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Image Enhancement using Histogram Equalization

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Abstract: - Image Enhancement is to process the input image in such a way that the output image is more suitable [1] for interpretation by the humans as well as by machines. The process of image enhancement is application specific. Histogram equalization is an important image enhancement technique commonly used for contrast enhancement. The histogram equalization technique is used to stretch the histogram of the given image. Greater is the histogram stretch greater is the contrast of the image. The histogram of an image normally refers to a histogram of the pixel intensity values.

Keywords:-Image Enhancement, Histogram Equalization, Histogram Equalization Techniques

I. INTRODUCTION

Image Enhancement is to process the input image in such a way that the output image is more suitable for interpretation by the humans as well as by machines. There are numerous techniques available in the literature for image enhancement depending on the specific application. Contrast enhancement by histogram equalization is one such technique. A histogram equalized image enhances the hard to perceive details of the original image. Nevertheless the original image contains useful information. As a result techniques like image fusion can be used to preserve the details of both the image The paper is organized as follow. Section 2 illustrates the related works. followed, in Section 3 presents the techniques of image enhancement. Section 4 presents the techniques of histogram equalization. Section 5 represents performance measures.

II. RELATED WORK

X. Fang et al. [1] proposed a method to improve the enhancement result with image fusion method with evaluation on sharpness. Image enhancement can improve the perception of information

C. Wang and Z. Ye [2] proposed a novel extension of histogram equalization, actually histogram specification, to overcome such drawback as HE (HISTOGRAM EQUALIZATION). To maximize the entropy is the essential idea of HE to make the histogram as flat as possible

Mary Kim and Min Gyo Chung[3]Recursively separated and weighted histogram equalization for brightness preservation and contrast enhancement

Chen Hee Ooi, Nicholas Sia Pik Kong, and Haidi Ibrahim[4]Bi-Histogram Equalization with a Plateau Limit for Digital Image Enhancement

Pei-Chen Wu, Fan-Chieh Cheng, and Yu-Kumg Chen[5]A Weighting Mean-Separated Sub-Histogram Equalization for Contrast Enhancement

S. D. Chen and A. Ramli [6-7] proposed a generalization of BBHE referred to as Recursive Mean-Separate Histogram Equalization (RMSHE) to provide not only better but also scalable brightness preservation

Y. Wang, Q. Chen [8] presented a novel histogram equalization technique equal area dualistic sub image histogram equalization, is put forward in this paper. First, the image is decomposed into two equal area sub images based on its original probability density function

Y. T. Kim [9] proposed a novel extension of histogram equalization to overcome such drawback of the histogram equalization

D. Rajan and S. Chaudhuri [10] presented two new techniques of using data fusion, based on the modality of the data generation process, to generate a super resolved image from a sequence of low resolution image intensity data

III. IMAGES ENHANCEMENT TECHNIQUES

Histogram equalization is one of the well known image enhancement technique. It became a popular technique for contrast enhancement because this method is simple and effective. In the latter case, preserving the input brightness of the image is required to avoid the generation of non-existing artifacts in the output image. Although these methods preserve the input brightness on the output image with a significant contrast enhancement, they may produce images with do not look as natural as the input.

The basic idea of HE method is to re-map the gray levels of an image. HE tends to introduce some annoying artifacts and unnatural enhancement. Histograms can also be taken of color images - either individual histogram of red, green and blue channels can be taken, or a 3-D histogram can be produced, with the three axes representing the red, blue and green channels, and brightness at each point representing the pixel count. The exact output from the operation depends upon the implementation, it may simply be a picture of the required histogram in a suitable image format, or it may be a data file of some sort representing the histogram statistics. Histogram equalization technique is commonly employed for image enhancement because of its simplicity and comparatively better performance on almost all types of images. The operation of HE is performed by remapping the gray levels of the image based on the probability distribution of the input gray levels. It flattens and stretches the dynamic range of the image's histogram and resulting in overall contrast enhancement. Contrast enhancement by histogram equalization is one such technique. A histogram equalized image enhances the hard to perceive details of the original image. Nevertheless the original image contains useful information. Gray level transformations are the examples of intensity transformations

IV. HISTOGRAM EQUALIZATION TECHNIQUES

Histogram equalization technique is commonly employed for image enhancement because of its simplicity and comparatively better performance on almost all types of images. Various histogram techniques have been proposed in literature and these are described below:

A. Conventional Histogram Equalization:-

For a given image X, the probability density function p(Xk) is defined as

$$p(X_k) = \frac{n^k}{n} \qquad (3.1\text{-}1)$$

For k = 0, 1, …, L – 1, where nk represents the number of times that the level Xk appears in the input image X and n is the total number of samples in the input image. p(Xk) is associated with the histogram of the input image which represents the number of pixels that have a specific intensity Xk. In fact, a plot of nk vs. Xk is known histogram of X. Based on the probability density function, the cumulative density is

$$c(x) = \sum_{j=0}^{k} p(X_j) \qquad (3.1\text{-}2)$$

Let's define a transform function f(x) based on the cumulative density

$$f(x) = X_0 + (X_{L-1} - X_0)c(x) \qquad (3.1\text{-}3)$$

Then the output image of the HE, Y = p{Y (i, j)}, can be expressed as

$$Y = f(X) = \{ f(X(i,j)) \mid \forall X(i,j) \in X \} \qquad (3.1\text{-}4)$$

Dynamic range expansion, Besides, CHE also flattens a histogram. Based on information theory, entropy of message source will get the maximum value when the message has uniform distribution property. As addressed previously, CHE can introduce a significant change in brightness of an image, which hesitate the direct application of CHE scheme in consumer electronics

B. Brightness Preserving Bi-Histogram Equalization:-

This method divides the image histogram into two parts. In this method, the separation intensity is presented by the input mean brightness value, which is the average intensity of all pixels that construct the input image. After this separation process, these two histograms are independently equalized. By doing this, the mean brightness of the resultant image will lie between the input mean and the middle gray level. The histogram with range from 0 to L-1 is divided into two parts, with separating intensity. This separation produces two histograms. The first histogram has the range of 0 to, while the second histogram has the range to L-1.

C. Dualistic Sub-Image Histogram Equalization:-

Following the same basic ideas used by the BBHE method of decomposing the original image into two sub-images and then equalizes the histograms of the sub-images separately, proposed the so called equal area dualistic sub-image HE (DSIHE) method [29]. Instead of decomposing the image based on its mean gray level, the DSIHE method decomposes the images aiming at the maximization of the Shannon's entropy of the output image. For such aim, the input image is decomposed into two sub-images, being one dark and one bright, respecting the equal area property (i.e., the sub-images has the same amount of pixels). In , it is shown that the brightness of the output image O produced by the DSIHE method is the average of the equal area level of the image I and the middle gray level of the image, i.e., L / 2. The authors claim that the brightness of the output image generated by the DSIHE method does not present a significant shift in relation to the brightness of the input image, especially for the large area of the image with the same gray-levels (represented by small areas in histograms with great concentration of gray levels), For example images with small objects regarding to great darker or brighter backgrounds.

D. Minimum mean brightness error Bi-HE:-

Still following the basic principle of the BBHE and DSIHE methods of decomposing an image and then applying the HE method to equalize the resulting sub-images independently, proposed the minimum mean brightness error Bi-HE (MMBEBHE) method. The main difference between the BBHE and DSIHE methods and the MMBEBHE one is that the latter searches for a threshold level that decomposes the image I into two sub-images I [0, lt] and I [lt +1, L −1], such that the minimum brightness difference between the input image and the output image is achieved, whereas the former methods consider only the input image to perform the decomposition. Once the input image is decomposed by the threshold level lt, each of the two sub-images I [0, lt] and I [lt +1, L−1] has its histogram equalized by the classical HE process, generating the output image. Assumptions and manipulations for finding the threshold level in O (L) time complexity was made in. Such strategy allows us to obtain the brightness (O [O, l] ∪ O [l +1, L −1]) of the output image without generating the output image for each candidate threshold level l, and its aim is to produce a method suitable for real-time applications.

E. Recursive Mean-Separate HE Method:-

Recall that the extensions of the HE method described so far in this section were characterized by decomposing the original image into two new sub-images. However, an extended version of the BBHE method named recursive means separate HE (RMSHE), proposes the following. Instead of decomposing the image only once, the RMSHE method proposes to perform image decomposition recursively, up to a scale r, generating 2r sub-images [25]. After, each one of these sub-images Ir [ls, lf] is independently enhanced using the CHE method. Note that when r = 0 (no sub-images are generated) and r = 1, the RMSHE method is equivalent to the CHE and BBHE methods, respectively. The brightness of the output image is better preserved as r increases. Note that, computationally speaking, this method presents a drawback: the number of decomposed sub-histograms is a power of two.

F. Mean Brightness Preserving Histogram Equalization:-

The mean brightness preserving histogram equalization (MBPHE) methods basically can be divided into two main groups, which are bisections MBPHE, and multi-sections MBPHE. Bisections MBPHE group is the simplest group of MBPHE. Fundamentally, these methods separate the input histogram into two sections. These two histogram sections are then equalized independently. However, bisections MBPHE can preserve the mean brightness only to a certain extent. However, some cases do require higher degree of preservation to avoid unpleasant artifacts. Furthermore, bisections MBPHE can only preserve the original mean brightness if and only if the input histogram has a quasi-symmetrical distribution around its separating point. But, most of the input histograms do not have this property. This condition leads to the failure of bisections MBPHE in preserving the mean intensity in real life applications. Multi-sections MBPHE group has a better mean brightness preservation as compared with the group of bisections MBPHE. In multi-sections MBPHE, the input histogram is divided into R sub-histograms, where R is any positive integer value. Each sub-histogram is then equalized independently. The creation of the sub-histograms can be carried out recursively (e.g. by using the mean or median intensity value), or based on the shape of the input histogram itself (e.g. using the locations of local maximum or local minimum). Yet, in these methods, the detection of the separating points' process normally requires complicated algorithms, which then associated with relatively high computational time. Furthermore, these methods usually increase the hardware requirement in the implementations for consumer electronic products. In addition, most of these methods put too much constrain on keeping the mean intensity value. As a consequence, not much enhancement could be obtained from most of these methods.

G. Dynamic Histogram Equalization:-

The Dynamic Histogram Equalization (DHE) technique takes control over the effect of traditional Histogram Equalization so that it performs the enhancement of an image without making any loss of details in it. DHE divides the input histogram into number of sub-histograms until it ensures that no dominating portion is present in any of the newly created sub-histograms. Then a dynamic gray level (GL) range is allocated for each sub-histogram to which its gray levels can be mapped by Histogram Equalization. This is done by distributing total available dynamic range of gray levels among the sub-histograms based on their dynamic range in input image and cumulative distribution (CDF) of histogram values. This allotment of stretching range of contrast prevents small features of the input image from being dominated and washed out, and ensures a moderate contrast enhancement of each portion of the whole image. At last, for each sub-histogram a separate transformation function is calculated based on the traditional Histogram Equalization method and gray levels of input image are mapped to the output image accordingly. The whole technique can be divided in three parts partitioning the histogram, allocating GL ranges for each sub histogram and applying Histogram Equalization on each of them.

H. Brightness Preserving Dynamic Histogram Equalization:-

The brightness preserving dynamic histogram equalization (BPDHE), which is an extension to HE that can produce the output image with the mean intensity almost equal to the mean intensity of the input, thus fulfils the requirement of maintaining the mean brightness of the image. This method is actually an extension to both MPHEBP and DHE. Similar to MPHEBP, the method partitions the histogram based on the local maximums of the smoothed histogram. However, before the histogram equalization taking place, the method will map each partition to a new dynamic range, similar to DHE. As the change in the dynamic range will cause the change in mean brightness, the final step of this method involves the normalization of the output intensity. So, the average intensity of the resultant image will be same as the input. With this criterion, BPDHE will produce better enhancement compared with MPHEBP, and better in preserving the mean brightness compared with DHE.

V. PERFORMANCE MEASURES

The performance - measures used in this paper provide some quantitative comparison among different fusion schemes, mainly aiming at measuring the definition of an image.

A. PEAK SIGNAL TO NOISE RATIO (PSNR):

PSNR is the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation

B. ENTROPY (EN):

Entropy is an index to evaluate the information quantity contained in an image. If the value of entropy becomes higher after fusing, it indicates that the information increases and the fusion performances are improved.

C. STANDARD DEVIATION:

It is the deviation about mean. It represents the dynamic range of values present in an image about the Mean.

D. AVERAGE GRADIENT:

It is used for measuring the clarity of the image

VI. CONCLUSIONS

Histogram equalization is a straight forward image processing techniques often used to achieve better quality images While designing image enhancement techniques the speed of execution of the program is also an important factor.

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