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A New Approach for Contrast Enhancement of Infrared Images Based on Contrast Limited Adaptive Histogram Equalization

H. I. Ashiba [1,*], *H. M. Mansour* [1], *M. F. El-Kordy* [2] *and H. M. Ahmed* [1].

[1] Department of Electrical Engineering, Faculty of Shoubra Engineering, Banha University, Egypt.
[2] Deptartment of Electronics and Electrical Comm., Faculty of Electronic Engineering, Menofia University, Menouf, 32952, Egypt.

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Abstract: This paper proposes a novel enhancement method for infrared images (IR) .This algorithm based on contrast limited adaptive histogram equalization (CLAHE) that adaptive and improves infrared images. Some attempts are proposed for enhancement of infrared images using this model, since infrared images have several many applications, it is expected that CLAHE would be better in their enhancement than histogram equalization (HE). The simulation results show the superiority of CLAHE to HE in the enhancement of IR images from both the visual quality and Peak-to-peak signal-to-noise ratio (PSNR) points of view. So, applying this proposed method reinforces visual details in IR images enhancement.

Keywords: Infrared *Images, Histogram Equalization and* The Proposed Enhancement method.

1 Introduction

IR vision is a key technology in a variety of military and civilian applications such as environment monitoring, biomedical diagnostics, and thermal probing of active microelectronic devices. Military applications include target acquisition, surveillance, nigh vision, homing, and tracking. Non-military uses include thermal efficiency analysis, remote temperature sensing, short-ranged wireless communication, spectroscopy, and weather forecasting[1-5].

Image quality enhancement is very important for all fields of image processing. Today infrared images become used to a lot of domains, however, low contrast and signal-to- noise ratio (SNR), this is a serious problem to IR images because of character of IR detectors and the effect of atmosphere. It is very important to enhance the contrast IR images that will affect the quality of segmentation and target recognition. Algorithms, that are used widely to enhance the contrast for images, are HE, histogram matching, gray level transform and un-sharp mask algorithm. The common disadvantage of above algorithms is that the noise in the image is magnified while the contrast is enhanced. Although many enhancing algorithms have been proposed [1-9] either noise in the image or high image quality is demanded.

An effective algorithm for enhancing contrast of IR images based on CLAHE is proposed to obtain excellent visual quality for IR images. Noise is reduced directly at the better resolution levels employing proposed de-noising algorithm. Contrast enhancement is implemented Experimental results show that the new algorithm enhance efficiently contrast for IR images. Visual quality of enhanced image employing the proposed algorithm is better than HE.

Histogram equalization is the most popular algorithm used to enhance the appearance of images. Suppose we have an image that is predominantly dark.

2 Histogram Equalization Method

Then its histogram would be skewed towards the lower end of the grey scale and all the image detail is compressed into the dark end of the histogram. If we could `stretch out' the grey levels at the dark end to produce a more uniformly distributed histogram then the image would become much clearer. The HE is a method in image processing of contrast adjustment using the image’s histogram. This method usually increases the global contrast of many images, through transforming the original image histogram to a

*Corresponding author e-mail: eng_h_2006@yahoo.com

uniform histogram that is, trying to make uniform the distribution intensity pixels of the image. The HE is obtained by next equation [7-9]:

$$S_k = (L-1)\sum_{j=0}^{x_k} p_{r\,(r_j)} \quad (1)$$

Where S_k is the new distribution of the histogram. $p_r(r_k)$ is related of the probability of occurrence of intensity level r_j in an image. This algorithm is based on the assumption the image quality is uniform over all areas and one unique gray scale mapping provides similar enhancement for all regions of the image.

3 The Proposed Enhancement method

The CLAHE approach is the proposed model. The CLAHE is the combination of this limited contrast approach with the AHE results is referred to as Contrast Limited Adaptive Histogram.

Adaptive histogram equalization (AHE) usually produces superior images when compared with interactive contrast enhancement. It was prove that can obtain better results if the original image has more dark regions.

For that image that has not too many variations in the levels of gray was observed that AHE has not good results. The noise is suppressing by contrast limited enhancement and the result images are better. AHE has the disadvantage to enhance not only the image, but also it enhances the noise in the image.

For improvement it was proposed the CLAHE. This method enhances the image and suppresses the noise. The CLAHE approach consists in: First the image is divided into several non-overlapping regions of almost equal sizes. Secondly the histogram of each region is calculated. Then, based on a desired limit for contrast expansion, a clip limit for clipping histograms is obtained. Next, each histogram is redistributed in such a way that its height does not go beyond the clip limit. The clip limit β is obtained by [10-15]:

$$\beta = \frac{MN}{L}\left(1 + \frac{\alpha}{100}(S_{max} - 1)\right) \quad (2)$$

Where α is a clip factor, if clip factor is equal to zero the clip limit becomes exactly equal to $\left(\frac{MN}{L}\right)$, moreover if clip limit is equal to 100 the maximum allowable slope is S_{max}. Finally, cumulative distribution functions (CDF) of the resultant contrast limited histograms are determined for grayscale mapping. The pixels are mapped by linearly combining the results from the mappings of the four nearest regions.

4 Experimental Results

In this section, the algorithm proposed in the previous section for enhancement of IR images is tested and compared with the traditional HE algorithm; two experiments are performed on two different IR images to show the performance of the proposed model. For the evaluation purpose, we depend on the visual quality of the obtained enhancement result as well as the quantitative analysis. This analysis of the experimental results is based on the mean square error (MSE) [3], [6]. The mean square error is defined as follows:

$$MSE = \sum_{i=1}^{M}\sum_{j=1}^{N}\frac{[F(i,j) - F_1(i,j)]^2}{M\times N} \quad (3)$$

Where F is the original IR image and F_1 is the enhanced IR image. The MSE is used to measure the difference between the original IR image and the enhanced IR image; the smaller the value of MSE and the smaller the difference, the better the enhancement of IR images performance. PSNR is defined as follows:

$$PSNR = 10 \times \log((F_{max})^2/MSE) \quad (4)$$

Where log is the natural logarithm operation and F_{max} is the maximum gray value of the pixels in the enhanced image. The bigger the value of PSNR, the better CLAHE performance. We estimated the MSE between the original and enhanced images and obtain two values of PSNR for both CLAHE and HE enhancement.

The steps of the algorithm are performed on these two images. The results of the first experiment are shown in Fig. (1). Part (a) gives the original IR image. Part (b) gives enhanced IR image after HE. Part (c) gives the enhanced IR image using the proposed algorithm. With comparing between Part (b) and Part (c) it is show the proposed enhancement algorithm has enhanced the visual quality of the processed image and the proposed algorithm has higher value than the HE. The PSNR results are given in table (1). A similar experiment is carried out on another IR image and the results are given in Fig.(2). The PSNR results are given in table (2). From these results, it's clear that the proposed approach has succeeded in obtaining better results in the enhancement of IR images than the HE from both the visual quality and PSNR points of view.

5 Conclusion

The paper has presented a new algorithm for contrast enhancement of IR images is the CLAHE. A comparison study is made between the traditional HE and the proposed CLAHE The experimental study shows that the application of the CLAHE is superior to the traditional application of the HE. The obtained CLAHE results have higher PSNR than the HE results. Also enhanced visual details are better in the CLAHE results than in the HE results

Table1

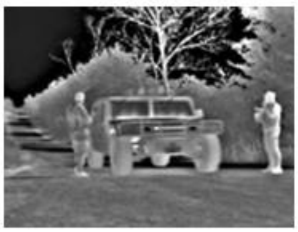
Method	PSNR
HE	34.5821
CLAHE	45.3848

Table 1 presents a comparison of the experimental results of contrast enhancement of IR images using the proposed CLAHE method and the HE method, in terms of the PSNR in the first experiment.

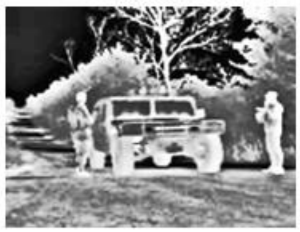
Table 2

Method	PSNR
HE	34.0896
CLAHE	44.2830

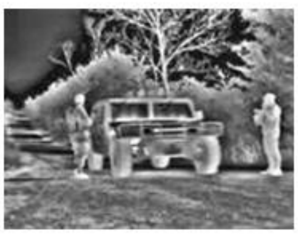
Table 2 presents a comparison of the experimental results of contrast enhancement of IR images using the proposed CLAHE method, and the HE method, in terms of the PSNR in the second experiment.



(a) Original IR image



(b) Enhanced IR after HE



(c) Enhanced IR image after CLAHE

Figure 1: Results of the first experiment.

(a) Original IR image

(b) Enhanced IR after HE

(c) Enhanced IR image after CLAHE

Figure 2: Results of the second experiment

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