Bi-Level Weighted Histogram Equalization with Adaptive Gamma Correction

Jeena Baby[1], V. Karunakaran[2]
1 PG Student, Department of Computer Science and Engineering, Karunya University
2 Assistant Professor, Department of Computer Science and Engineering, Karunya University

Abstract:
In this paper the bi-level weighted histogram equalization is combined with adaptive gamma correction method for better brightness preservation and contrast enhancement. The main idea of this method is to initially divide the input dimmed image into R, G and B components and apply the probability density function and weighting constraints on each component separately. And finally, an adaptive gamma correction method is applied to each component and their union produces a brightness preserved and contrast enhanced output image. The performance of this technique is calculated using Absolute mean brightness error (AMBE) measure.

Keywords: *Contrast enhancement, brightness preservation, histogram equalization, peak signal to noise ratio, absolute mean brightness error, adaptive gamma correction, probability density function, cumulative density function.*

I. INTRODUCTION

Contrast enhancement means improving the visual appearance of the images as well as videos to make it more satisfactory to the human or machine. Contrast enhancement comes under the image enhancement techniques. It is used in both image as well as video processing for better visual perception. Several contrast enhancement techniques are already available. Each technique has got merits and demerits. Histogram equalization is a very traditional technique where the intensity values of the image are redistributed. Due to environmental lighting conditions or because of the defects in the photographic devices, images may suffer from poor contrast. So in order to improve the image quality contrast enhancement is done. Histogram equalization is a simple and effective technique commonly for contrast enhancement [9].

Generally, the image enhancement techniques are categorized into two: direct [2] and indirect enhancement techniques. In direct enhancement techniques, the contrast of the image is directly defined by a definite contrast term [2]. But in indirect enhancement techniques the contrast is improved by redistributing the intensity values of the image [1]. Histogram equalization [9] techniques can be divided as local and global. In global, the active range of intensity can be extended using the histogram of the image and thereby increase the quality. In histogram equalization [9], cumulative distribution function is used to normalize the distribution of intensities, so that the output image will have uniform distribution of intensities. HE will produce a washed out effect in the images [9].

In local HE, the histogram as well as the information obtained from the neighborhood pixels are used for this technique. Here the image is divided into several sub-blocks and then perform HE on each block. The final image is produced by merging these sub-blocks. The most popular indirect enhancement technique is called histogram modification techniques [3]. These are easy techniques which can be implemented in a faster way [1]. A gamma correction method comes under these HM techniques. Here a varying adaptive parameter γ is used. Transform- based gamma correction [17] is the simplest and it can be derived as

$$T(l) = l_{max}(l/l_{max})^{\gamma} \tag{1}$$

Where l is the intensity of each pixel in the input image and l_{max} is the maximum intensity. Since a fixed parameter is used in gamma correction different images will display same changes in intensity. In order to solve this problem a bi level weighted histogram equalization technique proposed in [16] is used. But this method also has some problems like over enhancement.

In section 2, related works are described. Section 3 presents the proposed technique. Section 4 discusses the performance metrics to measure the quality of contrast enhanced image. In section 5, results are discussed and conclusion is given in section 6.

II. RELATED WORKS

Here some previous works related to histogram equalization and adaptive gamma corrections are discussed. The bi level weighted histogram equalization (BWHE) method [16] segments the input histogram into two sub histograms based on its mean intensity value. The major problem of this method is the over enhancement and the introduction of irregularity, called blocking effect.

In segment dependent dynamic multi-histogram equalization [18] the input histogram is divided into n segments based either on its mean or median and a range is calculated. Histogram equalization is done based on this range and finally the output image will be normalized. This method is not suitable for color images. Another method called adaptive gamma correction with weighting distribution combines the traditional HE method and TGC method [17].

III. PROPOSED METHOD

To solve the problems of the earlier works, a new method has been proposed which combines the bi level HE with the adaptive gamma correction method [5]. It will produce a high quality image and the computation is also less. This bi level HE is a technique which combines two methods Weighted Threshold Histogram Equalization (WTHE) [13] and Brightness preserving Bi-Histogram equalization (BBHE) [3]. The algorithm for the proposed method can be described as follows in which the equations are derived from [16] and [17]:

1. Input image is separated into R, G and B components. The following steps are applied to each of the components separately.
2. Compute the probability density function (PDF) of each component.
3. Find the mean pdf m of each component.
4. Then apply the constraints described below on each component.

$$P_C(r_k) = T(P(r_k)) = \left\{ \begin{array}{c|c} \alpha & if\ P(r_k) > \alpha \\ (\frac{P(r_k)-\beta}{\alpha-\beta})^r & if\ \beta \leq P(r_k) \leq \alpha \\ 0 & if\ P(r_k) < \beta \end{array} \right\} \quad (2)$$

Where $\alpha = v * \max(P(r_k))$, 0.1< v<1.0, β=0.0001 and r is the power factor such that 0.1< r<1.0.

5. Find the mean of constrained pdf and then compute the mean error.

$$m_e = m_c - m \quad (3)$$

6. Add the mean error m_e to constrained pdf P_c.
7. Find the cumulative density function C using the P_c.
8. After that find the weighted pdf value using the below equation:

$$P_w(l) = P_{c_{max}}(\frac{P_c(l) - P_{c_{min}}}{P_{c_{max}} - P_{c_{min}}})^\alpha \quad (4)$$

9. Then the modified cdf can be approximated as:

$$C_w(l) = \sum_{l=0}^{l_{max}} P_w(l) / \sum P_w \quad (5)$$

Where the sum of pdf_w can be calculated as:

$$\sum P_w = \sum_{l=0}^{l_{max}} P_w(l) \tag{6}$$

11. Finally the gamma value is calculated as:

$$\gamma = 1 - C_w(l) \tag{7}$$

And apply this in the gamma correction formula as:

$$T(l) = l_{max}(\frac{l}{l_{max}})^{\gamma} = l_{max}(\frac{l}{l_{max}})^{1-C_w(l)} \tag{8}$$

The AGC method will gradually increase the low intensities and avoid the decrease of the high intensity. So in order to avoid the undesirable effects produced in the image, a weighting distribution is also applied [4]. According to [6] and [7] color images are enhanced using HSV color model, where the hue (H) and saturation (S) is used to represent the color content and value (V) represents the luminance intensity.

In bi-level histogram equalization the computation of constrained pdf helps to control the equalization of images. After finding out the pdf it is clamped to an upper threshold value α and lower threshold valueβ. The value of v comes in the range of 0.1 to 1.0 so that, the pdf's are clipped with high probabilities. If the value of v is beyond this limit, then over-enhancement occurs. The value of r is always less so that, over-enhancement is very rare. The mean error is calculated in order to recompense the change in the mean luminance level.

IV. IMAGE QUALITY MEASUREMENT

Here two parameters are used to measure the quality of the image. They are: Peak Signal to Noise Ratio (PSNR) for contrast enhancement measurement [8] and Absolute Mean Brightness Error (AMBE) for measuring the mean brightness value [8].

4.1. Peak Signal to Noise Ratio

The PSNR [8] is used to compute the peak signal to noise ratio between two images. The ratio is used as a quality measurement between the original and contrast enhanced image. The higher the PSNR value, the better the quality of the image.

To compute the PSNR value initially the mean-squared error is calculated using the following equation:

$$MSE = \sum_{M,N}[I_1(m,n) - I_2(m,n)]^2 \tag{9}$$

Where M and N are the number of rows and columns in the input images. Then the PSNR can be calculated as follows:

$$PSNR = 10 \log 10 \, [\frac{R^2}{MSE}] \tag{10}$$

R is the maximum variation in the input image data type.

4.2. Absolute Mean Brightness Error

The proposed method is trying to preserve the brightness of the images by considering the value of AMBE [8]. It is calculated as:

$$AMBE = |E[Y] - E[X]| \tag{11}$$

Where E[Y] is the mean of contrast enhanced image and E[X] is the mean of original image.

V. RESULTS AND DISCUSSION

The performance of the proposed method bi-level histogram equalization with adaptive gamma correction (BWHEAGC) was tested on several color images. The images are shown in Figure 1. To compare the performance of the proposed method the same images are enhanced using AGCWD [17] method, BWHE and SDMHE methods. The performance of all these methods are qualitatively measured using PSNR and AMBE.

In this paper 8 dimmed images are used for contrast enhancement and comparison. The contrast enhancement of images (a) and (e) and their corresponding histogram are shown in Figure 2 and Figure 3 respectively.

Figure 1. Eight dimmed images

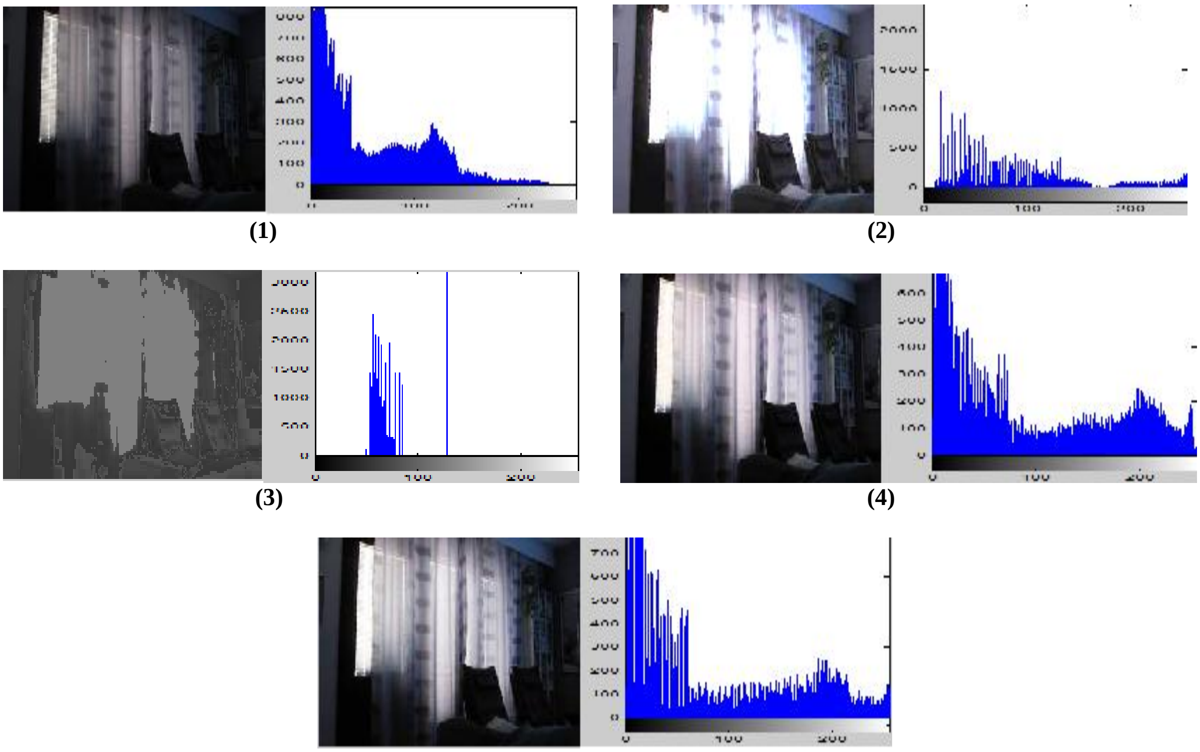
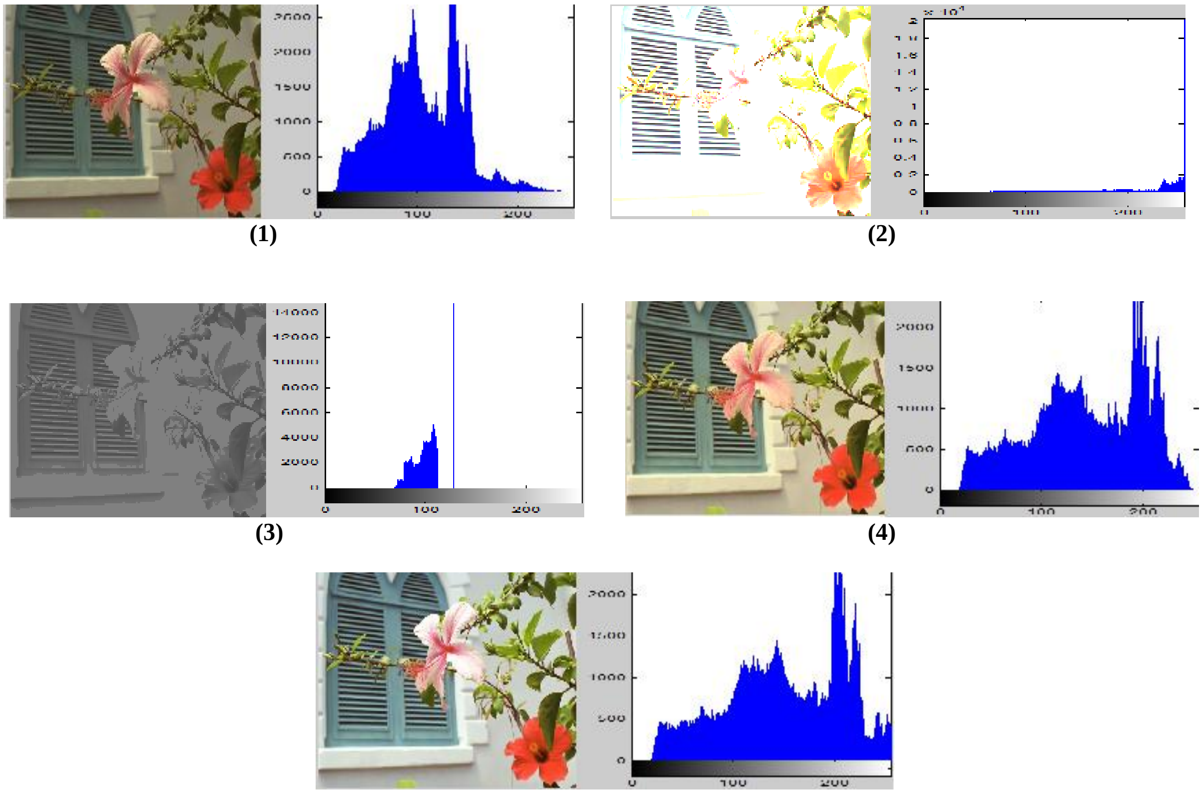


Figure 2. Contrast enhancement of image (a), (1) original image, (2) BWHE method, (3) SDMHE method, (4) AGCWD method, (5) Proposed method



(1) **(2)** **(3)** **(4)** **(5)**

Figure 2. Contrast enhancement of image (e), (1) original image, (2) BWHE method, (3) SDMHE method, (4) AGCWD method, (5) Proposed method

From the above contrast enhanced images it is clear that the BWHE [16] method and the SDMHE [18] method are producing poor results. In BWHE method over-enhancement is the problem. This problem is solved in the proposed method by using an adaptive gamma correction method. The SDMHE method is suitable only for gray level images. The AGCWD [17] method and the proposed method are giving visually acceptable images. But the output produced by the proposed method is better. The performances of these methods are measured using two parameters namely, PSNR and AMBE. The PSNR values are given in Table 1 and the AMBE values are given in Table 2.

Table 1. Comparison of PSNR values

Image \ Method	BWHE	SDMHE	AGCWD	BWHEAGC
(a)	8.2298	10.2595	14.6281	15.9629
(b)	8.3320	11.1200	13.5193	15.2113
(c)	11.9212	7.8042	20.1488	20.2374
(d)	7.8913	10.0006	15.4067	15.6079
(e)	5.4459	14.9751	15.4850	13.4838
(f)	11.0392	11.1143	15.5627	16.7379
(g)	7.9589	9.1970	17.6459	17.6741
(h)	15.1585	9.4252	17.0107	20.2862

By comparing the PSNR values produced by each of the four methods it is clear that the proposed method (BWHEAGC) produces better results. Because, from the definition of PSNR it is clear that, higher its value better will be the image quality. Also from the Table 2, we get the values of AMBE measure which indicates that the brightness is preserved in the output images. Lower the value of AMBE better will be the brightness preservation.

Table 2. Comparison of AMBE value

Image \ Method	BWHE	SDMHE	AGCWD	BWHEAGC
(a)	5.8938	0.9116	1.5164	0.4639
(b)	2.3363	9.3737	9.8524	0.1690
(c)	4.2299	0.4463	0.8360	0.0882
(d)	9.6491	3.2908	1.8068	0.5882
(e)	1.0146	0.2724	1.3507	0.6385
(f)	7.0487	6.5929	8.4963	0.3330
(g)	0.1944	8.6451	4.6604	0.4523
(h)	16.5474	3.1738	9.2396	0.4170

VI. CONCLUSION

In this paper, the contrast of dimmed images are enhanced with the help of bi-level weighted HE with adaptive gamma correction method. This technique is accomplished using two methods, bi-level weighted histogram equalization where, the pdf and cdf is calculated in a constrained manner and the adaptive gamma correction method where, a weighting is done on this constrained pdf. Then using the calculated gamma value the transformation is done. It is computationally simple method and has a high degree of detail preservation. From the calculated values of PSNR and AMBE measures it is clear that the proposed method has better brightness preservation and is the best method for contrast enhancement.

REFERENCES

[1] T. Arici, S. Dikbas, and Y. Altunbasak, “A histogram modification framework and its application for image contrast enhancement,” IEEE Trans. Image Process., vol. 18, no. 9, pp. 1921–1935, Sep. 2009.

[2] A. Beghdadi and A. L. Negrate, “Contrast enhancement technique based on local detection of edges,” Comput. Vis, Graph., Image Process., vol. 46, no. 2, pp. 162–174, May 1989.

[3] Y. Kim, “Contrast enhancement using brightness preserving bi-histogram equalization,” IEEE Trans. Consum. Electron., vol. 43, no. 1, pp. 1–8, Feb. 1997.

[4] M. Kim and M. G. Chung, “Recursively separated and weighted histogram equalization for brightness preservation and contrast enhancement,” IEEE Trans. Consum. Electron., vol. 54, no. 3, pp. 1389–1397, Aug. 2008.

[5] Z.-G. Wang, Z.-H. Liang, and C.-L. Liu, “A real-time image processor with combining dynamic contrast ratio enhancement and inverse gamma correction for PDP,” Displays, vol. 30, no. 3, pp. 133–139, Jul. 2009.

[6] M. Hanmandlu and D. Jha, “An optimal fuzzy system for color image enhancement,” IEEE Trans. Image Process., vol. 15, no. 10, pp. 2956–2966, Oct. 2006.

[7] M. Hanmandlu, O. P. Verma, N. K. Kumar, and M. Kulkarni, “A novel optimal fuzzy system for color image enhancement using bacterial foraging,” IEEE Trans. Instrum. Meas., vol. 58, no. 8, pp. 2867–2879, Aug. 2009.

[8] Kim M. and Chung G., “Recursively Separated and Weighted Histogram Equalization for Brightness Preservation and Contrast Enhancement,” IEEE Transactions on Consumer Electronics, vol. 54, no. 3, pp. 1389-1397, 2008.

[9] Rafael G. and Richard W., Digital Image Processing, Prentice Hall, Gonzalez, 2002.

[10] Shanmugavadivu P. and Balasubramanian K., “Image Edge and Contrast Enhancement using Unsharp Masking and Constrained Histogram Equalization,” Communications in Computer and Information Science, vol. 140, no. 2, pp. 129-136, 2011.

[11] Shanmugavadivu P., Balasubramanian K., and Somasundaram K., “Median Adjusted Constrained PDF based Histogram Equalization for Image Contrast Enhancement,” Communications in Computer and Information Science, vol. 204, no. 1, pp. 244-253, 2011.

[12] Shanmugavadivu P., Balasubramanian K., and Somasundaram K., “Modified Histogram Equalization for Image Contrast Enhancement using Particle Swarm Optimization,” International Journal of Computer Science, Engineering and Information Technology , vol. 1, no. 5, pp. 13-27, 2012.

[13] Wang Q. and Ward R., “Fast Image/Video Contrast Enhancement Based on Weighted Thresholded Histogram Equalization,” IEEE Transactions on Consumer Electronics, vol. 53, no. 2, pp. 757-764, 2007.

[14] Kabir H., Al-Wadud A., and Chae O., “Brightness Preserving Image Contrast Enhancement using Weighted Mixture of Global and Local Transformation Functions,” International Arab Journal of Information Technology, vol. 7, no. 4, pp. 403-410, 2010.

[15] A. Polesel, G. Ramponi, and V. Mathews, “Image enhancement via adaptive unsharp masking,” IEEE Trans. Image Process., vol. 9, no. 3, pp. 505–510, Mar. 2000.

[16] Shanmugavadivu Pichai, Balasubramanian Krishnasamy, and Somasundaram Karuppanagounder, “Bi-Level Weighted Histogram Equalization for Scalable Brightness Preservation and Contrast Enhancement for Images”, The International Arab Journal of Information Technology, Vol. 10, No. 6, November 2013

[17] Shih-Chia Huang, Fan-Chieh Cheng, and Yi-Sheng Chiu, “Efficient Contrast Enhancement Using Adaptive Gamma Correction With Weighting Distribution”, IEEE Trans. Image processing, Vol. 22, no. 3, Mar 2013.

[18] MohammadFarhanKhan, EkramKhan,Z.A.Abbasi, “Segment Dependent dynamic multi-histogram Equalization for Image Contrast Enhancement”, Elsevier Digital Signal Processing 25(2014) 198–223.