Journal of Electrical Technology UMY (JET-UMY), Vol. 4, No. 2, December 2020
ISSN 2550-1186 e-ISSN 2580-6823

# Retinal Digital Image Quality Improvement as A Diabetes Retinopatic Disease Detection Effort

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**Abstract** – *Image processing is a technical term useful for modifying images in various ways. In medicine, image processing has a vital role. One example of images in the medical world, namely retinal images, can be obtained from a fundus camera. The retina image is useful in the detection of diabetic retinopathy. In general, direct observation of diabetic retinopathy is conducted by a doctor on the retinal image. The weakness of this method is the slow handling of the disease. For this reason, a computer system is required to help doctors detect diabetes retinopathy quickly and accurately. This system involves a series of digital image processing techniques that can process retinal images into good quality images. In this research, a method to improve the quality of retinal images was designed by comparing the methods for adjusting histogram equalization, contrast stretching, and increasing brightness. The performance of the three methods was evaluated using Mean Square Error (MSE), Peak Signal to Noise Ratio (PSNR), and Signal to Noise Ratio (SNR). Low MSE values and high PSNR and SNR values indicated that the image had good quality. The results of the study revealed that the image was the best to use, as evidenced by the lowest MSE values and the highest SNR and PSNR values compared to other techniques. It indicated that adaptive histogram equalization techniques could improve image quality while maintaining its information.*

***Keywords***: *Image processing, retinal imagery, diabetic retinopathy*

## I. Introduction

Diabetes is a metabolic disease characterized by high blood sugar levels (hyperglycemia) due to a lack of insulin in the body. According to WHO, in 2014, the number of diabetics in the world was estimated at 387 million. Furthermore, the WHO stated that in 2012, diabetes became the leading cause of 1.5 million deaths. In 2014, Indonesia alone had around 9.1 million diabetics, the fifth-highest number in the world. High sugar levels continuously for years can cause complications in other organs, including the eyes. Complications of diabetes attacking the eye, specifically the retina, are called diabetic retinopathy (DR) or diabetic retinopathy and can cause blindness [1].

In medicine, direct observation of diabetic retinopathy is carried out by doctors on the retinal images of patients taken using a fundus camera. However, the retinal image produced by fundus cameras often has poor quality. Therefore, various image processing techniques should be applied to improve retinal image quality. A good quality retinal image can help doctors classify the DR phase quickly and precisely.

Image processing is a series of attempts to manipulate and modify images without changing the content of information attached to an image [2]. Each stage in image processing is intended to enhance image features, both useful for visual display and further image analysis [3]. One image processing application is to manipulate photos, two-dimensional images produced by the camera to record objects, and specific moments.

As explained above, retinal photo images

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recorded using a fundus camera often have poor quality. It can reduce the accuracy of the doctors' diagnosis of diabetic retinopathy. Therefore, in this study, a method to improve the quality of retinal digital images was designed with variations in histogram equalization techniques, contrast stretching, and increased brightness. The performance of the three techniques was measured using Mean Square Error (MSE), Peak Signal to Noise Ratio (PSNR), and Signal to Noise Ratio (SNR). This research aimed to determine the best method for improving the retinal digital image quality to assist doctors in detecting DR, the method with the lowest output MSE value, and the highest PSNR and SNR image output values.

## II. Basic Theory

### *II.1. Literature Review*

To obtain an exudate, a characteristic of diabetic retinopathy, a binary image, or a black and white image is required. In research conducted by Pratama [4], binary images are generated by applying specific threshold values to the pre-processing images. This value is used to partition the pixel values in the pre-processed image into two gray levels, black and white. In the pre-processing stage of this study, adaptive histogram equalization (adapthisteq) was used to improve image quality, mainly to make the exudate pixels clearer.

A binary retinal image is also required to determine abnormalities other than the exudate in the retinal image. According to Putra [5], some processes should obtain binary retinal images include gray scaling, Gaussian filtering, histogram equalization, and median filtering. A series of these processes is needed to improve the retinal image quality before the binarization process is carried out.

Pre-processing aims to improve image quality by manipulating image parameters. In Setiawan [6], the pre-processing process consisted of grayscale, Gaussian filtering, histogram equalization, and masking. The results of processing were used as detection of retinopathy. The pre-processing process was also used in the diabetes retinopathy detection system built by Putra [7]. The pre-processing stage, consisting of gray scaling and scaling processes, was applied to the image before the binarization process was carried out on the image. The application of the gray scaling and scaling process aimed to facilitate the detection system of the disease.

### *II.2. Diabetes Retinopathy*

Diabetes is a syndrome or disease resulting from a deficiency of the hormone insulin. The hormone insulin in the body is tasked with stimulating cells to absorb glucose, which later functions as a source of energy [8]. The decrease in the body's insulin levels causes glucose not to be absorbed optimally, causing the increased glucose levels in the blood. High glucose levels in the blood can continuously cause complications in other organs, such as in the retina of the eye, referred to as diabetic retinopathy. This disease causes abnormalities in the retina, and in the worst conditions, will cause blindness. Some of the factors causing this disorder are the duration of diabetes, age, blood pressure level, puberty, pregnancy, and others [9].

Diabetic retinopathy in a person can be identified through observations by an ophthalmologist on the retinal image recorded using a fundus camera. Here is an example image of a fundus camera tool, as can be seen in Fig. 1.

Fig. 1. Camera Fundus (CDC, 1989)

From the results of the camera, the results obtained in the form of images of the retinal eye image. One of the results of a retinal color image of a fundus camera can be seen in Fig. 2.

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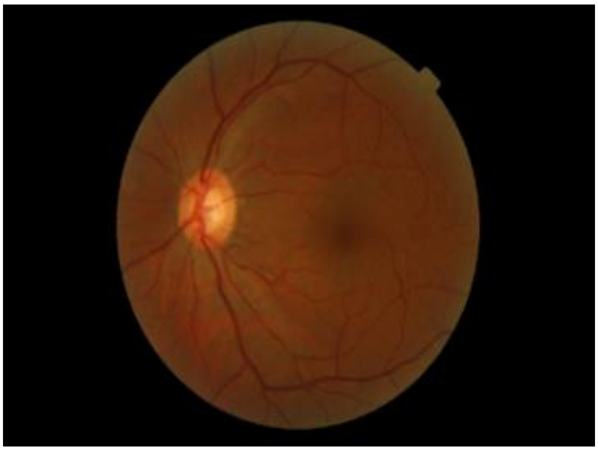

Fig. 2. Retina Imagery (CDC, 1989)

*II.3. Image Processing*

Image is a two-dimensional function, f (x, y), where x and y are spatial coordinates and f in each pair of coordinates (x, y) is called the intensity or gray level of an image at that point (x, y) [10]. Digital image size is expressed in points or pixels and can also be in units of length (mm or inches = inch). As a one-dimensional signal that can be expressed with a 1 × M vector, digital images are also represented by a matrix of size N × M (N denotes row or height, while M represents column or width), as shown in Fig. 3.

$$f(x,y) = \begin{bmatrix} f(0,0) & f(0,1) & \cdots & f(0,M-1) \\ f(1,0) & f(0,0) & \cdots & f(1,M-1) \\ \vdots & \vdots & \vdots & \vdots \\ f(N-1,0) & f(N-1,1) & \ldots & f(N-1,M-1) \end{bmatrix}$$

Fig. 3. Digital Image Matrix (Afternoon, 2005)

In general, the term digital image processing states two-dimensional image processing using digital computers [2]. In other words, image processing is a variety of techniques used to manipulate and modify images. Image processing is a crucial part underlying a variety of real applications, such as medical image-based disease detection, pattern recognition, remote sensing via satellite or aircraft, and machine vision [11].

*II.4. Image Quality*

The contrast of an image can be briefly explained in Fig. 4. The image in Fig. 4 (a) is said to have low contrast because it is too bright or overexposed. The image histogram shows that the image intensity values in Fig. 4 (a) left only fill the upper half of the gray level area available. In contrast, the image in Fig. 4 (c) is underexposed, that is, the image is too dark, marked by the intensity values of this image only filling the lower area of the gray level provided. It is also an image with bad contrast. In Fig. 4 (b), it is an example of an image with good contrast, which, when viewed in the histogram, the gray level available is filled with an almost even distribution of pixels [12].

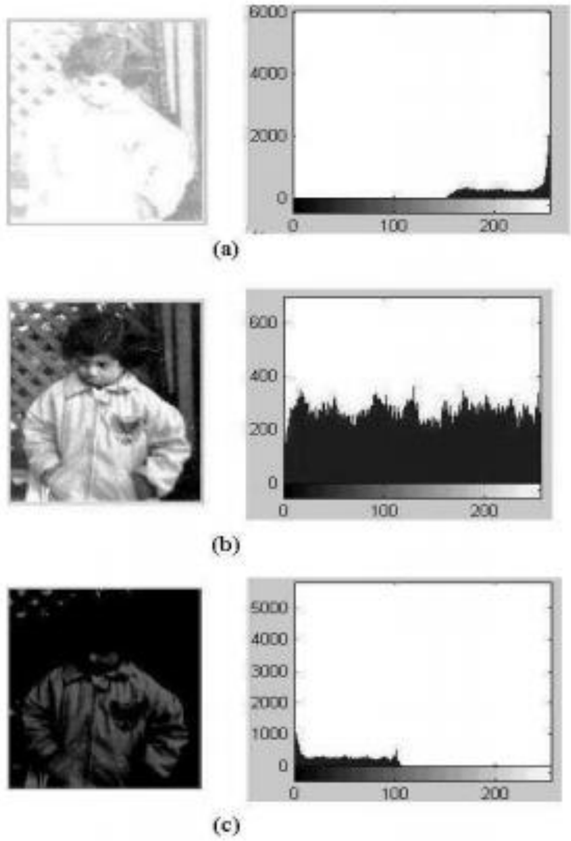


Fig. 4. Understanding of image contrast: (a) The image is overexposed, (b) The image with good contrast, and (c) The image is underexposed

The brightness of the image can be changed to make it brighter or darker. Image brightness can be improved by adding or subtracting a constant to (or from) each pixel in the image. As a result of this operation, the image histogram shifts right and left, respectively, for image addition and subtraction brightness operations. For example, Fig. 5 (a) is a Zelda image (with its histogram) that appears dark, while Fig. 5 (b) is a lighter Zelda image (with its histogram) (value b = 80). With this operation, the image histogram in Fig. 5 (a), previously assembled on the left, becomes shifted to the right (Fig. 5 (b)) [13].

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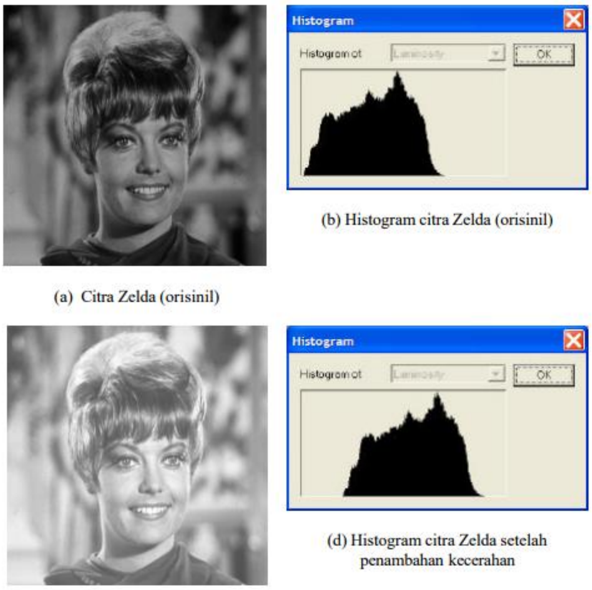

(a) Citra Zelda (orisinil)

(b) Histogram citra Zelda (orisinil)

(c) Citra Zelda setelah penambahan kecerahan dengan *b* = 80

(d) Histogram citra Zelda setelah penambahan kecerahan

Fig. 5. Zelda Image: Top: before the brightness enhancement operation. Bottom: after the operation of adding brightness with b = 80

Histogram equalization is done to change the intensity value of the image so that the distribution is uniform, or in other words, each degree of gray has a relatively equal number of pixels [14]. Furthermore, the Adaptive Histogram Equalization Method is also known, which in this method, the image is divided into blocks of size n × n, then each histogram equalization process is carried out. [15]-[18].

The floating process or thresholding will produce a binary image with two gray-level values (black and white). In general, floating color images or grayscale images to produce binary images are as seen in [19].

## III. Methodology

The stages of the study can be explained as follows.

Stage 1. Literature Study

A literature study was carried out by finding information from books and research in advance to enhance previous research.

Stage 2. Retrieval of Research Data

Retrieval of research data was done by downloading a retinal digital image sourced from a database sourced from Diaretdb1 with a resolution of 1500 × 1152 pixels and PNG format.

Stage 3. Image Processing

Image processing began by providing input in the form of a retinal digital image. These images are color images that will be converted into grayscale images. After that, there were three kinds of improvements in image quality, namely histogram equalization, contour level, and brightness level.

Stage 4. Performance Measurement Method

Of the three methods used, image quality performance was calculated using several parameters such as MSE, SNR, and PSNR. Mean Squared Error (MSE) aimed to value of the error squared. The error shows how big the difference is between the estimated results and the value to be estimated [20].

Signal to Noise Ratio (SNR) is the ratio of power in a signal to the power contained by a noise appearing at specific points during transmission. PSNR is used to measure the quality of an image. The recommended PSNR values range from 30 dB to 45 dB [21].

Stage 5. Determination of the Best Quality Image

At this stage, the image with the best performance value will be selected, namely MSE, PSNR, and SNR. The image with the highest value of these parameters is the image that has the best image quality.

Image processing begins with making the digital retina color image as input. Furthermore, the input image will be converted into a gray image (grayscale). After that, three methods of enhancing image quality, namely histogram equalization, contrast settings, and brightness settings, will be applied to gray images separately. Then, the image of the results of the application of the three methods will be measured in the value of MSE, SNR, and PSNR. The best quality image obtained from the parameter assessment will be selected as the output of this study.

## IV. Results And Discussion

Image processing aimed to enhance image features, such as those useful for visual display and further image analysis. Used database sourced from Diaretdb1 with a resolution of 1500 × 1152 pixels and PNG format. The process of enhancing the image did not change the content of information attached to digital data. The process of digital image analog image conversion was called digitization, and the tool was called a digitizer, functioning to convert an image to a numerical representation process suitable for input by a computer. Digital

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images were obtained automatically from a digital image capture system (digitizer) that performed image formation and formed a matrix where the elements were expressed as light intensity values at a discrete set of points. On the digitizer, the received signal was still an analog signal that should be changed digitally by changing the continuous price to a discrete price. Furthermore, a discrete image was processed on a digital computer to be ready to be displayed on the display monitor by processing a digital video processor through image processing to the pixels in the image.

However, binary images are images where the pixels only have two intensity values, 0 and 1. The 0 represents the background color, and 1 represents the ink/object color (foreground) or a number 0 for color black and number 255 for white. The binary image was obtained from the previous threshold image value.

### *IV.1. Color Retina Digital Image*

The RGB image is one type of image where each pixel represents three primary colors, namely, Red, Green, and Blue (RGB). Each base color uses 8-bit storage, meaning that each color has a gradation of 255 colors. Thus, each pixel has 16 million color combinations. Due to its many color combinations, an RGB image is called a True Color image. Here is a picture of the color image of the retinal image, as seen in Fig. 6.

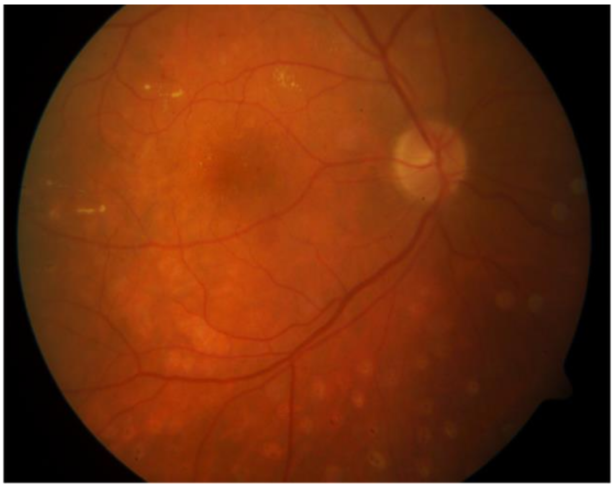

Fig. 6. Example of an RGB Color Image

### *IV.2. Grayscalling*

The retinal color image above was made into a grayscale image. Grayscale image structure can represent the structure of color images, thereby the computational load is lighter, as in the following retinal image, as seen in Fig. 7.

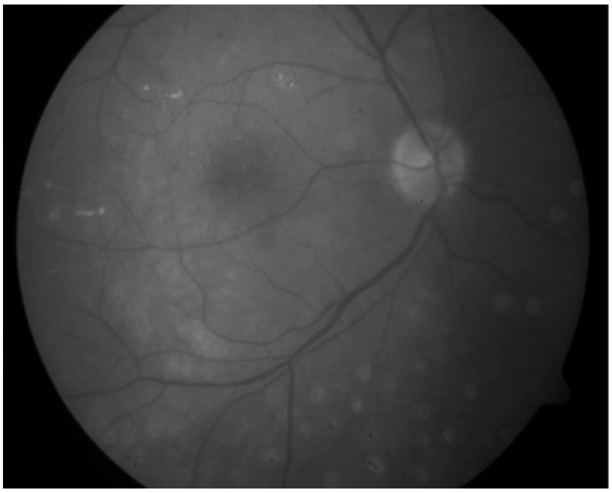

Fig. 7. Example of Grayscale Retina Image

The grayscale image requires information on the color distribution. Therefore, an image histogram is needed. The grayscale retinal image has a relatively dark color distribution because the image histogram is only filled at a low intensity, i.e., dark intensity. Fig. 8 shows histogram of a grayscale retina image.

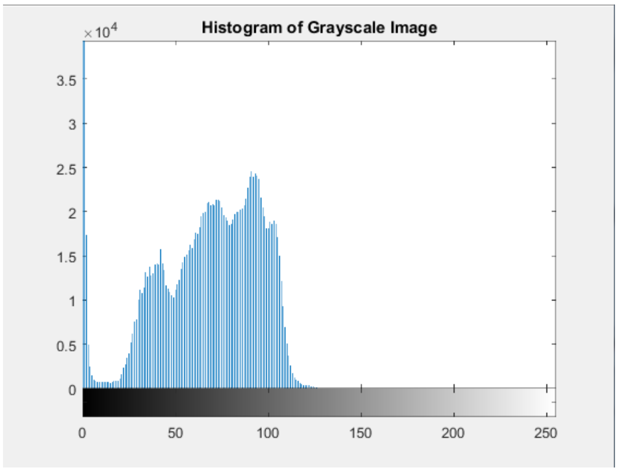


Fig. 8. Histogram of a Grayscale Retina Image

### *IV.3. Histogram Equalization*

One enhancement technique is histogram equalization, an image processing technique aiming to produce a uniform image. A uniform image was carried out by changing the intensity of an image into an image with a relatively similar histogram value at each level. Another name for histogram

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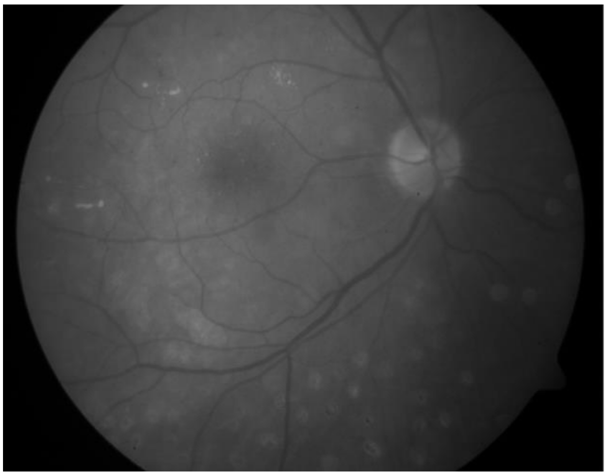
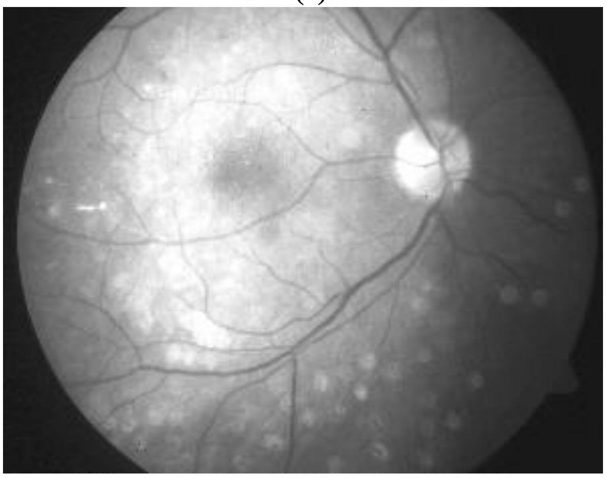
equalization is histogram linearization. The following is a retinal image produced by one histogram equalization techniques, namely global histogram equalization, as shown in Fig. 9, (a) before and (b) after the global histogram equalization technique.



(a)



(b)

Fig. 9. Imagery (a) Before and (b) After the Global Histogram Equalization Technique

The retinal image structure appeared clearer from the picture, but the distribution of pixel intensities was not evenly distributed, as seen in Fig. 10.

Because the results of the previous technique were not good, the adaptive histogram equalization technique was used. This technique is a development technique from the previous technique. This technique performs histogram equalization based on the value of the neighboring pixel intensities. In contrast to the technique globally, only histogram equalization is based on the overall value of the pixel. The following are the results of the retinal image from the adaptive histogram equalization technique, as can be seen in Fig. 11.

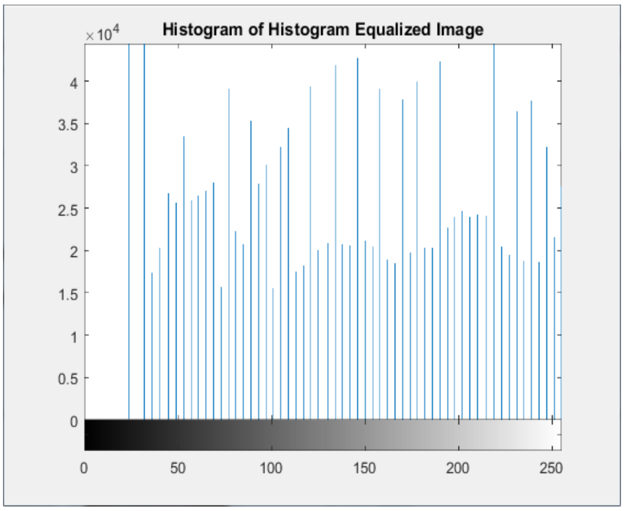
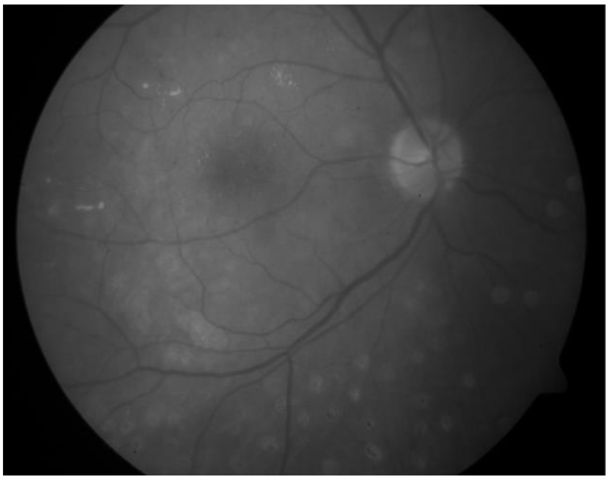
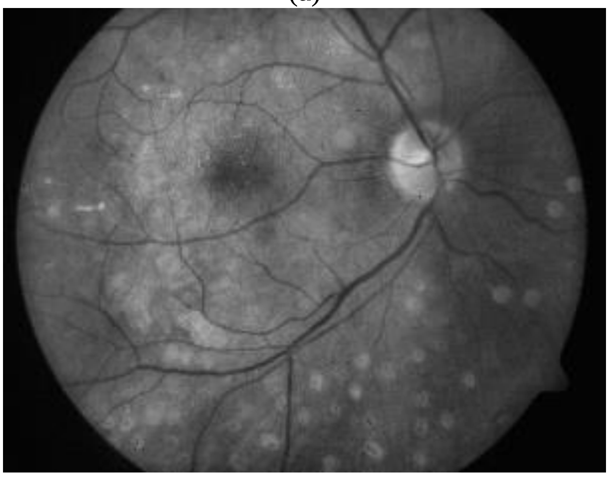



Figure 10. Retinal Image Histogram with Global Image Equalization Techniques



(a)



(b)

Fig. 11. Imagery (a) Before and (b) After the Adaptive Histogram Equalization Technique

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The images in Fig. 11 above depicts a clear image structure, indicating a proportional increase in image quality. It was made clear by the increasingly small objects in the retinal image, causing the information in the image to be increasingly visible. An image histogram resulting from this technique can also be seen in Fig. 12.

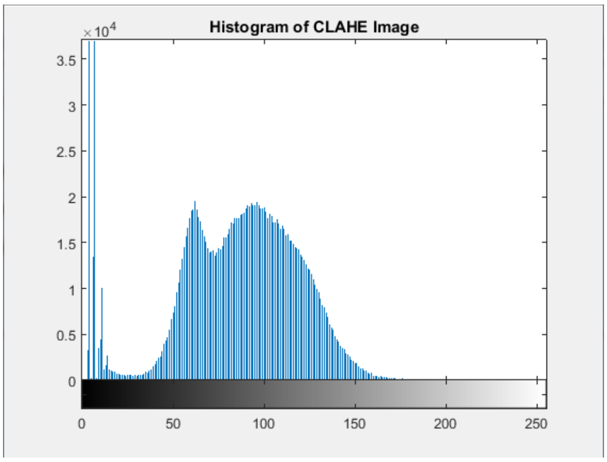


Fig. 12. Retinal Image Histogram with Adaptive Histogram Equalization Technique

From several techniques to improve image quality, several parameters were assessed, namely Mean Square Error (MSE), Signal to Noise Ratio (SNR), and Peak Signal to Noise Ratio (PSNR). The following are the results of the method performance assessment, as shown in Table I.

Table I. Method Performance Assessment Table

| Technique | Quantitative | | |
|---|---|---|---|
| | MSE | SNR (dB) | PSNR (dB) |
| Global histogram equalization | $6.403 \times 10^3$ | -1.318 | 10.067 |
| Adaptive histogram equalization | $4.713 \times 10^2$ | 10.014 | 21.398 |

Some techniques could not be assessed for performance. In the technique, the comparison image was an image with an unequal amount of intensity. For example, the grayscale technique could not be calculated for its performance because its image could not be compared to the previous image (color image) having a higher image intensity than the grayscale image. Performance could be calculated for other techniques because the images before and after the technique were grayscale format images.

## V. Conclusions

The image used was the best, as evidenced by the lowest MSE value and the highest SNR and PSNR values compared to other techniques. It indicated that adaptive histogram equalization techniques could improve image quality while maintaining its information.

Recommendations to perfect this research can be added to other image quality improvement methods; thereby, more optimal results can be obtained.

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