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Extraction of The Neural Edge and its Properties for The Retina Infected with Glaucoma

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Abstract - *Glaucoma is a prevalent disease of the retina. The primary objective of the current study is to improve the expectation system to ensure that a person might get a Glaucoma and using the effective algorithms to skillfully identify the parts which will be influenced. To recognize and isolate the optic disc, optic cup and neuro-retinal rim, the method is invented in the current study which in return helps in the recognition of the change in the cup size and comparing it with the disc cup. The algorithm employed two steps to individualize the optic disc from the anatomical structure of the retina image and the major step depends on the severity threshold. It is the function of the schematic technique to notice the previous disorders, their size and locations depending on following steps which are: subtracting the region of the optic cup from that of the optic disc, dividing the resulted regions into four quadrants, comparing them according to ISNT and calculating the rim to disc ration where the four modern catcher algorithms are figured. Consequently, the researcher aims for the early discovering of the neural edge of the retina and its characteristics. This mechanism is used in more than 650 images of the retinal fundus of the ORIGA dataset is an important method for documenting retinal health. It has been worked on MATLAB 2020B where it accuracy reached to 98%.*

KEYWORDS- Neuro Retinal Rim(NRR) , Optic Disk (OD), Optic Cup(OC), Retinal Image, Glaucoma, Intensity Threshold, fundus, Cup to Disc Ratio (CDR), ISNT (inferior, superior, nasal, temporal quadrants).

I.INTRODUCTION

Glaucoma is a disease affects the retina as whole. This disease occurs due to the increased intraocular pressure. All scientific and applied analyses confirm that glaucoma is first causer of humans' visual impairment. Glaucoma is a common eye disease caused by increased pressure of the aqueous humor in the eye, called intraocular pressure (IOP) [1]. This pressure causes a damage to the optic disc (OD), which is the head of the optic nerve and it is responsible for transmitting images to the brain. Glaucoma leads to an increase in eye pressure. Early diagnosis and treatment of glaucoma is important to prevent irreversible vision loss [2]. The documented version of the statistics of the World Health Organization denotes that the number of glaucoma infections in 2010 was 60.5 million [3], and more than 64 million cases were recorded in 2013 [4], due to age and population expansion. The number of glaucoma patients in the world is expected to rise to 80 million in 2020, and about 111.8 million by 2040 [5]. Episodic thoughts appear in their phases, polls, surveys, sentences, thinking, collecting and sleeping sickness, as in figure:

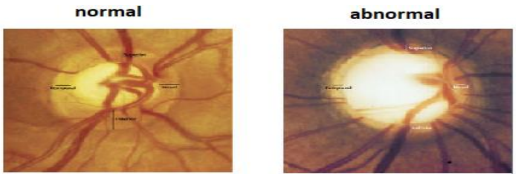


Fig. 1. Normal Retinal (left) and Glaucoma Retinal (right)

The major target of the paper is to extract of the neural edge and its properties for the person might suffer from glaucoma in the retinal fundus images by efficient algorithms.

II.RELATEDWORK

Reference [3] design and implementation of an algorithm for Identification of glaucoma. The method of the novel uses the morphological Techniques to extract two major advantages of detection Glaucoma, that is, the ratio of the area of NRR in ISNT quadrants, cup to disk ratio. The developed methods were tested on three Various databases such as DMED, FAU.

Reference [6] created a multi-scale deep neural networks CNN for detecting the OD and fovea. The OD and OC, as well as the fovea, are identified. Using this deep learning process, you may learn more precisely and quickly. convolutional neural network for OD detection and fovea. The OD and OC, as well as the fovea, are identified. Using this deep learning method, you may learn more precisely and quickly.by using databases accessible to the general public.

Reference [7] The proposed method for retail OD was introduced by combining shape and intensity threshold techniques to obtain accurate detection of OD. Finely divided OD is a very important factor in exudate diagnosis in diabetic retinopathy and glaucoma in its early stages. More than three data sets were relied upon, namely Origa, Rim-One 3 and Drishti.

Reference [8] proposed an offline CAD system for the diagnosis of glaucoma. This application is developed using image processing, deep learning and machine learning approaches. The Le-Net architecture is used for image validation and region of interest (ROI) detection. Use the bright spot algorithm. Optical disk and optical cups were segmented with the help of U-Net that was designed and assembled using SVM, Neural Network, and Ad Boos, with dataset RIM-ONE, DRIVE.

Reference [9] designed an approach for glaucoma recognition. Their method consists of two indicators of glaucoma; Cup to Disc Ratio and Rim to Disc Ratio (RDR). Optic disc and cup segmentation are done by applied morphological operations and Otsu threshold on the green channel of retinal fundus image. Neuro retinal Rim is extracted by subtracting the region of the optic cup from the optic disc region, then the ISNT rule is implemented on the NRR in order to calculate the value of RDR. Support Vector Machine (SVM) is used as a classifier and the dataset used is DIARETDB1 which contains 60 images.

Reference [10] proposed a method that uses anatomical atlases with no rigid registration and has three phases: the first phase retrieves the image from the OD model maps based on the content, the second phase constructs the test image specific anatomical model, and the third stage extracts the optic disc boundaries to use a threshold approach and smoothens the image with the final ellipse fitting.

III.METHODOLOGY

The proposed system consists from four stage: optical Disk extraction, optical Cup extraction NRR region extraction as well as extract NRR region properties using new masks the following Fig.2, is show that.

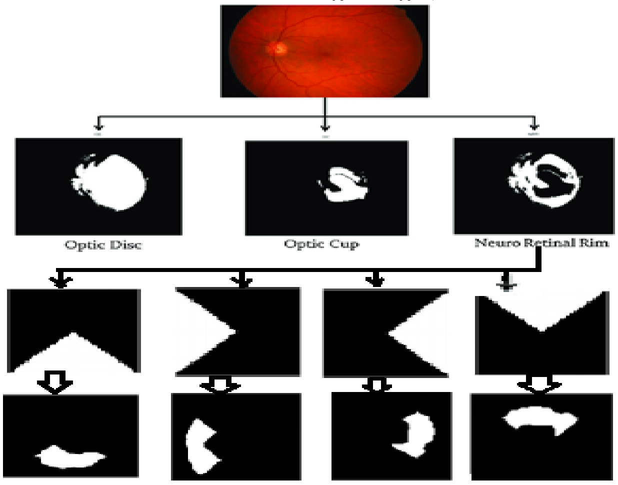
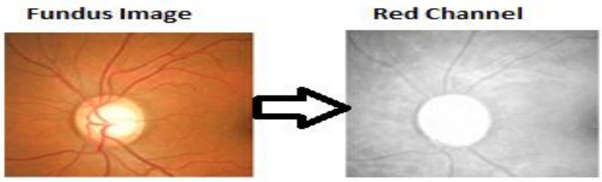


Fig. 2. proposed system

IV.OPTIC DISK DETECTION

In fact, any image is an RGB color image Fundus image of the retina consists of three channels (green, blue and red), with a density from 1 to 256 and according to what we saw in this picture, the blue channel is the channel that contains the least information, and the red channel is the brightest and clearest channel, as well as the blue channel contains a lot of color details, but it is not like the red channel, and because the optical disc is a light yellow area, and therefore work was done on the red channel in the proposed method for extracting because the disc contains more yellow color. Finally, the red channel is the clearest and brightest for disc detection Depending on the maximum density of the red channel as in the equation (1).



$$\text{BW}(x,y) = \text{Red Channe} \geq \text{Max Intensity} - 2 \qquad (1)$$

Occasionally, an image is a binary image contains the OD with some of the undesirable or noise objects which appear depending on the (SD) of the image of the red channel, when the value of (SD) is lower, the following figure shows these states:

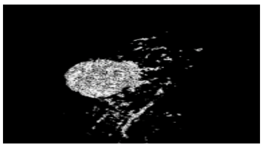


Fig. 3. Detection of OD with undesirable objects

to remove unwanted objects, the resulting binary image is labeled with a ten-connections and removed all connected components (objects) that have fewer than (1000) pixels from the binary image, the following Fig.4, shows the absence some of these unwanted objects:

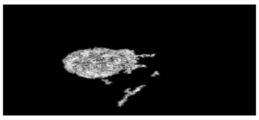


Fig. 4. Absence some of the unwanted objects

The final step in this section is the elimination of the objects which are smaller than OD and keeping the larger object which is often the OD, as shown in the figure and in the same figure the OD has detected accurately but it contains some unwanted objects and it appears as a single object

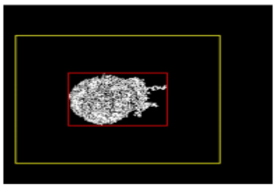


Fig. 5. OD Detection

some morphological processes will be performed to optimize the OD segmentation. The first one is an opening operation with structuring element as disc shape and the size is 5 and in second figure is retrieval RGB color for OD

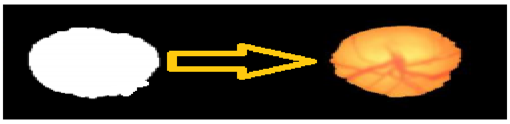


Fig. 6. OD binary image and RGB OD

V.OPTIC CUP DETECTION

The OC region is one of the regions where the branching blood vessels are located, which resulted in difficult OD due to the high density of BV in the OC region. Glaucoma also changes the shape and size of that area, which requires a very large effort to extract it.

A. Adjustment of OD Contrast

To segment OC accurately an automatic threshold must be used, the image must be well contrasted, so the adjustment will be applied on the images depending on the standard deviation of each image. As positioned in Equation (2).

$$\text{ODadjusted} = (\text{OD}, [\text{Rl Gl Bl to Rh Gh Bh}]) \qquad (2)$$

Fig.7. shows The values are 0.2, 0.2, 0; 0.6, 0.8, 0.5 respectively.

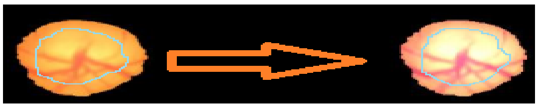


Fig. 7. Various contrast of OD

B. Green Channel Extraction

The green channel is the best channel for OC extraction. OC area is Brighter in the OD area with the presence of blood vessels. As shown in Fig.8.

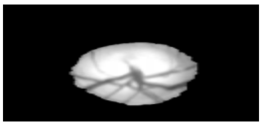


Fig. 8. Green Channel of OC

C. Image Threshold

For OC extraction threshold to be automatic, the standard deviation is calculated for the entire green channel, and as in the equation is (3).and the Fig.9.show Thresholder images.

$$\text{Threshold} = 255 - \frac{\text{SD Green Channel}}{4} \qquad (3)$$

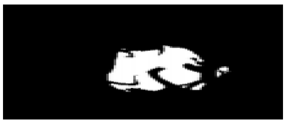


Fig. 9. Thresholder images of OC

D. Morphological Closing

To remove the gaps between the parts of the binary image of OC and label it, closing operation is done. The structuring element must be larger than the largest gaps in the image. The Fig.10 show optimum size used of the structuring element (SE) is 50 with a disc-shape.

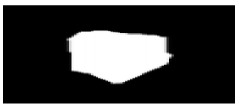


Fig. 10. Binary image of OC

VI. NEURO RETINAL RIM (NRR)

The area between the Optic Disc and the Optic Cup, called the NRR area, which is one of the most important areas, facilitates the detection of glaucoma. The area between the optic disc and the optic cup is called the edge of the retinal nerve rim that contains neural components. Fig.11. shows the characteristic of the Retinal neural edge patterns in normal images.

Fig. 11. Binary of Neuro Retinal Rim area

NRR is the area between the OD boundary and the OC boundary. In order to find the exact NRR as shown in the Fig.12 below, the binary image of OD is cropped and the unnecessary black areas on the image boundaries are removed so that the resulting image is OD with a black area of only 20 pixels, then the following equation (4) is executed:

$$\mathbf{NRR} = \mathbf{OD}\_\text{Cropped} - \mathbf{OC}\_\text{Cropped} \qquad (4)$$

The following algorithm depicts the steps of this operation.

Algorithm: Neuro Retinal Rim (NRR) Computation

Input: Binary Images of both segment OD and OC.

Output: Neuro Retinal Rim (NRR).

1: Load binary images of both segment OD and OC.

2: Crop binary images of both segmented OD and OC with black region of 20 pixels

3: Subtract the OC region from the OD region to find NRR region.

4: Return Neuro Retinal Rim (NRR).

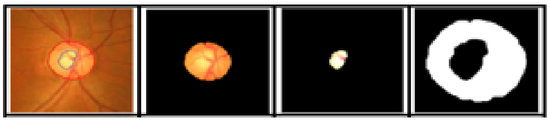


Fig. 12. Results of NRR segmentation in OD images

Its length is not constant in all areas of the normal eye that follow the ISNT rule. This rule states that the length of the edge of the retinal nerve is located in the lower region and not in the upper region, followed by the nose region and the past time as shown in the Fig.13 below. In glaucoma patients, the retinal nerve rim does not follow the ISNT rule.

- Normal ⟹ I >S >N >T
- Abnormal ⟹ N>S>T>I **or** N &S> T&N

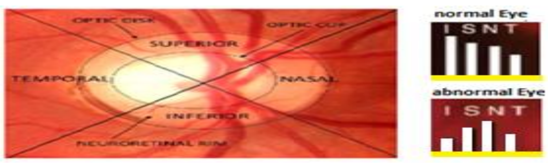


Fig. 13. Characteristic of NRR in a normal image

Actually, after continuous experiments, the researchers noticed that the evolution in the loss of NRR in a glaucoma tablet. These changes are associated with the development and location of early visual field defects Glaucoma in normal eyes, the optic disc and cup are consistent (there is an imminent connection between them) and if one of them is noticeably enlarged or it indicates something, then this would indicate glaucoma. Small disc with large cup size or cup-to-disc asymmetry will suggest glaucoma, especially if the NRR composition does not comply with the ISNT rule. As illustrated in the figure below:

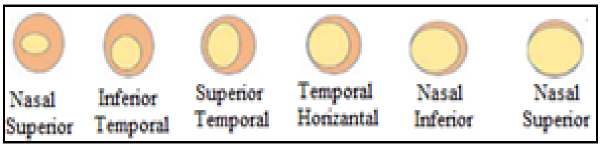


Fig. 14. Progression of (NRR) loss in glaucoma

A. Masks Images Creation

Mask images act as an image filter, so it is assumed that the mask image is such case the required quadrant must have a value of 1 or white. Throughout this significant stage of the extraction of feature from the NRR rim area, masks were discovered in a new way and modern algorithms that were not previously worked in all other sources During which the NRR rim area was divided into four sections(ISTN) and the pixel value was relied on (index loops), as this method achieved shortening a lot of time needed for testing, as well as smart filling, which dictates the areas to be filled with white color without going through any other places that were useless to the researchers and tested in vain as in the previously used detectors. and as follows:

1) Algorithm: Inferior Quadrant Mask Creation

Input: The Number of Rows and Columns for NRR Img.

Output: Inferior Quadrant Region.

1: [Rows, Columns] = size (Neuro Retinal Rim);

2: Inferior= Set zeros (Rows, Columns)

3: Initial Columns=1;

4: For I = Rows **: -1 :** Center Rows

5: For J = Columns **: -1 :** Initial Columns

6: Inferior (I, J) = 1;

7: End For

8: Initial Columns = Initial Columns +1;

9: Columns = Columns -1;

10: End For

11: Return Inferior Quadrant Mask

This algorithm is implemented through a series of operations in two loops as follows:

The "J" loop starts from the end of the columns and decreases until it reaches the Initial Columns, and the algorithm sets the value of the pixel becomes equal 1 in the image based on the number of Columns specified by the loop "J", when the value of Columns becomes equal to the value of Initial Columns, the loop "J" ends. The "I" loop starts from the end of the Rows and ends when initial value of I it reaches the Center of Row (decreasing). Finally, result indicates that the Inferior Quadrant Mask is found and printed only in the determined area by white color, and the algorithm is terminated. As shown in the figure below:

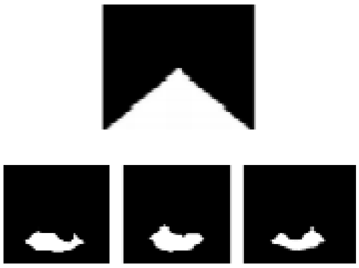


Fig. 15. states the resulted images of inferior regions

2) Algorithm: superior Quadrant Mask Creation

Input: The Number of Rows and Columns for NRR img.

Output: Superior Quadrant Region.

1: [Rows, Columns] = size (Neuro Retinal Rim);

2: Superior = Set zeros (Rows, Columns)

3: Initial Columns=1;

4: For I = 1 **to** Center Rows

5: For J = Initial Columns **to** Columns

6: Superior (I, J) = 1;

7: End For

8: Initial Columns = Initial Columns +1;

9: Columns = Columns -1;

10: End For

11: Return Superior Quadrant Mask

This algorithm is implemented through a series of operations in two loops as follows: In this case, the algorithm sets the value of the pixel becomes equal 1 in the image based on the number of Columns specified by the loop "J", when the value of Columns becomes equal to the value of Initial Columns, the loop "J" ends. The "I" loop ends when initial value of I increases until it reaches the Center of Row. Finally, result explains that the superior Quadrant Mask is found and printed only in the determined area by white color, and the algorithm is terminated. As shown in the figure below:

Fig. 16. Shows the resulted images of superior regions

3) Algorithm: Temporal Quadrant Mask Creation

Input: The number of rows and columns for NRR image

Output: Temporal quadrant region.

1: [Rows, Columns] = size (Neuro Retinal Rim)

2: Temporal = Set zeros (Rows, Columns)

3: Initial Row=1;

4: For J = 1 to Column

5: For I = Initial Row to Row-1

6: Temporal (I, J) = 1

7: End For

8: Initial Row = InitRow+1;

9: Row=Row-1;

10: If Row<=1 then Break

11: End If

12: End For

13: Return Temporal Quadrant Mask

This algorithm is implemented through a series of operations in two loops as follows: The algorithm sets the value of the pixel becomes equal 1 in the image based on the number of rows specified by the loop **"I",** when the value of **Row** becomes equal to the value of **Initial Row,** the loop **"I"** ends If the value of **Row** becomes equal 0, then the loop **"J"** execution ends and stopped for Column and Row loops. Finally, the result is that the **Temporal Quadrant Mask** is found and printed only in the full the area by white color, and the algorithm is terminated. As shown in the figure below

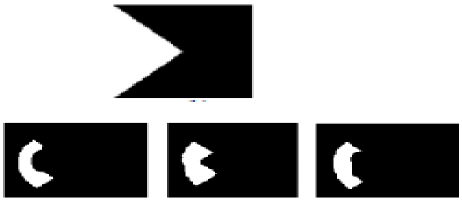


Fig. 17. Temporal regions of NRR

4) Algorithm: Nasal Quadrant Mask Creation

Input: The Number of Rows and Columns for NRR

Output: Nasal Quadrant Region.

1: [Rows, Columns] = size (Neuro Retinal Rim);

2: Nasal = Set zeros (Rows, Columns)

3: Initial Row =1;

4: For J = Columns: **-1: Center Colum**

5: For I = Initial Row **to** Rows-1

6: Nasal (I, J) = 1;

7: End For

8: Initial Row = InitRows+1;

9: Rows=Rows-1;

10: If Row<=1 then Break

11: End If

12: End For

13: Return **Nasal** Quadrant Mask

This algorithm is implemented through a series of operations in two loops as follows: The "J" loop starts from the end of the columns and decreases until it reaches the beginning of the columns, and The algorithm sets the value of the pixel becomes equal 1 in the image based on the number of rows specified by the loop "I", when the value of Row becomes equal to the value of Initial Row, the loop "I" ends. If the value of Row becomes equal 0, then the loop "J" execution ends and stopped for Column and Row loops. Finally, result is that the Nasal Quadrant Mask is found and printed only in the determine area by white color, and the algorithm is terminated. As shown in the figure below:

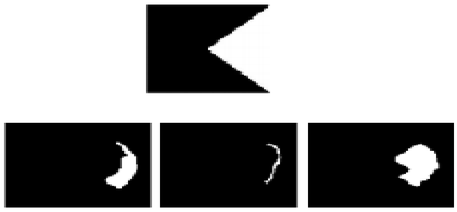


Fig. 18. Nasal regions of NRR

Finally, the RNN results after applying the Inferior, superior, nasal and temporal masks, as in the figure below:

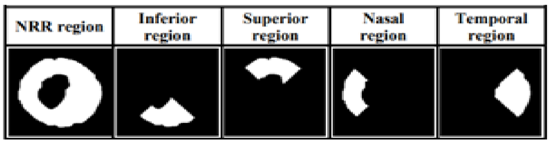


Fig. 19. Results of ISNT regions

VII.RESULT AND DISCUSSION

Using the main structure of Optic Disk, OC and NRR The morphological process and severity threshold method were proposed. The proposed method is applied on four data sets, namely MESSIDOR, DRISTHI, ORIGA, and RIM, the performance parameter used to evaluate the proposed system is accuracy, as shown in the equation (5) below:

$$Accuracy = \frac{TP+TN}{TP+FP+TN+FN} \qquad (5)$$

Calculated accuracy results for the tested dataset with a MESSIDOR groups, DRISTHI, ORIGA, The RIM was 96.05, 93.02, 98.08, 95.04 respectively, the average accuracy for all data sets used is 95.54. When comparing these results with other testing methods as shown in Table 1.

TABLE 1 COMPARATIVE RESULTS OF OD,OC AND NRR SEGMENTATION

Research	**Dataset**	**Accuracy**
Al-Bander et al. in 2018	MESSIDOR	97%
Hafsa Ahmed * et al. April 22-24, 2014	DMED, FAU	97.5%
Kanchana and Naga Kiran, in 2019	DIARETDB1 With 60 image	94%
Rutuja Shinde.2021	RIM-ONE,DRIVE	98.67%

sharma et al, In 2019.	RIM, DRIONS	95.8%
Hayder et al In 2020	Origa, Rim-One 3 and Drishti	97.1%
Proposed method	MESSIDOR DRISTHI ORIGA RIM	96.5% 93.2% 98.8% 95.4%

VIII.CONCLUSION

This study provides an efficient automated method by combining shape and intensity threshold techniques to obtain accurate detection of OD. Masking or removing any OD noise from fundus image by using several filters including Morphological structuring element, so detection is important, which improves detection accuracy. Also, in the second stage, accurate detection of optic cup funnel through the green channel was performed, as most methods for diagnosing glaucoma are based on features of OD, Optic, and RAR, such as measuring the ratio of optical cup diameter (OC) within OD to OD diameter (CDR)), to measure the width of the retinal nerve rim (NRR) that lies between OD and OC. In the last stage, the four edges of the NRR were discovered and the characteristics were extracted according to the above-mentioned algorithms, which proved their effectiveness and shortened the implementation time and accuracy. The proposed method gives detection speed and accuracy for OD limits, optical cup and NRR. The proposed method was applied to four different datasets, as shown in the first table, the results are very good and promising. The proposed system can be used for research and development in the future, improvement and reliable detection of infected in all detectors that can use this software method.

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