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ORIGINAL CONTRIBUTION

COMPARISON OF BI-HISTOGRAM EQUALIZATION METHODS

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ABSTRACT

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 method enhances a digital image by enhancing the contrast flattens the histogram and stretches the dynamic range of intensity values by using the cumulative density function but it does not preserve the image brightness since it is a global operation and the mean brightness of its output image is always the middle gray level regardless of the input mean, because the "desired" histogram is flat. To overcome this problem we have used some Bi-Histogram equalization methods and compare the output images obtained from them. In Bi-Histogram Equalization method, input image has been divided into two sub images based on Mean Brightness, Absolute Mean Brightness Error or Equal Area Property (both sub images contain equal no. of pixels, one being dark and the other being bright) and then both the sub images get equalized separately and finally they gets summed up to get the required Equalized output histogram .In this paper we have compared some important Bi-Histogram Equalization Techniques such as Brightness Preserving Bi-Histogram Equalization (BBHE),Dualistic Sub Image Histogram Equalization (DSIHE) and Minimum Mean Brightness Error Bi-Histogram Equalization(MMBEBHE). A novel extension of bi-histogram equalization that allows better brightness preservation is presented. It separates the input image's histogram using threshold level that minimizes error between input and output mean brightness (Absolute Mean Brightness Error, AMBE). An efficient, recursive, integer-based computation for AMBE is formulated. Simulations results show that it gives best performance among algorithms of same family.

KEYWORDS— BBHE, DSIHE, MMBEBHE, AMBE, dynamic range

1. INTRODUCTION

Histogram Equalization (HE) is widely used for contrast enhancement in medical image processing and radar image processing. However, it is not commonly used in consumer electronics because it may significantly change the original brightness and cause undesirable artifacts. Brightness Preserving Bi-histogram Equalization (BBHE) and Equal Area Dualistic Sub Image Histogram Equalization (DSIHE) have been proposed to preserve the original brightness. However, there are images that are not enhanced well by BBHE and DSIHE, as they require more preservation. This paper proposes a novel extension of BBHE referred to as Minimum Absolute Mean Brightness Error Bi-Histogram Equalization (MMBEBHE) to achieve better brightness preservation.

Bi-Histogram Equalization technique is capable to preserve the original brightness to a certain extends brightness preserving bi-HE.

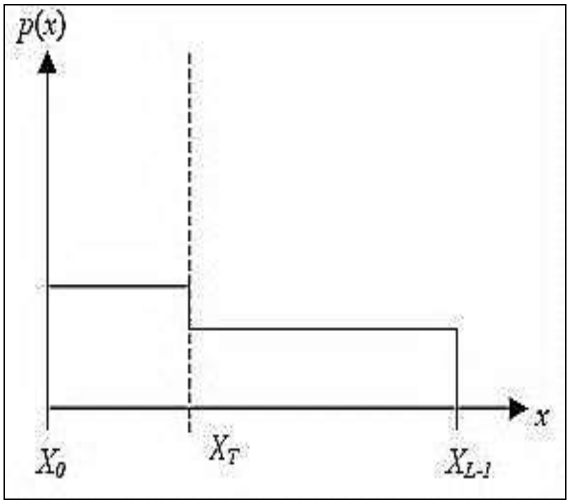

Figure 1: Input Histogram Divides into Two sub-histograms

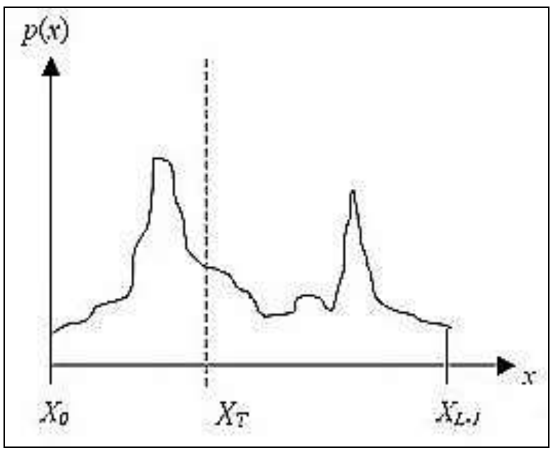

Figure 2: Equalized Sub-histograms

A. BRIGHTNESS PRESERVING BI-HISTOGRAM EQUALIZATION (BBHE)

In BBHE, Input histogram has been divided into two histograms based on the Mean brightness of the image, then the two sub images have been equalized separately and finally they gets added up to give the final Bi-Equalized image. 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.

The following steps have to be maintained for BBHE-

1. Consider Input image X(i, j).
2. Compute Histogram of X= {H(X)}.
3. Histogram splitter based on mean brightness (X_m).
4. Compute lower sub image C_L (X) & Upper sub image C_u (X).
5. Output mapping Y(i,j) based on C_L (X) and C_u (X).

(a)

(b)

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Figure 3: (a) Original Image (b) DSIHE Equalized Image and (c) Histogram Equalized Image

B. MINIMUM MEAN BRIGHTNESS ERROR BI-HE METHOD (MMBEBHE)

Minimum mean brightness error bi-histogram equalization (MMBEBHE) is an extension of the BBHE technique to achieve better brightness preservation. To evaluate the effectiveness we chose the metric, i.e., AMBE (Absolute Mean Brightness Error), which is given by-

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)}.

Lower AMBE indicates that the brightness is better preserved. MMBEBHE, which perform bi-histogram equalization with minimum AMBE is thus been proposed. MMBEBHE decomposes the image I into two sub-images I [0,X_T] and I [X_T+1, L −1] according to the threshold level.

The minimum brightness difference between the input image and the output image is achieved.

Each of the two sub-images I [0,X_T] and I [X_T+1, L −1] has its histogram equalized by the classical HE process

It follows that histogram should be separated based on threshold level that yield minimum AMBE. MMBEBHE algorithm consists of the following steps:

1. Calculate the AMBE for each of the threshold level.
2. Find the threshold level, X_T with minimum AMBE.
3. Separate the histogram into two using the threshold level, X_T found in step 2 and equalize them independently as in BBHE.

(a) (b)

Figure 4: (a) Original Image and (b) DSIHE Equalized Image

2. RESULTS AND INTERPRETATIONS

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Figure 3: (a) BBHE Equalized Image (b) DSIHE Equalized Image and (c) MMBEBHE Equalized Image

3. CONCLUSION

Bi-Histogram Equalization should separate histogram using threshold level that yield minimum AMBE for maximum brightness preservation. Simulation results clearly show that MMBEBHE outperform the BBHE and DSIHE. Note that the result of MMBEBHE is very similar to DSIHE but is better compared to BBHE in term of background color preservation. The results of BBHE and DSIHE are much darker with unnatural enhancement. Result from MMBEBHE indicates increased brightness preservation and displays a more natural enhancement.

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