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Comparison of Histogram Based Image Enhancement Methods on Iris Images

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Abstract. Iridology, which is an alternative diagnosis that links iris patterns, colour, tissue weakness, damage and other characteristics, which can obtain evidence about the patient's systemic health. Iridology can be integrated with the best technology such as computer vision for accurate identification of abnormalities in various organs of the human body. By extracting information from iris image data. Image quality improvement is needed because often the images tested have poor quality, for example images experiencing lighting, noise (noise), the image is too dark or bright, the image is not sharp, and blurred. In this research, the iris image quality was improved by the method of HE, AHE and CLAHE. The results of the improvement of 40 iris images obtained an average value of MSE and RSME, the smallest of the three methods is the CLAHE method, so that the CLAHE method is best used for iris image improvement. Overall, based on the PSNR values, the three methods are good for enhancing image contrast because they have an average PSNR of more than 30dB.

Keywords : AHE, CLAHE, enhancement, HE, image, iris

1. Introduction

The development of computer technology and services has led to increased efficiency, diagnosis and treatment that is very reliable, fast and accurate against dangerous diseases. Many ways to detect disease, one of them with a blood test. However, taking blood samples called the invasive method, causing injury and pain that causes discomfort [1]. In an effort to reduce discomfort when detecting early, other non-invasive methods are needed.

According to Harris et al, Complementary and Alternative Medicine (CAM) therapy is quite popular for chronic diseases such as diabetes and arthritis. CAM has become very popular in the last few decades. Many medical practitioners believe this therapy is unorthodox, but in many countries CAM is widely used for health care applications [2]. Harris et al found that about 52% and 38% used CAM in Australia



and the United States. The researchers also found a significant upward trend in the population of CAM use.

One of the therapies in CAM is iridology, which is an alternative diagnosis that links iris patterns, color, tissue weakness, damage and other characteristics, which can obtain evidence about the patient's systemic health. Iridology practitioners match their interpretations with iris charts. The iris of the eye is divided into zones that correspond to certain body organs [3]. Iris charts / maps help as an additional source for diagnosing medical conditions. Um et al investigated the relationship between the iridological constitution and the ACE polymorphism in hypertension [4].

Iridology can be integrated with the best technology such as computer vision for accurate identification of abnormalities in various organs of the human body. Computer vision is a contemporary technology that involves transforming data from still or video cameras into new decisions or representations for the purpose of achieving certain goals [5]. One of the most prominent fields of computer vision applications is medical imaging. This area is marked by the extraction of information from image data for the purpose of making a patient's medical diagnosis.

In making medical diagnosis based on iris image data, the stage of enhancing image quality is the initial stage (pre-processing) which has an important role, before entering the image processing stage, the feature extraction stage and the classification stage. The image that is improved in quality becomes better quantitatively. In improving iris image quality, one of the main concerns is image contrast improvement. Optimal image contrast produces an overall clear image, in addition to contrast, noise reduction also greatly affects image quality.

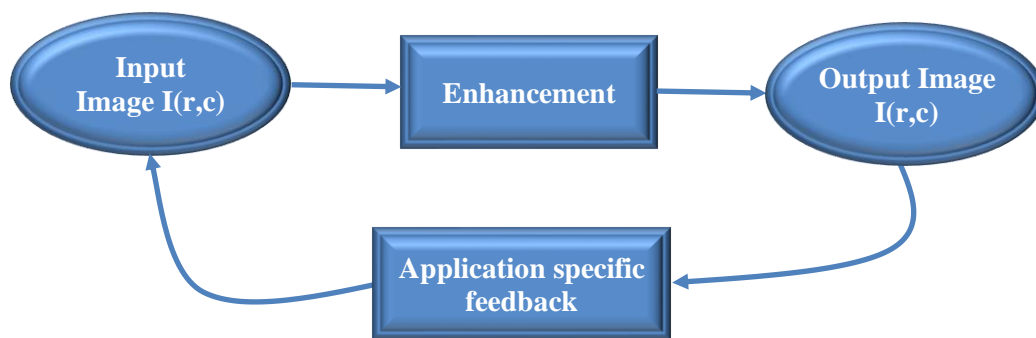


Figure 1. The Image Enhancement Process. As with image analysis, feedback from the application is of paramount importance.[6]

In the process of enhancing the image, the image is taken as input and an enhancement algorithm is applied to it. After that the enhanced image is taken as output as shown in Figure 1. The techniques commonly used for image enhancement are noise removal, edge enhancement and contrast enhancement. The contrast enhancement technique is the most popular. Contrast enhancement is one of the most important techniques for image enhancement [7]. In this paper, I will compare three methods of image contrast improvement, namely Histogram Equalization (HE), Adaptive Histogram Equalization (AHE) and Contrast Limited Adaptive Histogram Equalization (CLAHE).

2. Methods

Image quality improvement is needed because often the image being tested has poor quality, for example images experiencing lighting, noise, the image is too dark or bright, the image is less sharp, blurry, and so on. The process of improving image quality aims to simplify the analytical steps that require detailed extraction of image objects. An image that is experiencing disturbances such as an invisible image object due to low lighting around the image is an image of poor quality. To overcome the problematic image

quality, a technique is needed to correct it. Figure 2 shows a block diagram of the system with the image enhancement method.

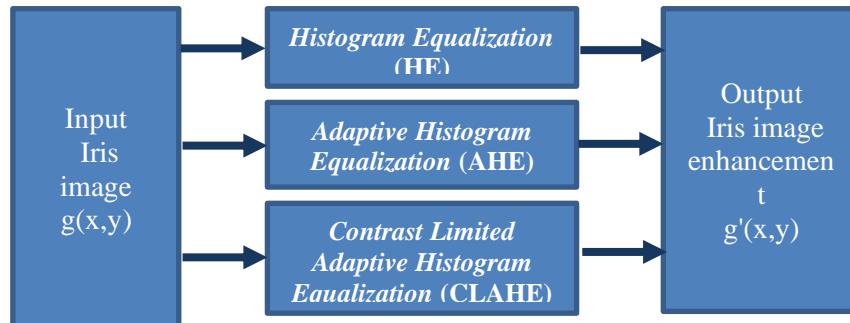


Figure 2. Block system diagram

2.1 Histogram Equalization (HE)

HE is a technique that is widely used for increased contrast because it is easy to use and performs better for all types of images. This is most commonly used in fields such as medical image processing, radar signal processing, etc. HE works by leveling the input image histogram and stretching the gray level dynamic range so that it is often referred to as histogram leveling [8].

The histogram of an image represents the relative frequency with which gray levels occur to maintain the average brightness of the input image. Modified histograms change the uniform distribution of gray levels for increased image contrast, which achieves good performance with low computational complexity. The histogram of an image shows the relationship between the gray level and the corresponding frequency. The histogram of the gray image $P(j)$ is expressed in equation (1):

$$P(j) = \frac{n_j}{NM}, j = 0, 1, \dots, L - 1 \quad (1)$$

where j denotes the gray level of an image, n_j is the number of pixels in the gray level j , and NM is the total number of the image pixels. It is obvious that the histogram is the probability distribution function of j . Based on $P(j)$, histogram equalization (HE) is performed as follows:

$$s_k = T(k) = (L - 1) \sum_{j=0}^k P(j) \quad (2)$$

where s_k stands for the mapping function $T(k)$ and maps each pixel value k of the input image into s_k ; L is the dynamic range of the output image. Through this adjustment, image intensity can be better distributed to the histogram. This allows for areas of lower local contrast to get higher contrast without affecting global contrast.

2.2 Adaptive Histogram Equalization (AHE)

Adaptive Histogram Equalization (AHE) is an image processing technique that aims to obtain images with intensity values, where the darkest point in the image reaches deep black and the brightest point in the image reaches brilliant white color [9][10]. AHE is also a contrast enhancement technique that has produced excellent images in medical imaging [11].

In adaptive histogram equalization, the image is divided into blocks (tiles) of $n \times n$ size, then each histogram equalization process is performed. Block size (n) can vary and each block size will give different results. Each block can overlap several pixels with other blocks [12]. The formula in equation (3) that follows will be used to work on the process of adaptive histogram equalization.

$$K_0 = \text{round} \left(\frac{c_i \cdot (2^k - 1)}{M \cdot N} \right) \quad (3)$$

where,

c_i : cumulative of the i gray scale value of the original image

<i>Round</i>	: operation for rounding to the nearest round number
K_0	: gray scale value of histogram equalization results
k	: number of imagery scale scale bits
M	: image height
N	: image width

2.3 Contrast Limited Adaptive Histogram Equalization (CLAHE)

CLAHE is a technique for improving image contrast by increasing image local contrast. Locally this image is obtained by forming several symmetrical grids on the image called the region size. The regional structure of the image is divided into three, namely the parts in the corner of the image are marked with the corner region (CR), the edges except CR are marked with the border region (BR), and the other parts in the middle are marked with the inner region (IR). The problem of excessive contrast enhancement can be overcome by using Contrast Limited Adaptive Histogram Equalization (CLAHE), namely by providing a boundary value on the histogram. This limit value is called the clip limit which states the maximum height of a histogram. How to calculate the clip limit of a histogram can be defined by equation (4) [13] :

$$\beta = \frac{M}{N} \left(1 + \frac{\alpha}{100} S_{max} \right) \quad (4)$$

where M is the number of pixels in each block, N is the dynamic range in this block, S_{max} is the maximum slope, and α is the clip factor.

2.4 Performance Metrics

The success rate and capability of an image quality improvement method can be determined by calculating the Mean Square Error (MSE) and Peak Signal to Noise Ratio (PSNR) values.

2.4.1 Means Square Error, MSE is the average square error value between the original image and image manipulation (the processed image). MSE is obtained by comparing the pixel values in the original image with the corrected image at the same pixel position [14]. This makes it possible to mathematically compare which method gives better results under the same conditions as image size noise, etc. Mathematically stated as follows [15] :

$$MSE = \left(\frac{1}{MN} \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} (g'(x, y) - g(x, y))^2 \right) \quad (6)$$

where,

g'	: the image after image enhancement
g	: original image
M	: number of rows in the original image
N	: number of columns in the original image

2.4.2 Peak Signal of Noise Ratio, PSNR is the ratio between the maximum values of the image measured with the amount of noise that affects the image. PSNR is usually measured in decibels (db). PSNR is used to determine the comparison of the original image quality before and after it is improved. The image quality will be assessed from the size of the PSNR value, the smaller the PSNR value, the worse the image produced [16][17]. Calculations of PSNR can be made using equations (7), as follows:

$$PSNR = 10 \log_{10} \frac{n^2}{MSE} \quad (7)$$

3. Result

In this research, image quality improvement will be carried out using 3 methods, namely the HE, AHE and CLAHE methods. In this study 40 iris images of 200x150 pixel grayscale were used.

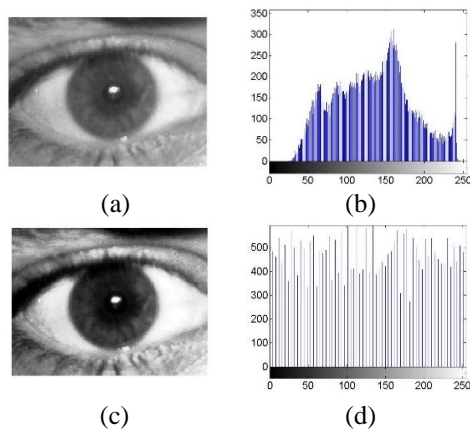


Figure 3. (a) Original Image; (b) Histogram of the original image; (c) Image enhancement using the HE method; (d) Histogram of HE image

Picture. 3 (a) shows the original image. The entropy of the original image is 7.5499. Figure 3 (b) is a histogram of the original image. The results of the iris image enhancement algorithm are shown in Figure 4 through Figure 6.

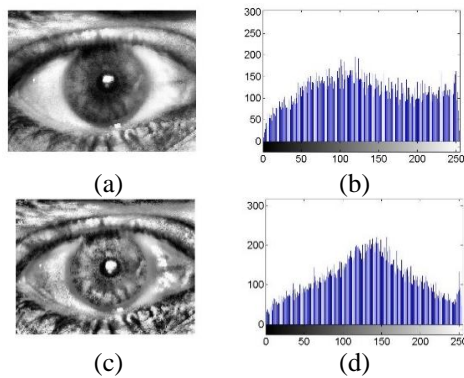


Figure 4. (a) Image enhancement using the AHE method; (b) Histogram of AHE images; (c) Image enhancement using the CLAHE method; (d) Histogram of CLAHE image

Fig. 3 (c) shows the enhanced image using the HE method. Image entropy is 5.9799. Picture. 3 (d) is a histogram of the image enhanced using the HE method. Picture. 4 (a) shows the image enhanced using the AHE method. Image entropy is 7.9338. Picture 4 (b) is a histogram of the image enhanced using the AHE method. Figure 4(c) shows the image enhanced using the CLAHE method. Image entropy is 7.8742. Figure 4(d) is a histogram of the image enhanced using the CLAHE method.

Table 1. The Comparison of Average MSE and PSNR value in the iris images

Method	HE	AHE	CLAHE
Average Matric			
MSE	148,1662	148,1459	131,5763
RMSE	12,1448	12,1439	11,4360
PSNR	60,9338	60,9343	62,1521

Table 1 shows the results of objective evaluations of 40 iris images with MSE and PNSR metrics. The size of the tested iris image is 150x200 pixels. Based on table 1, the smallest average value of MSE and RMSE is the CLAHE method, with an average MSE of 131.5763 and an average of RMSE of 11.4360. The highest average PSNR value is also in the CLAHE method with a value of 62.1521.

4. Conclusion

In this study, in general, the HE, AHE and CLAHE methods can be used to improve iris image contrast. Based on the MSE and RSME values of the three methods used to improve iris image contrast, the best

results use the CLAHE method. But overall, based on the PSNR values, the three methods are good methods for increasing the iris image contrast because they have an average PSNR value above 30dB.

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