Color Retinal Image Enhancement using CLAHE

Agung W. Setiawan, Tati R. Mengko, Oerip S. Santoso
Biomedical Engineering Research Group
SEEI, Institut Teknologi Bandung
Bandung, Indonesia
awsetiawan@biomed.ee.itb.ac.id, tmengko@itb.ac.id,
oerip@informatika.org

Andriyan B. Suksmono
Telecommunication Engineering Research Group
SEEI, Institut Teknologi Bandung
Bandung, Indonesia
suksmono@stei.itb.ac.id

***Abstract*—*Common method in image enhancement that's often use is histogram equalization, due to this method is simple and has low computation load. In this research, we use Contrast Limited Adaptive Histogram Equalization (CLAHE) to enhance the color retinal image. To reduce this noise effect in color retinal image due to the acquisition process, we need to enhance this image. Color retinal image has unique characteristic than other image, that is, this image has important in green (G) channel. Image enhancement has important contribution in ophthalmology. In this paper, we propose new enhancement method using CLAHE in G channel to improve the color retinal image quality. The enhancement process conduct in G channel is appropriate to enhance the color retinal image quality.*

Keywords—color; retinal image; asymmetric; enhancement; CLAHE

I. INTRODUCTION

Image enhancement has important contribution in ophthalmology, especially in retinopathy diabetic in detecting micro aneurysms. The detection can be done manually by the ophthalmologist or automatic detection using image processing technique (known as Computer Aided Diagnosis / CAD). Fundus camera is a standard imaging modality in eye hospital or clinics, we can use this camera to obtain retinal image. The image quality is depending on acquisition process, for example, lighting, eye blinking, and eye movement. Image quality is very important, due to the fact that the ophthalmologist use this image to conduct diagnosis. If there is some noise in the image, this will decrease the sensitivity and specificity. The examples of good and poor quality of color retinal image are shown in Figure 1.

There are some important features in color retinal image that are: color and contrast (especially optic disc and blood vessels). Noise that appears in this image is caused by the uneven illumination. To reduce this noise effect in color retinal image due to the acquisition process, we need to enhance this image. Color retinal image has unique characteristic than other image, that is, this image has important in green (G) channel, due to the fact that in this channel, the blood vessels appear more contrast than the background. In this research, we will explore this characteristic and apply image enhancement technique to improve the image quality.

(a) (b)

Fig. 1. *(a) Good and (b) poor quality of color retinal image.*

II. COLOR RETINAL IMAGE ENHANCEMENT

Image histogram is representation of image intensity value. The histogram main function is to give statistical information of the image. Due to this reason, we can manipulate the histogram to conduct image enhancement.

Common method in image enhancement that's often use is histogram equalization, due to this method is simple and has low computation load. In this research, we use Contrast Limited Adaptive Histogram Equalization (CLAHE) to enhance the color retinal image. This enhancement method is widely used in ophthalmology, for example in automatic detection of micro aneurisms, retinal blood vessel segmentation.

One of the main features in color retinal image is the blood vessel contrast. The contrast of an image is combination from the range of intensity value and differentiation of the maximum and minimum pixel values. The objective of image enhancement using histogram manipulation is to get the uniform distribution of the intensity. The image with low contrast has narrow effective intensity range. Histogram equalization spread the intensity distribution and adjusts the intensity of the original image.

The flowchart of the color retinal image enhancement that's proposed in this research is shown in Figure 2. We use RGB color retinal image as input image. The first process is to split the color image channel, so we have three images: R, G, and B image channels. The image enhancement process using CLAHE only conduct in G channel, due to the fact that this

channel has important blood vessel structural information than the other ones. Then we have enhanced G channel image. The next process is to merge the three image channel (R, enhanced G, and R). In the end of the process, we obtain the enhanced color retinal image.

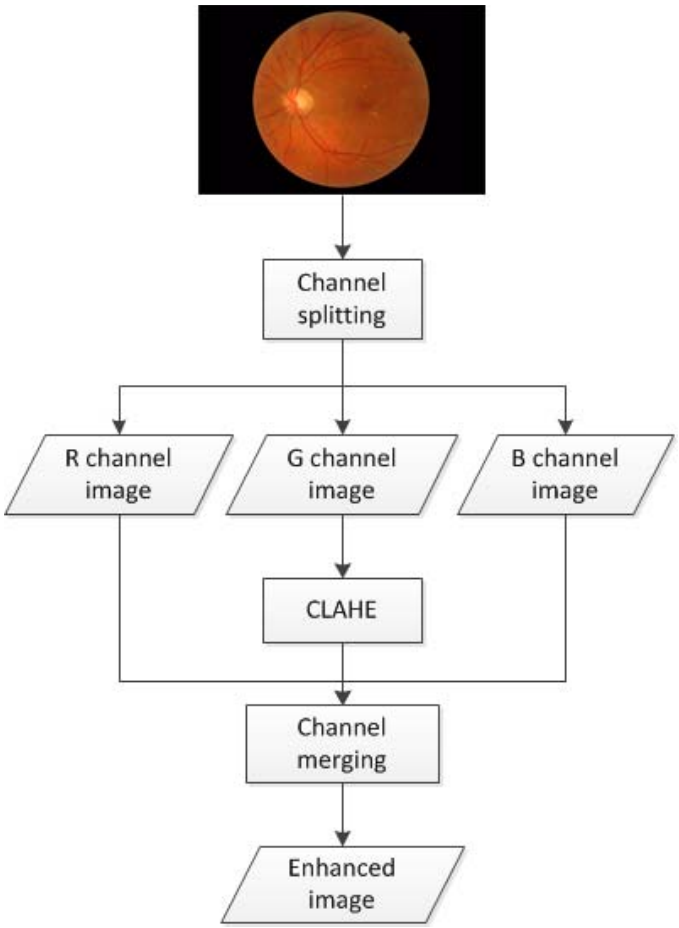

Fig. 2. *Color retinal image enhancement flowchart*

Fig. 3. *Input image*

One of the input images that are used in this research is shown in Figure 3. From the visual observation, we can see that there are some noises, haze, in the image. The structural blood vessel information is not too contrast, especially the tiny one. So, we need to improve this color retinal image quality.

III. Result

In this section, we will show four enhanced images. The first one is in Figure 4 show the enhanced image using CLAHE in R channel. From the visual observation, we can see that there is more noise in the image than the original (input) image. Some retinal blood vessels disappear or not too contrast. The second enhanced image is the image result from our method that is the enhanced image using CLAHE in G channel, can be seen in Figure 5. In this figure, we can see the blood vessel structural information more contrast than the original (input) one. We can see the tiny blood vessel and can get information from this image.

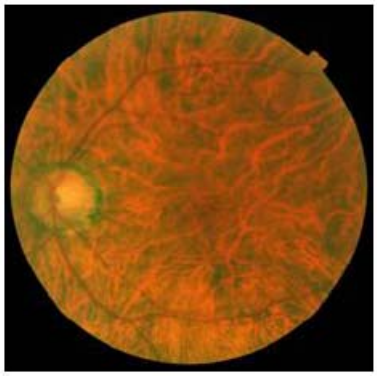

Fig. 4. *Enhanced image using CLAHE in R channel.*

Fig. 5. *Enhanced image using CLAHE in G channel.*

In Figure 6, we can see the enhanced image using CLAHE in B channel. The enhancement process doesn't improve the image quality significantly and tend to be poor than the original one. There is some haze that enveloped the color retinal image. The information that's needed by ophthalmologist doesn't appear clearly in this image.

Fig. 6. *Enhanced image using CLAHE in B channel.*

The last enhanced image is shown in Figure 7, the enhanced image using CLAHE in all (RGB) channel. The enhancement process is conduct in three image channels. From the visual observation, in this image we can see the retinal blood vessel but not so clear compare to the enhanced image in Figure 5. The retinal image background is dominating the color and texture information. From the literature review, we can get the R channel is dominating the color retinal image. So, if we apply image enhancement in this channel, the enhanced image will be dominated by the R channel. This explanation is same as the enhanced image in Figure 4.

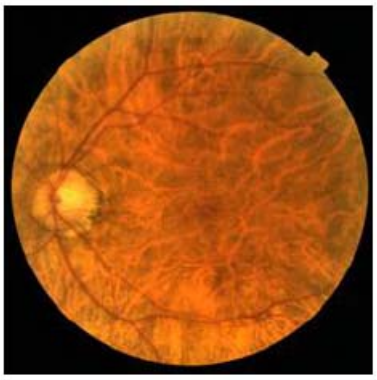

Fig. 7. *Enhanced image using CLAHE in all (RGB) channel.*

We can see other enhanced color retinal image using CLAHE in G channel in Figure 8. There are two color retinal images. The first row is the original image, the second one is the enhanced image using CLAHE in G channel, and the last one is the enhanced image using CLAHE in all (RGB) channel. In this image, we want to give additional information / data that our color retinal image enhancement method is suitable to improve the retinal image quality.

IV. CONCLUSION AND FURTHER DEVELOPMENTS

In this research, we propose new enhancement method using CLAHE in G channel to improve the color retinal image quality. We can conclude that the enhancement process conduct in G channel is appropriate to enhance the color retinal image quality. In this paper, we use visual observation to assess the enhanced images and compare them with the original ones. Next development is to conduct the quantitative method to assess the enhanced image.

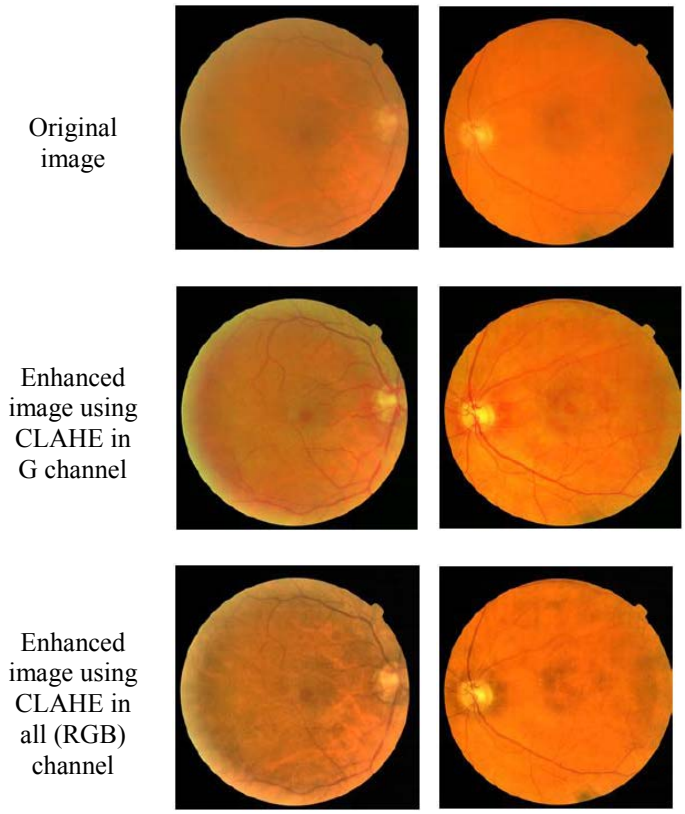

Fig. 8. *Another original and enhanced image using CLAHE in G channel.*

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