

# Retinopathy Detection of EYE Images in Diabetic Patients

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## Abstract

**Objective:** To detect the retinopathy in patients who are suffering from long term diabetes. This Diabetic Retinopathy (DR) causes the blindness in aged population. **Methods:** Initially, RGB retina image is to be converted into a gray scale image. Contrast Limited Adaptive Histogram Equalization (CLAHE) is performed on this gray scale image to adjust the different intensity variations to uniform intensity. **Findings:** Then morphological opening operation is performed to remove the background noise and to enhance blood vessels. Later, perimeter is extracted from morphed image by using canny edge detection. After this, graythresholding is performed on morphed image for extracting area. Then the resultant image shows the retinopathy. By following the above steps the retinopathy in diabetic patients can be detected easily. **Application:** This study is simple, suitable, sophisticated and an automated approach to detect DR using image processing techniques. The resultant image will give more segmented details for further diagnosis.

**Keywords:** Canny Edge Detection, Diabetic Retinopathy, Morphological Opening, Thresholding, CLAHE

## 1. Introduction

Retinopathy is an eye disease caused due to damage of blood vessels in retina. Diabetic Retinopathy is an ocular manifestation of diabetes<sup>1</sup>. Symptoms of this disease may include blurry vision, dark spots, leakage of blood vessels, double vision, pain in eyes, vision loss at the corners of eyes, swelling of retina<sup>2</sup>.

Major factors effecting DR are poor control of blood sugar and the age of diabetes. Pregnant women having diabetes are mostly affected. The four stages in diabetic retinopathy are: Mild DR Stage, Moderate DR stage, Severe DR stage and Proliferative DR stage. The pictorial representation of effect of DR. Diabetic Retinopathy cannot be cured. But vision can be improved by using some

laser treatments. It is to be done before the severe retina damage<sup>3</sup>.

According to recent researches of WHO (World Health Organization) nearly 5 percent of total cases of blindness are due to Diabetes<sup>4</sup>. Based on a recent review of 35 population based studies, the prevalence of DR, Vision Threatening Diabetic Retinopathy (VTDR), proliferative diabetic retinopathy, diabetic macular edema among individuals with diabetes is 34.6%,10.2%,7.0% and 6.8% respectively<sup>5</sup>. By extending these results to globe, we can estimate that the people who suffer from diabetes will grow from 126.6 million in 2011 to 191.0 million by 2030. The people with VTDR will increase from 37.3 million to 56.3million. Around 80% of population having diabetes for nearly 10 years or more years has the

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same stage of diabetes<sup>6</sup>. In<sup>7</sup> worked on classification of unhealthy eye from healthy eye and they attempted for automatic DR using computer based approach with the use of Convolutional Neural Networks (CNNs). In<sup>8</sup> used image analysis techniques like fuzzy clustering, top-hat transform, gray mathematical morphology etc., for early detection of diabetic retinopathy.

## 2. Preliminaries

### 2.1 RGB to Gray Scale Conversion

RGB image is also known as Colour image. In RGB image each pixel is specified by three values each one for Red, Green and Blue components of pixel scalar.  $M * N * 3$  array of class uint8, uint16, single, or double whose pixel values specify intensity values. The values range from [0, 1] for single or double arrays. The values range from [0, 255] for uint8. The values range from [0, 65535] for uint16. A RGB image can be represented as intensity function.

$$I_{\text{RGB}} = (F_R, F_G, F_B)$$

where,  $F_R(x, y)$  = Intensity of the pixel (x, y) in the Red channel

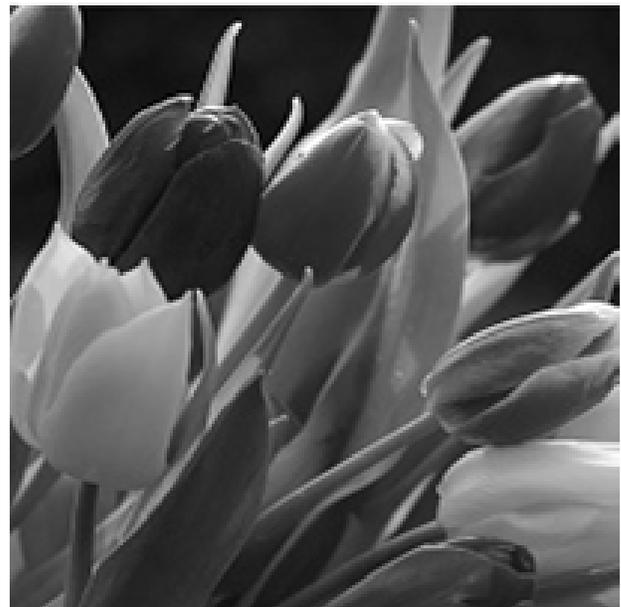
$F_G(x, y)$  = Intensity of the pixel (x, y) in the Green channel

$F_B(x, y)$  = Intensity of the pixel (x, y) in the Blue channel

Gray scale image is also known as intensity or gray level image. Array of class int16, single or double, uint8, uint16 whose pixel values specify intensity values. The values range from [0, 1] for uint8. The values range from [0, 65535] for uint16. The values range from [-32768, 32767] for int16.

$$I = \text{rgb2gray}(\text{RGB})$$

In this equation, `rgb2gray` function converts colour image into gray scale image by removing the hue and saturation information by retaining luminance. The example is shown in Figure 1.



**Figure 1.** RGB vs. Gray image.

## 2.2 Contrast Limited Adaptive Histogram Equalization (CLAHE)

CLAHE is one of the most popular spatial domain methods of Image enhancement. It is very useful method where the requirement of brightness is very high like under water environments or geographic channels. The slope of CDF function is given in Figure 2.

Adaptive Histogram Equalization (AHE) tends to over amplify the contrast in near constant regions of the image. But the histogram here is highly concentrated due to this AHE may cause noise to be amplified near constant regions. CLAHE differs from AHE by the limitation of contrast amplification and this reduces the noise amplification. Here the pixel value is given by slope of the transformation function which is proportional to the slope of the neighbourhood of Cumulative Distribution Function (CDF)<sup>9</sup>.

## 2.3 Morphological Opening

Morphological Operations are generally performed to remove the background noise. Here opening operation is performed which is erosion followed by dilation. Opening operation removes small objects from foreground and places them in background. Here the small objects from

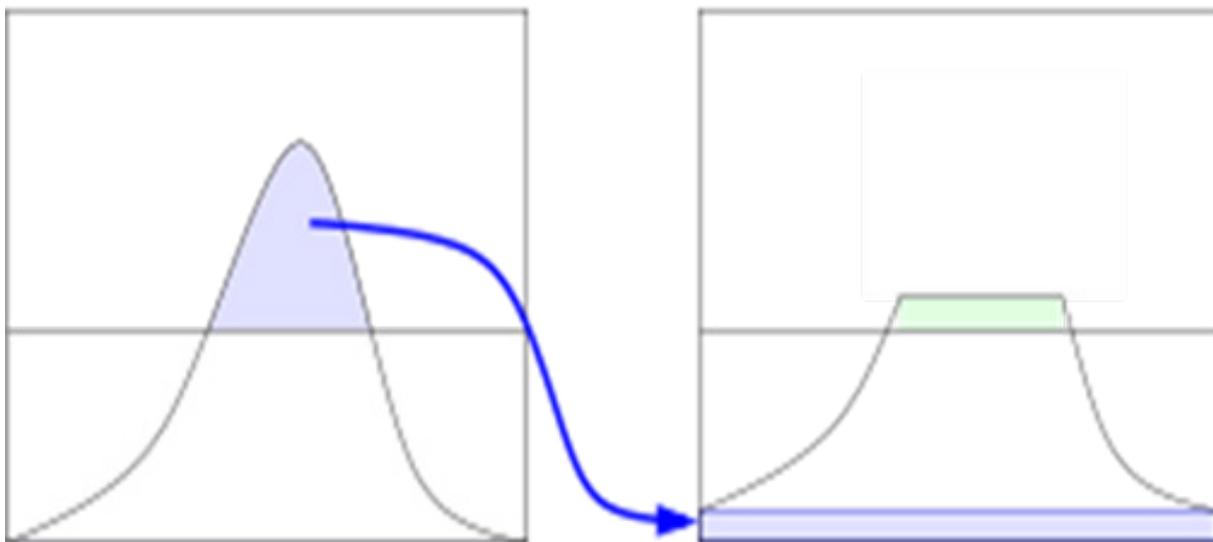
foreground are generally taken as bright pixels of an image. In this technique structuring elements such as disk like structures, diamond like structures are used<sup>10</sup>.

Scale multiplication is analyzed in the frame work of canny edge detection. The product of the responses of the detection filter at two scales is defined as the scale multiplication. The localization criteria can be improved by the scale multiplication at a small loss in detection criteria. Here the product of two criteria for scale multiplication is greater than that of a single scale which makes the canny edge detection even more better<sup>11</sup>.

Graythresholding is mostly used in Image segmentation especially for extending into 2-dimension histogram. The 2-dimensional Otsu method<sup>12</sup> utilizes the gray-level information of each pixel and its spatial correlation information within the neighbourhood. This gives better results compared to single dimensional Otsu method when the images are corrupted by noise<sup>13</sup>.

## 3. Proposed Method

This section deals with the proposed algorithm to identify the DR image with automation process. The flow of proposed work is shown in Figure 3. The algorithm is discussed below:



**Figure 2.** Slope of transformation function vs. Neighbourhood of CDF.

**STEP 1:** Conversion of a colour image to a RGB image is a simple step. Every pixel in a colour image is a combination of Red, blue and green components. The key used to convert a colour image to a gray scale image is 'rgb2gray'.

$$I = \text{rgb2gray}(\text{colour image})$$

The basic algorithm to find 3 parameters a, b, c and set the gray level value at each pixel Y as

$$Y = aR + bG + cB$$

Where R=Red component of the pixel

G=Green component of the pixel

B=Blue component of the pixel

a, b, c are parameters

**STEP 2:** Contrast Limited Adaptive Histogram Equalization is very useful to increase the brightness for geographical channels or underwater environments. All three equalized components are group together to form the colour equalized image. Contrast

Limited Adaptive Histogram Equalization was developed by enhancing the low contrast medical images.

By using uniform distribution the mathematical expression for standard Contrast Limited Adaptive Histogram equalization method is

$$G = [G_{MAX} - G_{MIN}] * P(F) + G_{MIN}$$

where,

$G_{MAX}$  = maximum value of the pixel

$G_{MIN}$  = minimum value of the pixel

G = computed value of the pixel

P(F) = Cumulative Probability Distribution of an equalization

Given retina image has different intensities. To equalize all those intensities as uniform intensity CLAHE is used.

$$C = \text{adapthisteq}(I)$$

Here the keyword 'adapthisteq' is used for CLAHE equalization and I is the gray scale image.

**STEP 3:** Morphological opening operation is performed in this step for clearer blood vessels and for removing background noise. Morphological opening is erosion followed by dilation. Pixels can be removed by using erosion on object boundaries and can be added by using dilation on boundaries of the object. The main element of the diabetic retinopathy is cracking of blood vessels. Hence it is very important step to differentiate blood vessels from background and extract them. In this model, for performing morphological opening disk like structure is used primarily with  $se=5$  to eliminate noise from the background and then diamond like structuring element is used with  $se=3$  to enhance the veins.

$$M = \text{imopen}(C, se);$$

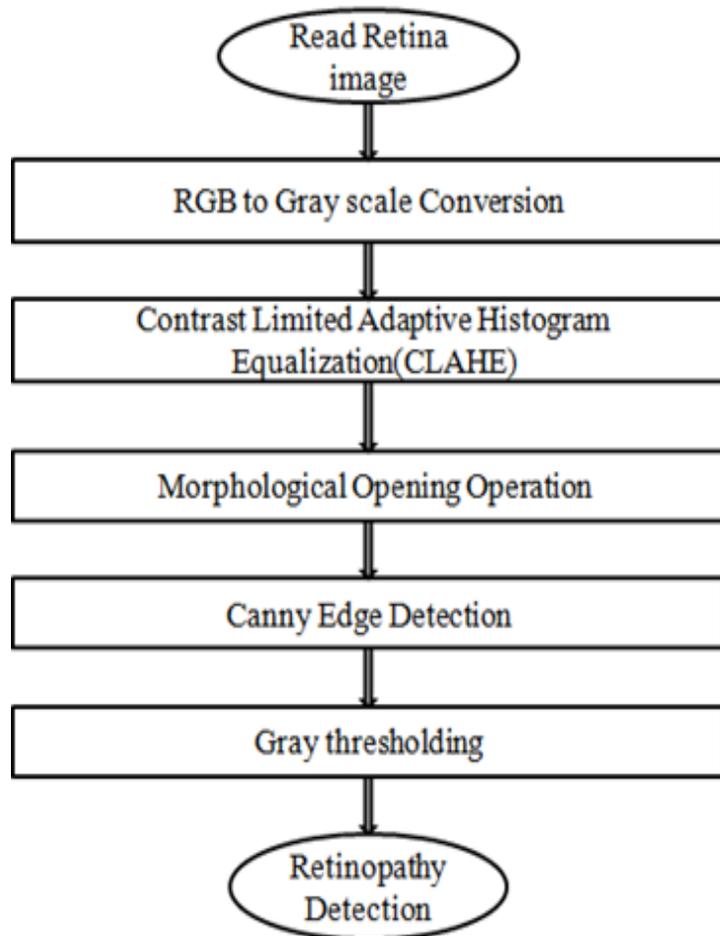
where, 'imopen' is a keyword which is used for morphological opening. C is the equalized image and se is the structuring element.

**STEP 4:** Canny edge detection technique is performed on morphed image to find the boundary objects in an image. By using canny edge detection perimeter of the images can be extracted for finding intensities at edges or boundaries.

For finding gradient magnitude, the equation is given by

$$\text{Edge\_Gradient}(G) = |G_x| + |G_y|$$

$$\text{Edge\_Gradient}(G) = \sqrt{G_x^2 + G_y^2}$$



**Figure 3.** Flow chart.

In this method, the boundaries of retina images can be found by using canny edge detection.

$$E = \text{edge}(M, \text{'canny'});$$

where, M is the morphed image.

**STEP 5:** Graythresholding partitions the given image into foreground and background. This method is only applied for gray scale images. By using Graythresholding, area of images can be extracted from morphed images. It gives better results compared to adaptive thresholding.

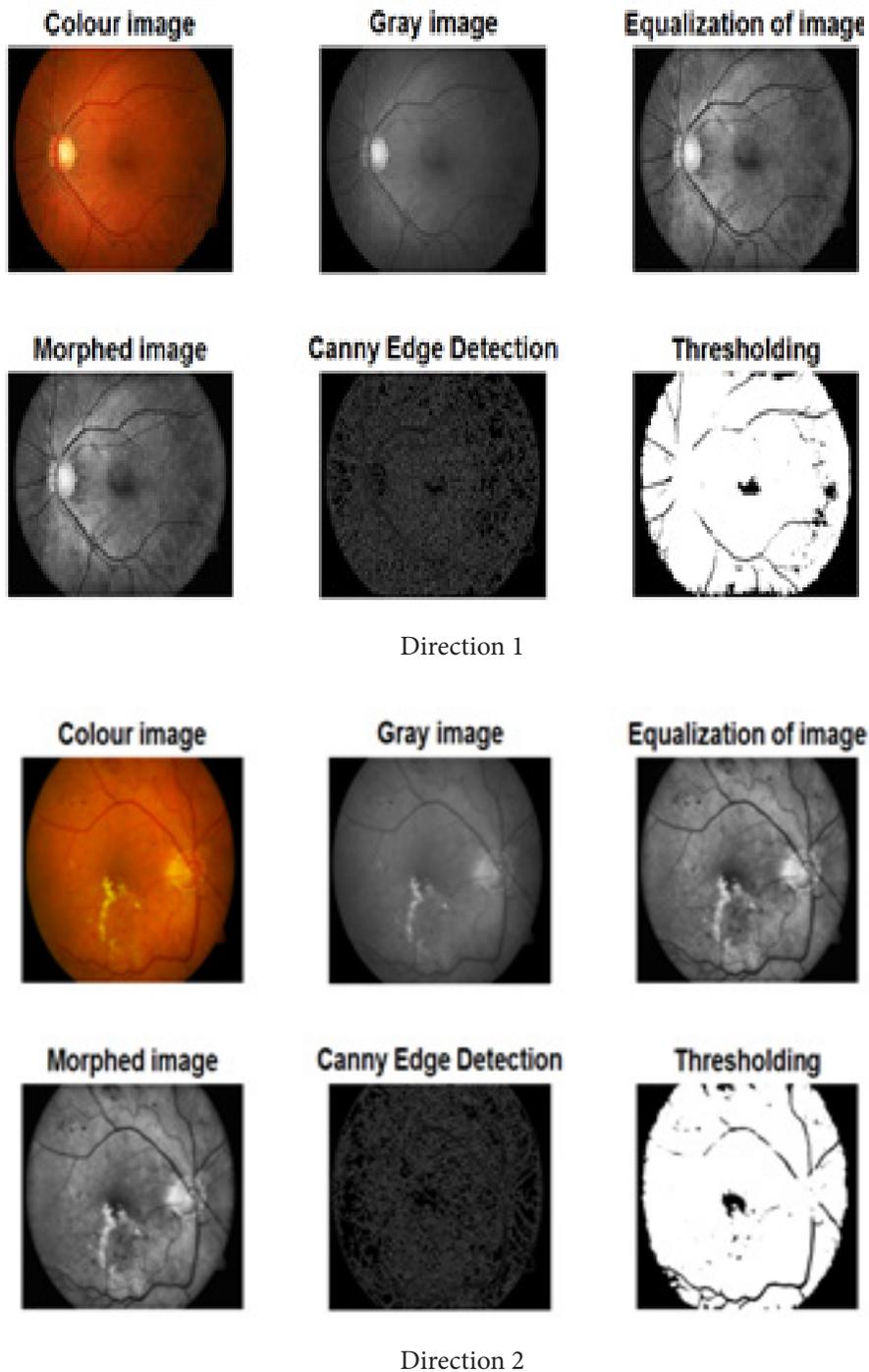
$$T = \text{graythresh}(E);$$

$$G = \text{im2bw}(M, T);$$

where, M is the morphed image and T is the threshold value of morphed image. After this step diabetic retinopathy can be easily identified.

## 4. Experimental Results

By employing 15 retina images as input we are able to get the effective results. The size of input retina image is 1152\*1500\*3 unit8, Gray image is 1152\*1500 unit8, equalized image is 1152\*1500 unit8, morphed image is 1152\*1500 unit8, canny edge detection is 1152\*1500 logical, Graythresholding is 1152\*1500 logical, structuring element is 1\*1 strel and the threshold value is  $T=0.2118$ .



**Figure 4.** Experimental results.

These simulation results were done by MATLAB 2007 software. The resultant images are shown in Figure 4 for two directional retina images.

## 5. Summary and Conclusion

In this paper work, Retinopathy Detection of eye images in diabetic patients was performed by using digital image

processing techniques. Firstly, the input retina image was read from data base then it was converted to gray scale image. Then, contrast limited adaptive histogram equalization was performed and the intensity variations were adjusted. By performing morphological opening operation the background noise was removed. After this, perimeter was extracted from morphed image by employing canny edge detection. Later, Graythresholding was performed to extract area of morphed image. Thus the retinopathy in diabetic patients was detected. The segmented details can be enhanced by using various kernel processing techniques or various morphological operations. This can be extended with advanced segmentation techniques in transform domain approach.

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