AUTOMATIC SEGMENTATION OF FOVEA AND CLASSIFICATION OF DIFFERENT STAGES OF DIABETIC RETINOPATHY

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ABSTRACT

Fovea is the centre most part of the macula. A healthy fovea is key for reading, watching, driving etc... Fovea detection helps doctors to identify diseases like diabetic retinopathy (DR), age related macular degeneration (AMD) and retinopathy of pre-maturity (ROP). Diabetic retinopathy is the most common diabetic eye disease and it can eventually leads to blindness. With the help of adaptive histogram equalization, threshoulding method and smoothing method can detect the fovea region. These features are proceeded with the help of Fuzzy C-Means clustering algorithm to detect the different diabetic retinopathy stages and the result will be compared with KNN. The accuracy of the diabetic retinopathy detection system is 98.5%.

Keywords: fovea, diabetic retinopathy, automatic screening, adaptive histogram equalization, fuzzy c-means clustering.

1. INTRODUCTION

One of the major complications of diabetes is diabetic retinopathy. The visions of many people in the world are threatened by the diabetic retinopathy. Diabetic retinopathy is the eye disease that causes the blindness or blurs the visions. It arises due to the high sugar level in the blood. The eye's sharpest and most colored vision occurs when light is focused on the tiny dimple on the retina called the fovea centralis or macula. This will provides highest resolution vision.

Anatomical structures such as blood vessels, exudates and micro aneurysms in retinal images are segmented and the images are classified as normal or DR images by extracting features from these structures and the Gray Level Co-occurrence Matrix (GLCM) [1] here support vector machine [SVM] classifier is used.

Retinal image analysis is one of the crucial topics in medical image processing. During the last three decades, people are trying to extract the different features (like blood vessels, optic disk, macula, fovea etc.) automatically from retinal image. Fovea is one of the important feature of a fundus retinal image. This paper present a simple and fast algorithm using Mathematical Morphology to find the fovea region [3].

Micro aneurysms are the first clinical sign of diabetic retinopathy. The number of micro aneurysms is used to indicate the severity of the disease. Early micro aneurysm detection can help reduce the incidence of blindness. This paper investigates a set of optimally adjusted morphological operators used for micro aneurysm detection on non-dilated pupil and low-contrast retinal images. The detected micro aneurysms are validated by comparing with ophthalmologists' hand-drawn ground-truth [4].

Optic disc (OD) and fovea locations are two important anatomical landmarks in automated analysis of retinal disease in color fundus photographs. This paper presents a new, fast, fully automatic optic disc and fovea localization algorithm [5] developed for diabetic retinopathy (DR) screening.

Image processing techniques is utilized in medical field widely nowadays. Hence therefore this technique is used to extract the different features like blood vessels, optic disk, macula, fovea etc automatically of the retinal image of the eye. The image for analysis is obtained from the DRIVE database [6].

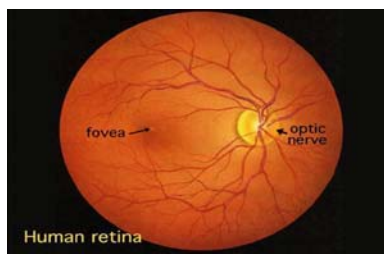

Figure-1. Human retina.

The above figure shows the human retina as seen through an ophthalmoscope. Ophthalmoscope is used in visual field. It's an device used for visualizing retina. The various methods used for fovea detection. This can include detection of blood vessel and optic disk. There are several algorithms in the literature for blood vessels detection. These results can be compared through standard DRIVE database images [8]. J. Staal *et al*. [7] have worked with a method based on extraction on image ridges, which coincide approximately with vessel centerlines.

The normal vision and the diabetic patient vision is entirely different. The following figure shows the difference.

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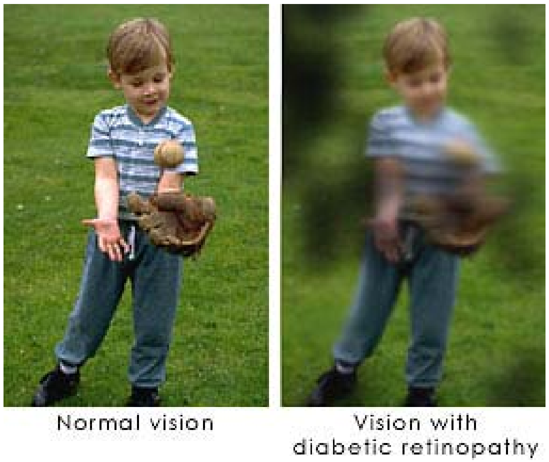

Figure-2. Normal vision and vision with diabetic retinopathy**.**

First figure is a normal vision and second figure is the diabetic affected patient vision. Diabetes causes changes in the blood vessels of the retina and small hemorrhages develop in the retina and macula.

2. METHEDOLOGY

The main features of a fundus retinal image were defined as the optic disc, fovea and blood vessels. Input to this system is a fundus image which is part of human eye that can be seen through the pupil. The disease, Diabetic Retinopathy (DR) detection involving the following fundamental parts. Pre-processing, feature extraction, fovea detection and disease identification. The basic system block diagram is given below.

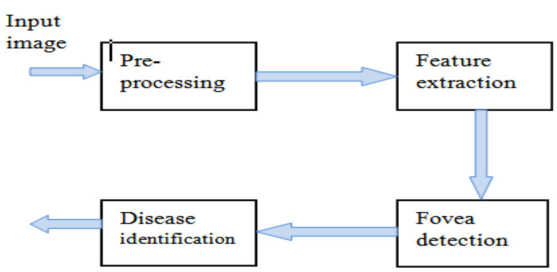

Figure-3. System block diagram.

Diabetic retinopathy identification involves these steps. Each block of the above diagram described below.

a) Pre-processing

This involves obtaining a gray image from green channel, background normalization, contrast enhancement and image binarization. Here input image is an fundus retinal image. Below shows the fundus image.

Figure-4. Fundus image.

The input images are fundus photographs like the one in Figure-4. Here histogram equalization is applied to green channel. This will increases the contrast to make it easier for algorithm to detect small changes and distinguish different tissues [11].

In the RGB image the green channel shows the best contrast between the vessels and background and is used for further processing. Then convert green channel image into a gray scale image because retinal blood vessels looks darker in gray image. Thus normalization and contrast enhancement is performed a well image quality. Normalization is performed by subtracting an approximate background from the gray image. A 30x30 median filter is applied to the gray image and the resulted image is subtracted plane to get normalized image. Adaptive Histogram Equalization is applied for contrast enhancement. A dark region including vessels, MAs, exudates and noise are dominant after contrast enhancement.

b) Feature extraction

Blood vessel segmentation, optic disc detection, fovea region. It enhancing the grey image, the uninformed illumination can be corrected and using the local transformation the contrast is increased [4]. The system is based on extraction of image ridges, which coincide approximately with vessel centerlines. The ridges are used to compose primitives in the form of line elements. With the line elements an image is partitioned into patches by assigning each image pixel to the closest line element [6]. The key idea is to enhance the relative contrast between the fovea and its surrounding such that it is well-separated in a retinal image [5]. Blood vessels segmentation blood of the retinal images allows early diagnosis of disease.

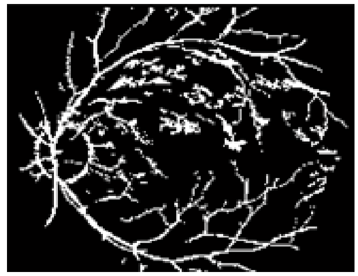

Figure-5. Detected blood vessel.

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Fovea is the centre part of the eye. It is responsible for vision. Fovea detection is a difficult process. So here we are using an efficient method to detect the fovea ie. adaptive histogram equalization. We propose to use a median filtering scheme to carry out demising of the image and thereby to find the fovea of the retina. For instance, popular convolution approaches suffer from variable retinal background and low contrast between vessels and surrounding pixels. Obtaining the center and surroundings of the optic disk, the diameter of the disk can be easily calculated. To localize the fovea region, we start with the image, containing only the blood vessels.

Based on the dark region and bright region we can classify the fovea, blood vessels and optic disc. As our goal is to detect fovea region, we are interested in achieving success in detecting blood vessels and optic disc [3].

c) Fuzzy C-Means clustering

In this paper, the presence of abnormalities in the retina such as structure of blood vessels and optic disc are detected using adaptive histogram equalization. Then these information's are using fuzzy c-means clustering algorithm to detect the diabetic retinopathy. The fovea detection is helps to detect the diseases.

Below figure shows the mild and early diabetic and moderate diabetic retinal image. The first figure having small number of hemorrhages. If the retina image having large number of hemorrhages, that is highly affected diabetic.

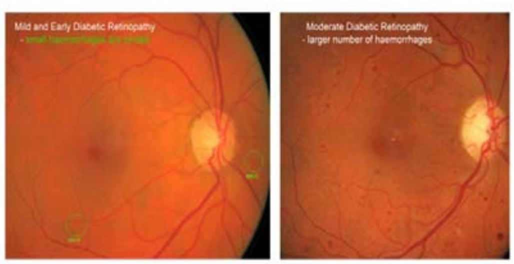

Figure-6. Diabetic images.

3. RESULT AND DISCUSSIONS

Diabetic retinopathy simply means that, there is damage to the retina, specifically to the small blood vessels of the eyes. We have used a little bit information of the OD and the blood vessels structure information around the macula region to localize the fovea region further accurately. Proposed scheme is simple but efficient in extracting the fovea region. First, fundus images are pre-processed in order to improve image contrast. Second, Image segmentation is applied in order to extract three features namely Blood vessels, optic disc and fovea. Those features are among the preliminary signs of diabetic retinopathy, a major cause of vision loss in diabetic patients. Early detection of diabetic retinopathy could improve patients' chance to avoid blindness. Those features values are then fed into fuzzy c-means classifier for classification to four classes (Normal, Mild, Moderate or Severe).

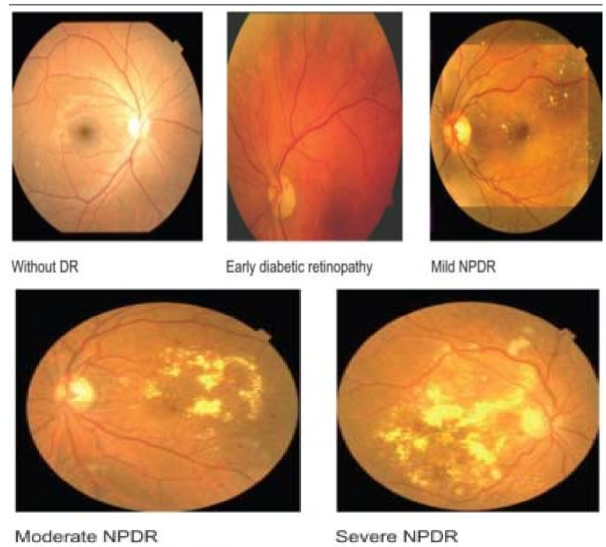

Figure-7. Simulation outputs.

The entire work is done by with the help of MATLAB. Experiment shows that the outcome the scheme is comparable with others when applied on standard data set (images). This is clear in the simulation output shown in Figure-7. Moreover, it performs well on our own data set (images) consisting of images with variation. Thus, the proposed scheme is robust also. The extracted optic disc and fovea region may help in further diagnosis of related diseases like Diabetic Retinopathy, Age related macular degeneration (AMD), Retinopathy of pre-maturity (ROP) and some other diseases of the patients.

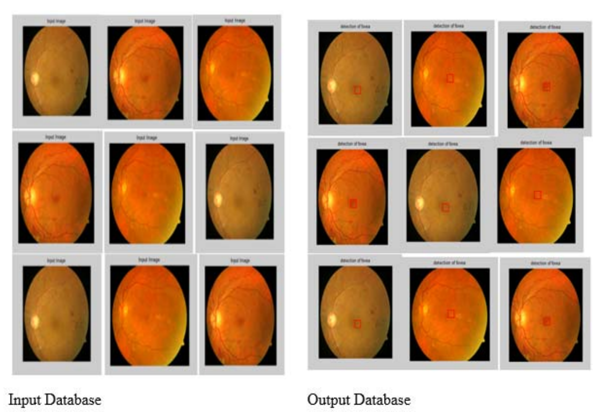

Figure-8. I/O data set.

Figure-8 shows the I/O data set. Which is used in experimental Moreover, it performs well on our own data set (images) consisting of images with variation. The input and output data base shows curresponding result.

The performance of classification algorithm is evaluated by computing the percentages of Sensitivity (SE) and accuracy definition are follows,

AC = (TP+TN)/(TP+TN+FP+FN)*100
SE = TP/(TP+FN)*100

where TP is the number of true positives, TN is the number of true negatives; FN is the number of false negatives, and FP is the number of false positives.

Table-2. Results of performance analysis using classifiers.

Parameters	KNN	Fuzzy C-means clustering
Accuracy	98%	98.5%
Sensitivity	97.8%	98.7%
Execution Time(m.sec)	266(m.sec)	260(m.sec)

4. CONCLUSIONS

The method to detect the fovea region of the eye and diabetic retinopathy identification. Two major algorithms are considered in analyzing it. First algorithm involves the isolation of blood vessels and next algorithm deals with the localisation of fovea. This method is simple and efficient in extracting the fovea. In the proposed approach of blood vessel detection, morphological operations and geometrical functions are used to arrive the output.

In the second algorithm of fovea localisation, sliding window technique is utilized to find the gray mixed black colour fovea. The proposed approach is further enhanced to detect the diabetic retinopathy disease through feature extraction and principal component analysis method. It performs well on individuals own data set consisting of images with variation. This method is robust also. This proposed methodology can be utilized in hospitals to detect diseases occurring on the eyes by doctors easily.

A hospital survey was conducted to accesses the pre valance of diabetic retinopathy and associated risk factors among diabetic retinopathy and associated risk factors among diabetic patients attending Lotus Eye Hospital, Coimbatore. From the hospital collected the fundus images and put them as the data base. While running the program successfully displayed the output of fovea region. The regular screening of the diabetic retinopathy is highly recommended as with the early detection of proliferative retinopathy and timely laser coagulation, which are known to prevent most of the diabetes-related blindness. An automatic method to detect Diabetic retinopathy eye diseases using a Fuzzy C-Means (FCM) clustering is proposed and the result compared with KNN. from the above performance analysis table we can see that the fuzzy c-means is give the best result.

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