Early Detection of Micro Aneurysm Detection in Diabetic Retinopathy

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Abstract— Diabetic retinopathy (DR) is a common retinal complication associated with diabetes. It is a major cause of blindness in middle as well as older age groups. Therefore early detection through regular screening and timely intervention will be highly beneficial in effectively controlling the progress of the disease. If not diagnosed and treated in time, diabetes can encourage other illnesses in the body of patients. One such illness is related to the retina of human eyes that affects the retina and retinal structure in certain ways. Hence a method for the automatic detection and classification of disease severity is aimed at this work. In this paper different image processing techniques are used to differentiate between the normal and the diseased image. The attempt is made to see where the problem actually lies so that proper diagnosis of patient can be done. Early treatment can be conducted from detection of microaneurysms. Microaneurysms are the earliest clinical sign of diabetic retinopathy and they appear as small red spots on retinal images. Early automated microaneurysms detection can help in reducing the incidence of blindness. In this paper, we review and analyze the techniques, algorithms and methodologies used for the detection of microaneurysms from diabetic retinopathy retinal images.

Key words: Diabetic retinopathy; Automated detection; Microaneurysms

I. INTRODUCTION

Due to modern living style, plenty of people are getting affected with Diabetes. The World Health Organization evaluated that 135 million people have diabetes mellitus worldwide and the number of people with diabetes will increase to 300 million by the year 2025. Diabetes is a systematic and chronic end organ disease that occurs when the pancreas does not secrete enough insulin or the body is unable to process it properly. A side effect of diabetes is Diabetic Retinopathy in which different parts of the retina get affected. Diabetic retinopathy is a medical condition where the retina is damaged because fluid leaks from blood vessels into the retina. Doctors recognize diabetic retinopathy by examining the features, such as blood vessel area, exudates, hemorrhages, microaneurysms and texture. [1]. Early diagnosis of diabetic retinopathy enables timely treatment that can ease the burden of the disease on the patients and their families by maintaining a sufficient quality of vision and preventing severe vision loss and blindness. In diabetic retinopathy, hemorrhage and microaneurysm detection are very important. The first detectable abnormalities are microaneurysms which represent local enlargements of the retinal capillaries [2]. In [5] detected microaneurysms, hemorrhages and exudates for grading of diabetic retinopathy using the Scottish Diabetic Retinopathy Grading Scheme. Another criterion for grading diabetic retinopathy presented in [5] use numbers of microaneurysm and hemorrhages to grade the diabetic retinopathy stage. Detection of microaneurysms[6] plays a vital role in the classification of diabetic retinopathy based on the severity level. When eyes get affected with diabetic retinopathy, the blood vessels become weak. The weakening of the blood vessels causes leakage of blood and lipoproteins, which causes abnormalities in the retina. With a large number of patients, the number of ophthalmologists is not sufficient to cope with all patients, especially in rural areas. Therefore, automated early detection could limit the severity of the disease and assist ophthalmologists in investigating and treating the disease more efficiently.

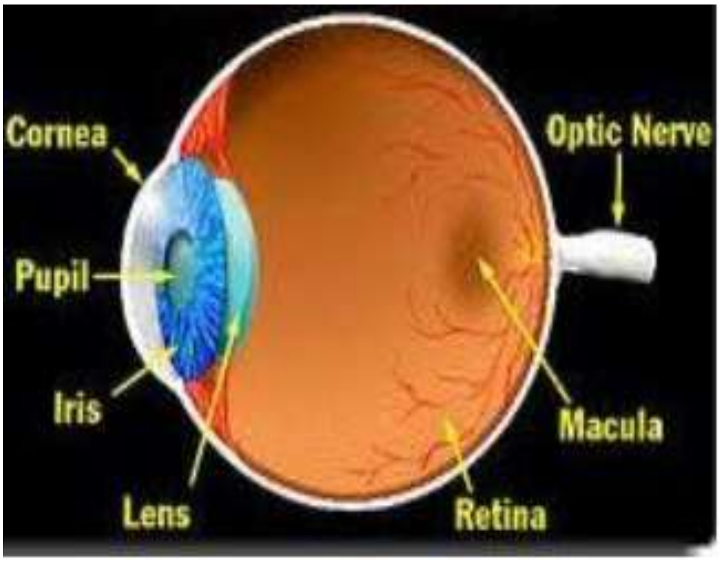

Fig. 1: Anatomy of Human Eye

Fig. 2: Normal Vision and Visio with Diabetic Retionopathy

Figure 1 shows the anatomy image of the human eye, The symptoms of diabetic retinopathy are blurred vision, seeing black spots in the centre of the eye, difficulty to see at night. If it is left untreated it causes complete blindness to the patients.

II. DETECTION OF MICRO ANEURYSMS

Diabetic Retinopathy has four major stages:

A. Mild Non Proliferative Retinopathy:

This is the earliest stage of Diabetic Retinopathy. At this stage, micro aneurysms occur in the retina. The micro aneurysms are a tiny area of blood which is extending out from an artery or vein in the backside of the eye.

B. Moderate Non Proliferative Retinopathy:

At this stage of Diabetic Retinopathy, some blood vessels that provide the nourishment to the retina are blocked. Hence there is no proper blood circulation through the blood vessels of the retina.

C. Severe Non Proliferative Retinopathy:

As the disease progresses, many blood vessels from the retina are blocked due to which several area of retina is discontinued with blood supply. The demand for growing new blood vessels is then send to the body through these affected areas.

D. Proliferative Retinopathy:

This is the advance stage of Diabetic Retinopathy. At this stage, the growth of new blood vessels takes place because of the signals sent by the retina for nourishment. These newly formed blood vessels are abnormal and have thin fragile walls. If these blood vessels leak blood, severe vision loss and even blindness can result into patient.

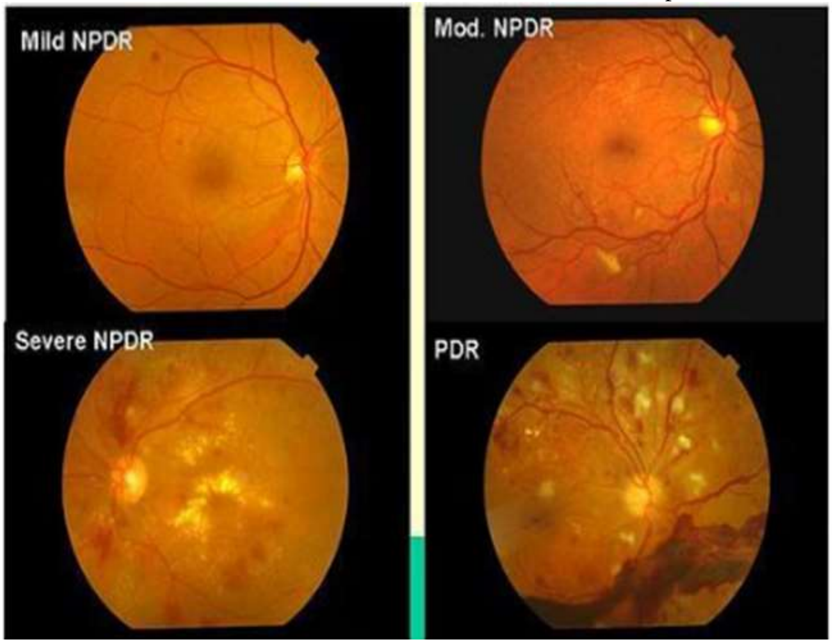

Fig. 3: Stages of diabetic retinopathy

Micro aneurysms are the preliminary symptom that is visible during the mild stage of diabetic retinopathy. These are seen as detectable lesions, which are the local distention of the retinal capillary. These outpunching of capillary walls can be seen as tiny, round, red dots. It's much difficult to identify micro aneurysms due its smaller size. When micro aneurysms are coated with blood, they may be indistinguishable from dot hemorrhages. Thus, the term “red small dot” is used to cover both micro aneurysms and small dot hemorrhages. Micro aneurysms are not necessarily permanent changes, but they may first appear and then disappear during some period of time.

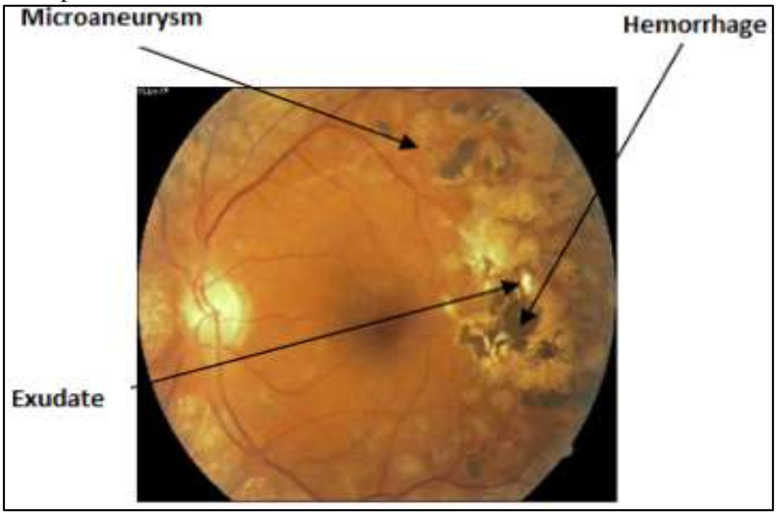

Fig. 4:

1) Inputs

There are several sources available for obtaining retinal images. The inputs for the detection of micro aneurysms were taken from databases such as STARE and DRIVE. These databases contain hundreds of images which are both normal and abnormal. An image without red lesions is considered normal and the one with red lesions is considered abnormal.

2) Detection of Micro Aneurysms

The size of the micro aneurysms is of great concern during the detection process. The schematic diagram for the extraction of micro aneurysms can be viewed as shown in fig above.

For automated detection of microaneurysms, two measures are mostly used: sensitivity and specificity. Confusion matrix is used for measuring the sensitivity and specificity.

True positives- Correctly identified means microaneurysms found as microaneurysms.
True negatives- Correctly rejected means non-microaneurysms found as non-microaneurysms.
False positives- Incorrectly identified means non-microaneurysms found as microaneurysms.
False negatives- Incorrectly rejected means microaneurysms found as non-microaneurysms.
Sensitivity is the probability of a positive test given that the patient has disease.

$$\text{sensitivity} = \frac{\text{number of true positives}}{\text{number of true positives} + \text{number of false negatives}}$$

Specificity is the probability of a negative test given that the patient has no disease.

$$\text{specificity} = \frac{\text{number of true negatives}}{\text{number of true negatives} + \text{number of false negatives}}$$

Sensitivity is essentially how good a test is at finding something if it is there, means the proportion of actual positives which are correctly identified. Specificity is a measure against false positives, how accurate a test is, means the proportion of negatives which are correctly identified.

3) Pre-Processing

A preprocessing stage is required for improving the image quality prior to the detection stage. The input image obtained from the database undergoes various preprocessing steps. The image from the database is resized by preserving the aspect ratio. Input retinal images from the database have been used to extract the green channel only. Here, the green plane of the original RGB color image used as red lesions has the highest contrast with the background in this color plane. It is observed that the contrast of the retinal images tends to be bright in the centre and diminish at the side. Green channel has greater contrast for the region of interest from the background. Images in green bands show structures most reliably. The histogram of the green channel reveals this. The extraction of green channel can be illustrated as

$$I= [IRIGIB] \qquad (1)$$

Pre-processing will remove the errors incurred during the acquisition of the image as well as it reduces the effect of brightness. The image after the extraction of the green component undergo contrast enhancement. The extracted green channel component is converted into grayscale so that the processing becomes more efficient. Enhancement of the region affected by micro aneurysms is done Contrast limited adaptive histogram equalization (CLAHE). This contrast enhanced image is partitioned into different regions and local equalization is done based on the histogram. The disjoint image regions are again recombined to get back the original image for processing.

4) Micro Aneurysm Detection

As mentioned earlier, major difficulty lies in the detection of micro aneurysms, since they are of much smaller in nature.

The detection of these smaller structures is of great importance since these are the structures present during the early stage of diabetic retinopathy. At earlier stages, these appear as smaller round red dots varying from 15 to 60 microns. For the accurate detection of the micro aneurysms, it is necessary to eliminate the optic disc. From the green channel extracted images the edges are detected and the regions are filled. The elimination of the circular border is done and the larger areas are removed from the image. To obtain the micro aneurysm affected regions, it's essential to eliminate exudates. Exudates are removed from the obtained image by adaptive histogram equalization twice and then comparison of the image with the image obtained during the last operation. Thus exudates get eliminated from the resultant image. The blood vessels and optic disc is eliminated to obtain an image containing only micro aneurysms.

5) Border Formation

For the efficient estimation of the circular border, the gray scale image is used. Then the edges are detected using edge detectors. The resultant region undergoes morphological operations followed by region filling. The resultant image is dilated and then subtracted from the eroded image to obtain the circular border clearly.

6) Mask Creation

The elimination of the optic disc is necessary because both micro aneurysms and optic disc appear as brighter regions in the image. For the elimination of the optic disc, a circular mask of the size of the optic disc is created. The maximum value for each of the columns is found. Then the largest among those values are found. The coordinates corresponding these brightest regions are then determined for the formation of the mask.

Steps:

Input: Color fundus image.

Output: Image containing only the micro aneurysm.

1) *The input image is preprocessed and the intensity is adjusted.*
2) *Contrast stretching is done followed by edge detection operation in order to detect the edges.*
3) *The circular border is removed.*
4) *Removal of the edges and larger areas are done using morphological operations.*
5) *Exudates are detected by applying adaptive histogram equalization technique.*
6) *The results of the two previous steps are compared in order to eliminate exudates.*
7) *Adaptive equalization followed by image segmentation is done to remove the blood vessels.*
8) *The resultant image contains only micro aneurysms.*

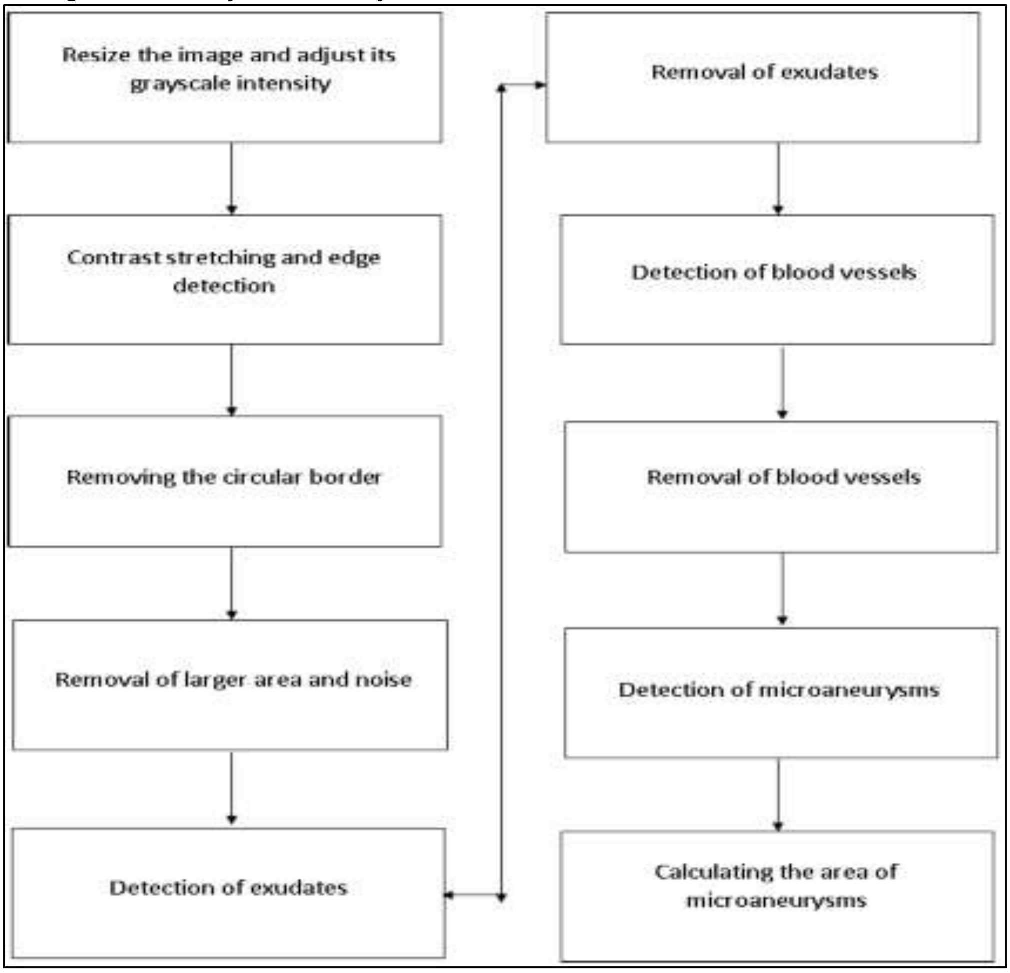

Fig. 5: Block diagram for the detection of micro aneurysms

7) Feature Extraction

The properties of the extracted micro aneurysms are

Area of Micro aneurysms

The mathematical expression for calculating the area of micro aneurysm is given by

$$Area = \frac{\text{total number of white pixels}}{\text{total number of pixels}}$$

Area of micro aneurysm is finally extracted and used for the severity classification.

8) Disease Severity

Severity of the disease is measured depending on the area calculated from the pre-processing and feature extraction. Depending on the severity, there are three categories such as mild, moderate and severe stage. A treatment can also be based on the severity. Certain known treatments are Vitrectomy, Scatter laser treatment, Focal laser treatment and Laser photocoagulation.

III. RESULTS & DISCUSSIONS

The goal of the present work was to build and test a simple screening system that can separate patients into two groups: patients in need of further examination and patients currently not needing further referral. In this paper, the proposed method is applied for tracing out normal eye and diabetic retinal eye. An Automatic eye screening system for diabetic patients is of much importance as it reduces the possibility of sudden vision loss by detecting the intermediate stage of the diabetic retinopathy. Three statistical methods for classification of common abnormalities in the retina from diabetic patients have been tested, and in general the results are comparable with those previously published. In addition to this, a number of problems and differences in the three classifiers have been revealed. This system intends to help the ophthalmologists in the diabetic retinopathy screening process for detecting the symptoms faster and more easily.

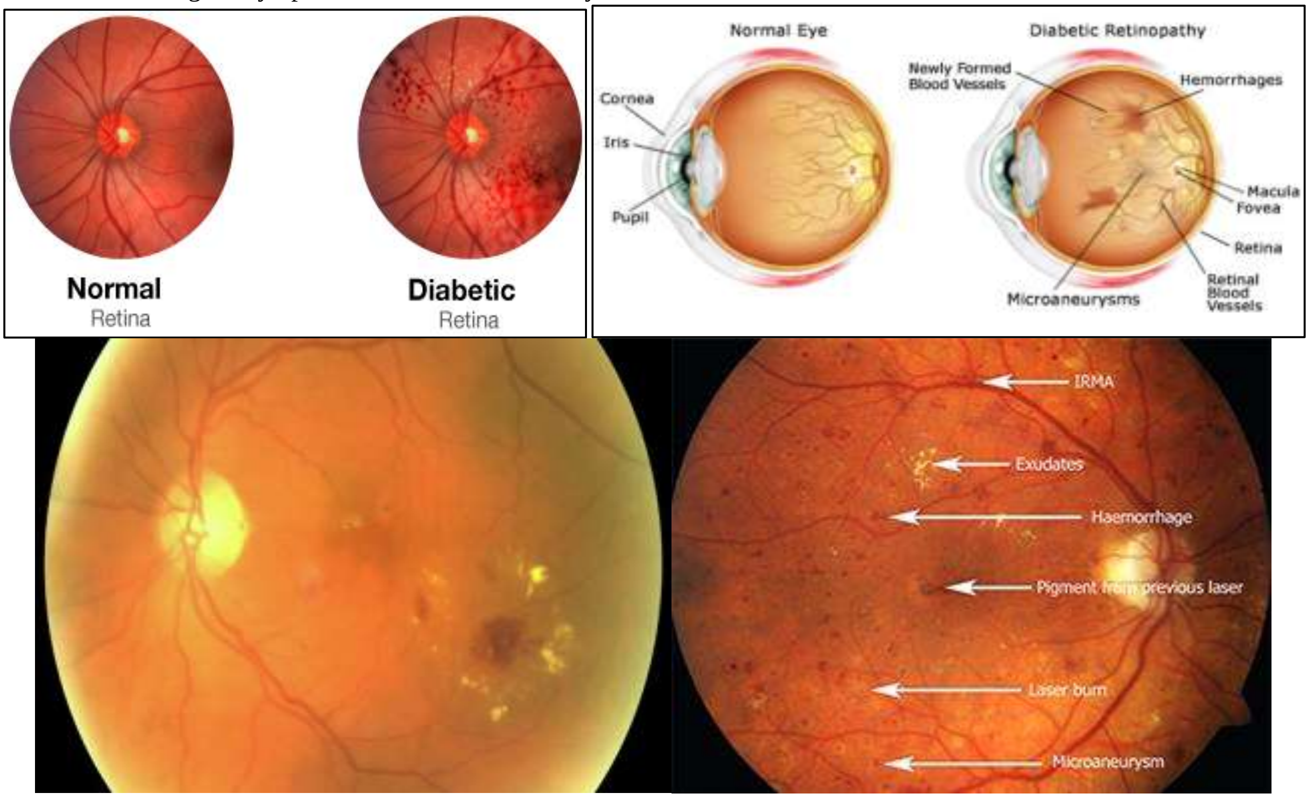

Fig. 6:

IV. CONCLUSION

Automatic detection of microaneurysm presents many of the challenges. The size and color of microaneurysm is very similar to the blood vessels. Its size is variable and often very small so it can be easily confused with noise present in the image. In human retina, there is a pigmentation variation, texture, size and location of human features from person to person. The more false positives occur when the blood vessels are overlapping or adjacent with microaneurysms. So there is a need of an effective automated microaneurysm detection method so that diabetic retinopathy can be treated at an early stage and the blindness due to diabetic retinopathy can be prevented. In this paper, some existing methods are reviewed to give a complete view of the field. On the basis of this work, the researchers can get an idea about automated microaneurysm detection and can develop more effective and better method for microaneurysm detection to diagnose diabetic retinopathy. Many eye pathologies are identified and promptly diagnosed using retinal images and it act as an accurate aid for ophthalmologists. Global prevalence of diabetes is nearly nine percent and its commonest complication is diabetic retinopathy, which is affecting the retina. Most common type of diabetic retinopathy is background or non proliferative diabetic retinopathy. The weakening of the blood vessels causes leakage of blood and lipoproteins, which causes abnormalities in the retina. The major abnormalities that occur in eyes due to diabetic retinopathy include microaneurysms, exudates, & haemorrhages. The main idea for the early detection of diabetic retinopathy is the detection of microaneurysms. It will help the ophthalmologists to know the severity of the disease and it can be detected at the early stage.

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