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Review Article

EARLY STAGE DETECTION OF GLAUCOMA AND ITS LEVELS USING FUNDUS IMAGES OF EYE

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Abstract
Glaucoma is a condition that can cause blindness of eye. It causes the damage of eyes optic nerve. The glaucoma results in the loss of vision. The fundus image can be helpful in detection of glaucoma. In past some experiments were carried out for the detection of this disease such as fast optic Disc segmentation in Retina, Discrete and empirical wavelet transform from fundus images, Intra ocular pressure detection etc. In this paper, an ideal framework is proposed which aims at developing a smart solution that helps in identification of glaucoma using MATLAB software tools. We have collected different fundus images of eyes as a dataset. The pre-processing of the fundus image takes place followed by segmentation and classification. The pre-processing module takes the help of some filters like Gaussian filters and guided image filters for removing the noise. Classification of healthy and diseased eye will help us to proceed for further medication.

Keywords: Glaucoma, Disc Segmentation, Fundus Images, Gaussian Filter, Guided Filter, Noise.

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INTRODUCTION

Glaucoma is a disease that eventually leads to blindness of eye. The glaucoma is irreversible as the optic nerve of the eye is affected by it. The entire optic nerve is destroyed by the glaucoma. Glaucoma results in deterioration of optic nerve, which in turn increases the fluid pressure on the front part of eye. Glaucoma cannot be cured but it can be controlled. The early detection of glaucoma enables appropriate monitoring and treatment, and to minimize the risk of vision loss. The existing research used intraocular pressure, Detection discrete and empirical wavelet transform, fast optic Disc segmentation methods for the detection of glaucoma. This paper makes use of a methodology, it obtains the cup-to-disc ratio (CDR) from the eye's fundus images. The input image is first resized and then converted into a grey scale image from RGB (red, green, blue). Filters such as the guided filter for edge preserving, smoothing on an image and Gaussian filter are used for removing noises. Optic disc and Optic cup segmentation are included in the next step. Morphological functions are approached for the segmentation part.

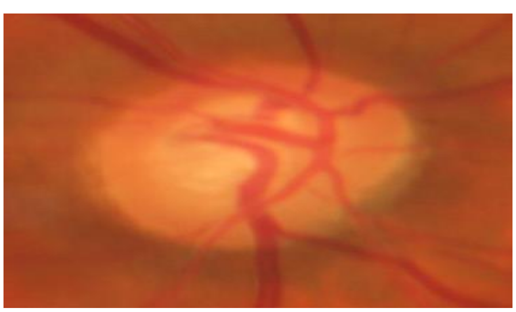


Figure 1: Fundus Image of the Eye

THE STATE OF ART

Huazhu Fu et al. (2018) suggested a Dis-aware Ensemble Network (DEnet) for the detection of the glaucoma. Initially, the global fundus image is taken and the optic disc region is segmented for the further processing. This experiment makes use of two glaucoma screening datasets ORIGA dataset containing 650 fundus images that include 16B glaucomatous eyes and 482. Firstly, Singapore Chinese eye study (SCES) dataset, which contains more than 1600 images with glaucoma. Next a dataset named as the Singapore-India Eye study (SINDI) is used. The process using (DEnet) yielded a good result with a running time of 0.5s and with 0.95 sensitivity.

Mohammad Naumon Zahoor et al. (2018) developed a process of end-to-end pipeline for detecting the glaucoma disease from the retinal images of eye. The end-to-end pipeline method includes finding the cup of the optic nerve. The disc of the optic nerve after segmentation undergo pre-processing. It is taken as the interest region for the segmentation of the cup of the optic nerve. The cup of the optic nerve is classified using the multi-layer perception (MLA). This method has produced an accuracy of 95.3%. A classifier is taken to separate the diseased eyes and normal eyes.

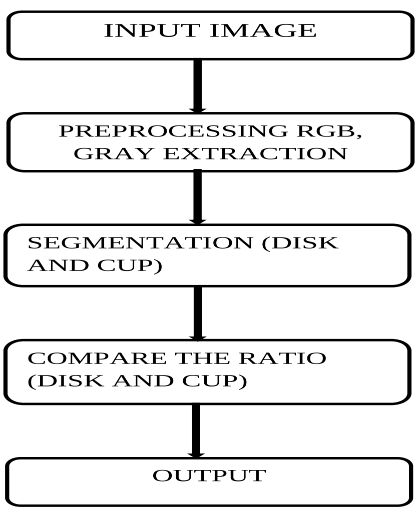
Ganesh E et al.(2018) suggested an algorithm known as rational dilation wavelet transform (RADWT) that helps in the detection of glaucoma. In this methodology prediction of glaucoma is obtained from the eye with the help of giant magnetic existence magnetometers (GMR) sensor. An increase in AH fluid production may cause an out- break of glaucoma disease efficiency of signal acquisition is validated by GMR sensor. This methodology generated results to discover glaucoma at an early stage with an accuracy of 90%. Also the internal pressure of eye predicted using sensors has given 91% and 89% accuracy for 10 normal eyes and 50 glaucomatous eyes respectively. Moreover, some therapeutic applications can make use of AH fluid.

Bhupendra singh kirar et al. (2018) made use of two methodologies namely discrete wavelet transform and empirical wavelet transform for the estimation of glaucoma discovered in eyes. DWT is used to decompose into different sub bands that are approximation, horizontal, vertical and diagonal. It is signal independent whereas EWT is a signal dependent decomposition technique. This experiment is performed on the medical image analysis group (MIAG) database consisting of 505 images that is 250 glaucomatous and 255 normal eyes for the purpose of classification Least Square SVM classifier is used. This experimental brought an outcome with 83.57% accuracy, 86.40% sensitivity and 80.80% specificity. It increased the diagnosis speed of ophthalmologist.

Mohammad Aloudat et al. (2019) knowing that progressive increase of the eye's pressure can cause glaucoma proposed a vision based framework for the screening of IOP that helps a glaucoma identification the framework uses a dataset of 400 images with 244 men and 156 women fundus images taken from the basma hospital. The process first undergoes segmentation, extraction followed by classification. The extraction of features include sclera extraction, pupil to iris ratio extraction after extraction the images undergo classification with the help of the classifiers namely support vector machine (SVM) and decision tree. In the future an extension of this paper may be proceeded to known the severity of IOP.

MATERIALS AND METHODS

In order to determine if a person suffers from glaucoma or not. It is not possible to find it from a general eye image. It requires the cup to disc ratio estimation by noticing the fundus images of eyes. Firstly, the cup boundary and disc segmentation CDR has to be detected. Ellipse fitting algorithm that are already defined in MATLAB can be used for removing boundary changes. If the ratio of the cup-to-disc is more than 0.56 indicates the presence of glaucoma, If CDR value is less than 0.5 there is no presence of glaucoma.



BLOCK DIAGRAM

Input Image

The input images are imported from dataset named Messidor for analysis. Firstly input images are obtained from different sources. Later, the large size of the image is reduced by arranging the resized pixels in an array. The dataset consists of 67 diseased and non-diseased eyes.

Pre-processing

Image pre-processing is a method that helps to convert an image into digital format it is necessary in order to extract some useful information from the image. Moreover, most of the application use grey or binary images as the processing of colour images is quite complex due to its irregular distribution of back-ground. Pre-processing consists of

1. Resizing image
2. Noise removal
3. Colour segmentation

1. Resizing Image

Depending on the requirement of the application the total number of pixels to quantity of pixels of input image needs to be increased or decreased. So that a better detailed image is available.

2. Noise Removal

Guided image filter and Gaussian filter can be for edge smoothing and blurring the image or to reduce noise respectively.

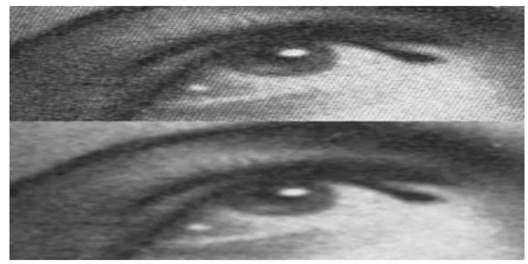


Figure 2: Gaussian Filter

Table 1: Noise Removal

S. no	INPUT IMAGE (Pixels)	GAUSSIAN FILTER (pixels)	GUIDED FILTER (pixels)
Image 1	173	173	174
Image 2	93	94	94
Image 3	170	169	169
Image 4	94	95	95
Image 5	153	153	153
Image 6	167	169	169
Image 7	117	119	120

The above table represents the pixel size of the images. For example, the input image 7 have a pixel size of 117 units. After smoothing the image using gaussian and guided filter will change the pixel values into 119 and 120 respectively.

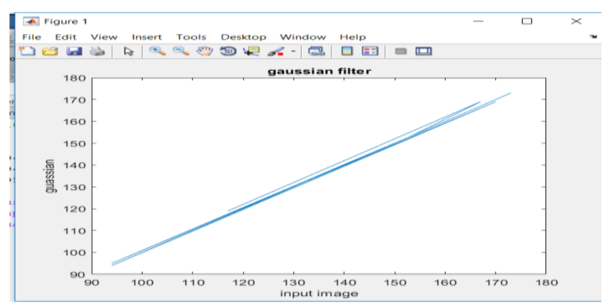


Figure 3: Gaussian Filter Graph

Figure 3 shows a graph for the input image and gaussian filter. Taking the input image on x-axis and gaussian filter on y-axis.

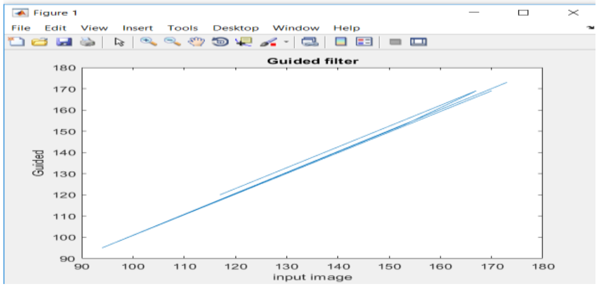


Figure 4: Guided Filter Graph

The above graph represents guided filter graph, showing slight variations in the pixel values after removal of noise. Taking the input image on x-axis and the guided filter on y-axis.

3. Colour Segmentation

Colour segmentation displays the image in three different colour components namely red, green, blue.

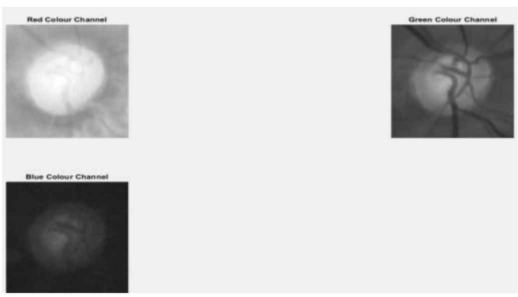


Figure 5: RGB Segmentation

After segmentation of colours it has been observed that the green segmented component is most suitable for further processing.

Segmentation

Segmentation is used for the partitioning of an image into several parts knows segments different types of segmentation techniques are developed such as, thresholding, K-mean clustering and Morphological functions based on segmentation. In order to represent the image in more meaningful outline these techniques are used.

1. Disc-Segmentation

Disc segmentation in retinal images can be obtained by detecting the disc boundary by using some morphological algorithms. Image segmentation using RGB colour conversion plays a major role here.

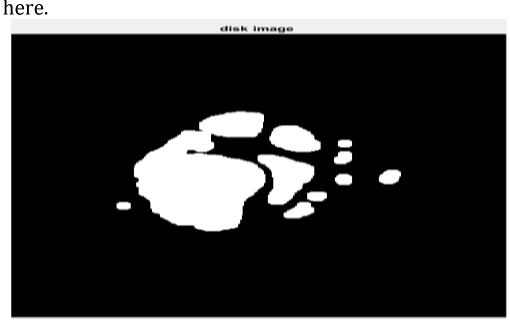


Figure 6: Disc Image

The above figure represents the dilated image of disc. This dilated image of the eye is extracted from the pre-processed input image.

2. Cup-Segmentation

The cup boundary of retinal image of eye can be known through cup segmentation colour and edge analysis technique can be used for detecting the cup boundary.

Figure 7: Cup Image

Figure 7 shows the segmented cup region. The dilated image is extracted after removing the noise. The green segmented component has to be taken into consideration for extraction process.

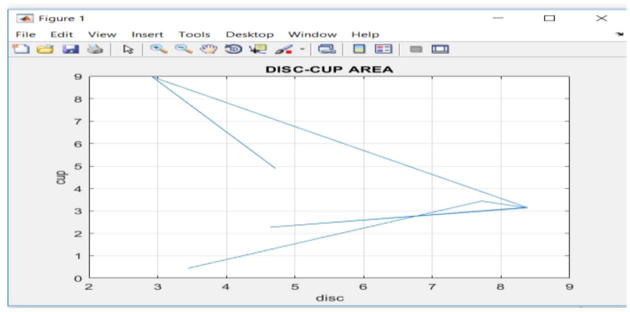


Figure 8: Cup and Disc Area

The cup and disc areas in the dilated images are represented in the above graph. Taking x-axis for the disc and y-axis for the cup.

Table 2: Cup and Disc Areas

FUNDUS IMAGES	DISC AREA	CUP AREA
Image1	4.7140	4.8963
Image2	2.9237	8.9738
Image3	8.3863	3.1432
Image4	4.6376	2.2742
Image5	8.3496	3.1542
Image6	7.7177	0.4459
Image7	3.1353	1.7831

The above table consists of the cup and disc areas of different input images. The values are used for further ratio calculation. For the image 1 disc area is obtained as 4.714.

Cup to Disc Ratio Measurements

After completion of the cup segmentation and disc segmentation steps. Cup segmentation ratio has to be computed. Ellipse fitting algorithms which are pre-defined in MATLAB are used for removing boundary changes. Now calculate distance the from this point to the segmentation cup border of the optic disc. Height of detected cup and disc contribute to CDR. Now calculate distance from this point to the segmentation cup border of the optic disc. Height of detected cup and disc contribute to CDR.

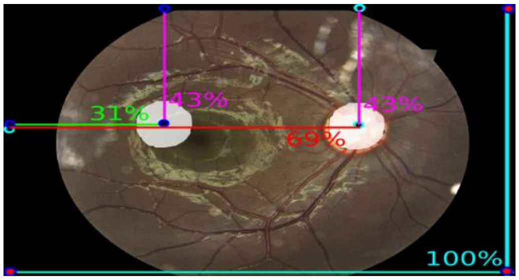


Figure 9: Cup-to-Disc Ratio

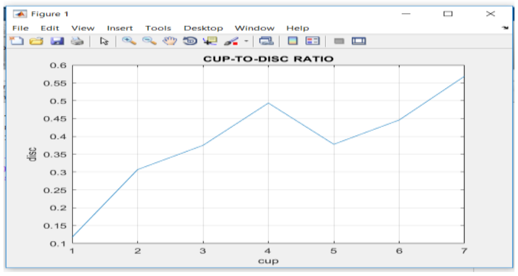


Figure 10: Cup and Disc Ratio

Figure 10 graph shows the cup-to-disc ratio of the image. If the CDR ratio is greater than 0.56 then the patient is said to be affected.

SEVERITY IN PATIENTS

As discuss earlier, glaucoma cannot be cured but it can be controlled. Knowing the stage or the severity of the glaucoma in patients is necessary for the proper treatment. Depending on the severity the risk of glaucoma can be classified into 3 categories using KNN algorithm.

STAGES:

1. Early stage.
2. Moderate stage.
3. Extreme stage.

Early Stage

If the CDR ratio is less than 0.29 then the risk of glaucoma is less in case of patients.

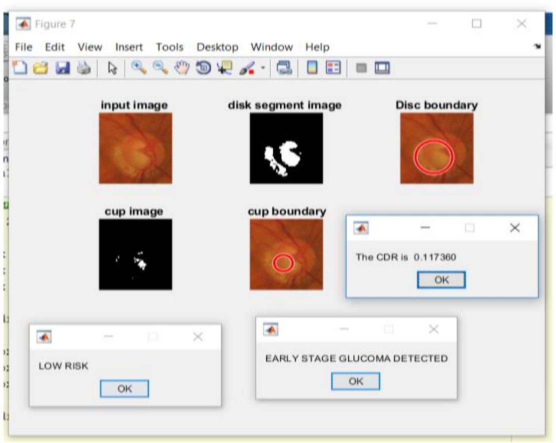


Figure 11: Early Stage

Low risk condition is the early stage of glaucoma. In case of early stage of glaucoma the patient needs to approach the doctor to avoid the condition getting worse.

Moderate Stage

The CDR ratio is lies in between 0.3 to 0.6.

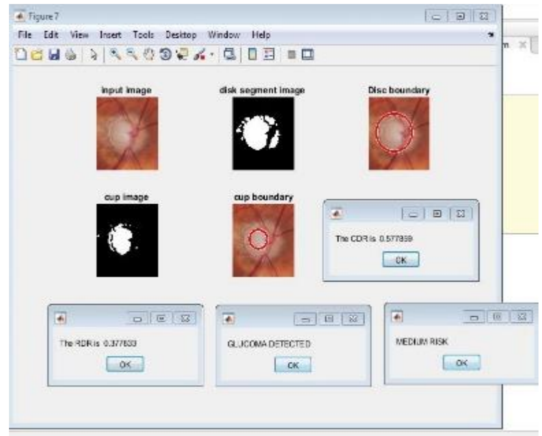


Figure 12: Moderate Stage

If the glaucoma is detected to be in moderate stage then approach the doctor at least once in every 3 months. The CDR ratio is more when compared to the early stage.

Extreme Stage

If the cup to disc is greater than 0.6 then the risk is *high.*

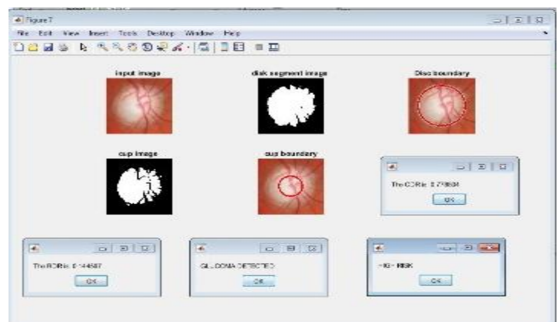


Figure 13: Extreme Stage

When the risk is high the glaucoma is very sever. The patient needs to approach the doctor very often, at least once in every month.

RESULTS AND DISCUSSION

		predicted	Predicted
	67	NO	YES
Actual	NO	9 True Negative (TN)	5 False Positive (FP)
Actual	YES	3 False Negative (FN)	50 True Positive (TP)

RECALL= (TP)/actual YES (1)

RECALL= 50/53

=0.94

ACCURACY= (TP+TN)/total (2)

ACCURACY= 59/67

= 0.88

PRECISION= (TP)/predicted YES (3)

PRECISION= 50/55

= 0.90

F-SCORE= (RECALL+PRECISION)/2 (4)

= (0.94+0.90)/2

= 0.92

The above confusion matrix shows true negative (TN), false positive (FP), false negative (FN) and true positive (TP) distributed over actual and predicted values of YES, NO. Formula (1) gives the recall value which is calculated by using, true positive and actual YES (TP+FN). The accuracy is obtained as

0.88 from the formula (2). Precision is calculated with the help of, true positive and predicted YES. F-Score is the average of recall and precision.

CONCULSON AND FUTURE WORK

We have developed a novel method to distinguish diseased and non- diseased eyes along with the classification of stages in the diseased eyes using KNN algorithm with the help of this experiment we can classify with an accuracy of 88%. Our dataset consists of 67 fundus images of eyes. The images are obtained from a dataset named Messidor and the input images are resized for further process. The resized image pixels are arranged like an array. A precision of 90% is obtained in process. In future a larger dataset of the retinal images and the fundus images can be considered, to make a deeper test of algorithm. We can also use neural networks for better classification in the future.

REFERENCES

1. Huazhu Fu, Jun Cheng and Yanwu Xu. Disc-aware Ensemble Network for Glaucoma Screening from Fundus Image. In 2017 an IEEE transaction Journal on medical imaging, 2017.
2. Alreja, G., Lotfi, A.Eustachian valve endocarditis: Rare case reports and review of literature(2011) Journal of Cardiovascular Disease Research, 2 (3), pp. 181-185. DOI: 10.4103/0975-3583.85266
3. Ganesh E., Member, IEEE, Shanker N.R., and Priya .M. Non-Invasive measurement of glaucoma disease at earlier stage through GMR sensor AH bio-magnetic signal from eye and RAWDT algorithm. In 2018, an IEEE journal, 2018.
4. Fan Guo,Yuxiang Mai, Xin Zhao, Xuancch Duan, Zhun Fan and Bin Xie. Yanbao: A mobile app using the measurement of clinical parameters for glaucoma screening. In 2017, an IEEE transaction journal on content mining, 2017.
5. Bhupendra Singh Kirar, Dheeraj kumar Agrawal. Computer aided diagnosis of glaucoma using discrete and empirical wavelet transform from fundus images. In 2018 an IET image process journal at Maulana Azad National institute of technology, Bhopal, India, 2018.
6. Mohammad Aloudat, Miad Faezipour and Ahmed El-Sayed. Automated vision based high intraocular pressure detection using frontal eye images. In 2018, an IEEE journal of Transactional Engineering in health and medicine, 2018.
7. S. S. Kanse and D. M. Yadav. Retinal fundus image for glaucoma detection: A review and study. Journal of Intelligent Systems, 28(1):43– 56, 2017.
8. Mohamed Saleem TS, Jain A, Tarani P, Ravi V, Gauthaman K. "Aliskiren: A Novel, Orally Active Renin Inhibitor." *Systematic Reviews in Pharmacy* 1.1 (2010), 93-98. Print. doi:10.4103/0975-8453.59518
9. Jyotiprava Dash and Nilamani Bhoi. A thresholding based technique to extract retinal blood vessels from fundus images. Future Computing and Informatics Journal, 2(2):103–109, 2017.