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VISUALIZATION OF QUANTITATIVE MODELING OF GLAUCOMA IN MULTI-MODAL IMAGE ACQUISITION

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ABSTRACT

Visualization is imperative for any living being. There are multiple reasons which lead to permanent vision loss. Glaucoma is one such eye disease which affects the perception of the individual. It is a degenerative, asymptomatic and irrevocable eye disease. Its advancement can be deferred by appropriate medical assessment at initial period. But far less Glaucoma is an enduring eye ailment which disturbs the optic nerve head of the retina due to intensification of intra ocular pressure (IOP) and consequence is damage to the visualization function of the individual. Wakefulness among the general public exists towards glaucoma and proportionately, number of people recognized is not as much related with affected. The existence of it can be identified by the vertical cup to disc ratio parameter obtained from the optic nerve head in fundus image. This paper proposes an algorithm which uses K-means clustering technique to segment the parameters, and a Graphical user interface has been designed using MATLAB 2018a. The simulated outcomes classify the fundus image as normal or glaucoma suspected and its effectiveness is confirmed with ophthalmologist upshots.

Key words: Fundus Image; Glaucoma; K-Means Clustering; Segmentation; Optic disc and Optic cup

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1. INTRODUCTION

Glaucoma is an enduring eye ailment which disturbs the optic nerve head of the retina due to intensification of intra ocular pressure (IOP) and consequence is damage to the visualization function of the individual[1]. In the primary phase, the IOP may not be upraised permanently but in due course it upsurge perpetually. While loss of sight is inevitable with age-related macular degeneration, the influence of the progression of glaucoma can be deferred if identified and treated at the right time. This disease is slow progressive in nature. Glaucoma is generally diagnosed by special eye imaging expensive technologies namely Heidelberg retinal tomography (HRT), optical coherence tomography (OCT) [2] and other devices. The 2D fundus photograph of the retina, captured by the optical fundus camera is comparatively inexpensive screening method.

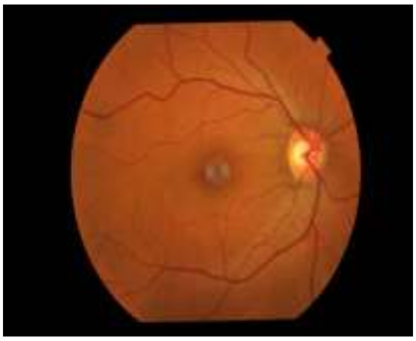

Figure 1 Fundus Image

The fundus image taken from the database is shown in Fig.1, the bright portion almost like an elliptic region is named as optic disc (OD) and is the field of interest of this analysis. It is a pink coloured, well-defined vertically oval area with average dimension of 1.76 mm vertically and 1.88 mm horizontally [3]. The optic cup (OC) is the brightest region inside the optic disc. The kinks in the blood vessels help judging the cup boundary and it is perplexing. Extraction of optic disc and optic cup from fundus image is requisite for glaucoma identification. The shape of optic disc and optic cup boundary may have pathological features and cautious scrutiny is demanded. Exploring the optic disc shed light on the association, concerning the optic nerve cupping and the reduction of eye sight. Significant loss of vision and blindness is the end result of untreated case of glaucoma. Manual inspection of fundus image by the ophthalmologist to identify the status of the image as normal or glaucoma, will be time consuming and impractical for large scale screening [1]. Tools help speedy solutions, so fine-tuned automatic screening system is highly appreciated in clinical practice at this hour. This paper brief a graphical user interface designed for programmed separation of optic disc and optic cup, the most acknowledged parameters for glaucoma screening in fundus image. The paper is outlined as follows. Section II summarizes methodology of glaucoma analysis using vertical cup to disc ratio (VCDR) and classifying the input image as normal or glaucomatous, followed by experiments and results are discussed in Section III and concluding remarks in Section IV.

2. METHODOLOGY

Diagnosis of medical images with computer assisted knowledge generates rapid [4] and accurate results in comparison with manual detection. Due to its innate, fundus imaging is extensively applied in the design of investigative care systems, to distinguish medical disarrays by exploring and offer clinical choices[5]. Therefore, a programmed decision support system with machine intelligence is proposed to make a consistent and fast, and mass screening of glaucoma, centered on the optic nerve structures and its methodology is represented in the following flowchart in Fig. 2.

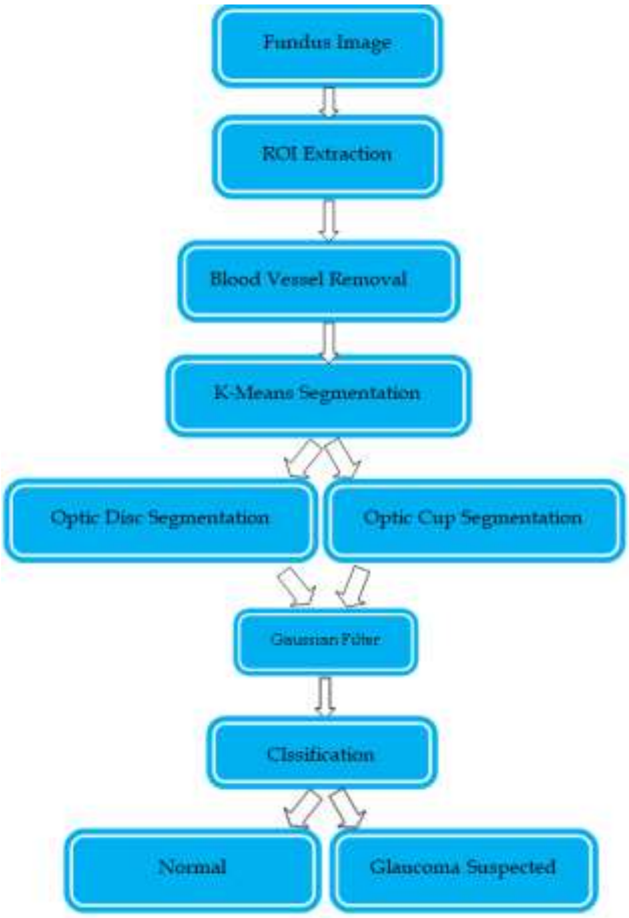

Figure 2 Flowchart of the proposed algorithm

2.1. Image Pre-Processing

ROI Extraction

The original retinal image is a color image of size 2144*1424 as shown in Fig.1. Optic disc localization is done in order to simplify the image handling function and to lessen the search area in image extraction. To achieve best complexity in terms of computation, down sample the original image and the region of interest (ROI) is identified and cropped to 256 * 256 is shown in Fig. 3(a).

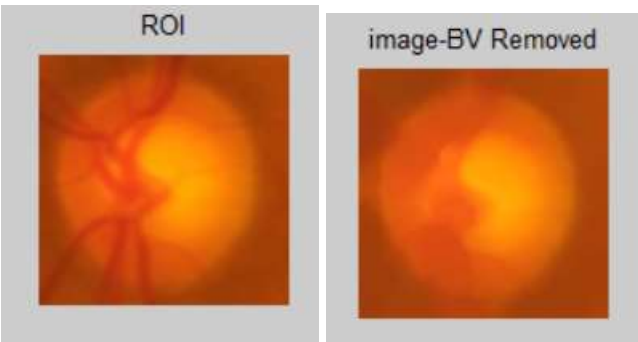

Figure 3 (a) ROI (b) BV Removed

Blood Vessel Removal

The visibility of blood vessels in the ROI degrades the performance of segmentation. Preprocessing improves the accuracy of segmentation by blood vessel removal process and it is enforced for factual splitting up of optic disc and optic cup. Morphological closing operation is applied to remove the blood vessels. Morphological dilation operation trailed by erosion is termed mathematical morphological closing and it is expressed in (1).

$$X \bullet B = (X \oplus B) \ominus B \quad (1)$$

Mathematical morphology is used to analyse the shape and inner structure of objects. The closing operation preserves the background region which matches the structuring element and removes the other elements [6] where X is the image and B is the structuring element. Blood vessel (BV) removed pre-processed image is shown in Fig. 3(b).

2.2. K-means Segmentation

Segmentation of optic disc and optic cup

Segmentation of image is the classification of image into dissimilar sets which is relevant and evident to examine. More precisely when applied with pixel classification technique, it exercise to assign each pixel with a label so that the identical label pixels stances definite features. Machine learning is the study of computer algorithms that improve inevitably through understanding, comprise with statistical skills. Image segmentaion, a key concept of digital image processing, pooled with machine learning generate worthy outcomes [7]. K-means segmentation algorithm is an unsupervised machine learning process applied in order to fragment the focus point from the framework. It aims to fragments or separates the resembling data into K-clusters on the basis of K-centroids [8], with the aim to reduce the estimate of squared distances among the cluster center and all pixels as shown in (2).

$$\sum_{j=1}^{K}\sum_{i \in C_j} \|x_i - \mu_j\|^2 \quad (2)$$

The optimal choice of K will create better clustering of the data pixels and leads to superior segmentation. As the number of K changes, the accuracy in segmentation also changes. The demarcation of Optic Disc and Cup is the key aspect in extracting the distinctive parameters from the fundus images [9]. K-means algorithm is a self-learning algorithm which extracts the required properties optic disc and optic cup from the fundus image and contributes to the classification process and Fig.4 shows the clustering effectiveness of algorithm.

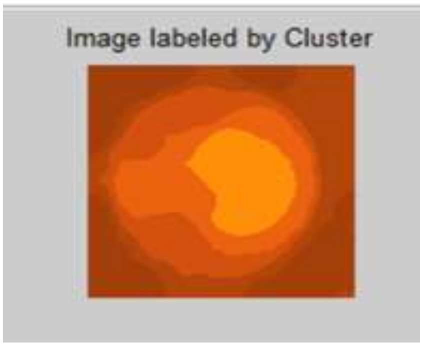

Figure 4 Image Cluster

2.3. Post Processing

Gaussian Filtering

When the features are extracted, part of an object is ignored. Mathematical morphology is the course of action to reconstruct the neglected minutiae [7], but still, the boundaries may be abridged. The post processing includes a smoothing operation for noise reduction. To remove outliers and to smooth the boundary of the binary image Gaussian filter is applied. Gaussian function will apply gaussian smoothing to preserve the edges and it is very effective for noise filtering [10] and represented in (3).

$$g(x,y) = \frac{1}{2\pi\sigma^2} \cdot e^{-\frac{x^2+y^2}{2\sigma^2}} \quad (3)$$

Fig. 5 shows the segmented OD and OC integrated with the original image for visualization.

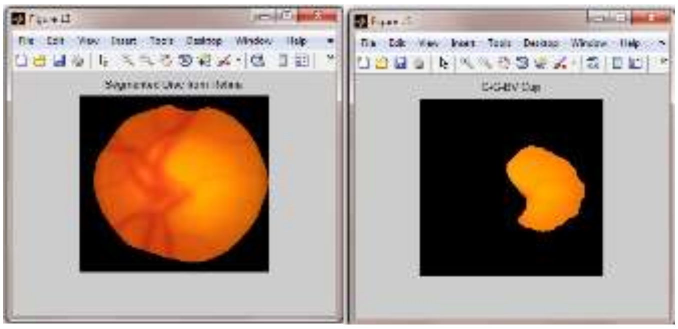

Figure 5 (a) Optic Disc 5(b) Optic Cup

2.4. Vertical Cup to Disc Ratio

The suggested technique effectively segment OD and OC and further upholds and brings out the smooth and sharp boundaries and used in computation of VCDR. The factor mostly used for diagnosis of glaucoma is vertical cup to disc ratio and it is shown in (4). It is computed by measuring the Vertical Cup Diameter (VCD) and Vertical Disc Diameter (VDD) of optic cup and optic disc respectively.

$$VCDR = \frac{VCD}{VDD} \quad (4)$$

2.5. Classification

Automated glaucoma detection has been achieved using K-means Machine Learning technique. The classification factor is VCDR. If it is less than 0.5, it is classified as normal image and otherwise it is classified as glaucoma suspected image.

3. RESULTS AND DISCUSSION

To analyze the proposed methodology, a Graphical User Interface (GUI) has been designed using MathWorks MATLAB 2018a [11]. A collection of healthy and glaucoma retinal fundus images from the database were shown in Fig. 6(a).

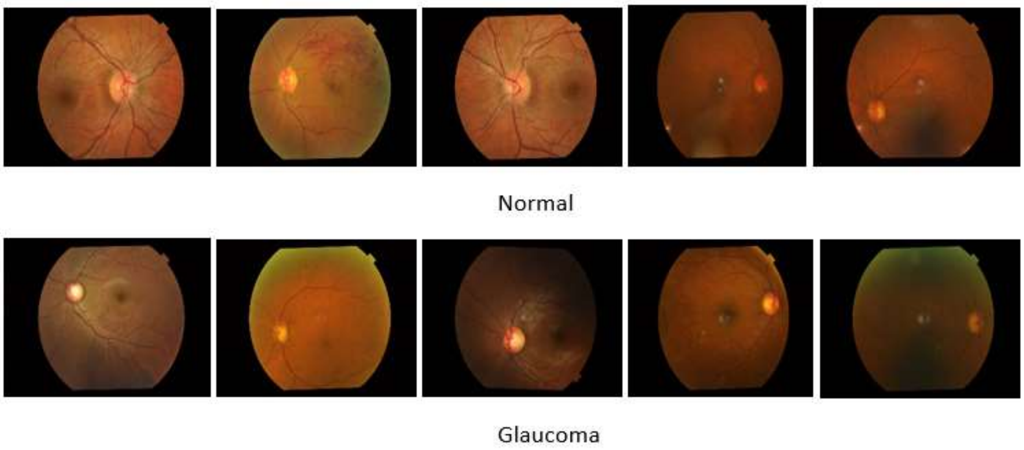

Figure 6 (a) Healthy and glaucoma fundus images from database

The images were saved in JPEG format with a 2144*1424 pixel matrix and the algorithm is tested on 38 images. This tool helps in predicting the given image as either healthy or glaucoma suspected based on the values obtained from the features extracted. Fig. 6 (a) and 6 (b) visualizes the result predicted using GUI and a prototypical OCT report respectively.

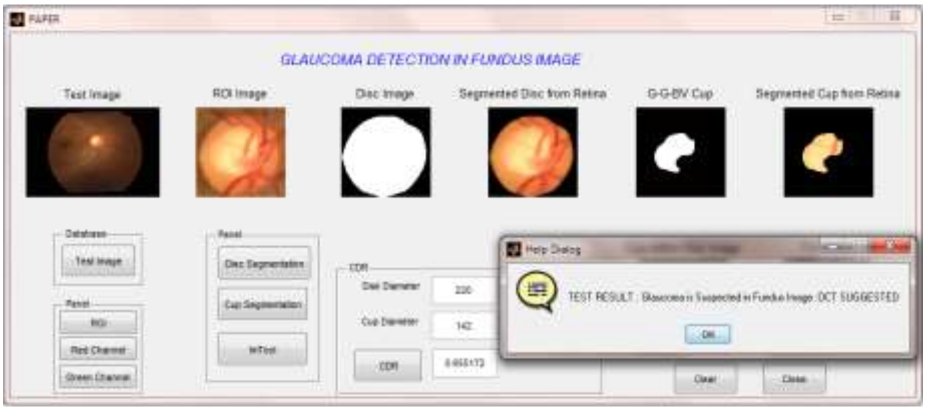

Figure 6 (a) Graphical User Interface Design

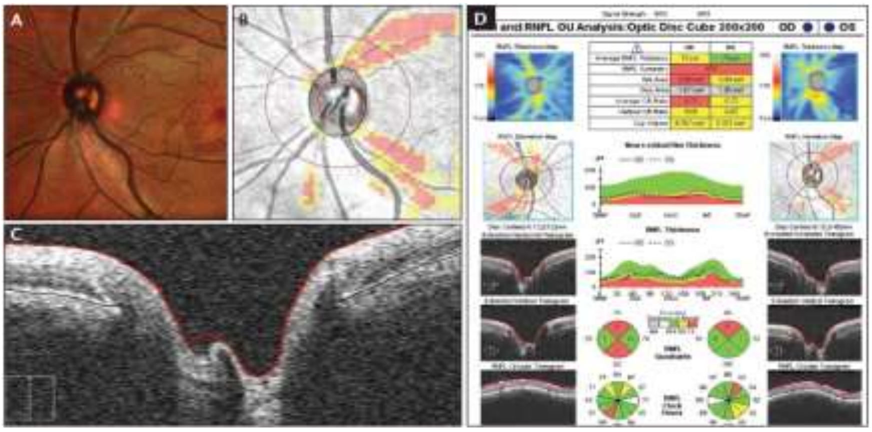

Figure 6 (b) OCT Scan Report [12]

Vertical Cup to Disc ratio is computed by the K-Means clustering algorithm and the result analysis of healthy and glaucoma images are tabulated in Table I.

Table 1 Result Analysis of Healthy and Glaucoma image

IMAGE	VDD	VCD	VCDR
Test Image1	312	203	0.650
Test Image2	286	201	0.702
Test Image3	168	111	0.660
Test Image4	156	109	0.698
Test Image5	167	88	0.526
Test Image6	210	124	0.59
Test Image7	110	48	0.436
Test Image8	100	39	0.39
Test Image9	95	28	0.294
Test Image10	117	41	0.350

The VCR computed by the K-means algorithm and OCT results of healthy and glaucoma images are tabulated in Table II. For most of the images the classification of K-means clustering algorithm complies whereas in few cases there is a mismatch of classification. The mismatch is due to the glaucomatous anatomic indemnities and variations [3], which influences the ultimate challenging facets of the disease identification approaches [3]. In specific instances the borderline between OD and background is uncertain due to pathological vicissitudes. The optic cup segmentation encounter more challenges than disc segmentation because of the perceptibility of the

Table 2 Result Analysis of VCDR

IMAGE	VCDR	
	OCT	ALGORITHM
Image 1	0.68	0.54
Image 2	0.44	0.47
Image3	0.74	0.65
Image4	0.67	0.55
Image5	0.56	0.52

Periphery and high compactness of blood vessels in the frontier of optic cup and disc region [9] and the figure of cup segmentation methods presented are fewer when compared with disc. Visualization of chart form of Performance Analysis of VCDR of OCT and K-means Algorithm is projected in Fig. 7.

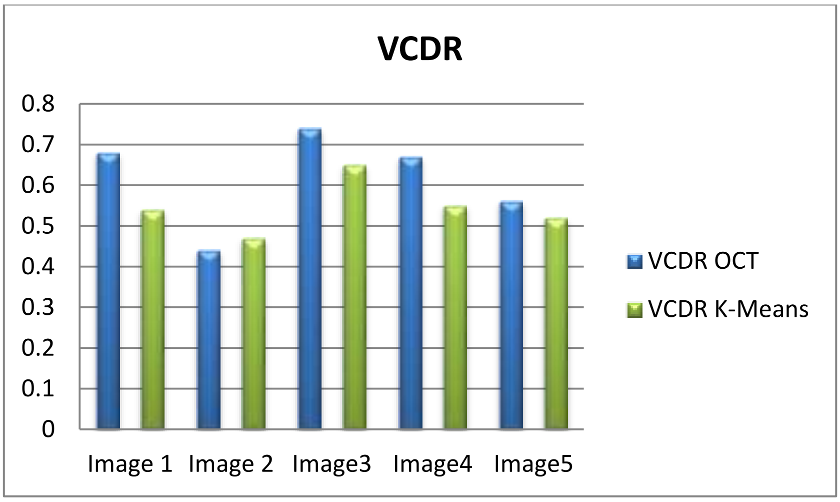

Figure 7 Performance Analysis of VCDR

Proposed computerized segmentation scheme graft equitably fine for standard and good eminence photographs. Appears that perfect outcome of little analogized and pathological optic disks it still remains a focus for forthcoming investigation.

4. CONCLUSION

Early exposure of glaucomatous vicissitudes is the strategy to reduce the fortuitous of substantial visible infirmity. The GUI developed inevitably segment optic disc and optic cup from fundus image, enumerates the VCDR to predict variation. Though its influence is trivial, it can be used in pre-screening and mass screening process, for eye awareness to make affordable eye treatment for the common people, and thus delay the advancement of the ailment. This system can be enhanced by adapting the segmentation technique to pathological optic disc.

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