International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9, Issue-7, May 2020

Classification of Glaucoma with OD Segmentation and Texture Feature Extraction using Random Committee

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Abstract: ***Glaucoma is an eye decease that can be recognized as the second most common cause of blindness. Glaucoma is an irreversible decease, so that it is necessary to prevent from glaucoma before the complete loss of sight. Manual screening of glaucoma among larger amount of count is complex due to the availability of experienced manpower in Ophthalmology is less. The research focuses on the analysis each and every features of retinal image in glaucoma and builds an optimistic automatic glaucoma screening system with reduced complexity. Presently, there are so many treatments are available to prevent vision loss due to glaucoma, but it should be detected in the begging stage. Thus, the objective is to develop an automated identification method of Glaucoma from retinal images. The steps involved in this work are Disc segmentation, texture feature extraction in different colour models and classification of images in glaucomatous or not. The obtained results having 94% accuracy.***

Key words: Glaucoma, OD Segmentation, Random committee, Feature Extraction.

I. INTRODUCTION

Glaucoma damages the optic nerves of the eye due to increased Intra-Ocular Pressure (IOP). This damage results in permanent vision loss due to the poor transmission of signals between brain and eye. The number of people having glaucoma around the world was estimated to be 64.3 million in 2013 and is expected to increase to 76 million by 2020. Glaucoma is termed as silent blinding disease because it never gives any warnings nor obvious symptoms to the patient. If has been left as untreated, most types of glaucoma progress towards permanent vision loss. There are two main kinds of Glaucoma: Open-angle glaucoma and Angle-closure glaucoma. Open-angle glaucoma is the common form of glaucoma which is caused by the clogging of drain canals that leads to an increased pressure in side of the retina. It has wide angle between the iris and cornea. The later (Angle-closure glaucoma) caused due to the block in the drainage canals that leads to a sudden increase in the Intra-Ocular Pressure which provide a narrow angle between the iris and the cornea. (figure:1.1)

Revised Manuscript Received on May 30, 2020.
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Most of the above diseases worsen without displaying any kind of observable symptoms. Thus, screening for glaucoma is important for their early detection and dispersion of effective treatment to prevent permanent blindness.

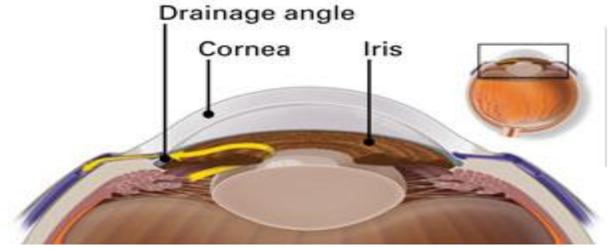


Figure 1: Cornea and Iris in eye

1.1 Glaucoma Identification

To understand the progression of Glaucoma, many imaging modalities are exist. These imaging modalities unveil the structural and functional information of the retina. Evaluation of multiple modalities further enhances the accurate diagnosis of the patient. In most of the imaging modalities light plays a major role in capturing information. Some of these modalities include Fundus-(Optical imaging), Optical Coherence Tomography-(cross sectional imaging), and Angiography Optical Coherence Tomography- (Flow imaging).

1.1.1 Fundus imaging

It is a non invasive modality and consists of low power microscope with an attached camera. The color fundus camera helps us to capture 3D retina as a 2D image as shown in figure:2 (left). This projection captures the presence of disorders and aids to monitor their change over time. Most of the screening systems existing today are use the fundus imaging as it is very cost effective compared to other techniques. There are several modes of examination using fundus imaging, namely color fundus photography, red free fundus photography, and angiography. In color fundus imaging natural light is used for imaging the retina, where as in red free fundus imaging a specified wavelength of light is used. Angiography is an invasive procedure and less frequent in usage. In this protocol, fluorescent dye is injected and its movement is observed in the vasculature structure.

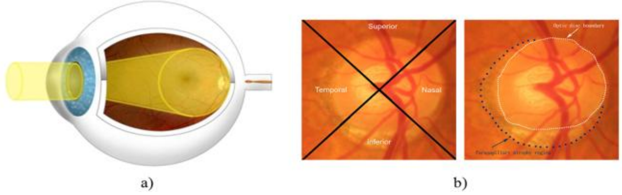


Figure 2: Retina captured with fundus camera (a)Sector division(b,l) (b) Parapapillary region (b,r)

For glaucoma, fundus imaging is the most common modality used for screening systems. In fundus, the presence of glaucoma is indicated by the presence of a bright striped radiation pattern from Optic Disc, enlargement of cup, as shown in figure:3. The radiation pattern changes its visual appearance according to variations in the Retinal Nerve Fiber thickness. The thickness variations can be caused by glaucoma process, or even in the healthy retina, the RNFL thickness varies anatomically depending on angular position around the ONH. In general RNFL measurement is performed in sectors as shown in figure:2 (b,r), where S:Superior, T:Temporal, N: Nasal, I: Inferior.

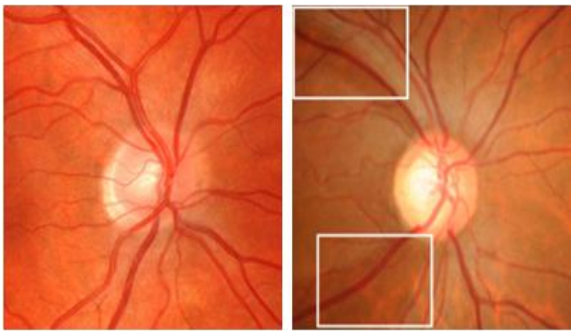
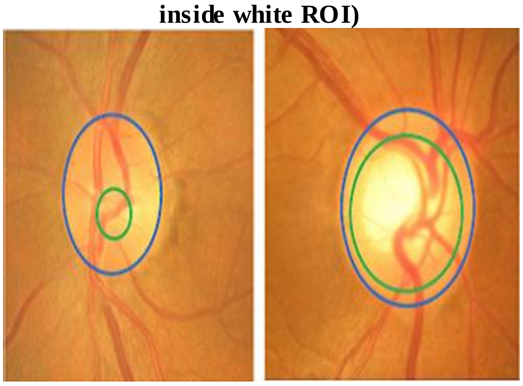


Figure 3(a) Typical RNFL pattern observed (Region inside white ROI)



4(b) Increased cup size

1.2 Motivation

The patient retinal images are classified as Glaucomatous based on measurements such as Visual fields, intraocular pressure, Optic Disc/Cup diameters etc. In almost all screening systems color fundus imaging is used as standard for screening because of its low cost, non-invasiveness and ease of use. Recently several studies revealed that diagnosis of patients are not correlated with usage of fundus and OCT images. In diagnosis of Glaucoma optic cup to disk ratio is also clearly detected from OCT than fundus image. These studies concluded fundus imaging alone may not be sufficient for screening. This calls for the requirement of multiple modalities for improving diagnosis of patient.

1.3 Key Contributions

The major contributions in developing detection algorithms for identifying and understanding Glaucoma from various modalities described in this thesis are:

- A robust, computationally efficient multimodal registration algorithm for registering fundus and OCT image pairs.
- A multimodal deep neural network framework for improving the detection of Glaucoma from fundus images.
- Understanding the progression of Glaucoma through clinical case studies and discovering the scope of new imaging modality angiography OCT for detection of Glaucoma.

II. RELATED WORK

The previously published work is mainly limited to the independent analysis of individual indicators which are either intra-papillary or peri-papillary indicators. There is no attempts have been reported to assess glaucoma with multiple visual indicators associated with the glaucomatous damage. So that, these methods are not capable of achieving the satisfactory performance in the detection of glaucoma from the colour retinal images.

Earlier presented methods mainly fall under two different detection strategies. In the first, intra-papillary indicators (OD deformations) are characterized by a set of image features and decision on the presence of glaucoma is taken by a classifier[1-4]. The second strategy uses a more natural way to assess OD by performing explicit segmentation of the OD and cup region [5-8]. The relevant parameters such as cup-to-disk diameter ratio, etc. are derived to quantify the amount of cupping. The decision on the presence of glaucoma is then taken using a clinically defined threshold on estimated disk parameter. The value of threshold is typically defined clinically from the OD image data of normative population.

It can be observed that above two detection strategies address different aspects associated with the assessment of glaucoma. First strategy aimed at detecting glaucoma via a classification approach which is inspired from object recognition methods used in computer vision literature. However, the feature extraction is restricted to OD region which implicitly discards peri-papillary indicators. The amount of anatomical variations in OD and cup sizes and imaging variations seen across patients makes selection of image features and classification method very difficult. Moreover, such approaches are by design incapable of describing local OD deformations which are crucial to classify border-line glaucoma cases.

The strategy which focuses on the accurate OD and cup segmentation, attempts to estimate parameters to quantify the extent of glaucomatous damage. In general, it is very difficult to achieve satisfactory segmentation performance of these regions particularly,

the cup region in the absence of three dimensional (depth) structural details. However, this is very suitable to encode local OD deformations better as compared to the former strategy.

This thesis addresses aforementioned limitations presented by the earlier approaches with novel solutions both at the level of analyzing individual indicators and classifying glaucoma from the information gathered from multiple indicators. The detailed description on earlier attempts for individual solution is provided in the respective chapters.

III. METHODOLOGY

The method proposed in this paper first segments the OD region from the retinal images. This segmented region, or region of interest will be used in extraction of the texture features using different color models, then the images can be classified as glaucomatous or not.

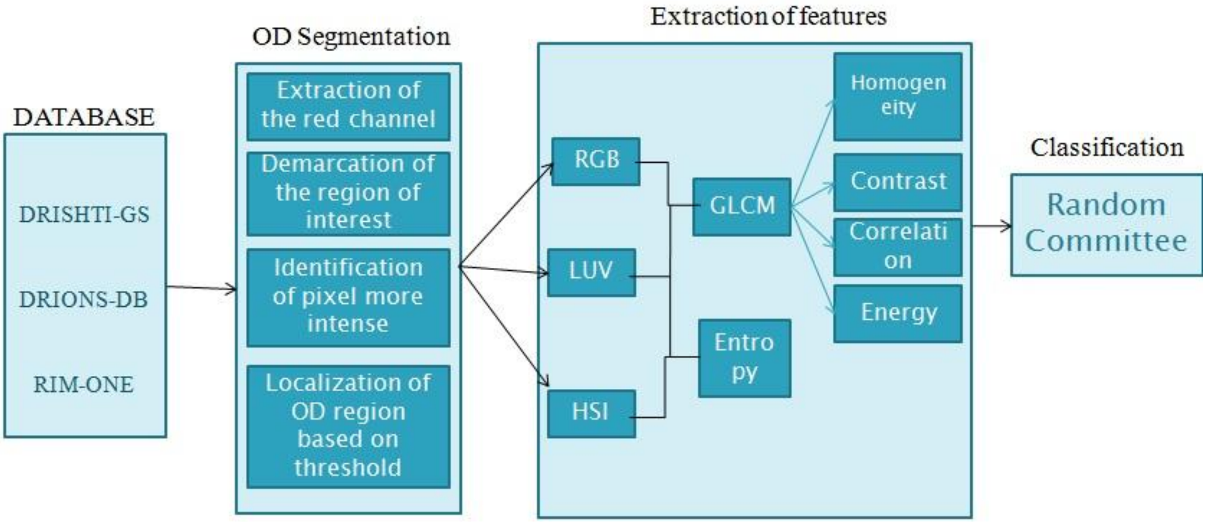


Figure 5: Architecture

Automatic detection method of Glaucoma is divided into four phases. From the acquisition of retinal images, segmentation of the OD region in order to extract the area of interest. From the segmented region it was possible to extract texture features using the Grey-Level Co-occurrence Matrix (GLCM) and entropy of images in different color models. Finally, the extracted features are used to classify the image as normal (without Glaucoma) or patient (with Glaucoma) using Random Committee.

3.1 Segmentation

The fundus retinal images in the database are in the RGB (Red-Green-Blue) color model. The OD is more easily found on the Red channel of this model, so the images were converted into red channel.

The region of interest was selected and cropped for the purpose reducing the processing area of the retina. The region de_ned refers to the rectangle located in the center of the image, side equal to 3/4 of the original image size. Figure 2 shows an example of ROI defined by the white rectangle.

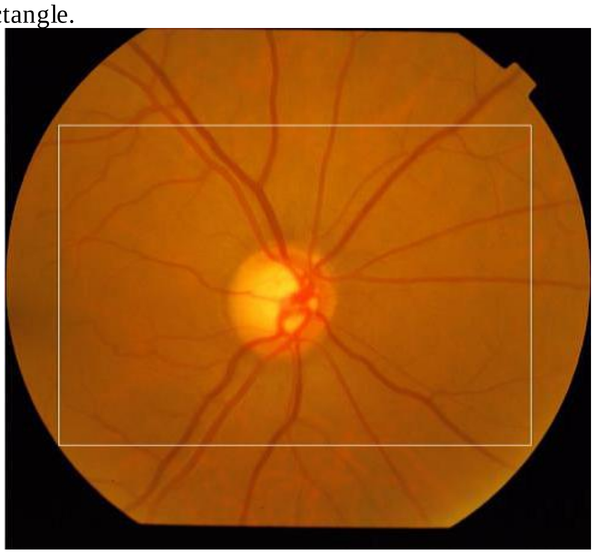


Figure 6: Example of selection of region of interest

From the ROI, the central pixel of a 5x5 window was defined as coordinate of the center of OD, that the average intensity of its pixels were the largest of the image. Based on this pixel, we calculating the radius of the Optic Disc region. It is worth mentioning that during the calculation of this radius, the pixel previously defined as the center of OD will be modified.

Calculate the threshold value using every pair of pixel in the image, with that threshold value we can locate the centre of the Optic Disc region. For this, four radius were drawn: up to the angle of 90o, down to the angle of 270o, angle of 0o to the right and angle of 180o to the left.

Due to the different intensities of the pixels in the images, a new threshold was calculated for each direction, as being the average between the largest pixel and the lesser color intensity in that direction. Thus, the radius in each direction will be defined as the distance between the pixel of the centre of OD and the first pixel that is less than the threshold value. From the four direction’s radius the OD region centre is located and the OD region is segmented.

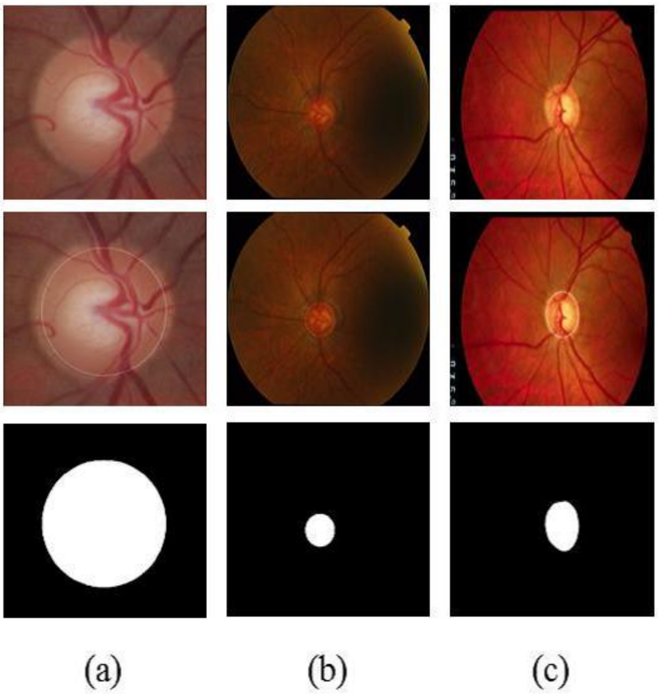


Figure 7: Example of the segmentation made by the proposed methodology for images of the base a)RIMONE, b)DRISTHI-GS and c)DRIONS-DB.

3.2 Feature Extraction

The features are extracted from the image by extracting all attributes from the retinal image. These features are used for pattern recognition. Depending on the purpose of the problem, feature extraction can return different features to a same image. Here we use the Gray-Level Co-occurrence Matrix (GLCM) in different color models for the feature extraction.

GLCM is a matrix method that build along all sets of pixels in the fundus image, which was developed by the veteran researcher Robert M. Haralick in 1970. It is a statistical method for feature extraction, which will be analyzed existing co-occurrences between pairs of pixels, in other words it is not examined each pixel individually but the pixel sets related through some pattern.

The GLCM is a square matrix that keeps informations of the relative intensities of the pixels in a image. It calculates the probabilities of co-occurrence of two gray levels i and j, given a certain distance (d) and an orientation (_) which can assume the values of 0o, 45o, 90o and 135o. All information on the texture of an image will be contained in this matrix.

From the GLCM, Haralick set 14 significant features, and the number of features used in a particular problem varies in accordance with its specifications [14]. Use all these features is not always needed. Actually, can worsen the performance of the method instead of improving. After be observed and tested the features, five of them were selected: Contrast, Homogeneity, Correlation, Entropy and Energy.

Each processed retinal image has been converted into following color models: RGB (Red, Green and Blue), HSI (Hue, Saturation and Intensity) and L*u*v. The GLCM matrix was calculated from these color models. Contrast, homogeneity, correlation and energy were calculated for each matrix. After the description of the images, the classification of images was carried out in glaucomatous or not.

3.3 Classification

After the feature extraction it is not possible to predict if an image has Glaucoma or not, so we are going for the classification step, where the attributes calculated in the previous step formed as the input vectors, which served as input to the classifiers. At this step we used the classifier Random Committee. The input vectors are linearly combined and overall output is produced using the ensampling averaging method. Next Section shows the results obtained for each one of these classifiers.

3.4 Evaluation Metrics of Classifiers

Most analysis criteria of the results of a classification comes from a confusion matrix which indicates the number of correct and incorrect classifications for each class. A confusion matrix is created based on four values: True Positive (TP), number of images correctly classified as glaucomatous; False Positive (FP), number of images classified as healthy when actually they were glaucomatous; False Negative (FN), number of images classified as glaucomatous when actually they were healthy and True Negative (TN), number of images classified correctly as healthy. From these amounts some statistics rates can be calculated to evaluate the performance of the classifiers. The rate of Precision, rate of Accuracy, rate of Recall and the rate of F-Measures (FM) are calculated respectively.

IV. RESULT AND DISCUSSION

Towards the finalization of the exploration work, acquire the optimum precision for the location of Glaucoma Disease. By watching the components of the fundus Image by the strategies for random committee relying on the yield of the classifier, the Glaucoma is distinguished. Subsequently, early detection of this sickness will assist us to take deterrent evaluation and estimation to predominate the infection in its initial course.

Table: Comparison of existing classification accuracy and MLP accuracy

Method	Abnormal	Normal
CDR Ratio	70.40	70.60
MLP	93.30	93.42
Random Committee	94.22	94.35

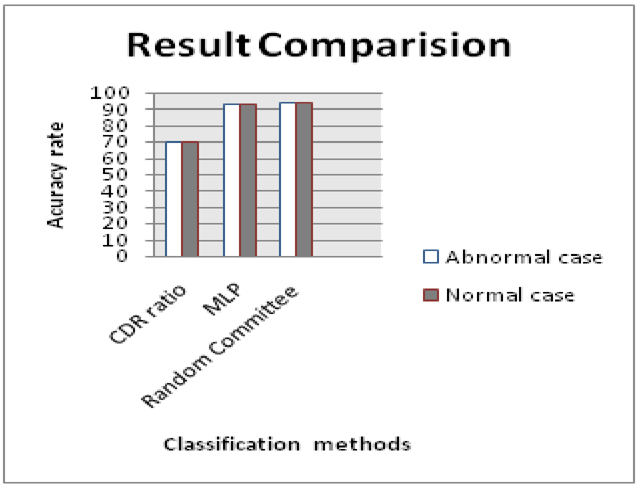


Figure 8: Comparison chart of classification accuracy

The above table shows the value comparison between existing CDR ratio method MLP and proposed method with Random Committee.

V. CONCLUSION

Digital image processing has become an area of study with great potential, which increasingly has contributed to society. In the health area, the digital image processing is being used in supporting diagnostic of diseases to be carried out effectively and cheaply. This paper provide a methodology of automatic detection of the Optical Disk in digital fundus images of eye. From this region the texture features were extracted using the Gray Level Co-occurrence Matrix in different color models. The evaluation of the detection of the OD was performed in three different image databases. The segmentation showed efficient results, accounting an accuracy greater than 94% when evaluated using a success rate requirement of 70%, which is the classical value found in the literature. The texture feature extraction was performed after the completion of the segmentation. Then, it was carried out the classification of the retinal images in glaucomatous or not glaucomatous. Multi Layer Perceptron classifier obtained the best results with an accuracy of 93.03% and the Kappa index of 0.80.

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3.Land use image classification using Deep Learning Networks - (IJREAM), 4(9), 333-337.
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