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Detection of Microaneurysms in Diabetic Fundus Images Using Preprocessing Techniques

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ABSTRACT

Diabetic retinopathy is one of the important reasons for vision loss that arises due to diabetes. Non-proliferative diabetic retinopathy is the preliminary stage of diabetic retinopathy disease which shows initial symptoms in the retina of human eye. In this paper, Microaneurysms are detected using different preprocessing steps and mathematical morphology techniques. Histogram stretching and CLAHE are used to give uniform illumination to the poor quality images. Morphology techniques are used remove the optic disc which may be misclassified as noise and to provide better visibility of Microaneurysms. This method provides us with better result inorder to identify Microaneurysms clearly without any misclassification.

Keywords: Histogram stretching; Morphology technique; Contrast Limited Adaptive Histogram Equalization

1. INTRODUCTION

Diabetes is a condition that arises among human when a human body cannot produce enough amount of insulin or it cannot respond to the insulin already produced. Some of the symptoms or conditions that arise due to the uncontrolled level of glucose in the blood are increased thirsty, frequent urination and weight loss. It also results in major conditions like heart attack, stroke and vision loss. A person with diabetes for more than 10 years seems to have Diabetic Retinopathy. Diabetic Retinopathy [1] is the diseased condition occurs in diabetic patients as a result of damage in the tiny blood vessel that nourishes the retina. Retina is considered to be the light sensitive region present at the back of the eye responsible for vision. Diabetic retinopathy had no initial signs or symptoms. As the disease prolongs, it results in vision loss or blurred vision. There are two stages in Diabetic Retinopathy. They are (i) Proliferative stage and (ii) Non-Proliferative stage. Non-Proliferative Diabetic Retinopathy is the preliminary stage of retinal disorder. At this stage, there are early warnings or symptoms that make the visibility of retinopathy disorder. Proliferative Diabetic Retinopathy is the advanced stage of retinal disorder which may even results in vision loss [2]. Initial symptoms of retinopathy which arises in the Non-Proliferative stage are concentrated more in the detection of Diabetic Retinopathy because once identified in its earlier stages, it can be cured. Some of the lesions that can be identified in the initial stage of diabetic retinal disorder are Microaneurysms, Exudates and Hemorrhages. Microaneurysm is the tiny bulges in the blood vessels that arise due to the weakening of blood vessels. When there is a breakage in blood retinal barrier, some cells and fluids are seeped out and they are named as exudates. Hemorrhage arises due to the leakage of blood from the ruptured blood vessels. In this paper, we are concentrated on the detection Microaneurysms among the initial lesions present. Microaneurysms are the initial symptom that arises in the retina and it appears as a small round shaped red dots. It is usually considered to have a smaller diameter when compared to that of the major optic veins. Diabetic retinopathy symptoms can be analyzed by taking the retina images from the eye with the help of

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fundoscopy or opthalmoscopy. Opthalmoscopy is the test carried out usually inorder to look in to the fundus of the eye.

Optimal wavelet transform method was used by G. Quellee *et al*. [3] to identify the presence of initial lesion named Microaneurysms. Here three different modalities of images are considered for analysis and quality of the images are improved with the use of template matching method. The main drawback seen in this paper is that, optimal wavelet transform method misclassifies the presence of Hemorrhages as Microaneurysms.

Niemeijer *et al*. [4] used Computer Aided Diagnosis (CAD) method to identify different lesions present in an image and to fuse the results to prescreen the severity of available lesions. In this paper, two different images are considered for analysis namely one with optic disc as center and the other one with macula as the centre. Different lesions are identified using five different stages of analysis including feature extraction and image quality detection and a fusion technique is employed to determine the severity of all available lesions. The main limitation here is that, the output identified is analyzed by only one ophthalmologist.

The earlier symptom of retinopathy called Microaneurysms was detected using Ensemble based method by B. Antal *et al*. and A. Hajdu *et al*. [5]. The quality of fundus images are enhanced here using different preprocessing techniques. Outputs obtained from different preprocessing techniques are combined using different feature extractors to identify the presence of Microaneurysms. In this Ensemble based method, errors arise due to the presence of different detectors. Also for retinopathy grading, other lesions like exudates and hemorrhages need to be considered.

Computational intelligence method was used by A. Osarch *et al*. and B. Shadgar *et al*. and R. Markham et al. [6] to identify Exudates. Here three stages of analysis are considered namely preprocessing, extraction of features and image classification method to detect the abnormal images. Here the other lesions like Microaneurysms and hemorrhages are considered for identification.

R. C. Gonzalez [7] considers preprocessing as the initial step of analysis inorder to enhance the image quality of a fundus image. Here Histogram Equalization, Global Histogram Equalization and Local Histogram Equalization were specified. Histogram Equalization is used for remapping the pixel values in an image to make the brightness value over the available dynamic range uniform. Global Histogram Equalization (GHE) does not improve the brightness value of local features present in a image while concentrating on the transformation of entire histogram of an image. Some artifacts are also enhanced along with the image. Local Histogram Equalization (LHE) uses a window that moves through all brightness values in an image and performs transformation using block overlapping method. The major drawback in this method is, it over enhances some portions like background noise also.

Histogram Specification (HS) proposed by R. C. Gonzalez [7] uses a predefined histogram values which are used to control the expected histogram value for a given image. Here smooth output cannot be obtained as the image varies in nature.

M. Abdullah-Al-Wadud et al., M. H. Kabir et al., M. A. A. Dewan et al. and Oksam Chae et al [8] use Dynamic Histogram Specification (DHS) at its initial stage. Here the specified histogram is produced based on some important points selected from the given input image. These specified histogram values are used to control the input image. It does not improve the overall contrast for the input image. It also causes some artifacts in the image.

C.C. Sun et al., S.J. Ruan et al., M.C. Shie et al. and T. W. Pai et al. [9] use Dynamic Histogram Equalization (DHE) at its preprocessing stage. It divides the histogram in to sub-histograms until no dominating part is available in the developed sub-histogram. For each sub-histogram, it allocates a particular gray level range. Then it applies histogram Equalization for each new sub-histogram. It does not made any limitations to maintain the intensity value of an image, also the visual Quality need to be improved further.

In this paper, Microaneurysms are detected with the use of mathematical morphology techniques. Here optic disc are removed, since the optic disc may be identified as drusen while identifying the initial lesions.

2. MATERIALS USED

Inorder to detect the non-proliferative diabetic retinopathy symptoms present at the retina of a human eye, fundus images need to be collected. Here Fundus images are taken from publicly available DIARETDB0 - Standard Diabetic Retinopathy Database of Calibration level 0. Here the fundus images are captured with a 50 degree field-of-view using a digital camera with unknown camera settings. This data set is said to be known as “calibration level 0 fundus images”. The DIARETDB0 database provides in total of 130 color fundus retinal images. In this 110 images collected, 20 images are without any lesions and 110 consists of initial lesions of diabetic retinopathy.

3. METHODOLOGY

The quality of fundus images captured using a fundus camera at different situations may vary in its quality. Usually quality may vary due to the eye movement at the time of photograph or may be due to the varying lighting conditions. In this paper, preprocessing of the fundus images is carried out at its initial stage of analysis to improve the quality of an image. In the stage, Histogram stretching and Adaptive histogram Equalization techniques have been implemented for a given input image. Next, mathematical morphology operations namely opening and closing are used inorder to remove the optic disc and to detect the exudates present.

Color normalization and Contrast Enhancement are the necessary steps that need to be done necessarily inorder to make intensity of an image uniform. In this paper, Histogram Stretching is used to enhance the brightness of the poor quality retinal image. Contrast of an image is defined as the difference among maximum and minimum pixel intensity values. In this method, the histogram is said to be stretched or

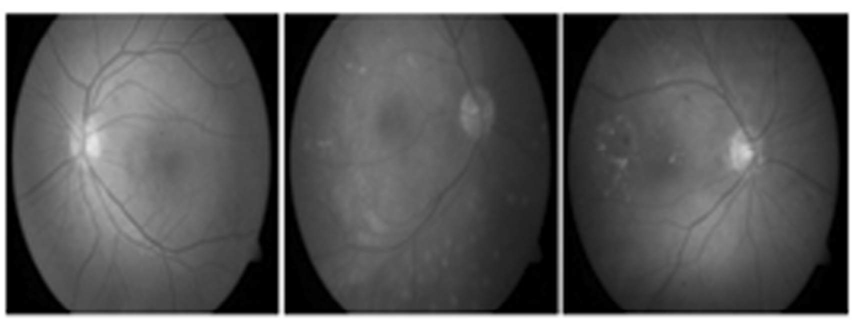


Figure 1: Sample images

(a) **(b)**

Figure 2: (a) Retinal Fundus Image, (b) Gray Converted Image

expanded inorder to make full use of the available dynamic range. Histogram Stretching can be done with the help of the following formula:

$$g(x, y) = \frac{f(x, y) - f_{\min}}{f_{\max} - f_{\min}} * (2^B - 1) \tag{1}$$

Here, f(x,y) represents the value of each pixel intensity, f_{min} and f_{max} represents the least and maximum pixel brightness value available in an image histogram. 2^B represents the available dynamic range actually present in an image. After performing Histogram Stretching, the intensity values are redistributed in uniform for the present dynamic value ranges.

Next step in preprocessing is to enhance the given image. Here, in this paper, image enhancement is carried out using Contrast Limited Adaptive Histogram Equalization (CLAHE). In this process, given histogram stretched retinal fundus images were sub divided in to different tiles. Here histogram equalization is separately performed on each tile. After performing Histogram Equalization, a single image is developed for all the tiles using interpolation method in order to avoid overlapping of edges. Here in each tiles, after determining its histogram, clipping is performed inorder to reduce the noise. Hence Histogram Equalization is performed on each tile after clipping. It is used inorder to eliminate the over amplification of unwanted noise in the homogeneous regions of an image.

Optic disc is the only region insensitive to light in the retinal portion of the eye. Hence optic disc is also known as blind spot[10] in the retina. The optis disc can be identified mistakenly as noise or drusen or as exudates since it is the brighter area in the retina. Therefore detection of optic disc is very important in the case of image analysis. Morphological processing technique uses local pixel transformation for region shaping. It is based on the comparison of pixel neighborhoods with a structuring element. Structuring Element is a predefined disc shaped image or mask that is used in processing the image. These structuring elements are placed on different pixels of the image with one pixel as center and compared with its neighboring pixels. Morphological operations may vary depending upon the functions we need to perform.. Some of the steps involved in Mathematical morphology technique are dilation, erosion, opening and closing. Dilation enlarges the foreground, shrinks background. It considers two images as inputs, image which is to be dilated and the structuring element which determines the function to be carried out for dilation on the input image. Dilation operator is given by:

$$D(I, H) = I \oplus H \tag{2}$$

Erosion shrinks foreground, enlarges Background. It first considers the image that need to be eroded and also a structuring element. Erosion operator used is:

(a) (b)

Figure 3: (a) Histogram Stretched Image, (b) Adaptive Histogram Equalized Image

$$D(I, H) = I \ominus H \quad (3)$$

Opening operation is erosion followed by dilation. Here stray brighter portions that are less than the compared structure element will be vanished and the larger image regions will be present in the output image. Closing operation is dilation followed by erosion.

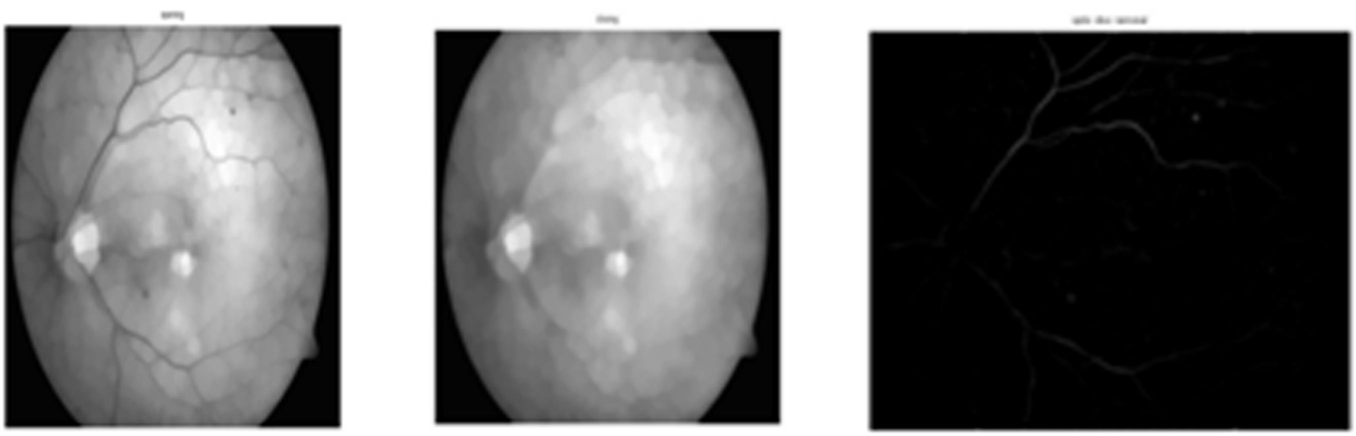
Opening operator is:

$$I \circ H = (I \ominus H) \oplus H \quad (4)$$

Closing operator is:

$$I \bullet H = (I \oplus H) \ominus H \quad (5)$$

After performing morphological operations, output image obtained are considered to perform further processing. After morphological opening and closing, subtraction is done on the resulting image obtained with the Contrast Limited Adaptive Histogram Equalization. The resulting image removes the optic disc and provides better result in the detection of Microaneurysms.



(a) (b) (c)

Figure 4: (a) Opening, (b) Closing, (c) Output

4. CONCLUSION

This paper proposes different stages of preprocessing that can be carried out on a low quality retinal image to generate an enhanced image which is used for the identification of initial lesions of diabetic retinopathy more precisely. Here color normalization is carried out inorder to improve the contrast and contrast enhancement is done inorder to make the intensity distribution present in an image to be uniform. Optic disc detection and segmentation is done using Mathematical Morphology techniques. From the optic disc removed images, Microaneurysms are clearly visible. Better feature extraction and classification methods can be used inorder to classify and grade the lesions present in the diabetic retinopathy images.

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