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Implementation of a new algorithm to improve contrast of digital images with various quality metrics

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Abstract: In certain applications, the time necessary to process the image is not as important as the quality of the processed images (e.g., medical imaging), but in other cases the quality can be sacrificed in favor of time. The proposed work focuses on the former case, and proposes a methodology for image contrast enhancement methods. The proposed method is based on histogram equalization (HE) for gray-level images. As far as HE methods for gray-level images are concerned, current methods tend to change the mean brightness of the image to the middle level of the gray-level range. This is not desirable in the case of image contrast enhancement for consumer electronics products, where preserving the input brightness of the image is required to avoid the generation of non-existing artifacts in the output image. To overcome this drawback, Bi-histogram equalization methods for both preserving the brightness and contrast enhancement have been proposed. Although these methods preserve the input brightness on the output image with a significant contrast enhancement, they may produce images which do not look as natural as the ones which have been input. In order to overcome this drawback, this thesis proposes a technique called Constrained Based Bi-Level Histogram Equalization (CBBHE) Algorithm for Digital Images, which consists of decomposing the input image into two sub-images, and then applying the Constrained based HE process to each one of them and finally, it combines the sub images to get enhanced image.

Keywords: Contrast Enhancement, Cumulative Density Function (CDF), Histogram, Histogram equalization, Probability Density Function (PDF), HE (Histogram Equalization)

1. INTRODUCTION

CPHE [1] is a fast and effective method for image contrast enhancement. In this method, the probability density function of an image is modified by weighting and thresholding prior to HE. This technique provides a convenient and effective mechanism to control the enhancement process, while being adaptive to various types of images. CPHE method provides a good trade-off between the two features, adaptivity to different images and ease of control, which are difficult to achieve in the GHE-based enhancement methods.
IIBLHE [2] is the extension of CPHE, combines the advantages of image inversion, HE and Constrained PDF based HE (CPHE) [1]. This method is carried out in three steps:

- Inverse the image
- Perform HE over the inversed image
- Re-inverse it and apply CPHE process

2. PROPOSED METHOD

The proposed Constrained Based Bi-Level HE (CBBHE) Algorithm for Digital Images is the extension of Constrained PDF Based Histogram Equalization (CPHE) and Image Inversion and Bi-Level Histogram Equalization (IIBLHE) methods. Histogram Equalization (HE) has claimed to be a simple image contrast enhancement technique. But it tends to change the mean brightness of the image to the middle level of the gray level range. This method controls the tendency of traditional Histogram Equalization to change the brightness of image after enhancement. It performs the enhancement of an image without making any loss of details in it. The proposed method to perform histogram equalization works in three steps:

- Divide the original image in two sub-images (Lower and Upper) with respect to the mean. Lower sub image is the collection of Pixels having value less than mean and upper one constituted of pixels having values large or equal to the mean.

- Apply constraint based function to compute new probability values for each pixel on sub images independently.
- Merge the sub-images to attain final enhanced image.

CPHE [1] and IIBLHE [2] uses equation 2.1, as given below, to find out the new probabilities values for each pixel in image, but Constrained Based Bi-Level HE (CBBHE) Algorithm for Digital Images has used equations 2.3, 2.4 and 2.5.In equation 2.1 when the value of current PDF reaches below the lower threshold P_l is replaced by Average value of the current PDF, but in CBBHE these values are replaced by 0, as shown in equation 2.5, instead of replacing with Average value of the current PDF.

$$P_c(r_k) = \Omega(P(r_k)) = \begin{cases} P_u & \text{if } P(r_k) \geq P_u \\ \left(\frac{P(r_k) - P_l}{P_u - P_l}\right)^r & \text{if } P_l \leq P(r_k) \leq P_u \\ Average(P(r_k)) & \text{if } P(r_k) < P_l \end{cases} \quad ...(2.1)$$

In CBBHE after dividing the image, the new PDFs of both sub divided images are computed by applying constraints P_{upr} and P_{lwr}. Each original probability density value of lower and upper replaced by a new PDF values $P_{CB1}(k)$ and $P_{CB2}(k)$ respectively, obtained by applying a transformation function Ω (.) to PDFs ,such that

$$P_{CB\,z}(i,j) = \Omega(P_z(i,j)) \quad \text{where, } Z = 0, 1 \quad \ldots(2.2)$$

if PDF value of the current pixel crosses upper limit, i.e. , $P_z(i,j) > P_{upr}$, then it would be replaced by upper limit itself , such that :

$$p_{z(i,j)} = p_{upr} \quad \ldots(2.3)$$

if it lies in between or equals to the lower and the upper limit, i.e., $P_{lwr} \leq P_z(i,j) \leq P_{upr}$, then new value is computed as :

$$p_{z(i,j)} = \left(\frac{P_z(i,j) - P_{lwr}}{P_{upr} - P_{lwr}}\right)^r \times P_{upr} \quad \ldots(2.4)$$

If it is below the lower limit then replaced by 0, as shown below:

$$p_{z(i,j)} = 0 \quad \ldots(2.5)$$

Now, (2.3), (2.4) and (2.5) will decide the new probability values for sub-divided images. The new PDF computes CDF of the two sub images as follows:

$$X_1(i,j) = C_1(i,j)(X_{\max 1} - X_{\min 1}) + X_{\min 1} = \sum_{i=0,j=0}^{L-1} P_1(i,j) \quad \ldots(2.6)$$

$$X_2(i,j) = C_2(i,j)(X_{\max 2} - X_{\min 2}) + X_{\min 2} = \sum_{i=0,j=0}^{L-1} P_2(i,j) \quad \ldots(2.7)$$

The final enhanced output image is obtained by clubbing (2.6) and (2.7), Y (i, j), can be shown as:

$$Y(i,j) = X_1(i,j) \cup X_2(i,j) \quad \ldots(2.8)$$

The transformation function Ω(.) clamps the original PDF at an upper threshold P_{upr} and at a lower threshold P_{lwr}, and transforms all values between the upper and lower thresholds using a normalized power law function with index r>0. In proposed level-mapping scheme, the increment for each intensity level is decided by the transformed function Ω (.). The increment can be controlled by adjusting the index r of the power law transformation function. The value of r, if r<1, will give a higher weight to the low probabilities in the PDF than the high probabilities. So, chances of over-enhancement are less if user sets the value of r less than 1. The upper limit P_{upr} sets a threshold on all levels and decides the cut-off point for high probabilities levels. If PDF values are higher than $P_{upr,}$ their increment stopped a maximum value and this limit is computed as:

$$P_{upr} = v \cdot P_{max}, \quad 0 \leq v \leq 1 \quad \ldots(2.9)$$

This limit of restricted number of high probabilities again avoids the dominance of high probabilities over low probabilities levels. Where P_{max} highest probability the original PDF and the real number v defines the upper threshold normalized to P_{max}. It is another parameter that controls the effect of enhancement. The lower threshold P_{lwr} is only used to cut out the levels whose probabilities are too low so as to better utilize the full dynamic range. The value of P_{lwr} is less important in controlling the enhancement and is set at a very low fixed value (e.g., 0.0001) in our algorithm. It can be seen when r=1, P_{upr}=1 and P_{lwr}=0 the proposed method reduces to the traditional HE. When r>1, more weight is shifted to the high-probability levels, and it would yield even stronger effect than the traditional HE. Using r>1 is less common due to its higher likelihood to result in over-enhancement, yet it is still useful in specific applications where the levels with high probabilities, e.g., the background, need to be enhanced with extra strength. The proposed transformation function introduces thresholding to the histogram.

3. RESULTS

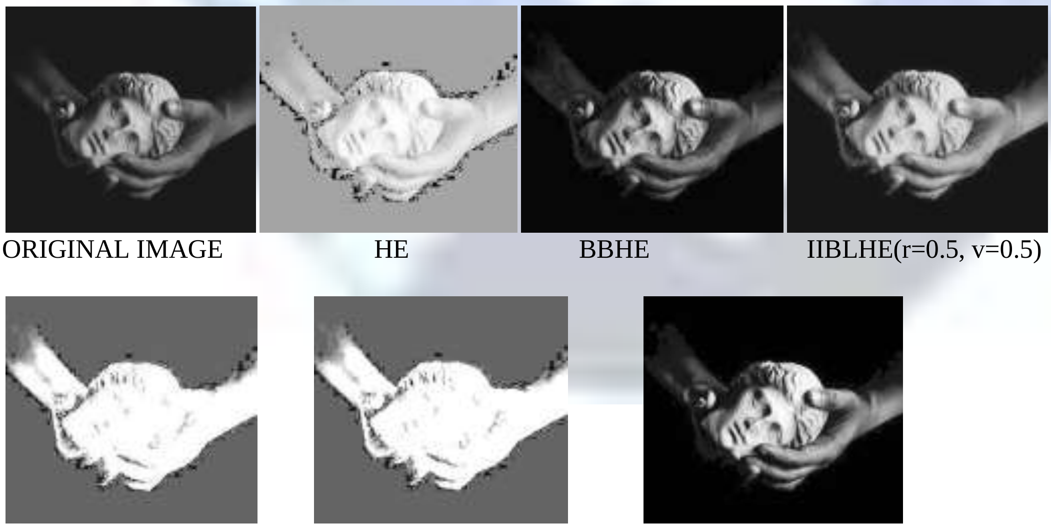
In this work images taken are natural gray images. The results have been obtained by applying various histogram techniques, naming HE, BBHE, DSIHE, CPHE, IIBLHE and CBBHE on different images. Images were extracted from CVG-UGR database. For the proposed CBBHE method the value of r=0.5 and v=0.5, have been taken. To start analysis and to assess the appropriateness of the processed images for consumer electronics products, for each image, PSNR (peak signal to noise ratio), SC (Structural Content) and AMBE (Absolute mean brightness error) is computed. These three quality measures have been used as the standard measures. The tables are composed of two fields:

- The names of the different HE methods and the different quality metrics.
- The data values obtained by the different HE techniques.

In different tables, compare the data values of each method with each other for respective image. The best values of PSNR, SC and AMBE are highlighted in Tables 3.1 & 3.2 respectively. The images produced by the proposed method are better in preserving the brightness, naturalness and prone to less arti-fact and the values given by this method are the best as shown in the tables. Once the images were analyzed considering their PSNR, SC and AMBE, image visual assessment was performed.

Test Image 1 (hands.jpg)

Figure 1 shows the original image and the resulting images of hands image obtained by HE, BBHE, DSIHE, CPHE, IIBLHE and CBBHE methods. The size of the original image is 512-by- 512. The values for index r =0.5 and for v =0.5 in CPHE, IIBLHE and CBBHE methods.



ORIGINAL IMAGE HE BBHE IIBLHE(r=0.5, v=0.5)

DSIHE CPHE(r=0.5, v=0.5) CBBHE(r=0.5, v=0.5)

Figure 1: Enhancement for the hands image based on different HE methods

Table 1 is depicting experimental results on standard hands images and it shows the degree of enhancement measured in terms of PSNR, AMBE and SC values for the already existing and for the proposed method.

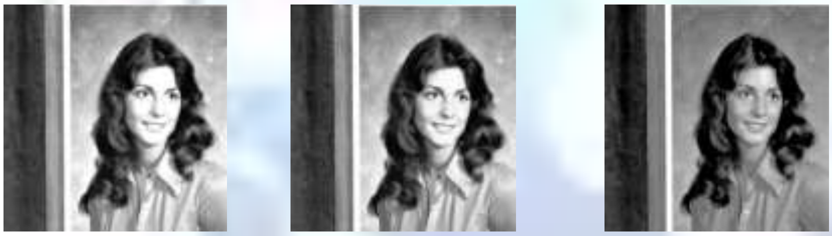
Table 1: Results after applying different methods of HE on hands image

METHOD/Q. Metric	PSNR	AMBE	SC
HE	4.47702	147.812	0.1143
BBHE	22.5483	10.7016	0.6108
DSIHE	17.8865	17.6599	0.4747
CPHE	6.00904	118.916	0.1385
IIBLHE	6.02103	118.812	0.1388
CBBHE	**29.5168**	**6.11838**	**0.9641**

Test Image 2 (woman.jpg)

Figure 2 shows the original image and the resulting images of woman image obtained by HE, BBHE, DSIHE, CPHE, IIBLHE and CBBHE methods. The size of the original image is 512-by- 512. The values for index r =0.5 and for v =0.5 in CPHE, IIBLHE and CBBHE methods.

ORIGINAL HE BBHE DSIHE



CPHE(r=0.5, v=0.5) IIBLHE(r=0.5, v=0.5) CBBHE(r=0.5, v=0.5)

Figure 2: Enhancement for the woman image based on various HE methods

Table 3.2 is depicting experimental results on standard woman images and it shows the degree of enhancement measured in terms of PSNR, AMBE and SC values for the already existing and for the proposed method.

Table 2: Results after applying different methods of HE on woman image

METHOD/Q.Metric	PSNR	AMBE	SC
HE	17.8296	15.4593	0.6939
BBHE	17.6673	15.0195	0.6928
DSIHE	18.1399	10.3749	0.7313
CPHE	16.0555	26.9865	0.6044
IIBLHE	17.9556	18.2698	0.6775
CBBHE	**29.3316**	**0.63096**	**0.9855**

CONCLUSION

This work has presented new methodology for image contrast enhancement through histogram equalization. An image that contains high contrast and well defined ridges and valleys, are called as good quality image, while a poor quality image is marked by low contrast and ill-defined boundaries between the ridges. The main objective of the thesis work is to implement an algorithm based on Histogram equalization for image contrast enhancement. The main motivation to use method based on histogram equalization to improve contrast in images was their simplicity and appropriateness for real-time applications [3,4]. Constrained Based Bi-Level Histogram Equalization Algorithm for Digital Images differ from other methods previously proposed some major points. It segments the image into two sub-images based on the original mean and find out the new probabilities values after applying some constraints. The proposed method is successful in enhancing the contrast of images while preserving their brightness and avoiding the appearance of unnatural artifacts.

REFERENCES

[1]. Balasubramanian, K. (2008),"Constrained PDF based Histogram Equalization for image contrast enhancement", Infocomp Journal of Computer Science, vol.7, pp.78–83.
[2]. Shanmugavadivu, P. and Balasubramanian, K. (2010), "Image Inversion and Bi Level Histogram Equalization for Contrast Enhancement", International Journal of Computer Applications, vol.15, pp.61-65.
[3]. Woods, R. E. and Gonzalez, R. C. (1981),"Real-time digital image enhancement", Proceedings of IEEE, vol.69, pp.643-654.
[4]. Reza, A. M. (2004), "Realization of the contrast limited adaptive histogram equalization (clahe) for real-time image enhancement", Journal of VLSI Signals Processing, vol.38, pp.35-44.