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.

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.

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 630 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 (SNDI) 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.

Figure 1: Fundus Image of the Eye
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 experiment 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.

<table>
<thead>
<tr>
<th>S. no</th>
<th>INPUT IMAGE (Pixels)</th>
<th>GAUSSIAN FILTER (pixels)</th>
<th>GUIDED FILTER (pixels)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Image 1</td>
<td>173</td>
<td>173</td>
<td>174</td>
</tr>
<tr>
<td>Image 2</td>
<td>93</td>
<td>94</td>
<td>94</td>
</tr>
<tr>
<td>Image 3</td>
<td>170</td>
<td>169</td>
<td>169</td>
</tr>
<tr>
<td>Image 4</td>
<td>94</td>
<td>95</td>
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</tr>
<tr>
<td>Image 5</td>
<td>153</td>
<td>153</td>
<td>153</td>
</tr>
<tr>
<td>Image 6</td>
<td>167</td>
<td>169</td>
<td>169</td>
</tr>
<tr>
<td>Image 7</td>
<td>117</td>
<td>119</td>
<td>120</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>FUNDUS IMAGES</th>
<th>DISC AREA</th>
<th>CUP AREA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Image1</td>
<td>4.7140</td>
<td>4.8963</td>
</tr>
<tr>
<td>Image2</td>
<td>2.9237</td>
<td>8.9738</td>
</tr>
<tr>
<td>Image3</td>
<td>8.3863</td>
<td>3.1432</td>
</tr>
<tr>
<td>Image4</td>
<td>4.6376</td>
<td>2.2742</td>
</tr>
<tr>
<td>Image5</td>
<td>3.496</td>
<td>3.1542</td>
</tr>
<tr>
<td>Image6</td>
<td>7.177</td>
<td>0.4459</td>
</tr>
<tr>
<td>Image7</td>
<td>3.1353</td>
<td>1.7831</td>
</tr>
</tbody>
</table>

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.
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Figure 9: Cup-to-Disc Ratio

Figure 10: Cup and Disc Ratio

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.

SEVERITY IN PATIENTS

As discussed 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.

Moderate Stage

The CDR ratio is lies in between 0.3 to 0.6.

Extreme Stage

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

RESULTS AND DISCUSSION

<table>
<thead>
<tr>
<th></th>
<th>predicted</th>
<th>Predicted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>True Negative</td>
<td>9 TN</td>
<td>5 FN</td>
</tr>
<tr>
<td>False Positive</td>
<td>5 FP</td>
<td>50 TP</td>
</tr>
</tbody>
</table>

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)

F-Score = (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 using, true positive and actual YES (TP+FN). The accuracy is obtained as
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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.

CONCLUSION 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