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An Automatic Computer Aided Diagnostic System for the Analysis of Glaucoma Using Super pixel Classification and Clustering Methods

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ABSTRACT

Glaucoma is a chronic eye disease that leads to vision loss. As it cannot be cured, detecting the disease in time is important. This research proposes optic disc and optic cup segmentation using superpixel classification for glaucoma screening. It uses the 2D fundus images. In optic disc segmentation, clustering algorithms are used to classify each superpixel as disc or non-disc. For optic cup segmentation, in addition to the clustering algorithms, the gabor filter is also included into the feature space to boost the performance. The segmented optic disc and optic cup are then used to compute the cup to disc ratio for glaucoma screening. The Cup to Disc Ratio (CDR) of the color retinal fundus camera image is the primary identifier to confirm Glaucoma for a given patient.

Keywords: *Glaucoma Screening, Optic Disc Segmentation, Optic Cup Segmentation, 2D Fundus Image, Superpixel Classification, Clustering Algorithms, Gabor Filter, CDR.*

1. INTRODUCTION

Glaucoma is an eye disease of the major nerve of a vision, called the optic nerve and it is often associated with elevated intraocular pressure, in which damage to optic nerve is progressive over a long period of time and leads to loss of vision. Glaucoma is a disease of the eye in which fluid pressure within the eye rises if left untreated the patient may lose vision, and even become blind. The disease generally affects both eyes, although one may have more severe signs and symptoms than the other.

Glaucoma cannot be cured, but its progression can be slowed down by treatment. Therefore, detecting glaucoma in time is critical to preserve the vision [1]. Since glaucoma progresses with few signs or symptoms and the vision loss from glaucoma is irreversible, screening of people at high risk for the disease is vital. There are two types of glaucoma (i) Open-angle glaucoma: The entrances to the eye's drainage canals are clear, but a blockage develops within the canal, trapping fluid and causing an increase in pressure in the eye. Vision loss is usually slow and gradual (ii) Angle-closure glaucoma: The entrance to the canal is either too narrow or is closed completely. pressure can rise very quickly. The known tests to detect Glaucoma are Tonometry (inner eye pressure), Ophthalmoscopy (shape and color of the optic nerve) & Perimetry (complete field of vision).

Hough transforms, and an anchored active contour model is proposed in [2]. A robust and computationally efficient approach for the localization of the different features and lesions in a fundus retinal image is presented in [3]. A constraint in optic disc detection is that the major blood vessels are detected first and the intersection of these to find the approximate location of the optic disc. A novel approach to automatically segment the OD and exudates is proposed in [4]. It makes use of the green component of the image and preprocessing steps such as average filtering, contrast adjustment, and thresholding. The other processing techniques used are morphological opening, extended maxima operator, minima imposition, and watershed transformation. An automated classifier based on adaptive neuro-fuzzy inference system (ANFIS) to differentiate between normal and glaucomatous eyes from the quantitative assessment of summary data reports of the Stratus optical coherence tomography is presented in [5]. There are two methods to extract the disc automatically, as proposed in [6]. The component analysis method and Region of Interest (ROI) based segmentation are used for the detection of disc. For the cup, component analysis method is used. Later the active contour is used to plot the boundary accurately. To automatically extract the disc, a variation level set method is proposed in [7]. For the cup, two methods making use of color intensity and threshold level set are evaluated. An automatic OD parameterization technique based on segmented OD and cup regions obtained from monocular retinal images is proposed in [8]. A novel

OD segmentation method is proposed which integrates the local image information around each point of interest in multidimensional feature space to provide robustness against variations found in and around the OD region. A new template-based methodology for segmenting the OD from digital retinal images is presented in [9]. Morphological and edge detection techniques followed by the Circular Hough Transform are used to obtain a circular OD.Within the OD as initial information. A novel method for glaucoma detection using a combination of texture and higher order spectra (HOS) features from digital fundus images is proposed in [10]. Support vector machine, sequential minimal optimization, naive Bayesian, and random-forest classifiers are used to perform supervised classification. A mathematical framework to link retinal nerve fiber layer (RNFL) structure and visual function using the data typically acquired in the clinical management of glaucoma is proposed in [11]. The model performed and generalized well over different populations from three clinical centers. The derived structure-function relationship accorded well with RNFL anatomy, and could be applied to reduce the variability that confounds the measurement of glaucoma damage.Stereo disc photograph is analyzed and reconstructed as 3 dimensional contour images to evaluate the status of the optic nerve head for the early detection of glaucoma and the evaluation of the efficacy of treatment is presented in [12]. To detect the edge of the optic nerve head and retinal vessels and to reduce noises, stepwise preprocessing is introduced. RetCam is a new imaging modality that captures the image of iridocorneal angle for the classification is presented in [13]. Glaucoma is the one of the two major causes of blindness, which can be diagnosed through measurement of neuro-retinal CDR is described in [14]. Automatic calculation of optic cup boundary is challenging due to the interweavement of blood vessels with the surrounding tissues around the cup. A multimodality fusion approach for neuro retinal cup detection improves the accuracy of the boundary estimation. Modeling of Scanning Laser polarimetry method is presented in [15] to model the change in images acquired by scanning laser polarimetry for the detection of glaucomatous progression.. Sobel edge detection, Texture Analysis, Intensity and Template matching techniques are used to detect Optic Disc. A system has been proposed to detect glaucoma using fundus image [16] consisting three different stages has ROI extensions, feature extraction stage and classification stage.

The existing methods of to detect glaucoma are (i) Assessment of Raised Intraocular Pressure (IOP): The IOP measurement using noncontact tonometry. But IOP is not good enough for glaucoma screening (ii) Assessment of Abnormal Visual Field: Abnormal visual field uses the process is called as perimetry. Perimetry is a visual field test that produces a map of your complete field of vision. This test will help a doctor determine whether your vision has been affected by glaucoma (iii) Assessment of damaged optic nerve head: Optic nerve head assessment can be done by a trained professional. Based on image features only automatic optic nerve head assessment is used for a binary classification between glaucomatous and healthy subjects.

The disadvantages of existing system are 3D images are not easily available and high cost of obtaining

3D images are may increases the pressure in tonometer the optic nerve is damaged, manual assessment is subjective and requires specialized training & time consuming and expensive.

2. IMPLEMENTED METHOD

The present article focuses on automatic glaucoma screening using CDR from 2D fundus images. The present work implemented superpixel classification based disc and cup segmentations for glaucoma screening. In this propose approach, preprocessing followed by a combined approach for image segmentation and classification using texture, thresholding and morphological operation. Multimodalities including K-Means clustering, Gabor wavelet transformations are also used to obtain accurate boundary delineation. Based on the segmented disc and cup, CDR is computed for glaucoma screening. The block diagram of the various modules implemented in the present implemented method is given in Fig. 1.

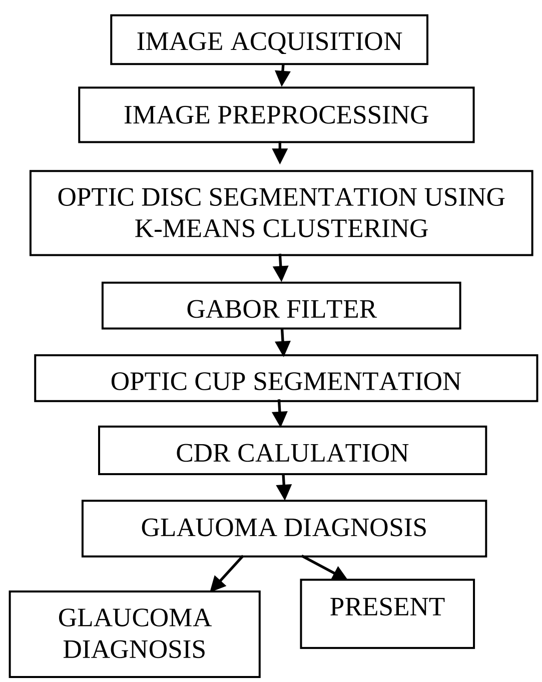


Fig.1. Block diagram of Implemented method

2.1 Image Acquisition

The retina can be observed and recorded using several methods. In the present work the glaucoma and normal funds photo graphs are taken from the canon CR5 mydratic with 450 field of view (FOV).

2.2 Image Preprocessing

In detecting abnormalities associated with fundus image, the images have to be preprocessed in order to correct the problems of uneven illumination problem, nonsufficient contrast between exudates and image background pixels and presence of noise in the input fundus image. Adaptive Histogram Equalization Method (AHEM). AHEM gives better performance, higher processing speed and work well for all images of different sizes, hence the reason for it being used as method of correcting un-even illumination.Contrast limited adaptive histogram equalization (CLAHE) is a computer image processing technique used to improve contrast in images.

2.3 Optic Disc Segmentation

Accurate segmentations of disc and cup are essential for CDR measurement. Several methods have been proposed for automatic CDR measurement from 2D fundus images.Fig.2 shows major structures of the optic disc

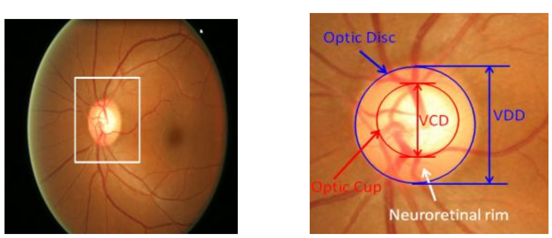


Fig.2. Major structures of the optic disc: The region enclosed by the blue line is the optic disc; the central bright zone enclosed by the red line is the optic cup; and the region between the red and blue lines is the neuroretinal rim.

Localization and segmentation of disc are very important in many computer aided diagnosis systems, including glaucoma screening. We propose a superpixel classification based method and combine it with the deformable model based methods.

2.3.1 Superpixel generation:

In the present work the simple linear iterative clustering algorithm (SLIC) [17,18] to aggregate nearby pixels into superpixels in retinal fundus images has been used. SLIC is fast, memory efficient and has excellent boundary adherence. SLIC is also simple to use with only one parameter, i.e., the number of desired superpixels, which adapts a k-means clustering approach to efficiently generate superpixels. By default, the only parameter of the algorithm is k, the desired number of approximately equally sized superpixels.

2.3.2 K-Means Clustering Algorithm

K-Means algorithm [19] is an unsupervised clustering algorithm that classifies the input data points into multiple classes based on their inherent distance from each other. The algorithm assumes that the data features form a vector space and tries to find natural clustering in them. K-Means algorithm is an unsupervised clustering algorithm that classifies the input data points into multiple classes based on their inherent distance from each other. The algorithm assumes that the data features form a vector space and tries to find natural clustering in them. The points are clustered around centroids µiAi = 1…k which are obtained by minimizing the objective

$$\sum_{J=1}^{K}\sum_{I=1}^{X} ||X_i^{(j)} - c_j||^2$$

Where || Xi(j)-cj||2 is a chosen distance measure between a data point □□ □ and the cluster centre □□ , is an indicator of the distance of the n data points from their respective cluster centres.

- Compute the intensity distribution (also called the histogram) of the intensities.
- Initialize the centroids with k random intensities
- Repeat the following steps until the cluster labels of the image do not change anymore.
- Cluster the points based on distance of their intensities from centroid intensities replicated with the mean value within each of the array and then the distance matrix is calculated.

$$c^{(i)} := \arg\min_{j} ||x^{(i)} - \mu_j||^2$$

- Compute the new centroid for each of the clusters.

$$\mu_i := \frac{\sum_{i=1}^{m} 1\{c_{(i)} = j\} x^{(i)}}{\sum_{i=1}^{m} 1\{c_{(i)} = j\}}$$

Where k is a parameter of the algorithm (the number of clusters to be found), i iterates over the all the intensities, j iterates over all the centroids and □□ are the centroid intensities.

2.3.3 ROI Processing

A region of interest (ROI) is a portion of an image that you want to filter or perform some other operation on. An ROI by creating a binary mask, which is a binary image that is the same size as the image you want to process with pixels that define the ROI set to 1 and all other pixels set to 0. Generate ROI mask for the selected optic disc area. The roi mask selects roi image from the exact selected area of the optic disc in the gray scale image.ROI image is converted to binary image. Binarization is a process where each pixel in an image is converted into one bit and you assign the value as '1' or '0'.Morphological operations are used to remove the unwanted objects in binary image.

2.4 Gabor Filter

In image processing, a Gabor filter a linear filter used for edge detection. Filters have been found to be particularly appropriate for texture representation and discrimination. In the spatial domain, a 2D Gabor filter is a Gaussian kernel function modulated by a sinusoidal plane wave. Gabor filters are directly related to Gabor wavelets, since they can be designed for a number of dilations and rotations. . The filters are convolved with the signal, resulting in a so called Gabor space. The Gabor space is very useful in image processing applications such as optical character recognition, iris recognition and fingerprint recognition. Gabor wavelets can be tuned for specific frequencies and orientations which is useful for blood vessels. They act as low level oriented edge discriminators and also filter out the background noise of the image. Since vessels have directional pattern so 2-D Gabor wavelet is best option due to its directional selectiveness capability of detecting oriented features and fine tuning to specific frequencies.

2.5 Optic Cup Segmentation

The optic cup is the white cup, area in the center of the optic disc. the optic cup consisting of two strata of cells. . In cup segmentation, To estimate the cup boundary we can able use two methods. They are ROI processing and thresholding or binarization. The roi processing is done as same as the procedure how the extracted optic disc image is obtained. The thresholding or binarization for Optic Cup segmentation Process is as shown below. This process will convert the given image into a thresholded or binarized image where we can easily get our Optic Cup. Binary images are produced from color images by segmentation. Segmentation is the process of assigning each pixel in the source image to two or more classes.

After obtaining the disc, the minimum bounding box of the disc is used for the cup segmentation. The disc and cup boundary detected from the segmentation methods may not represent the actual shape of the disc and cup since the boundaries can be affected by a large number of blood vessels entering the disc. Therefore the morphological operations are employed to reshape the obtained disc and cup boundary. Then CDR is calculated by taking the ratio of the area of cup to OD.

2.6 CDR Calculation and Diagnosis

After obtaining the disc and cup, various features can be computed. The cup to disc ratio (CDR) compares the diameter of the cup portion of the optic disc with the total diameter of the optic disc. Based on the segmented disc and cup boundary, we can calculate the disc area diameter (VDD) and cup area diameter (VCD). Then the cup to disc ratio (CDR) is computed as

CDR = Area of Cup (VCD)/Area of Disc (VDD)

The computed CDR is used for glaucoma screening. When CDR is greater than a threshold, it is glaucomatous, otherwise it will be considered as a healthy one. Generally, the normal cup to disc ratio (CDR) is 0.3. The cup to disc ratio is above 0.3, then it suggests glaucomatous, otherwise normal.

Software Specification: MATLAB 2013 Version

3. RESULTS AND DISCUSSION

The input image was actually acquired using canon CR5 non mydriatic camera with a 45 degree field of view. In the present work, preprocessing such as, image filtration, contrast enhancement and histogram equalization are performed as shown in the fingers.

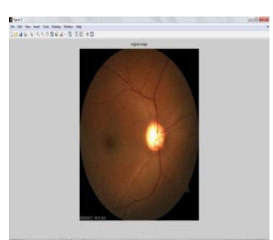


Fig. 3. Original Image

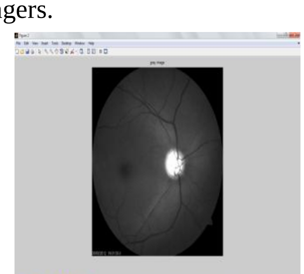


Fig. 4. Gray image Equalized

Fig. 5. Histogram

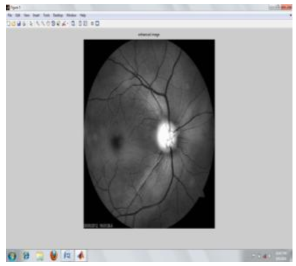


Fig. 6. Enhanced image

In optic disc segmentation fig7, the superpixel generation is carried out as pre processing image. It aggregates the nearby pixel in to superpixels. In this technique, the search is often its best matching pixel from the neighbourhood based on the color and spatial proximity.

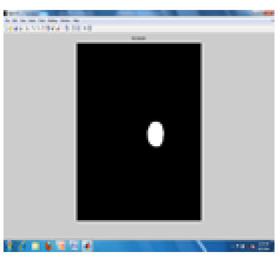


Fig. 9. ROI Mask

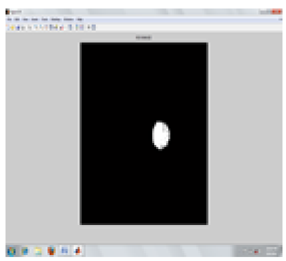


Fig. 10. ROI image

The output of the SLIC technique is given as input to the K-Means clustering algorithm. It classifies the input data in to multiple clusters as in fig 8. ROI processing is used to obtain the optic disc areas shown in fig 9 ,fig 10 and also apply the image in gabor filter technique. It is a linear filter used for edge detection.
By applying thresholding or binarization technique the segmented optic disc is determined. Then apply the binarization technique to segmented optic disc image, optic cup will be segmented. The binarization will convert the image in to a gray scale image as seen in fig 10, fig 11, where it can easily segment the optic cup from the disc region is shown in fig 12.

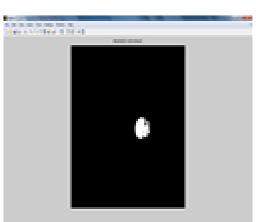


Fig. 10. Binarized vein image

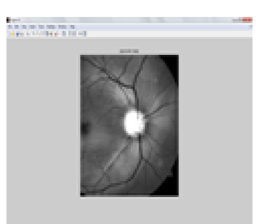


Fig. 11. Grayscale image

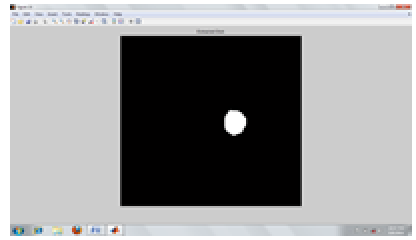


Fig. 12. Extracted optic disc image

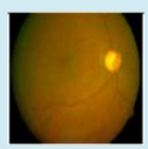
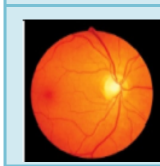
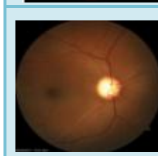
The optic disc and optic cup diameter is measured to calculate the cup to disc ratio (CDR). Hence CDR value is useful to explain the conclusion of the eye of the patient with the above reference values in the tabl1.

Table1: Reference values of CDR.

REFERENCE VALUES	
Normal	≤ 0.3
Moderate	0.3<CDR<0.6
Severe	>0.6

The proposed work is carried for different retinal images and shown in below as a table 2

Table 2: Cup to Disc Ratio (CDR) for different retinal images

Images	Cup area	Disc area	Cup to Disc Ratio (CDR)	Glaucoma Condition
	2750	8684	0.3166	Normal
	2893	5032	0.5749	Moderate
	3834	3050	0.7955	Severe

4. CONCLUSION

This project is implemented using superpixel classification based optic disc and cup segmentations for glaucoma screening. This project is implemented and evaluated for Glaucoma detection in patients using multimodalities including simple linear iterative clustering (SLIC) algorithm, K-Means clustering, and Gabor wavelet transformation of the color fundus camera image to obtain accurate boundary delineation. Using structural features like CDR (Cut to Disc Ratio), the ratio value exceeds 0.3 shall be recommended for further analysis of a patient to the ophthalmologist. This shall help in patients worldwide by protecting further vision deterioration through timely medical intervention. The accuracy of the proposed method is much better than the IOP measurement, abnormal visual field and previous CDR based methods.

REFERENCES

[1] Michelson, G., W¨arntges, S., Hornegger, J., Lausen, B., 2008. The papilla as screening parameter for early diagnosis of glaucoma. Dtsch Arztebl Int 105 (34-35), 583–589.

[2] R. Chrastek a, M. Wolf a, K. Donath, "Automated segmentation of the optic nerve head for diagnosis of glaucoma", Journal of Medical Image Analysis in Elsevier, Functional Imaging and Modeling of the Heart, August 2005, pp 297-314.

[3] Ravishankar, S. Jain, A. Mittal, "Automated feature extraction for early detection of diabetic retinopathy in fundus images", IEEE conference on Computer Vision and Pattern Recognition, 2009, pp 210-217.

[4] Ahmed Wasif Reza & C. Eswaran & Subhas Hati, "Automatic Tracing of Optic Disc and Exudates from Color Fundus Images Using Fixed and Variable Thresholds", Journal of Medical Systems, Feb 2009, pp 73 -80.

[5] Mei-Ling Huang, Hsin-Yi Chen, Jian-Jun Huang, "Glaucoma detection using adaptive neuro-fuzzy inference system", Journal of Expert Systems with Applications, 2007, pp458-468.

[6] S.Kavitha, S.Karthikeyan, Dr.K.Duraiswamy, "Early Detection of Glaucoma in Retinal Images Using Cup to Disc Ratio", IEEE Second International conference on Computing, Communication and Networking Technologies, 2010, pp 1-5.

[7] J. Liu, D. W. K. Wong, J.H. Lim, X. Jia, "Optic Cup and Disk Extraction from Retinal Fundus Images for Determination of Cup-to-Disc Ratio", IEEE third conference on Industrial Electronics and Applications, June 2008, pp 1828 -1832.

[8] Gopal Datt Joshi, Jayanthi Sivaswamy, "Optic Disk and Cup Segmentation From Monocular Color Retinal Images for Glaucoma Assessment", IEEE Transactions On Medical Imaging, June 2011, pp 1192-1205

[9] Arturo Aquino, Manuel Emilio Gegundez- Arias, and Diego Marin, "Detecting the Optic Disc Boundary in Digital Fundus Images Using Morphological, Edge Detection, and Feature Extraction Techniques", IEEE Transactions on Medical Imaging, Nov 2010, pp 1860-1869.

[10] U. Rajendra Acharya, Sumeet Dua, Xian Du, "Automated Diagnosis of Glaucoma Using Texture and Higher Order Spectra Features", IEEE Transactions On Information Technology In Biomedicine, May 2011, pp 449-455.

[11] Haogang Zhu, David P Crabb, David F Garway-Heath, "A Bayesian Radial Basis Function Model to Link Retinal Structure and Visual Function in Glaucoma", IEEE third conference on Bioinformatics and Biomedical Engineering , June 2009, pp 1-4.

[12] H. J. Kong, S. K. Kim, J.M. Seo, "Three Dimensional Reconstruction of Conventional Stereo Optic Disc Image", IEEE Proceedings of the 26th Annual International Conference, Sep 2004, pp 1229-1232.

[13] Jun Cheng, Jiang Liu, Beng Hai Lee, "Closed Angle Glaucoma Detection in RetCam Images", IEEE Proceedings of the 32nd Annual International Conference, Sep 2004, pp 4096-4099.

[14] Zhuo Zhang, Jiang Liu, Wing Kee Wong, "Neuro-Retinal Optic Cup Detection in Glaucoma Diagnosis", IEEE Proceedings of the 2nd International Conference on Biomedical Engineering and Informatics, Oct 2009, pp 1-4.

[15] Koen A. Vermeer, Frans M. Vos, Barrick Lo, "Modeling of Scanning Laser Polarimetry Images of the Human Retina for Progression Detection of Glaucoma", IEEE Transactions On Medical Imaging, May 2006, pp 517-528.

[16] K.Narasimhan, Dr.K.Vijayarekha, "An efficient automated system for glaucoma detection using funds image". Journal of theoretical and applied information technology, November 2011, pp 104-109.

[17] Radhakrishna Achanta, Appu Shaji, Kevin Smith, AurelienLucchi, Pascal Fua, and Sabine S□usstrunk, SLIC Superpixels, EPFL Technical Report 149300, June 2010.

[18] Radhakrishna Achanta, Appu Shaji, Kevin Smith, AurelienLucchi, Pascal Fua, and Sabine S□usstrunk, SLIC Superpixels compared to state-of- the- art superpixel methods, IEEE Transaction on Pattern Analysis and machine intelligence, November 2012, pp 2274-2281.

[19] Sushma G. Throtat,"Automated Glaucoma Screening using CDR from 2D Fundus Images", International Journal of Computational Engineering Research, May 2014, pp 1-8.

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