique. This point has a higher intensity pixel point. Each of the pixels in a region is the same concerning some characteristics such as color, intensity, and texture.

In this work, the region grows based on the pixel intensity, pixel connectivity and mean standard deviation. The Euclidean distance used to measure the similarity between two color vectors. The optic cup is detected, and it showed in Fig 7(a). This segmented optic cup from the technique as mentioned earlier to overlapped on the original image shown in Fig.7(b).

Fig. 7(a). Optic Cup segmented image

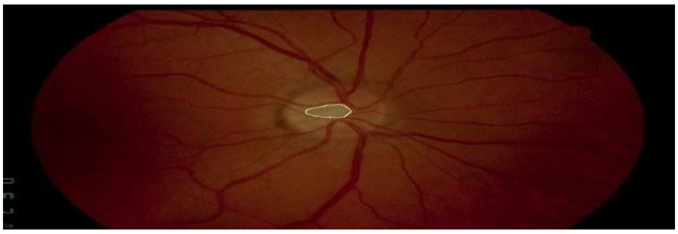


Fig. 7(b). Optic Cup region marked image

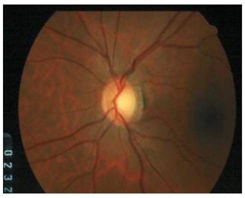
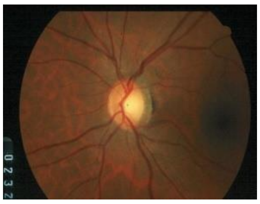
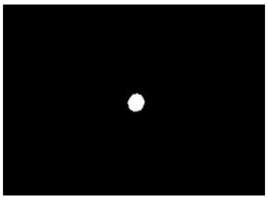
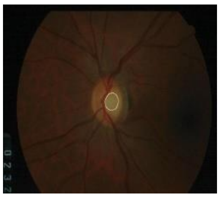
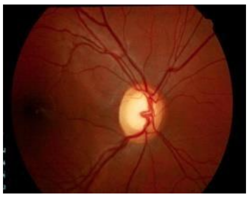
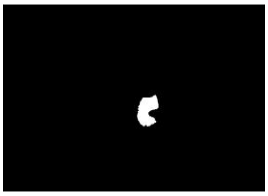
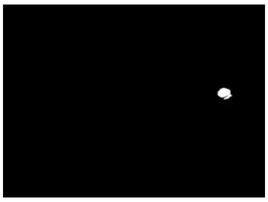
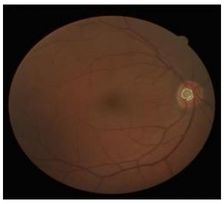
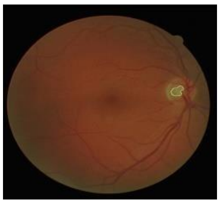
IV. RESULTS

The proposed method subjected to the various models in the databases. The performance of the proposed plan is calculated using the Confusion Matrix. Confusion Matrix is a predictive value evaluation performed by as compared to the results sought by people.

TABLE I. . QUANTITATIVE PERFORMANCE FORMULA

Description	**Formulae**
Accuracy	$\frac{TP+TN}{TP+TN+FP+FN}$
Sensitivity	$\frac{TP}{TP+FN}$
Specificity	$\frac{TN}{TN+FP}$
Precision	$\frac{TP}{TP+FP}$
F-score	$\frac{2TP}{2TP+FP+FN}$
G-mean	$\sqrt{TPR*TNR}$

TABLE II. PROPOSED METHOD RESULTS

Input Retinal image	**Optic Disc located image**	**Optic Cup segmented image**	**Optic Cup region marked image**	**Performance measures results**
				A = 100 S = 98 Sp = 99 P = 91 Fs = 76 Gm = 89
				A = 99 S = 98 Sp = 99 P = 97 Fs = 78 Gm = 86
				A = 100 S = 94 Sp = 91 P = 89 Fs = 75 Gm = 82
				A = 98 S =98 Sp =94 P = 82 Fs = 71 Gm = 87
				A = 99 S = 98 Sp = 94 P = 89 Fs = 84 Gm = 93
				A = 100 S = 88 Sp = 99 P = 90 Fs = 84 Gm = 94

True Positive (TP) is what the program predicts is right and people say it is true.

True Negative (TN) is what the program predicts is not true, and people say it is not true.

False Positive (FP) is what the program predicts is true, but people say that is not true.

False Negative (FN) is what the program predicts is not true, but people say that true.

The performance metrics of the segmentation based on the pixel-wise comparison with the ground truths images are shown in Table I.

The input image, located optic disc, segmented optic cup, and visual cup region marked region and the parametric measure of the picture given in Table II.

V. CONCLUSION

Glaucoma is a significant eye disease globally is due to an increase in intraocular pressure. It causes permanent vision loss, and its early prognosis is complicated. The present work provides an image processing technique used to automatically detect the center of the optic disc and segment the optic cup for prediction of glaucoma by developing software algorithms in MATLAB. This new method consists of three main steps including pre-processing, localization of optic disc and optic cup segmentation. In the first step, green Chanel image and filtering methods used for removing noises. In the second step, Region localization using entropy is applied to locate Optic Disc center. In the third step, the Optic Cup has segmented by region growing technique. The developed algorithms implemented in DRIONS and DRIVE datasets of retinal fundus images. Proposed algorithm is obtained 100% Accuracy rate(A),98% Sensitivity(S), 99% Specificity(Sp), 95% Precision(P), 87% F-score(Fs), 94% G-mean(Gm) and trivial computation time.

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