Brightness Preserving Image Enhancement Using Modified Dualistic Sub Image Histogram Equalization

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Abstract - Histogram equalization (HE) is one of the common methods used for improving contrast in digital images. However, this technique is not very well suited to be implemented in consumer electronics, such as television because the method tends to introduce unnecessary visual deterioration such as the saturation effect. One of the solutions to overcome this weakness is by preserving the mean brightness of the input image inside the output image. This paper provides the modified dualistic sub image HE method which preserves the brightness of the image.

Keywords- Image contrast enhancement, histogram equalization, AMBE, ENTROPY, PSNR, brightness preserving enhancement.

I.INTRODUCTION

The goal of image enhancement techniques is to improve a quality of an image such that enhanced image is better than the original image. Several image enhancement techniques have been proposed in both spatial and transform domains. In the spatial domain techniques, intensity values of images have been modified whereas in the transform domain techniques, transform domain coefficients are modified, typically, scaled.

Histogram equalization (HE) [1] is a simple and effective contrast enhancement technique which distributes pixel values uniformly such that enhanced image have linear cumulative histogram. The HE technique is a global operation hence; it does not preserve the image brightness. To overcome this issue local-HE [2] and brightness preserving local HE [3]-[13] techniques have been proposed. In Brightness preserving bi histogram equalization (BBHE) [3] and dualistic sub-image histogram equalization (DSIHE) [4] techniques,

A histogram has been divided into two sub-histograms such that one contains high intensity pixels and another contains low intensity pixels. And then equalize each part independently with HE technique. The BBSE and DSIHE techniques use mean and median values, respectively as separation intensity to divide the histogram into two sub-histograms. Minimum mean brightness error bi-histogram equalization (MMBEBHE) [5] is an extension of the BBHE technique.

Hence it is inappropriate to explicitly conclude which method actually demonstrates the best performance.

So the scope of this paper is to highlight only the methods used for brightness preserving image enhancement using histogram equalization.

This paper is organized as follows: section II explains various algorithms employed for brightness preserving image enhancement. Section III explains different criterion for brightness preservation as well as image enhancement, section V explains the test images used Section VI gives results of method in tables section VII
Shows resultant output images section VIII concludes the paper followed by references.

II. ALGORITHM

[1] HE (Histogram equalization):

In this section, we briefly describe conventional histogram equalization and its variant methods. In what follows, we will use the symbols and notations similar to the ones in.

- X = {X(i, j)} is an image with L discrete gray levels {X0, X1, ···, XL-1}, where X (i, j) is the intensity of the image at the 2D position (i, j) and X(i, j) ∈ {X0, X1, ···, XL-1}.
- H(X) = {n0, n1, ···, nk, ···, nL-1} is the image X's histogram, where nk is the number of pixels whose gray level is Xk.
- XM: the mean brightness of the image X
- XG: the middle gray level of the image X, i.e., (X0+XL-1)/2.

Conventional Histogram Equalization:

Consider the input image X. Based on the histogram H(X), the probability density function (PDF) of the image is defined

P (k) =k/N=k/ n0+n1+n2+n3+…. +nL-1 for k=0, 1, 2… L-1; (1)

Where N is the total number of pixels in the image. From the PDF in (1), the cumulative distribution function (CDF) is defined as

$$C(k) = \sum_{j=0}^{k} p(j) \text{ for } k=0, 1\ldots L-1. \quad (2)$$

Note that c (L-1) = 1 from (1) and (2). Based on the CDF, histogram equalization now maps an input gray level Xk into an output gray level f (k), where f (k), commonly called a level transformation function, is defined as

$$(k) = X_0 + (X_{L-1} - X_0).c\ (k). \quad (3)$$

Thus, histogram equalization remaps the input image into the entire dynamic range [X0, XL-1]. Note also that theoretically conventional histogram equalization produces the output image whose mean brightness is XG regardless of the brightness of the input image.

[II] BBHE (Brightness Preserving Bi Histogram Equalization):

BBHE first decomposes the input histogram H(X) into two Sub-histograms HL(X) and HU(X) by using the input mean XM, Where HL(X) is associated with the gray levels {X0, X1, ···, XM}: and HU(X) is associated with the gray levels {XM+1 , XM+2 , ···, XL-1}. Then it performs conventional histogram equalization on HL(X) and HU(X) independently. It is shown that if the histogram H(X) has a symmetrical distribution around XM, the mean brightness of the output image is (XM + XG)/2.

[III] BPDHE: (Brightness Preserving Dynamic Histogram Equalization):

This is proposed in this paper consists of five steps:

1. Smooth the histogram with Gaussian filter.
2. Detection of the location of local maximums from the smoothed histogram.
3. Map each partition into a new dynamic range.
4. Equalize each partition independently.
5. Normalize the image brightness.

[IV] MDSIHE (MODIFIED Dualistic Sub-Image Histogram Equalization):

If a gray level XD satisfies c (XD) = 0.5, then it is called the median of the image X. DSIHE is similar to BBHE except that the threshold for histogram segmentation is the median XD of
the input image. That is, the input histogram H(X) is partitioned into two sub-histograms HL(X) and HU(X) not by the input mean XM, but by the input median XD. Each of HL(X) And HU(X) is then equalized independently as BBHE.Before histogram equalization histogram normalization is done.

III. CRITERION FOR BRIGHTNESS RESERVATION

To evaluate the effectiveness we chose three widely-used metrics, i.e., AMBE (Absolute Mean Brightness Error), PSNR (Peak Signal-to-Noise Ratio), and entropy.
They are described in detail below.

1] ABSOLUTE MEAN BRIGHTNESS ERROR:

AMBE(X, Y) = |XM - YM|, where XM is the mean of the input image X = {X (i, j)} and YM is the mean of the output image Y = {Y (i, j)}.

2] INSPECTION OF VISUAL QUALITY:

In addition to the quantitative evaluation of brightness preservation using the AMBE values, it is also important to qualitatively assess. The major goal of the qualitative assessment is to judge if the output image is visually acceptable to human eyes and has a natural appearance.

IV. CRITERION FOR CONTRAST ENHANCEMENT

1] PEAK SIGNAL TO NOISE RATIO:

Assuming that N is the total number of pixels in the input or output image, MSE (Mean Squared Error) is calculated through.

$$PSNR=10\log_{10}(L-1)^2/MSE$$

Based on MSE, PSNR is then defined as.
Note that the greater the PSNR, the better the output image quality.

$$MSE= \sum_i\sum_j \left| X(i,j)-Y(i,j)^2 \right| / N$$

2] ENTROPY:

For a given PDF p, entropy Ent[p] is computed. In general, the entropy is a useful tool to measure the Richness of the details in the output image.

$$Ent[p] = -\sum_{k=0} (k)\log_2 p\ (k)$$

3] INSPECTION OF VISUAL QUALITY:

In addition to the quantitative evaluation of contrast enhancement using the PSNR and entropy values, it is also important to qualitatively assess the contrast enhancement.

The major goal of the qualitative assessment is to judge if the output image is visually acceptable to human eyes and has a natural appearance.

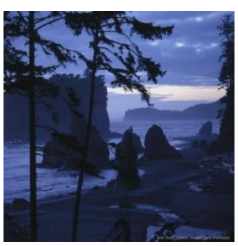
V. Test image used

(1)

(2)

(3)

(4)



(5)

VI. Results:

A] AMBE measurement:

IMAGE	GLOBAL HE	LOCAL HE	ADHE	BBHE	MDSIHE
Image 1	57.95	58.29	33.73	11.84	7.184
Image 2	57.57	58.70	27.73	16.75	8.316
Image 3	31.26	33.79	34.68	7.097	7.873
Image 4	67.00	69.93	25.54	12.93	2.351
Image 5	64.91	65.73	23.46	17.64	1.848
AVG	**55.7408**	**57.292**	**29.031**	**13.2575**	**5.5147**

IMAGE	GLOBAL HE	LOCAL HE	ADHE	BBHE	MDSIHE
Image 1	0.0213	0.0264	0.0016	0.9942	0.9998
Image 2	0.0200	0.01777	0	0.9817	0.9995
Image 3	0.7202	0.7208	0	0.9998	0.9994
Image 4	0.0096	0.0097	0	0.9770	0.9999
Image 5	0.0187	0.0132	0	0.9453	0.9994
AVG	**0.15796**	**0.15791**	**0.0016**	**0.9796**	**0.9996**

B] PSNR measurement:

C] Entropy measurement:

IMAGE	**GLOBAL HE**	**LOCAL HE**	**ADP HE**	**BBHE**	**MDSIHE**
Image 1	11.99	11.383	15.29	15.826	16.02
Image 2	11.2717	9.9791	16.49	13.961	14.10
Image 3	16.0063	14.029	15.11	18.258	18.18
Image 4	11.1001	10.028	16.94	16.939	17.87
Image 5	10.7025	9.6213	17.67	16.393	16.80
AVG	**12.2141**	**11.008**	**16.304**	**16.275**	**19.975**

VII. Resultant output images:

* Input Image 1

Global Histogram Equalization

Contrast Limited Adaptive Histogram Equalization

Local Histogram Equalization

VIII. CONCLUSION

Here we have discussed results of first five methods that are available for contrast enhancement & brightness preservation such as conventional global HE, local HE, ADPHE, BBHE, DSIHE.

The last method as MDSIHE gives better results than all other.

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