An Adaptive Threshold Based Image Processing Technique for Improved Glaucoma Detection & Classification

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Introduction

Glaucoma is an optic neuropathy which is one of the main causes of permanent blindness worldwide. This paper presents an automatic image processing based method for detection of glaucoma from the digital fundus images. In this proposed work, the discriminatory parameters of glaucoma infection, such as cup to disc ratio (CDR), neuro retinal rim (NRR) area and blood vessels in different regions of the optic disc has been used as features and fed as inputs to learning algorithms for glaucoma diagnosis. The experimental results indicate that such features are more significant in comparison to the statistical or textural features as considered in existing works. The proposed work achieves an accuracy of 94.11% with a sensitivity of 100%.

Proposed Algorithm

The proposed method of Glaucoma detection involves using parameters which show discriminatory changes with occurrence of glaucoma. All the features used for detection are related to optic nerve head region. So, in order to extract the features, optic disc and optic cup need to be segmented. From the segmented optic disc and cup, the aforementioned features are calculated. The block diagram for the proposed methodology is shown in Fig 1.

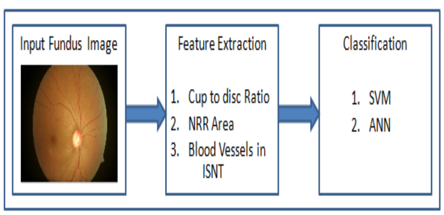

Figure 1. Block Diagram of proposed method

Glaucoma is a disease related to the optic nerve head (ONH) region. So, in order to segment the ONH, a preprocessing of fundus images is needed. In the preprocessing step, the statistical features, such as mean and standard deviation, from the image are used and subtracted from the image iteratively. This preprocessing step highlights only the ONH region in the fundus image. The preprocessing is applied to red channel and green channel for optic disc and cup segmentation respectively. The output of the preprocessing step is shown in Fig 2.

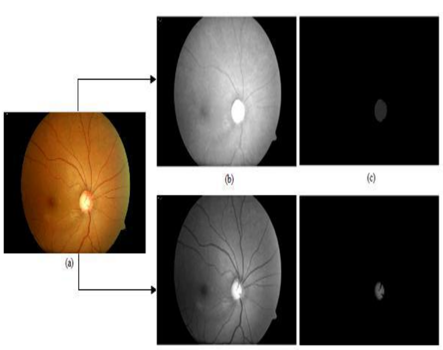

Figure 2. *Preprocessing (a) Input Image (b) Red Channel (c) Preprocessed Red Channel (d) Green Channel (e) Preprocessed Green Channel*

The optic disc and cup are segmented from the respective preprocessed channel images using adaptive threshold which is implemented by using the statistical features of the preprocessed image and a Gaussian filter which is used for smoothing the histogram of the preprocessed channel images. The segmented optic disc and cup are shown in Fig 3.

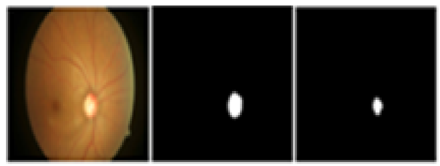

Figure 3. *Segmentation (a) Input Image (b) Optic Disc (c) Optic Cup*

Cup to disc ratio (CDR) is used as one of the feature for glaucoma classification in the proposed work and is calculated by finding the ratio of the optic cup area to optic disc area. For a glaucomatous eye, the CDR value is greater than 0.3.

The neuro retinal rim (NRR) is obtained by subtracting the cup from the disc. This is illustrated in Fig 4. The NNR area in each ISNT quadrant is found out as shown in Fig 5 and used as a feature for glaucoma classification.

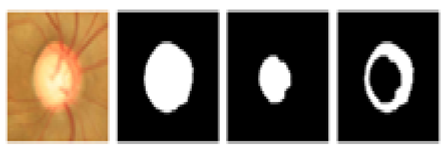

Figure 4. *(a) Cropped Input Imge (b) Optic Disc (c) Optic Cup (d) Neuro Retinal Rim*

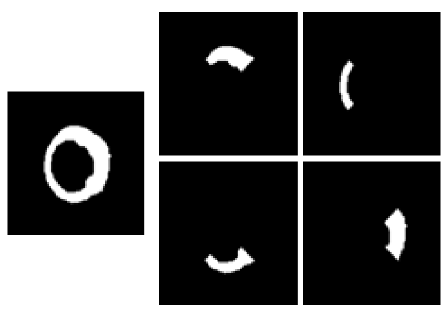

Figure 5. *(a) Full NRR (b) NRR Area in Superior (c) NRR Area in Nasal (d) NRR Area in Inferior (e) NRR Area in Temporal*

The CDR, NRR area and blood vessels area in ISNT quadrants is calculated using the following formulas:

$$\text{Cup to Disc Ratio, C} = \frac{\text{Cup Area}}{\text{Disc Area}} \quad (1)$$

$$\text{Neuro Retinal Rim Area, N} = \frac{\text{Area in Inferior quadrant} + \text{Area in Superior quadrant}}{\text{Area in nasal quadrant} + \text{Area in temporal quadrant}} \quad (2)$$

$$\text{Blood Vessels Area, B} = \frac{\text{Area in Inferior quadrant} + \text{Area in Superior quadrant}}{\text{Area in nasal quadrant} + \text{Area in temporal quadrant}} \quad (3)$$

Another feature used is blood vessels area in ISNT quadrants. The blood vessels on the optic disc are found out using bottom hat transformation. The extracted blood vessels area in each ISNT quadrant is found out and used as feature for classification of glaucoma. The extracted blood vessels are shown in Fig 6.

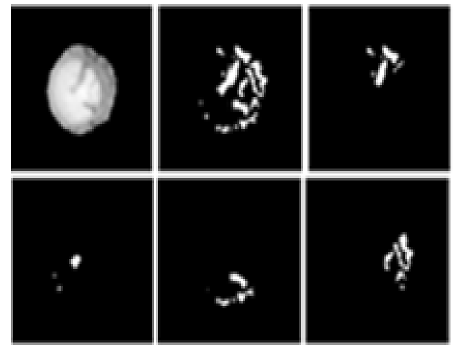

Figure 6. *(a) Green Channel showing only Disc Portion (b) Blood Vessels on Optic Disc (c) Blood Vessels in Superior (d) Blood Vessels in Nasal (e) Blood Vessels in Inferior (f) Blood Vessels in Temporal*

Results

The algorithm has been successfully implemented on a database of 63 fundus images which were labeled by doctors as normal or glaucomatous and positive results were obtained which can be seen in Table 1. The accuracy obtained by the proposed algorithm was 94.11% with a sensitivity of 100%.

Table 1. *Accuracy of Detection*

Classifier	Accuracy	Specificity	Sensitivity
SVM	94.11	100	90
ANN	89.6	100	78.1

Conclusions

The Glaucoma detection is done by taking into consideration, the Cup-to-Disc Ratio (CDR), Neuro Retinal Rim (NRR) area and blood vessels in the different regions of the optic nerve head. The segmentation of the optic disc and cup is threshold based and completely adaptive by using local statistical features of fundus image. Unlike the existing methods where constant threshold is used, the adaptive nature of the proposed threshold based segmentation algorithm helps in improving the accuracy of the system and find acceptability to a wide range of images of various qualities. The rim area and blood vessels in ISNT quadrants is calculated and both these values along with CDR are fed as input to the classifier. An accuracy of 94.11% with sensitivity of 100% and specificity of 90% is obtained from the proposed method using SVM and ANN classifiers. The framework can be used screening of Glaucoma over a large population. This proposed work is clinically significant, as the accuracy of this method is high and competitive with existing methods.

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