Detection and Counting of Microaneurysm for Early Diagnosis of Maculopathy

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Abstract Diabetic maculopathy can damage the central vision. It is also called a pathological disorder [1]. Microaneurysm is the first sign of diabetic maculopathy [2]. In this paper, we are extracting and counting the diabetic maculopathy lesion "Microaneurysm", using digital image processing technique. For this research, we used 100 fundus standard images and obtained 97.9% good result on it.

Keywords Maculopathy · Microaneurysms · Fundus · Lesion

1 Introduction

Maculopathy is the disease of the retina. When diabetes patient's sugar level goes high at that time, it impacts on the retina and that time retina will be damaged and fluid and fatty material come from the eye. Microaneurysms are small red dots on the retinal surface, which occur due to capillary occlusion leading to a lack of oxygen and progression of the disease. Vision loss occurs when they occur in the macula. If microaneurysms are created near macula it can be harmful to the macula and if the macula is damaged by microaneurysm, a patient may lose his vision. That is why microaneurysm detection is very important in the first stage [3] (Fig. 1).

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Fig. 1 Fundus image with microaneurysm

2 Methodology

Digital image processing technique helps to detect the microaneurysms [11]. For the present study, we used standard database like STARE [4], DRIVE [5], DIRETDB0 [6], and DIRETDB1 [7]. For detection of microaneurysm fundus, standard image was used, then preprocessing on those images was done and then histogram equalization was done for enhancement and intensity transformation function. For finding the boundaries for extraction use segmentation, then grading and classification will be done mild, moderate, and severe. From the STARE database, we have taken 35 images, from the DRIVE database we have taken 20 images, from the DIRECTDB0 database we have taken 25 images, and from the DIRECTDB1 database we have taken 20 images and these are the open-source standard database (Fig. 2).

2.1 Preprocessing

In preprocessing, we read the standard fundus image and then extract the green channel.

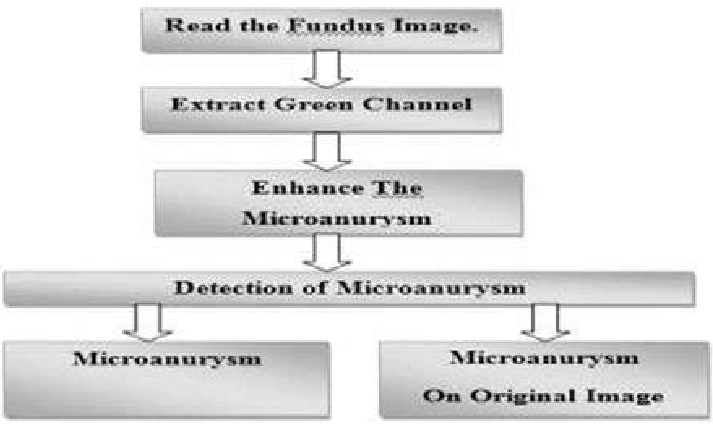


Fig. 2 Counting and detecting microaneurysm using this flowchart

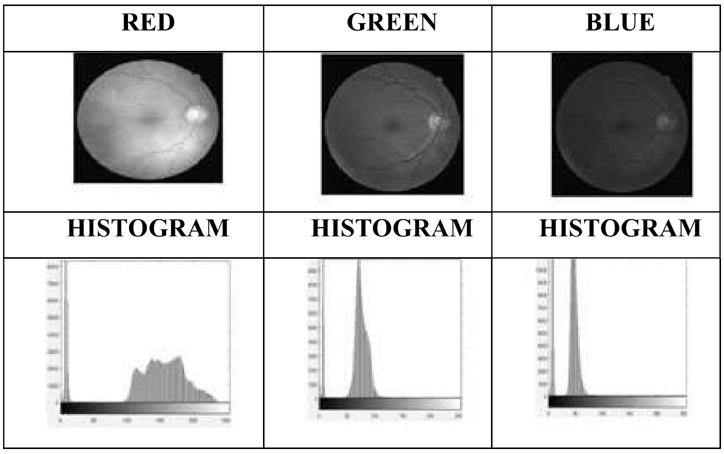


Fig. 3 RBC channel with histogram

2.1.1 Green Channel

In the following line, we see there are three channels like green, red, and blue but we use here green channel because the green channel is better than the other two channels) (Fig. 3).

$$g = \frac{G}{(R + G + B)} \tag{1}$$

2.2 *Microaneurysm Enhancement*

2.2.1 Intensity Transformation Function

For the enhancement of microaneurysms, we used the intensity transformation function. If the need for an image at a certain period is brighter or darker, it modifies the frequency principles, the frequency metamorphosis purpose, that also improves the contrast with certain values[8]. Pixel pre- and postprocessing values are denoted as f(x, y) and g(x, y).

$$g\ (x, y) = T\left[f(x,y)\right] \tag{2}$$

T represents transformation of pixel value from f(x,y) to pixel (x,y). Input image is a f(x,y) and g(x,y) is output or processed image [9].

2.2.2 Histogram Equalization

Histogram equalization generates output image with the same pixel intensity distribution, meaning that the output image histogram is compressed and systematically increased [10]. Here ps(s) and pd(d) are the density functions of the image likelihood. The histogram equalization of the image follows equations:

$$u = T(s) = \int_0^s ps(x)dx \tag{3}$$

The histogram equalization image is acquired by a same transformation function as follows:

$$v = Q(d) = \int_0^d pd(x)dx \tag{4}$$

The values of d for the image are acquired as follows:

$$d = Q^{-1}[u] = Q^{-1}[T(s)] \tag{5}$$

2.2.3 Detection of Boundaries Using Segmentation

The segment label C $\overrightarrow{X}$ = K for a pixel $\overrightarrow{X}$ is the k which maximizes the ownership of $\overrightarrow{F}$ $\overrightarrow{X}$ in the MoG model M. That is,

$$c(\vec{x}) = \arg\max_k \left[\frac{\pi_k g\left(\vec{F}(\vec{x})\right)\vec{m}_k, \Sigma_k}{p\left(\left(\vec{F}(\vec{x})\right)|M\right)} \right] \tag{6}$$

2.2.4 Support Vector Machine

In Support Vector Machine (SVM), there are many different hyperplanes that could be selected to distinguish the two types of data points. Our goal is to find a plane with the highest margin, i.e., the maximum distance between the two class data points.

3 Experimental Result

If microaneurysm count is 0 at that time we can say it is normal. If the count is 5 then it is mild and if it is more than 5 and less than 10, then we can say it is moderate and the last one if it is greater than 10 then at that time we can say it is severe. In the following line, we can see extracted microaneurysm from the fundus image (Tables 1 and 2).

Table 1 Extraction of retinal microaneurysms

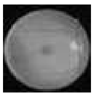
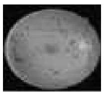
Sr. No	Original image	Extraction of Microanurysms	Microanurysms on original image
1			
2			

Table 2 Statistical count of microaneurysms

Sr. No	Image name	Microanurysms count
1	01_test	6
2	04_test	2
3	15_test	15
4	27_training	3

4 Classification and Grading

We used support vector machine supervising technique for the classification and grading, and we got the 97.9% accuracy on 100 fundus picture, we also used another classifier, but SVM gives a lot of good results, that is why we used SVM here. The following figure shows the precision and ranking of the classifier (Fig. 4).

We can see in the right-hand side of figure, there is the result of the classification which is 97.9% and in the figure on left-hand side of the bottom there are four colors, namely, blue, orange, yellow, and purple which show the grading of microaneurysm count. Blue indicates the mild, orange color indicates the moderate grade, yellow color shows the normal, and purple indicates the severity of the maculopathy lesion "Microaneurysm" grading.

5 Conclusions and Discussion

The extraction of microaneurysm is very vital in diabetic maculopathy. Microaneurysm is the first sign of maculopathy. This present research is useful for the ophthalmologists.

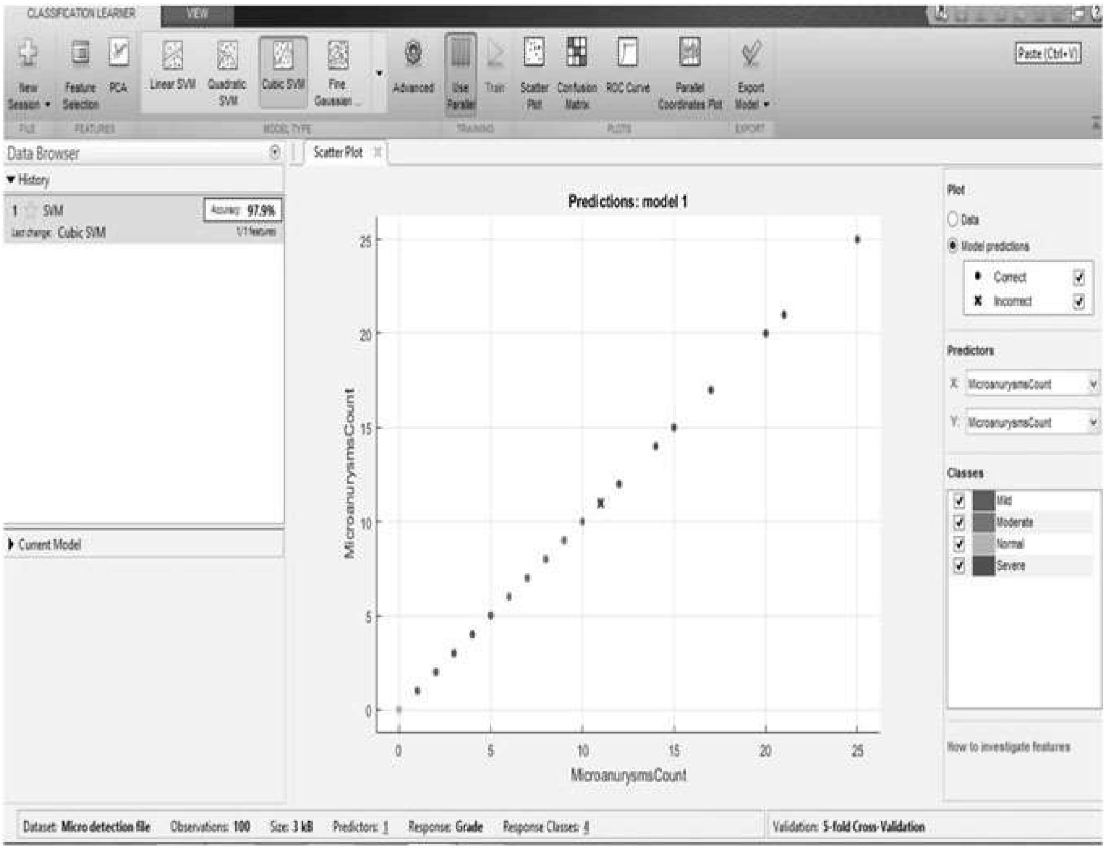


Fig. 4 Classification and grading of microaneurysms

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