A Robust Computer Aided System for Retinal Screening

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Abstract- **Diabetic retinopathy (DR) and Diabetic Maculopathy (DM) are nowadays two of the most frequent causes of blindness and vision loss. In addition, these diseases will experience a high growth in the future due to diabetes incidence increase and ageing population in the current society. Computer aided diagnosis system is very much used for medical image screening. There are some limitations to find the fundus diseases from fundus images. This proposed work investigates discrimination capabilities in the texture, color and histogram of fundus images to differentiate between pathological and healthy images. For this purpose, Gray level co-occurrence matrix taken as a texture descriptor, in addition the color and histogram features to increase the feature strength. Initially the optical cup to disk ratio and rim to disc ratio is find out to analyze the glaucoma disease with expert results. Then the DR and DM analyzed with the help of extracted features. Then SVM classifier acting as a classifier to find the diseases. The proposed procedure obtaining promising results. Thus the proposed system well suitable for fundus image screening, compared to other conventional computer aided system methods.**

Index Terms- **CDR, RDR, GLCM, Color moments, Color histograms, SVM Classifier.**

I. INTRODUCTION

Computer aided detection plays a pivotal role in addressing prevention of avoidable blindness by automated detection of retinal pathologies and can thus alleviate the burden of screening from ophthalmologist [5]. It not only alleviate the burden on the clinicians by providing objective opinion with valuable insights but also offers early detection and easy access for patients. The basic concept of CAD is t provide computer output as a second opinion to assist radiologist image interpretation by improving the accuracy of detection.

Glaucoma, Diabetic retinopathy, Diabetic maculopathy are three major eye diseases which leads to vision loss. Glaucoma is a severe eye disease where the optic nerve head is gradually damaged. Glaucoma is a one of the disease which cannot be cured completely. Early screening will allow the ophthalmologist to identify the disease during the early stage[1].Fundus image feature extraction and ocular parameter evaluation are carried out for eye image analysis. Ocular parameter considered are optic cup to disc ratio (CDR) and rim to disc ratio (RDR).Feature extraction involves optic disc segmentation, optic cup segmentation and optic rim segmentation. For computer aided detection of glaucoma, CDR and RDR is calculated via threshold segmentation, is employed in this paper.

Diabetic retinopathy is a leading cause of vision loss caused by damage to the retina [3]. It is a side effect of diabetes which is caused when the blood vessels in the eye start getting blocked due to high sugar content in the blood. Reduced blood supply to the retina can even cause blindness.

Diabetic maculopathy is a condition that can result from retinopathy. Maculopathy is a damage to the macula, the part of the eye which provides us our central vision. It causes the leakage of blood, fat from blood vessel to the retina. Feature extraction such as texture feature and color feature extraction is employed for the automated detection of DR and DM. For texture extraction GLCM and for color feature extraction color histogram and color moments method are used. This paper proposed a method for automatic detection and classification of the retina as glaucoma, DR and DM affected eye or healthy eye.

II. OCCULAR PARAMETER

A. Optic Cup To Disc Ratio (CDR)

CDR is defined as the ratio of optic cup diameter to optic disc diameter. Optic disc is the area where the optic nerve and blood vessels enter the retina. The disc can be flat or it can have a certain amount of normal cupping. CDR is one of the important indicator of glaucoma.

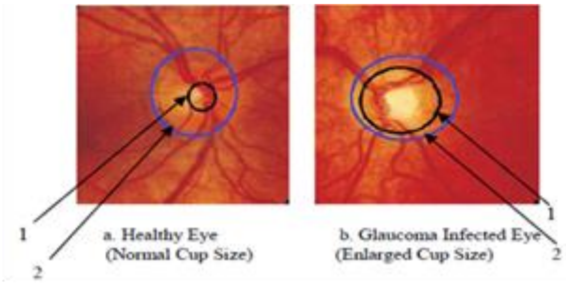

Fig1: Effect of glaucoma on CDR

Because as glaucoma advances the cup enlarges and occupies most of the disc area and there will be no change for optic disc. In figure 1(a) and 1 (b), the 1 and 2 represents the optic disc and optic cup boundary. If the cup fills 1/10 of the disc, the ratio will be 0.1. If it fills 7/10 of the disc, the ratio will be 0.7.If CDR is greater than 0.4 then glaucoma is detected.

B. Rim To Disc Ratio (RDR)

Optic rim is the region between the optic disc and optic cup. Once the optic disc and optic cup are segmented the rim region can be obtained by subtracting the optic cup from the optic disc.

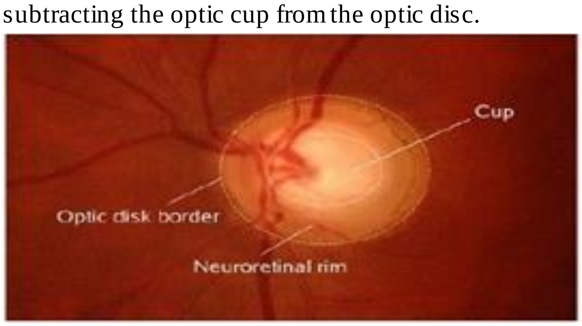

Fig 2: Rim region

If the ratio is less than 0.25, then glaucoma is detected.

III. SEGMENTATION

The process of dividing a digital image into multiple segments is defined as image segmentation. The aim of segmentation is to simplify the representation of an image into something that is more meaningful and easier to analyze. Image segmentation is typically used to locate objects and boundaries in images. Image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain characteristics.

A. Threshold Segmentation

Threshold segmentation is the simplest image segmentation method. This method employs a threshold value to turn a gray-scale image into a binary image. The key of this method is to select the threshold value. Threshold is the simplest method of image segmentation. Threshold can be used to create binary images from gray scale image.

During segmentation each pixel in the source image is assigned to two or more classes. Binary images can be produced from color images by segmentation. If there are more than two classes then the usual result is several binary images. In image processing, threshold is used to define the boundary by split an image into smaller segments using at least one color or gray scale value. The advantage of obtaining first a binary image is that it reduces the complexity of the data and simplifies the process of recognition and classification. A threshold value (T) is selected to convert a gray level image to a binary image.

A gray scale or color image is the input image to the threshold operation. Then output is a binary image representing the segmentation. Black pixels correspond to background and white pixels correspond to foreground (or vice versa). Based on the intensity value, the pixels are partitioned and segment image into foreground and background.

IV. FEATURE EXTRACTION

Feature extraction involves simplifying complexity in image to describe a large set of data accurately from the image. Feature extraction is the process of transforming the input data into a set of features which can very well represent the input data. It is a special form of dimensionality reduction. Obtaining the significant feature from the original data is the main goal of feature extraction.

Different types of feature extraction in image processing are:

- Texture feature extraction
- Color feature extraction

A. Texture Feature Extraction

Texture is considered as one of the main feature of any image. The second order statistical features for an image is obtained by Gray level co-occurrence matrix (GLCM) and it operates on spatial domain. The haralick texture features are energy, correlation, homogeneity, contrast. GLCM considers the relation between two pixels at a time, called reference pixel and a neighbour pixel. A GLCM is defined by a matrix in which the number of rows and columns are equal to the number of gray levels in an image.

B. GLCM And Its Features

GLCM is a statistical method of texture feature extraction that considers the spatial relationship of pixels in a given offset [9]. GLCM is created from a gray-scale image. The GLCM functions characterize the texture of an image by calculating how often pairs of pixel with specific values and in a specified spatial relationship occur in an image, and then extracting statistical measures from GLCM matrix.

Texture feature calculations use the GLCM contents to give a measure of the variation in intensity at the pixel of interest. Typically, the co-occurrence matrix is computed based on two parameters, which are the relative distance between the pixel pair d measured in pixel number and their relative orientation. Normally, is quantized in four directions such as 0º, 45 º, 90 º and 135 º.Where i & j are the gray level values in an image.

GLCM directions of analysis:-Horizontal (0˚ or 180˚), Vertical (90˚ or 270˚), Right Diagonal (45˚ or 225˚), Left diagonal (135˚ or 315˚). Denoted as P_{0^0} ,P_{45^0}, P_{90^0} ,P_{135^0}

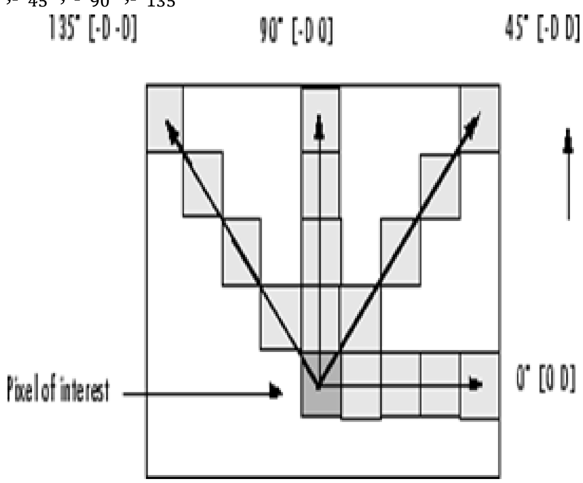

Fig 3: Direction Analysis

The figure shows the directional analysis of P (0°), P (45°), P (90°), P (135°) in an image. If the adjacent pixel to the pixel of interest is along x axis then it referred to as 0° directional analysis. If the adjacent pixel to the pixel of interest is along 45° then it referred to as 45° directional analysis. If the adjacent pixel to the pixel of interest is along 90° then it referred to as 90° directional analysis. If the adjacent pixel to the pixel of interest is along 135° then it referred to as 135° directional analysis. For each direction GLCM can be calculated. GLCM is a Ng x Ng matrix, where Ng is the number of gray levels in the input image.

GLCM should be a symmetric and normalized matrix to obtain features. To make a matrix symmetric, we should take transpose of GLCM and add it with the original GLCM. To get a normalized matrix, calculate sum of all elements in a GLCM and divide each element of the matrix with the obtained sum. Texture features are extracted from the normalized symmetrical GLCM.

The properties or features extracted from normalized symmetrical GLCM are

1. Energy.
2. Correlation.
3. Homogeneity.
4. Contrast.

1. Energy:

Energy parameter is also called as Uniformity. Energy measures textural uniformity, i.e., pixel pairs repetitions. Energy is a feature that measures the smoothness of the image. Less smooth the region is, the more uniformly distributed P_{ij}.

$$\text{Energy}=\sum_{i=1}^{Ng}\sum_{j=1}^{Ng} p_{ij}^{2} \quad (1)$$

2. Homogeneity:

It also known as inverse difference moment and calculates closeness of distribution of elements in the GLCM to the GLCM diagonal. Homogeneity is a measure that takes high values for low contrast images.

$$\text{Homogeneity} = \sum_{i=1}^{Ng}\sum_{j=1}^{Ng} \frac{1}{1+(i-j)2} p_{ij} \quad (2)$$

3. Correlation:

It calculate the correlation of pixel and neighbour pixel in the whole image.

$$\text{Correlation}= \sum_{i=1}^{Ng-1}\sum_{j=1}^{Ng-1} \frac{(i,j)P(i,j)-\mu_x\mu_y}{\sigma_x\sigma_y} \quad (3)$$

4. Contrast:

It is the difference between the highest and the lowest values of a contiguous set of pixels. It measures the amount of local variations present in the image.

Contrast= $\sum_{i=1}^{N_g}\sum_{j=1}^{N_g}(i-j)^2 P_{ij}$ (4)

B. Color Feature Extraction

Color is an important and the most straight-forward feature that humans perceive when viewing an image. Human vision system is more sensitive to color information than gray levels so color is the first candidate used for feature extraction. Color histogram is one common method used to represent color contents. Color moments are also used to extract the features. Color moments are mainly used for color indexing purposes as features in image retrieval applications in order to compare how similar two images are based on color.

Color moments are mainly used for features extraction to compare two images are based on color to find similarity between them. Color moments are measures that can be used differentiate images based on their features of color.

1. *Mean:*

The first color moment can be interpreted as the average color in the image, and it can be calculated by using the following formula:

Mean = $\sum_{j=1}^{N}(1/N)P_{ij}$ (5)

2. *Standard Deviation:*

The second color moment is the standard deviation, which is obtained by taking the square root of the variance of the color distribution.

$\sigma_i = \sqrt{(1/N)\sum_{j=1}^{N}(p_{ij} - E)}$ (6)

C. Color Histogram

A color histogram shows different types of colors appeared and the number of pixels in each type of the colors appeared. A color histogram aims only on the proportion of the number of different types of colors, rather than spatial location of the colors. The color histogram shows the brightness distribution for each color individually. This is important because we can easily see if one color is overexposed and clipped which means that we might be loosing important detail for that color range.

V.SYSTEM MODEL

The fundus image is uploaded and segment optic cup and optic disc through threshold segmentation to calculate cup to disc ratio (CDR) and rim to disc ratio (RDR).Then the CDR and RDR value is checked. If the CDR is greater than the threshold value and if RDR value is less than threshold value, then glaucoma is detected.

The steps are illustrated in figure 1.2

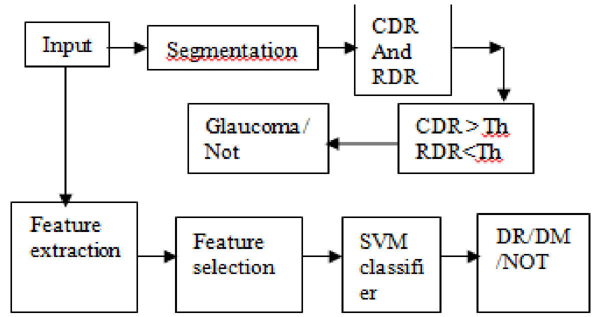

Fig 4: Block diagram

Then features such as texture features and color features are extracted via GLCM and color moments and color histogram methods. Then the selected features are given to the SVM classifier. After that detect the healthy and unhealthy eye.

VI .SIMULATION RESULTS

The display format of computer aided detection system is given below. In this system the input fundus image is uploaded and it provide the segmentation of optic cup and optic disc. After that we have to respond with the queries asked, here the queries are based on symptoms.

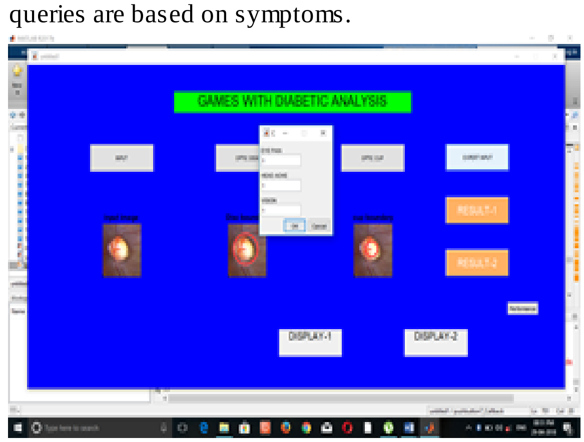

Fig 5: Step 1

Then we have to respond with the queries asked by clicking '1' for yes and '0' for no.

Fig6: Step 2

Fig 7: Step3

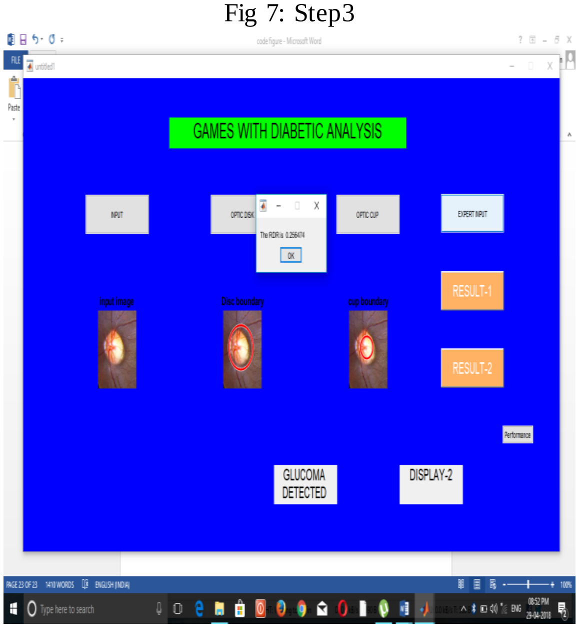

Fig 8: Step 4

After that it display the CDR and RDR value.

Fig 9: Step 5

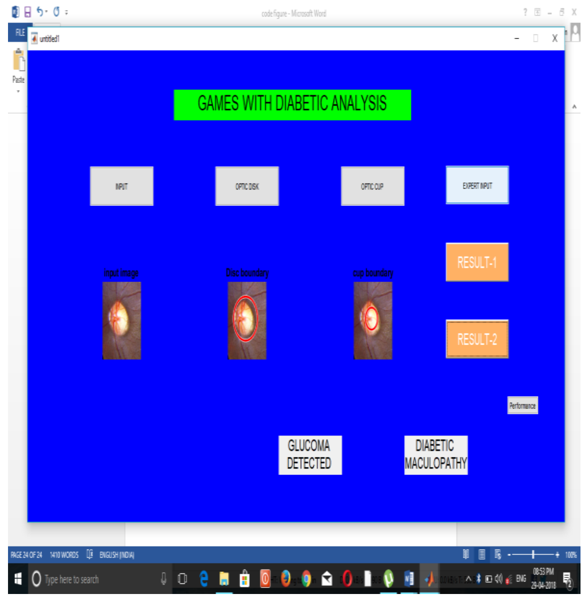

Fig 10: Step 6

The result shows that the person is affected with both glaucoma and diabetic maculopathy.Similarly it detect the disease diabetic maculopathy in the same manner.

VII. CONCLUSION

Glaucoma, Diabetic retinopathy and Diabetic maculopathy are the main eye diseases which leads to vision loss. The proposed computer aided system perform accurately in detection of these diseases. The proposed framework employs two criteria such as optic cup to disc ratio and rim to disc ratio to detect glaucoma. Feature extraction methods such as texture feature extraction and color feature extraction methods are used to detect diabetic retinopathy and diabetic maculopathy. Gray level co-occurrence matrix (GLCM) is used to extract texture features. As a result four features such as energy, entropy, correlation, homogeneity are computed using GLCM. Color moments and color histogram methods are used for color feature extraction. The proposed system is utilized to analyze the three diseases among the patients. Hence the system gives a promising results and provides mastery to remote territories.

ACKNOWLEDGEMENT

I would like to express profound to our Head of the Department and my guide Ms. Sangeeta T. R for her encouragement and for providing the necessary guidance and serious advice for my work.

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