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RETINAL IMAGE ANALYSIS FOR DIAGNOSIS OF GLAUCOMA USING ARM PROCESSOR

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Abstract: Glaucoma is the disease which effect on the human eye which may cause blindness if not treated properly. Glaucoma occurs due to increased pressure call Intra Ocular Pressure. The glaucoma detection will be carried out using Image Processing Methods like NFL (Nerve Fibre Layer) defects detection and texture analysis, Neuro Retina Optic Cup Detection and Image Segmentation.

For the development of the system, ARM based processor and high resolution with night vision camera is used. Using camera module will capture fundus images. Image Processing algorithm will process this image further with Morphological Operation and apply various techniques for detection and correction of medical images.

This research work will detect glaucoma at preliminary stages. It is helpful for medical practitioner and researchers as well as patients. This proposed method is automated, portable, cheapest and more accurate and efficient device.

***Index Terms* - Optic Cup, Optic Disc, image segmentation, Morphological Operations, blood vessels, CDR, retinal image, arm processor.**

I. INTRODUCTION

Glaucoma is an eye disease cause by elevated intraocular pressure in which the optic nerve is progressively damaged, leading to deterioration in vision and quality of life.[1]. Unlike other eye diseases like cataract and myopia, glaucoma is not curable and vision loss cannot be repaired. Early detection of Glaucoma is thus essential for early treatment to prevent vision deterioration and blindness. [3].

Different techniques have been used for optic disc (OD), optic cup (OC), or optic disc with optic cup segmentation. In diagnosis of glaucoma, ophthamologists are concerned with optic disc and optic cup. Optic disc region is a palor circular region located in densely populated vessels. Optic disc region is centered by a yellowish intense region called optic cup. Region between Optic disc boundary and optic cup boundary creates a circular rim called neuroretinal rim (NRR). Ratio of Cup size to disc size is called Cup to disc ratio (CDR). CDR is a vital factor in analysing the pressure of glaucoma in human eye [4].

Determining the cup-to-disc ratio is a very expensive and time-consuming task currently performed only by professionals. Therefore, automated image detection and assessment of glaucoma will be very useful. There are two different approaches for automatic image detection of the optic nerve head [5]. The first approach is based on the very challenging process of image feature extraction for binary classification of normal and abnormal conditions. The second and more common approach however is based on clinical indicators such as cup-to-disc ratio as well as inferior, superior, nasal, and temporal (ISNT) zones rule in the optic disc area [5]. CDR value ≤ 0.5 indicates a healthy eye [6]. Morever, increase in CDR value decreases the neuroretinal rim. Figure 1 shows the optic disc and optic cup image with Neuroretinal Image.

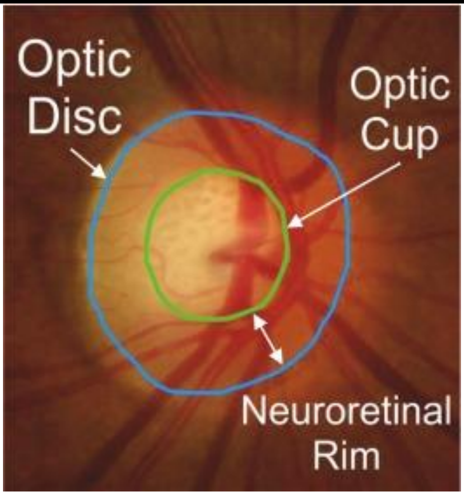

Figure 1: Optic Disc and Optic Cup with Neuroretinal Rim[7]

This paper proposes a fast and low computational cost HW/SW embedded system for automatically classifying digital fundus image into either normal or glaucomatous types in order to aid ophthalmologists to give a more accurate diagnosis of glaucoma.

II. RELATED WORKS

Some portable device based solutions for aiding the diagnosis or progression of glaucoma have been proposed. Portable Eye Examination Kit (Peek) [8] is a kit for acquiring eye images from a smartphone in order to simplify eye exams; however, it does not automatically calculates VCDR.

Several general computer-based solutions using image processing techniques for VCDR estimation have been proposed in past works. A super pixel classification method for cup segmentation from an eye fundus image where the disc has already been segmented. Super pixels are segmented, blood vessels are extracted and removed, then super pixels are classified as part of the disc or cup based on color and location.

Kim [27] uses the novel Fractal Analysis feature-based techniques for detecting and predicting glaucomatous progression is demonstrated. The performance of our method is compared with those of conventional feature-based methods (Wavelet Fourier Analysis and Fast Fourier Analysis). Our method yields an AUROC of 0.82, compared with those of 0.70 and 0.71 for WFA and FFA, respectively. The effectiveness of multiclassification of progressors, no progressors, and ocular normal subjects is also shown using Gaussian kernel-based multiclass SVM. Our FA feature-based multiclass SVM method achieves a correct rate of 0.88 using FA, compared with those of 0.82 and 0.86 using WFA and FFA, respectively. In addition, it is also shown that multiclass SVM can simultaneously discriminate the different stages of progression.

Ahmed Almazroa [18] proposes a method to localize the Region of Interest using Interval Type-II fuzzy entropy-based thresholding based on Differential Evolution in order to determine the location of the optic disc. The optic disc segmented by applying the active contour after removing blood vessels. On the other hand, cup segmentation was conducted in two stages. The one method the blood vessels were extracted in order to detect the vessel kinks to help detect the cup boundaries. The Interval Type- II fuzzy entropy-based thresholding using Differential Evolution were applied again on the localized image to detect the intensity of the optic cup borders. Using Hough transform method, the boundaries of the optic cup can be extracted. In the second method, the disc segmentation was involved in order to improve the cup centroid accuracy by developing two more functions for X and Y coordinates.

Anusorn [12] uses morphological closing operation, Canny edge detection algorithm, K-means clustering algorithm and an ellipse fitting method for disc segmentation. For cup segmentation, histogram based on G channel is analyzed for defining a threshold in order to use a threshold level-set algorithm. After that morphological opening operation and an ellipse fitting algorithm are employed.

Yadav D [26] proposes automatic detection of glaucoma color fundus images. The texture features extracted are localized around the optic cup which gives clear results for the purpose of distinct identification and classification. Texture features are not much explored and seems to be promising in the field of glaucoma detection. A database of 20 images was used as test set. With the help of ART-1 images were classified with the help of test- train ratios. This method gives 72% of accuracy in classification.

As can be seen most of the related works uses costly image processing methods, such as Hough transforms, Canny edge detection, NFL, K-means clustering and inpainting algorithms, being very processor intensive and memory consuming. Their focus is only on accuracy and they are intended to run in computer desktops that have great processing and memory capacity, not on an embedded system with strict processing and memory constraints.

III. PROPOSED METHOD

In order to identify Glaucoma, CDR value is evaluated based on optic disc and cup segmentation. In the proposed method, the vertical diameter of Disc and Cup are calculated by getting the coordinated or the value of the diameter directly using formula. Vertical disc and cup diameters are calculated by getting the coordinated of the upper and lower pixels of disc and cup respectively Then (1) is applied, where xlower , ylower and xupper and yupper are the x, y coordinated of the lower and upper pixels respectively. Finally CDR is defined as the ration of the diameter of Optic Cup to the diameter of Optic Disc.(2),if the value of CDR is higher than 0.6 indicates that the patient has high risk of Glaucoma.

$$d = \sqrt{(xlower - xupper)2 + (ylower - yupper)2} \quad (1)$$

CDR = Diameter of Optic Cup / Diameter of Optic Disc (2)

3.1 Optic Disc Segmentation

In a RGB eye fundus image, the optic disc region has color intensity in the red channel more than any other channels. Based on this analysis, disc segmentation uses only the red channel of the original image. As the optic disc has high intensity in red channel, histogram equalization is applied to enhance contrast between disc and blood vessels.

After Histogram equalization is applied, a contrast image is extracted, this extracted image after histogram equalization is applied threshold for isolating disc and removing blood vessels. The threshold value is generally set between 160 to 255 and here 160 means that if the value exceeds 160 the complete area will become while pixels and all other values below 160 becomes black pixels and reversed is found if the threshold is inverted.

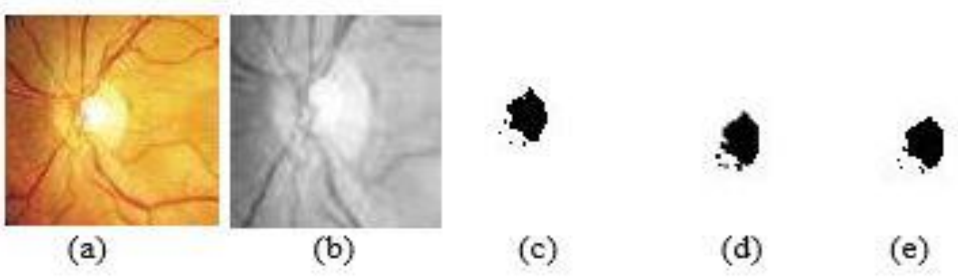

Figure 2. (a) Original image (b) Red channel image (c) Thresholding (d) Erosion (e)Opening

After removing excess blood vessels and thresholding, the masked image will be extracted this shows the optic disc region. This optic disc image undergoes morphological erosion operation followed by morphological dilate operation and morphological opening operation to remove noises and to smooth the disc edges. For erosion, the Kernel is set is (3,2) pixels to remove noise outside the disc region and the opening operation further smoothen the edges(Figure 2).

3.2 Optic Cup Segmentation

In comparison with the Optic Disc Segmentation, Optic Cup Segmentation is quite difficult as the visibility of the cup region is reduced as blood intersect the cup-disc boundary. Usually, extraction of optic cup is carried out in Gray scale image. Here, in the proposed method, Green channel of a fundus image is extracted it is found that the contrast between the cup and disc regions is higher in Green channel. A morphological closing operation is used with a circular structuring element which generated a new image that is added to the Green channel original image in order to improve contrast between cup and disc.

After this, thresholding is done to remove blood vessels and it empirical value is set to 255. The last step is employing a closing operation using a circular structuring element to fill the existing holes (Figure 2).

On the proposed approach, structuring elements were defined empirically based on minimizing processing time and memory consumption. Most of the related works use costly techniques such as K – means clustering, Hough transform and ellipse fitting methods to analyze the diameter of the cup and disc (Figure 3).

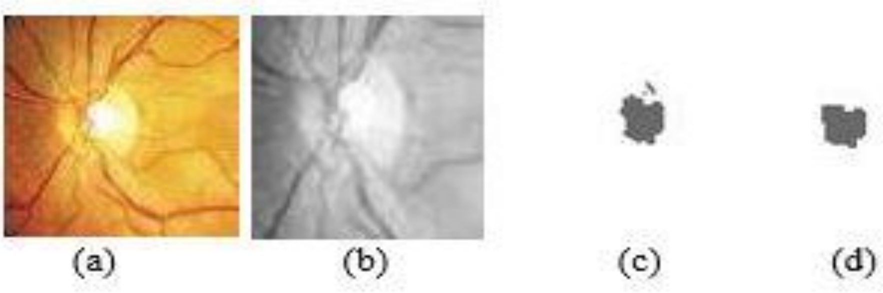

Figure 3 (a) Original image (b) Green channel image after closing and adding (c) Thresholding (d) Closing

IV. RESULTS AND DISCUSSION

For validating the proposed VCDR calculation method, 30 low resolution fundus images were evaluated. 10 images were from healthy patients and 20 were from glaucomatous ones. Fundus images were obtained from RIM-ONE public image database [15]. RIM-One images are acquired from different hospitals and there first release was employed as a training to set a thresholding values, while the second release was used as an experimental set. All the images were evaluated by ophthalmologists providing a gold standard.

4.1 Accuracy Evaluation

Table 4.1: Accuracy Evaluation

Patients	Number of Images	Correct Evaluation	% of accuracy
Healthy patients	10	10	100.00
Glaucomatous	20	17	85.00
Overall	30	27	90.00

Table 4.1 displayed the result of number of images evaluated for both healthy patients and glaucomatous patient. The CDR evaluation method made a correct diagnosis in 27 images out of 30 images and gives an overall accurate rate of 90%.

Although the images used are based on different datasets, it is fair enough to compare them. The comparison between this approach and other related works is as mentioned in Table 4.2.

Table 4.2: Accuracy Comparison of proposed method with related methods

Methods used by different people	Techniques Used	Percentage of Accuracy
Ahmed [18]	ROI and Fuzzy Entropy	80.00
Anusorn [12]	K-means Clustering and Ellipse Fitting	89.00
Yadav D[26]	Texture Feature	72.00
Kim[27]	Fractal Analysis Feature	88.00
Proposed method	Morphological Operation and CDR	90.00

IV. CONCLUSION

To prevent blindness and vision loss it is required to diagnose the glaucoma at early stages. a visual measurement of vertical cup to disc ration may reduce the accuracy of glaucoma evaluation. especially in developing countries and remote areas in which there is lack of professionals and equipment's. Proposed method detects whether patient is healthy or is at risk of glaucoma. This imaging technique does not require patient at the time of testing as only retinal image is sufficient. Cup to Disc ratio calculation method for glaucoma detection is superior to earlier methods. This uses super pixel segmentation method to detect disc and cup. This uses simple linear iterative clustering algorithm. Super pixel segmentation has less complexity than pixel-based methods. The only parameter of segmentation is number of super pixels. Increasing this number increases accuracy of correct boundary but time required is more. Hence tradeoff between accuracy and time is achieved.

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