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Glaucoma Detection Using Fundus Images of the Retina

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Abstract. In the paper that we are proposing we make use of the image processing technique that can be further used to detect or predict whether the eye is glaucomatic which leads to increase in the size of the optic cup in turn affecting the optic disc. Glaucoma being the second major reason for blindness was very difficult to detect in the early stages. Here in this paper, we make use of the retinal fundus images and glaucoma is being detected using the features that we extract from the fundus images. The first feature that we extract includes one of the basic physiological parameters which is the Cup to Disc ratio (CDR) and the second feature that we extract is the neuro retinal rim which has the inferior, superior, nasal and the temporal quadrants of-ten called the ISNT quadrants which can be used to detect glaucoma in the fundus image of the eye.

Keywords: Glaucoma, Fundus Images, Cup to Disc Ratio (CDR).

1. Introduction

Being the major cause of permanent blindness, Glaucoma is a disease where the intraocular pressure i.e., (IOP) rises severely, and can also go up to 60-70 mm Hg. Usually, the pressures higher than 25-30 mm Hg can cause vision loss on a long term. In most of the cases of a glaucomatic eye the very high pressure of the blood may result in the increase in the resistance of the fluid in the eye fluid system but whereas in a normal eye which is healthy there is an equal balance between the fluid produced in the eye and to that which is coming out. This balance is very useful in keeping the IOP of the eye unchanged but in the case of glaucoma the balance in not maintained which finally results in abnormally increasing the IOP of the eye which in turn can damage the optic nerve. Since the cup size increases with the increase in IOP the cup to disc ratio also increases. In the case of a normal eye the cup to disc ratio is less than 0.5 but when we consider the case of a glsucomatic eye the cup to disc ratio is greater than 0.5. We also see that the NRR i.e., the neuro retinal rim is also affected as the size of the cup increases. The NRR can be defined as the region that is present between the optic cup and the optic disc boundary. In the cases of glaucoma, we can see that the area covered by the nasal and the temporal region is much higher than that covered by the inferior and the superior regions in the NRR. In the figure 1 we can see a digital fundus image of a normal eye and that of the glaucomatic eye.

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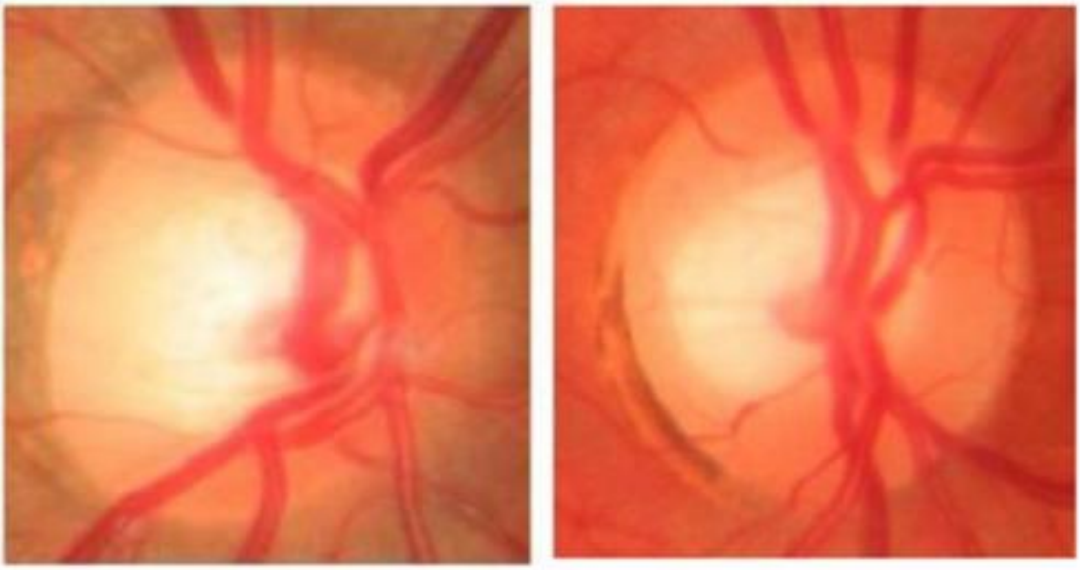

Fig. 1. Left to right: Normal disc where CDR is less than 0.5 and Glaucomatic disc where CDR is greater than 0.5.

The strategies mainly include the use of a green part later which the pre-processing, morphological openings, small inserts extended maxima operator, water conversion are done. Then automatically the optic disc and the region of interest i.e., ROI and the component for the component analysis which is done for the cup acquisition is proposed. Then the morphological methods are used to extract the optic cup and the optic disc which are used to predict glaucoma. Here in our proposes method we are making use of 450 pictures with some of the details like having a specificity of 80 percent and a sensitivity of 100 percent and a cup having a precision of 90 percent is achieved.

2. Literature Survey

The foremost cause for permanent blindness is Glaucoma. Here, IOP [intraocular pressure] is extremely high, sometimes extremely high up to 60-70 mmHg. If the pressure is greater than 25-30 mmHg it can lead to vision loss when left untreated for a long period. Usually, this abnormal high pressure leads to rise in the resistance of the fluid through the eye drain system. The new approach uses Morphological techniques to draw out features to find out Glaucoma they are the NRR for ISNT quadrants, Cup to Disc Ratio. [1]

Glaucoma is further expressed as ‘multi factorial optic neuropathy’ which is a blind disease that have an effect on 66.8 million people globally. Being the second leading of permanent blindness, its diagnosis is also very difficult and it also has taken very long time to predict and diagnose this. On the other hand, it is also very difficult to control this. Intra ocular pressure being the major factor for permanent blindness, there is no specified limit that is defined that causes this. The increase in the intraocular pressure will lead to reduced clarity in the vision and will lead to permanent blindness. If glaucoma already exists with a feature, it becomes very difficult to diagnose and would require advanced surgery and attention. The optical disc space is taken using the ROI - based separation. Compared to other methods this ROI based separation gives lesser difference. Calculation of other methods efficiency is done using the cup to disc ratio. [2]

It is roughly calculated that in 2013, 64.3 million people globally between the period of 40 to 80 years were glaucoma detected. This was anticipated to come to 76 million by 2020 and 111.8 million by 2040. The occurrence of glaucoma is 2.5% in people of all generation and 4.8% in people over 75 years of age. The medical record of the patient's family and changes in the structure of the optic disk

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and intraocular pressure are the main reasons in cause of glaucoma. An increase in IOP is caused due to the release of the aqueous humour. Many regions are identified by the ophthalmologists in order to detect glaucoma. Some of the problems like blood vessel abnormality is also used to find. In detecting glaucoma, we can also use wave-based entropy features. Here we can also increase the accuracy by selecting the proper kernel functions. This is also used to detect glaucoma at a very early stage and can also use to diagnose major details. [3]

The optic cup and the optic disk have some space between them called the Neural Retinal Rim. It is the intersection point of the retinal blood vessels. If the fundus image does not reveal any flaw in the brightest bit of the image, then the eye image is healthy. Numerous deep learning techniques have been employed but the accuracy or rightness is too low. Status information about the retinal imagery is given by the automatic segmentation of retinal blood vessels. A type of deep encoder decoder architecture i.e., SegNet is used for the multi pixel segmentation of many classifications. With the character of the convolution of models and the use of an productive GPU, separation can be finished rapidly. The time needed to split using DCNN properties will be around 1.25 seconds as reported by the authentic segmentation technique. There are numerous disorders and age-related factors which have an effect on the eyes. Glaucoma is the second foremost source of loss of vision, cataract stands first. Here, destruction to the optic nerve becomes greater progressive vision loss. To keep eye pressure, the persons eye has to produce aqueous humour that run through the eyes. If it fails to run repeatedly, there may be optic nerve damage resulting in vision loss. This damage to the optic nerve can be determined by means of Optical Coherence Tomography. Certain factors like CDAR, CDR, RDAR and H-V CDR are contemplated. The scrutinization in addition notifies us that either OD and OC techniques work finest for images with low quality. [4]

In many cases intense pressure in the eye leads to damage. As a result, the vessels of the eye also get damaged. In a glaucomatic eye the redness in the sclera is visible but in the case of a normal eye the sclera is transparent and no eye vessels are same. In order to reach higher accuracy feature like relationship of redness and sclera can be of greater use. [5]

At first it is easy for the specialist to get the IO weight with the help of a tool to get the cup part of the fundus image. Alternative form the cup to disc ratio and the neuro retinal rim are being suggested. According to some strategies the cup to disc ratio and the neuro retinal rim releases can be done using a fluffy grouping method. This depends on the diameter of the cup and its development within the area of the optic plate. This kind of model also makes it more efficient in the extraction of cup and the plate. Through this glaucoma can be detected with higher accuracy. [6]

If glaucoma is not detected at an early stage this can lead to permanent blindness. This vision loss or blindness can be prevented only when glaucoma is detected at an early stage. This glaucoma is one of the major chronic and rapidly increasing disease of the eye in the urban areas. The screening for glaucoma is a very big process and it is also time consuming since it requires every region of the eye to be checked. The deep learning system for glaucoma uses algorithms like KNN, SVM which are highly efficient. Promising results are found by these methods which one brought into practice in the future to test large scale patients. [7]

Principal component analysis and gray level co-occurrence matrix was applied and then the collected data was made normally. Using this gray level co-occurrence matrix results in calculation of element and also results in high degree of accuracy. These methods are used and customized to obtain results and the extracted features are localised in the fundus images. The above method shown has an average of about 72% accuracy. [8]

Clinical measurements may be right but requires more time. Extracted visual features may have additional data related with the image than others. Most of the methods available are learning-based or class-based methods. These methods are done with one’s hands based on pathological regions and lower comparative standard [9]. Two channels called M-net and DENet are presented here. M-Net will be the seg-mentation-based approach that solves the OC and OD division into a single multi-level framework. DENet is a learning-based approach that combines four deep streaming across different levels and modules. These two approaches forecasts glaucoma in a specified fundus image [10].

3. Database of the Retinal Image

The RGB retinal fundus images that is used here is taken from multiple sources like the DMED database, the MESSIDOR and the FAU database. Here we performed the experiment on 450 fundus images which are all of variable sizes but all were in the RGB colour space only. The photos in the website were taken by adjusting the lighting conditions and a fundus camera [11].

4. Proposed Approach

Here to detect glaucoma the we need to calculate the cup to disc ratio and the Neuro retinal rim ratio which can be done by the dual extraction with the mean threshold morphological method in the ISNT quadrants [12]. For the measurement of the NRR the NRR itself is used but for the testing of CD the optic cup and the optic disc is used.

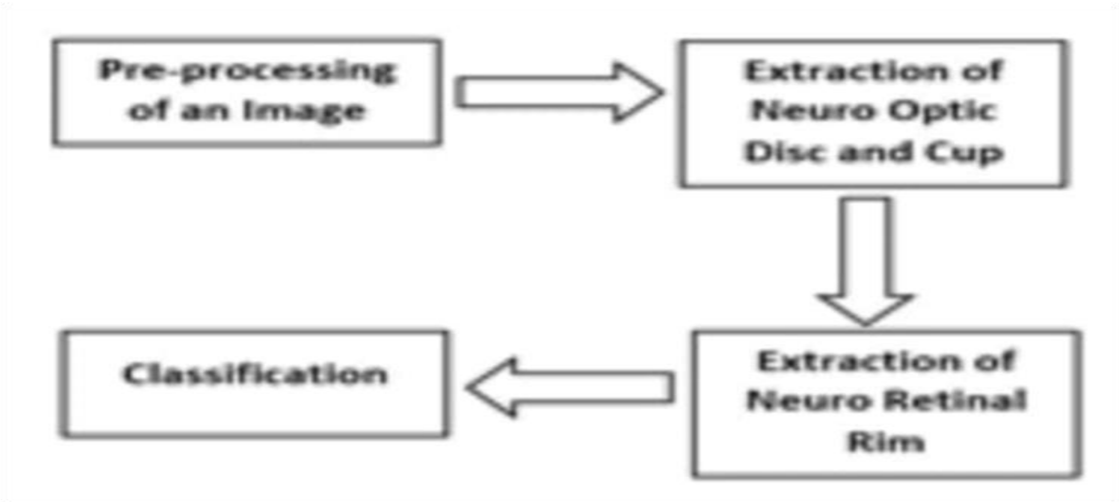

Fig. 2. Proposed Approach.

A. Image Pre-processing

The light orange bright part is the optic disc and the region of interest is the one in pink in the coloured retinal fundus images [13]. Then the region of interest is extracted from the images buy cutting to solid values and then resizing it to 256x256.Then from the real image the green plane is taken so that an improvised version of optic cup with good brightness is obtained.

This is shown in figure 2.

Then the original image taken is changed to HSV aircraft. Then as shown in the figure 3 we can see a better difference in the optic disc in the output of the V-plane in the HSV image after the complete analysis of the number of images.

B. Optic Disc and Optic Cup Extraction

The basic tool for glaucoma detection is the CDR screening which is calculated by extracting the optic cup and the optic disc [14]. Then the green plane is extracted from the real image is used to remove the optic cup and then is converted to the image of a gray scale. Then the binary image is obtained from the gray scale image.

When the cup border is not clear because of the gradual change in the color of the cup the threshold value for the cup release varies. Then the line value of the line design is calculated. This means that the value was between 0.4 to 0.57 in most of the images for us. The gaps that are formed in the images due to the presence of blood vessels are filled with the function of a natural structure like dilation and erosion is used for the same structure in the fundus dataset [15]. The optic cup parameters in the result image is obtained by a Gaussian filter by smoothening it as shown in figure 2. Then the number of white pixels is calculated which is then used to calculate the area of the optic cup.

Then from the HSV image the optic disc value plane. The. The gray scale image is obtained from the plane V. From this gray scale image, we obtain a binary image by finding the exact value of the gray scale image. Then the unnecessary objects in the image is removed by setting the threshold value to 1500. Then Gaussian filtering is done for this image to smooth the parameters as shown in figure 3. Then in order to get the CDR the cup space is divided by disc space. Then by using the canny filter the OD and the OC are obtained in the resulting dataset.

C. Extraction of Neuro retinal Rim

Another major way of detection of glaucoma is by using the NRR [16]. The part of the area that covers the lower part is thinner than that of the upper part when it is compared to the amount of area that is covered by the nose to the temporary region in glaucoma. To get the NRR output and to apply the functionality to the cup and disc image the optic disc and the optic cup have been removed After the extraction of the NRR image a 256*256 size mask can be made used to calculate the region that the NRR covers in the ISNT quadrants Each time the size mask is tilted at an angle of 90 degrees which can be used to calculate the ratios separately for each quadrant. Figure 5 represents the size mask and its surrounding versions. At last, only the white pixels that cover the ISNT measurement area is calculated.

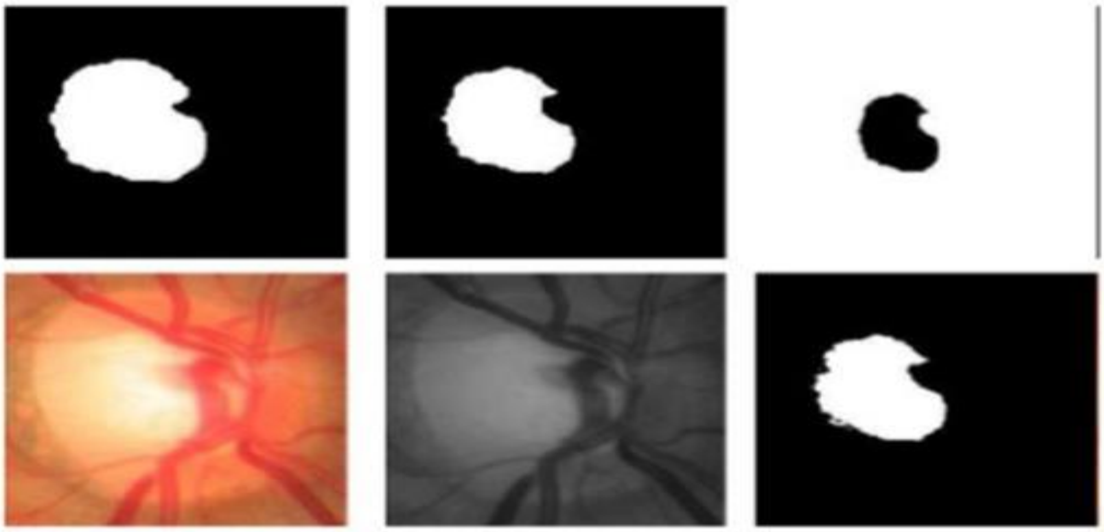

Fig. 3. Left to Right: (a) RGB Image, (b) Gray scale of green plane, (c) Binarized Image, (d) Dilate, (e) Erode, (f) Compliment of detected cup.

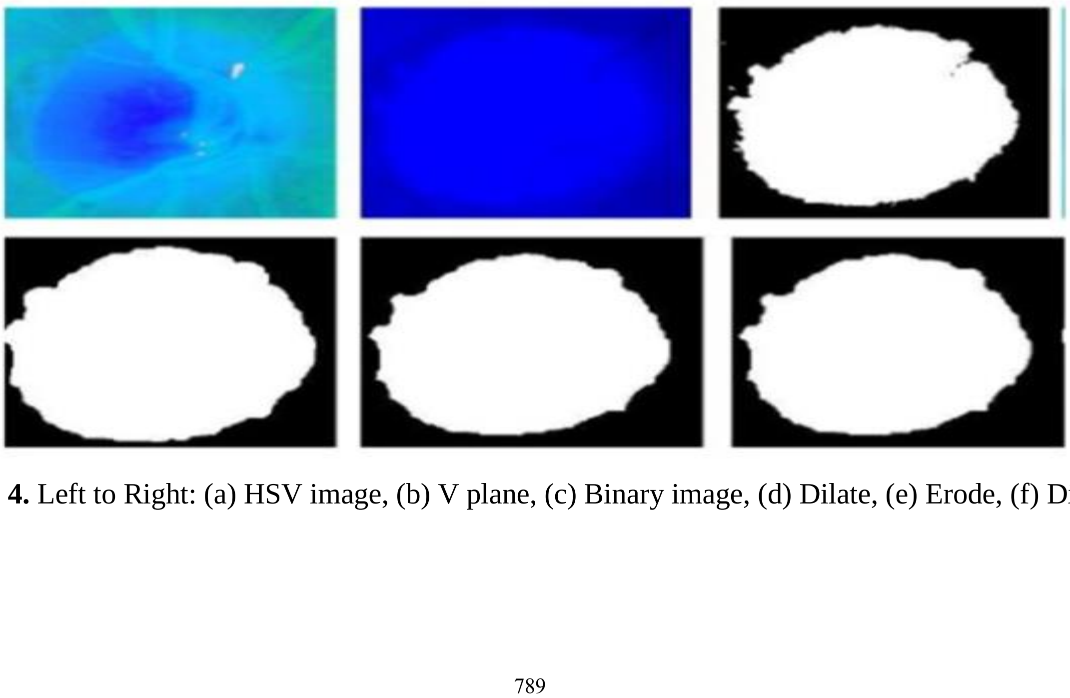

Fig. 4. Left to Right: (a) HSV image, (b) V plane, (c) Binary image, (d) Dilate, (e) Erode, (f) Disc.

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Fig. 5. Left to Right: (a) Cup Edge, (b) Disc Edge, (c) Neuro retinal Rim (NRR), (d) NRR Edge.

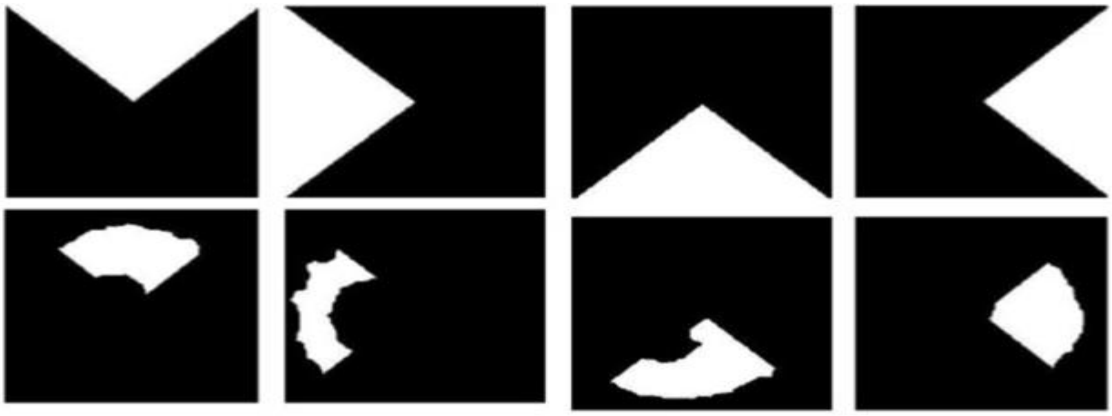

Fig. 6. ISNT Quadrants

Top row images: Masks – (a) Superior region, (b) Temporal region, (c) Inferior region, (d) Nasal region. Bottom row images: ISNT masks multiplied with Neuro retinal Rim (NRR)

D. Classification

Separation of glaucoma was performed using the two extracellular features mentioned above. The retinal imagery with glaucoma has a cup to disc ratio higher than 0.5 and does not follow the ISNT rules. A distinct retina which is healthy has a cup to disc ratio lower than 0.5 and obeys the ISNT rule. If at all a confusion or a conflict arises between the cup to disc ratio and the ISNT rule in the fundus image then it is set as a suspect.

5. Experimental Result

All classified outcome could have a misclassified rate and, on any instance, it can lead to recognition of an abnormality from false result, or can also lead to classification of an abnormality which is not there at all. Generally, the rate of misclassification can be calculated by the correct, false positive and false negative values using the below formula:

$$Accuracy = \ (C_n + \frac{C_p}{F_n} + F_p + C_n + C_p)\ 100$$

Here Cn is True Negative value,
Cp is True Positive value,
Fn is False Negative value and
Fp is False Positive value.

Table 1. Performance Evaluation Result.

	Type of Classifier	True Positive value of model	False Positive value of model	Accuracy of model
CASE I	Proposed Method	360	40	97 percent
CASE I	Existing Method	353	202	92.5 percent
CASE II	Proposed Method	360	40	97 percent
CASE II	Existing Method	290	268	93 percent

6. Conclusion

In this paper, we have designed and executed an algorithm to detect glaucoma in the eye. The novel way utilizes Morphological techniques to take out two major features for the detection of Glaucoma i.e., Ratio of NRR area in the ISNT quadrant and the Cup to Disc Ratio. The implemented methods were tested on three different databases that are DMED, FAU and, MESSIDOR. The proposed technique accomplishes a typical precision percentage of 97 and having 180 seconds of computational expense.

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