Diabetic Retinopathy-Early Detection Using Image Processing Techniques

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Abstract - **Diabetic retinopathy is the cause for blindness in the human society. Early detection of it prevents blindness. Image processing techniques can reduce the work of ophthalmologists and the tools used automatically locate the exudates. Early detection helps the patients to aware of the seriousness of the disease. In this paper we present a method which is automatic and involves two steps: optic disk detection and exudates detection. The extraction of optic disk is done using propagation through radii method. Exudates detection is done using feature extraction, template matching and enhanced MDD classifiers and the methods are compared.**

Index terms - **Diabetic retinopathy, exudates, optic disk, template, ophthalmologists, feature, classifier**

I.INTRODUCTION

Diabetic retinopathy is a highly specific vascular complication and the prevalence of retinopathy is strongly related to the duration of diabetes. It is beneficial to have regular cost-effective eye screening for diabetes. Kavitha, D. Shenbaga Devi, S.et.al (2005) suggested an algorithm which detects the exudates through three steps. Least square polynomial curve fitting algorithm segments the blood vessels, multilevel thresholding extracted the optic disk and exudates [1]. Multilayer perceptron (MLP), radial basis function (RBF) and support vector machine (SVM) needs to train the images for detecting the hard exudates [2]. An automatic method to detect exudates from low-contrast digital images of retinopathy patients with non-dilated pupils using a Fuzzy C-Means (FCM) clustering is proposed. Contrast enhancement preprocessing is applied before four features, namely intensity, standard deviation on intensity, hue and a number of edge pixels, are extracted to supply as input parameters to coarse segmentation using FCM clustering method. The first result is then fine-tuned with morphological techniques [3]. Giri Babu Kande et.al used two approaches for exudates and optic disk. The centre of optic disk was estimated by finding a point that has maximum local variance. The color morphology in Lab space was used to have homogeneous optic disk region. The boundary of the optic disk is located using geometric active contour with variational formulation. Exudates are identified which includes Preprocessing, Optic disk elimination, and Segmentation of Exudates. The enhanced segments are extracted based on Spatially Weighted Fuzzy c-Means clustering algorithm [4]. Fisher's linear discriminates analysis [5] used colour information to perform the classification of retinal exudates. An adaptive threshold algorithm was developed to detect and to measure the exudates in gray value images of patients with diabetic retinopathy [6]. By means of a dynamic thresholding procedure, the common usual preprocessing shading correction was omitted since the compensation of irregularities of illumination is implicitly contained in the algorithm. A Osarehet.al [7] used an artificial neural network classifier to segment the exudates region. Our approach is based on the detection of yellowish objects as exudates and the edges are found using sobel operator.

II.OPTIC DISK DETECTION

A. Propagation Through Radii

The optic disk location is identified and Principal Component Analysis method [8] with certain modifications makes the method to be fast and robust. We tried a different method in which a circle (circle of best fit) is defined that encloses the optic disc with minimum number of pixels that does not belong to the optic disc. The original fundus image is subjected to contrast limited Adaptive Histogram Equalization. The centre of the box containing optic disc is defined by coordinates (x, y). In general to represent a circle in discrete space we use x+rcosθ, y+rsinθ. θ lies from 0 to 360. The arbitrary initial value of r is 10. Thus we have ({x+10cos0, y+10sin0}, {x+10c0s1, y+10sin1}… {x+10cos360, y+10sin360}) . Each of them representing a point in the circumference of the circle. Now the first point (corresponding to θ=0) on the circumference is taken. Keeping it as the centre point and a pixel is chosen above (x+(r+1) cosθ, y+(r+1) sinθ) and below(x+(r-1) cosθ, y+(r-1) sinθ) that. The difference of pixel intensity value between the upper point and centres point and also between lower point and centre point is computed. A threshold is set (5 in our case) and if the difference value is greater than the threshold make the center point is made black. This procedure is repeated until the difference value becomes greater than the threshold, each time shifting the centre point upward along the radius by incrementing the initial r value .The final r value is the radius corresponding to that θ. This is done for all the points present in the circumference of the circle i.e., for θ ranging from 0 to 360. Hence we get radius for all 360 degrees, and then the mean radius is found. Our next step is to find mean centre. This is done by finding midpoint of line joining circum points of supplementary angles for θ=0 to 180.The mean of these x and y co-ordinates of the midpoints gives us the mean centre. The circle of best fit is drawn with mean centre as the centre and mean radius as the radius. As error margin can be added to the mean radius, this ensures that the optic disc is completely enclosed.

B. Binary Imaging Method

The optic disk is the only brightest part in retinal images and next to it comes the exudates. The optic disk center is found and propagation through radii method is employed and the entire optic disk region is blackened and removed. Now the image is left with exudates as the brightest region. Binary Imaging method is used and proper threshold value is set and the exudates can be easily identified from the image.

C. Template Matching

The normal and healthy retinal image is taken and it is kept as the reference to isolate the abnormalities in the test image. This reference image acts as the template. Both the reference image and test images are converted from RGB to GRAY levels and then pixel by pixel both the images are compared. During comparison, the additional objects present in the test image get isolated and they are clearly visible in the output. If the test image is normal, then while comparison it gets cancelled as there is no difference of pixel value between the two, where as in the test image with exudates, the optic disc gets cancelled and only exudates are separated in the output. The basic requirement of this method is that, we should have a normal and healthy retinal image as reference and the test images must be taken in the same orientation as the reference, it should be of same lighting, angle, etc… It should be taken in the same manner as that of the reference, then only this algorithm will work well or else it would produce wrong result. Hence this basic need must be satisfied to work with this method.

D. Enhanced Mdd Classifier

This image works on the RGB co-ordinates rather than spherical co-ordinates. In the MDD Classifier method, the centre of class is found using a training set and hence remains fixed. But this may cause problem because of difference in image illumination and their average intensity. So a method is employed such that the centre of class (C_{yell} and C_{bgnd}) varies dynamically depending on the image.

From previous Optic Disc detection method we know the position of the optic disc for the image. Using this knowledge we select a group of pixels that surrounds the Optic Disc and the mean of these pixels form the C_{bgnd}. Optic Disc usually has the same color and intensity as that of exudates. So the pixels that belong to the OD are used for calculation for C_{yell}.

$$C_{yell} = 1/m \sum_{i=1}^{m} Y_i \quad (1)$$

$$C_{bgnd} = 1/n \sum_{i=1}^{n} B_i \quad (2)$$

Where m & n are number of pixels in yellowish and background region respectively, that are used to calculate these centres and Yi and Bi are the vectors of the 3 color features in the different region of OD and background. The method attempts to detect exudates by using the two important features of exudates, its color and its sharp edges. Once the optic disk is detected, the detection of yellowish objects is carried out performing color segmentation based on statistical classification method [9] and [10]. It is based on the fact that if a group of features can be defined so that the objects in an image map to non intersecting classes in feature space, then we can easily identify different objects classifying them into corresponding classes. We define two classes yellowish objects and background which are characterized using only three color features(R, G, and B).

E. Detection of Objects with Sharp Edges:

There are various algorithms to find the edges of an image like Sobel, canny etc…In our case we used Sobel operator to find the sharp edges. We have a binary image with edges being shown white. This image contains the edges of optic disc, blood vessels, exudates and also the image boundary. So this cannot be independently used to determine the exudates. To detect only exudates and to remove all the false detections in the previous stages, we combined the two images obtained using MDD and edge detecting method through a Boolean operation, feature based AND [10]. In feature based AND, ON pixels in one binary image are used to select object in another image. We used the image with objects having sharp edges to select objects in the image with yellowish elements, because in the last one the lesions are detected completely, not only their contours. Thus we obtain lesions characterized by two desired features-yellowish color and sharp edge.

III.RESULTS

A. Binary Imaging Method

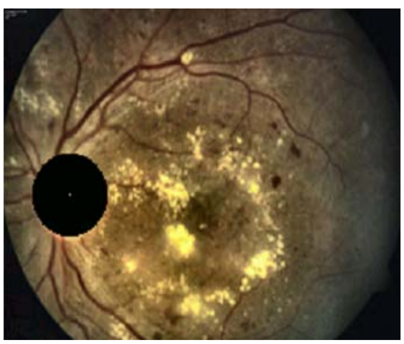

Figure1. Input OD Extracted Image

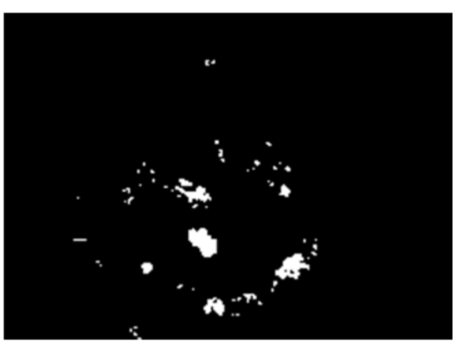

Figure 2 Output Binary Images Showing Exudates in White

B. Template Matching

Figure 3 Reference Image

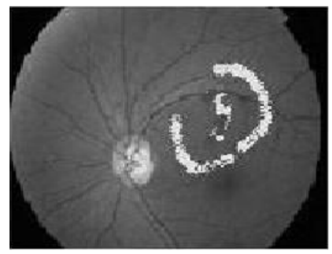

Figure 4 Test Image

Figure 5 Output Image with Exudates Detected

C.MDD Classifier

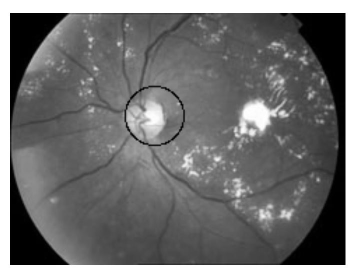

Figure 6 Input Images with Optic Disc Circled

Figure 7 Optic Disc Extracted Image

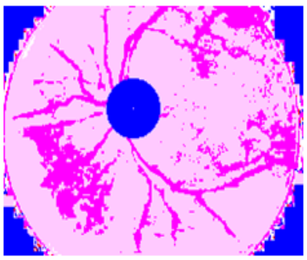

Figure 8 Images Converted to Spherical Coordinates

Figure 9 Output Image with Exudates Marked as Black

Figure 10 Boundaries of Exudates

IV.CONCLUSION

The position of optic disk is determined using the Principal Component Analysis method with certain modifications which makes the method to be fast and robust. When the program was executed in a system having a configuration of 1GB RAM and 3.2GHZ processor, the final output was obtained on an average of 20 seconds. The identified Optic Disc area is trimmed and then removed from the retinal image. The program was tested on fifty images. When the results were verified by binarizing the Optic Disc extracted images, it was found that the Optic Disc was completely extracted for 39 images. Out of the remaining 11, 4 were poorly acquired fundus images. By using propagation through radii method the chance of detecting exudates in the proximity of the Optic Disc increases by 25-40%. Later the exudates present are identified using Enhanced MDD classifier. Of the 39 images for which the Optic Disc was correctly extracted 35 images were abnormal images with exudates and 4 images were healthy normal images. By visual inspection it is found that though it did not find all the exudates in few images, the MDD classifier identified all the 35 abnormal images as abnormal and 3 normal images as normal. So once a retinal image is fed to the system, the result indicates the presence of exudates. This is useful when ophthalmologist visits an eye camp, he can get the retinal images of many patients using fundus camera and once these images are fed to system, the abnormalities can be easily detected. This reduces the analysis time and improves the efficiency.

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