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A Survey of Contrast Enhancement Technique for Remote Sensing Images

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ABSTRACT: Recent trends show that the usage of image processing is becoming more and more prominent in our daily life. In addition to television, camera and personal computer, many high-tech electronic products, such as hand-phone, or even a refrigerator, nowadays are being equipped with capabilities to display digital images. Unfortunately, the input images that are captured by (or provided for) these devices are sometimes not really in good brightness and contrast. Therefore, a process known as a digital image contrast enhancement is normally required to increase the quality of these low Contrast images. Histogram Equalization is a widely used contrast enhancement method in image processing applications. The algorithm can be easily implemented; however, it tends to transform the average brightness of an image towards the middle of the gray scale. In addition, unpleasant artefacts often appear in the enhanced images. Here in this paper a survey of all the techniques related to contrast enhancement of images is given. Also the paper contains all the advantages and disadvantages of these techniques.

Keywords: Contrast enhancement, discrete wavelet transform (DWT), remote sensing image, Classical Histogram Equalization, Adaptive Histogram Equalization

I. INTRODUCTION

Image enhancement is a process involving changing the pixel intensity of the input image, so that the output image should subjectively look better [1]. The utility of digital images is very much common for all kinds of display gadgets. Image enhancement is used in the following areas: Removal of noise from an image, enhancement of the brighter image and highlight the edges of the objects in an image. The goal of image enhancement is to improve the image quality, so that the processed image is better than the original image for a specific application or set of objectives. These methods include histogram equalization, gamma correction, high pass filtering, low pass filtering, homomorphic filtering, etc. In calculation to applications in medicine and the space program, digital image processing techniques now are used in a broad range of applications. Computer procedures are used to enhance the contrast or other features of the image for easier interpretation of x-rays and other images used in industry, medicine and the biological sciences [1].

Image enhancement operation improves the qualities of an image in terms of contrast, brightness characteristics, reduction of noise contents, etc. Sometimes an image may be too dark containing blurredness and therefore it is difficult to recognize the different objects or scenery contained in the image. These techniques find application in areas ranging from user electronics, biomedical image processing to aerospace image processing. Of the many techniques available for image contrast enhancement, the techniques that use first order statistics of digital images (image histogram) are very popular. The reason of image enhancement is to improve the interpretability or perception of information contained in the image for individual viewers, or to make available an improved input for other automated image processing systems. It plays an important role in the use of images in various applications like cancer and tumor detection, medical image processing, radar image processing etc.

There are many image enhancement techniques that have been proposed and developed, the most popular method being Histogram Equalization (HE) [3] has been the most popular approach to enhancing the contrast in various application areas such as medical image processing, object tracking, speech recognition, etc. HE-based methods cannot, however, maintain average brightness level, which may result in either under- or oversaturation in the processed image. Other techniques are brightness preserving bi-histogram equalization (BBHE) [4], dualistic sub-image histogram equalization (DSIHE) [5], recursive mean separate histogram equalization (RMSHE) [6], Gain controllable clipped histogram equalization(GC-CHE) [7], Minimum mean brightness error bi-histogram equalization in contrast enhancement (MMBEBHE) [8], Brightness Preserving Histogram Equalization with Maximum Entropy (BPHEME) [9], contrast enhancement of satellite images based on the discrete wavelet transform (DWT) and singular value decomposition [10], brightness preserving dynamic histogram equalization (BPDHE) [11].

A novel approach for contrast enhancement based on histogram equalization [12] and Image Dependent Brightness Preserving Histogram Equalization (IDBPHE) [13]. The proposed method includes identifying the bright regions using Discrete Wavelet Transform (DWT) with optimal edge detection algorithm.

II. RELATED WORK

A. Contrast Enhancement

The contrast enhancement is one of the challenges of the most important research of image enhancement. There are many methods for enhancing the contrast in the literature has been proposed, a very popular technique for improving the image histogram equalization (HE). This technique is commonly used for the development of the image due to its simplicity and relatively better performance on almost all types of images. This technique has some limitations that are described in the following section. Some researchers have focused on improving the histogram equalization improving local contrast as adaptive histogram equalization, which helps to enhance the contrast locally as shown in Fig. 1 [2].

(a) **(b)**

Fig. 1. Contrast Enhancement.

(a) A Low Contrast image (b) A High Contrast Image

The Fig.1. (b) Shows the results of enhancing the contrast of the image given in Fig. 1 (a). The low contrast image has been enhanced using the Histogram Equalization technique.

B. Histogram Equalization

Histogram equalization (HE) is a popular method to enhance the contrast of an image. Its basic idea lies in mapping the gray levels based on the probability distribution of the input gray levels. The method is described in images with background and foreground both bright or both dark. In particular, the method to get a better view of the bone structure in the X-ray images and better details in photographs that are under or overexposed to lead. HE has been applied in different fields such as medical image processing and radar image processing. A key advantage of this technique is that it is fairly straightforward and effective. The computation is not computationally intensive. It is powerful in highlighting the borders and edges between different objects, but may reduce the local details within these objects, especially smooth and small ones as shown in Fig. 2.

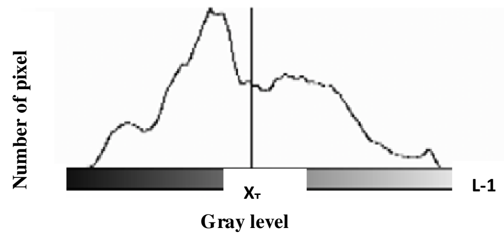

Fig. 1. Bi-histogram equalization.

The histogram with a range from 0 to L-1 is divided into two parts, with separating intensity $X_{T.}$ This taking apart produces two histograms. The original histogram has the range of 0 to $X_{T,}$ while the second histogram has the range of X_{T+1} to L-1.

Another disadvantage of the method is that it is indiscriminate. It may enlarge the contrast of background noise, while decreasing the usable signal. This technique may produce images with over enhancement. HE tends to introduce some annoying artefacts and not natural enhancement. A histogram basically plots the frequency at which each gray-level occurs from 0 (black) to 255 (white). Histogram represents the frequency of occurrence of all gray-level in the image, that means it tell us how the values of individual pixel in an image are distributed.

III. HISTOGRAM EQUALIZATION APPROACHES

There are various histogram equalization approaches with their own advantages and disadvantages.

a) Classical Histogram Equalization (CHE).
b) Adaptive Histogram Equalization (AHE).
c) Brightness preserving Bi- Histogram Equalization (BPBHE).
d) Recursive Mean Separate Histogram Equalization (RMSHE).

1. Classical Histogram Equalization (CHE). The traditional Histogram Equalization is a universal operation. Here the Equalization is applied to the entire image. For a given image X, the probability density function P (X_k) is defined as:

$$P(X_k) = n^k/n$$

For $k = 0, 1\ldots L - 1$, where n^k represents the number of times that the level (X_k) appears in the input image **X** and n is the total number of samples in the input image.

The algorithm for Classical Histogram Equalization

i. Start the program
ii. Read the image from the recent folder.
iii. Find the size of the image.
iv. Obtain the histogram of the image
v. Compute the new values by the use of the general histogram equalization method.
vi. Acquire the probability density function and cumulative distribution function.
vii. Construct a new image by replacing original gray values with the new gray values.

viii. Optionally, acquire the histogram and original image to compare them with the cumulative histogram of the new image.
ix. Demonstrate graphics results.
x. Stop

Disadvantage

- The traditional Histogram Equalization method does not take the mean brightness of an image into account.
- The CHE method may result in in excess of enhancement and saturation artifacts due to the stretching of the gray levels over the full gray level range.

To overcome these drawbacks and increase contrast enhancement and brightness preserving many HE-based techniques have been proposed as shown in Fig. 3.

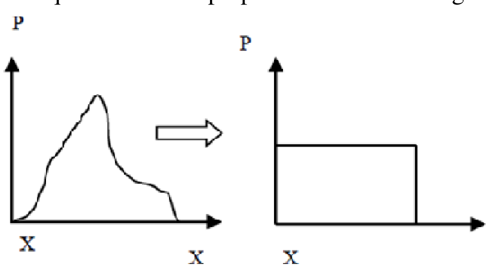

Fig. 3. Histogram and its Equalized Histogram.

2. Adaptive Histogram Equalization (AHE). Adaptive histogram equalization is a computer image processing technique used to get better contrast in images. It operates in tiny regions in the image, called tiles, rather than the whole image. Every tile's contrast is enhanced, so that the histogram of the output region approximately matches the histogram specified by the 'Distribution' parameter. Neighbouring tiles are then combined by bilinear interpolation to eliminate artificially limits aforesaid. In contrast, particularly in homogeneous areas may be limited to avoid amplification of noise which may be present in the image.

Algorithm for Adaptive Histogram Equalization

i. Start the program.
ii. Obtain all the inputs like image, no of regions, dynamic range and clip limit.
iii. Pre-process the inputs.
iv. Process each contextual region producing gray level mapping.
v. Interpolate gray level mapping in order to assemble the final image.
vi. Stop.

Disadvantages

- It can produce significant noise because it tends to amplify noise.

- It also fails to hold on to the brightness through to the input image

3. Brightness Preserving Bi- Histogram Equalization (BPBHE). Here bi-histogram equalization the histogram of the original image is separated into two sub histograms based on the mean of the histogram of the original image, the sub-histograms are equalized independently using distinguished histogram equalization, which produces butter histogram as shown in Fig. 4.

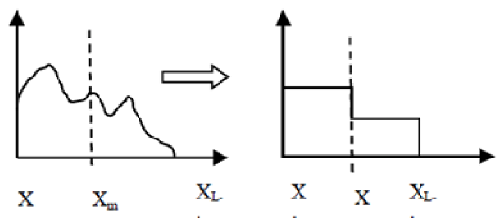

Fig. 4. BI-histogram Equalization Method.

Where:

X_m - mean of the image X, (and imagine that X_m ε $\{X_0, X_1 \ldots. X_{L-1}\}$), Based on the mean, the input image is decomposed into two sub-images X_L and X_U.

This indicates that the BPBHE preserves the brightness compared to HE where output mean is always the middle gray level.

Algorithm for BPBHE.

i. Start the program
ii. Read the original image
iii. Construct the histogram of the image
iv. Compute the mean of the histogram.
v. Divide the Histogram into two parts Based on the mean
vi. Equalize each Partition independently using Probability Density Function and Cumulative Density Function
vii. Stop

Disadvantage

- Higher degree of brightness preservation is not possible to avoid annoying artefacts

In some images, the conservation of brightness is not sufficient to avoid unpleasant artifacts. They clearly show that the upper the brightness preservation is important for these pictures, to avoid unpleasant artifacts. During this case RMSHE turn out higher results, as mentioned below.

4. Recursive Mean Separate Histogram Equalization (RMSHE). Recursive Mean-Separate Histogram Equalization (RMSHE) is another technique to provide better brightness and evolutionary conservation gray scale and color images. During the separation is performed once BHE RMSHE recursively executes the separation on the basis of their respective mean. Mathematically, it is analyzed that the images of average output brightness of brightness of the input images converge the average number of recursive mean separation increases. The outputs mean E (Y) for RMSHE recursion level r = n is given as:

For, r=0. $E(Y) = X_G$

r=1, $E(Y) = (X_M+X_G)/2$

r=2, $E(Y) = 3(X_M+X_G)/4$

$$r = n,\ E(Y) = ((2n-1) + X_M + X_G)/2^n$$
$$= X_M - [(X_G - X_M)/\ 2^n]$$

Here $X_G = (X_0+X_{L-1})\ /2$

Indicates with the aim of as the recursion level, n grows larger; E(Y) will ultimately converge to the put in mean, X_m.

Consequently, this algorithm allows an attractive property to alter the brightness level depending on the image requirement. The recursive nature of RMSHE also allows scalable brightness conservation, which is very helpful in consumer electronics.

Disadvantage

- The number of decomposed subs-histograms is a power of two as shown in Fig. 5.

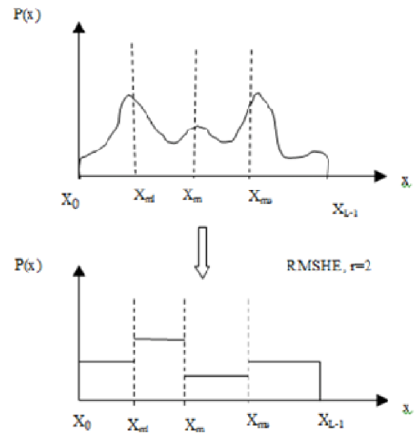

Fig. 1. Shows Histogram equalization for RMSHE, r = 2.

According to Kim [2], one drawback of the histogram equalization can be found in the fact that the brightness of an image can be altered after the histogram equalization, just because of to the flattening property of the histogram equalization. Therefore, it is hardly utilized in consumable electronic products such as TV where preserving the original input brightness may necessary in order not to introduce unnecessary visual deterioration. Kim proposed a technique called Brightness preserving bi-histogram equalization. The main motive behind this technique was to preserve the brightness of the image while enhancing its contrast.

Brightness preserving bi-histogram equalization (BBHE) [2] is to utilize independent histogram equalizations separately over two sub-images obtained by decomposing the input image based on its mean with a constraint that the resulting equalized sub-images are bound by each other around the input mean. It will be shown mathematically that the proposed algorithm preserves the mean brightness of a given image significantly well compared to typical histogram equalization while enhancing the contrast and, thus, provides much natural enhancement that can be utilized in consumer electronic products.

In the view point of H/W implementation, however, the proposed algorithm requires more complicated H/W than the typical histogram equalization.

Yu Wang [3] Proposed Dualistic sub-image histogram equalization (DSIHE). They also do the same thing that BBHE. In Dualistic sub-image histogram equalization (DSIHE), the image is decomposed into two equal area sub-images based on its original probability density function. Then the two sub-images are equalized respectively. At last, we get the result after the processed sub-images are composed into one image. The simulation result indicates that the algorithm can not only enhance image information effectively, but also keeps the original image luminance well enough to make it possible to be used in video system directly.

For further improvement, S. Chen proposed the recursive mean-separate HE (RMSHE) [4] method. The recursive mean-separate HE iteratively performs the BHE and produces separately equalized sub-histograms. However, the optimal contrast enhancement cannot be achieved since iterations converge to null processing.

In 2008, T. Kim and J. Paik, proposed Gain controllable clipped histogram equalization (GC-CHE) [5]. This contrast enhancement method is generalization of the existing bi-histogram equalization (BHE) and recursive mean-separate histogram equalization (RMSHE) methods. (GC-CHE) provide both histogram equalization and brightness preservation. More specifically the adaptive contrast enhancement is realized by using clipping histogram equalization with controllable gain. The clipping rate is determined based on the mean brightness, and the clipping threshold is determined based on the clipping rate. The clipping rate is adaptively controlled to enhance the contrast with preserving the mean brightness. GC-CHE method outperforms existing histogram-based methods, such as HE, BHE, and RMSHE, in various situations.

Minimum Mean Brightness Error Bi-Histogram Equalization (MMBEBHE) [6] technique was proposed by Chen and Ramli. In this technique the histogram is partitioned based on a threshold level which is equivalent to minimize the difference between the input mean and output mean. In case of preserving the brightness of original image this method is better than BBHE and DSIHE.

In 2005, Chao Wang proposed a technique called Brightness Preserving Histogram Equalization with Maximum Entropy (BPHEME) [7]. The idea behind their technique was to find the target histogram that maximizes the entropy, keeping in view that the brightness of the original image is preserved, and then applies histogram transformations to transform the original histogram to the targeted one. The results showed that this technique is better than BBHE, DSIHE and MMBEBHE as shown in Fig. 6.

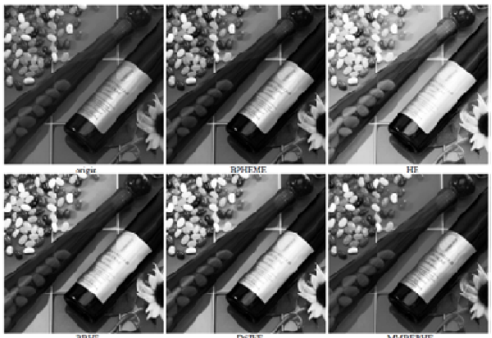

Fig. 6. Enhancement for bottle based on HE, BBHE, DSIHE, MMBEBHE, BPHEME.

In 2009, Demirel [8] proposed new method for enhancing the contrast of satellite images based on the discrete wavelet transform (DWT) and singular value decomposition. The technique decomposes the input image into the four frequency sub-bands by using DWT and estimates the singular value matrix of the low–low sub-band image, and, then, it reconstructs the enhanced image by applying inverse DWT. Their technique showed better results than conventional BPDHE. In spite of the improved contrast of the image, this method tends to distort image details in low- and high-intensity regions.

Continuing with the research Ibrahim et. Al. Proposed their method for preserving the brightness, dynamic histogram equalization (BPDHE) [9], To avoid peak remapping, Ibrahim and Kong, in their Brightness Preserving Dynamic Histogram Equalization (BPDHE) technique, use the concept of smoothing a global image histogram using Gaussian kernel followed by its segmentation of valley regions for their dynamic equalization. The problem with this technique is that this technique processes the crisp histograms of images to enhance contrast. The crisp statistics of digital images suffers from the inherent limitation that it does not take into account the inexactness of gray-values. Additionally, crisp histograms need smoothing to achieve useful partitioning for equalization.

H. Yeganeh proposed A Novel Approach for Contrast Enhancement Based on Histogram Equalization [10], Histogram based techniques is one of the important digital image processing techniques which can be used for image enhancement. One of the advantages of histogram based techniques is simplicity of implementation of the algorithm. Also, it should be mentioned that histogram based techniques is much less expensive compared to the other methods Histogram based techniques for image enhancement is mostly based on equalizing the histogram of the image and increasing the dynamic range corresponding to the image. Histogram Equalization (HE) method has two main disadvantages which affect efficiency of this method.

For solving the above problems, some techniques have proposed, for example, using Bi-Histogram Equalization (BHE) algorithm instead of Histogram Equalization (HE). It should be mentioned that Bi Histogram Equalization (BHE) is one of the best proposed algorithm; H. Yeganeh proposed algorithm applies any preprocessing steps on the histogram corresponding to the image and then applies histogram equalization.

In 2010, P. Rajavel proposed Image-dependent brightness preserving histogram equalization (IDBPHE) [11] technique to enhance image contrast, while preserving the image brightness The curvelet transform and histogram matching technique are used to enhance the image. The proposed IDBPHE technique undergoes two steps. (i) The curvelet transform is used to identify bright regions of the original image. (ii) Histogram of the original image is modified with respect to a histogram of the identified regions. A histogram of the original image is modified using a histogram of a portion of the same image, hence; it enhances image contrast while preserving the image brightness without any undesired artifacts.

In 2013, Kim and Kang [12] proposed algorithm compute brightness-adaptive intensity transfer functions using the low-frequency luminance component in the wavelet domain and transforms intensity values according to the transfer function. More specifically, we first perform discrete wavelet transform (DWT) on the input images and then decompose the LL sub-band into low-, middle-, and high-intensity layers using the log-average luminance. Intensity transfer functions are adaptively estimated by using the knee transfer function and the gamma adjustment function based on the dominant brightness level of each layer. After the intensity transformation, the resulting enhanced image is obtained by using the inverse DWT. The disadvantage of this technique is that it does not perform a local contrast enhancement, it only performs global enhancement and does not preserve edge information of remote sensing images.

III. CONCLUSION

This paper contains the complete survey of various techniques of contrast enhancement using histogram equalization. Many image contrast enhancement techniques like Histogram Equalization (HE), Classical Histogram Equalization (CHE), Adaptive Histogram Equalization (AHE), Brightness preserving Bi- Histogram Equalization (BPBHE), Recursive Mean Separate Histogram Equalization (RMSHE), these methods are discussed so that using the drawbacks of the previous techniques we can implement a more efficient technique or the contrast enhancement.

REFERENCES

[1]. Rafael C. Gonzalez (2004), and Richard E. Woods, 2nd edition, Prentice Hall. Digital Image Processing.

[2]. R. Gonzalez and R. Woods, (2007). 3rd ed. Englewood Cliffs, N.J.: Prentice-Hall, Digital image processing.

[3]. Kaur M., Kaur J., Kaur J., (2011). Survey of Contrast Enhancement Techniques based on Histogram Equalization, *IJASA*, Vol. **2**, No. 7, pp. 137-141.

[4]. Kim, (1997) Contrast enhancement using brightness preserving bi-histogram equalization, *IEEE Trans. Consum. Electron.,* Vol. **43**, no. pp.1–8,

[5]. Y. Wan, Q. Chen, and B.M. Zhang, (1999). Image enhancement based on equal area dualistic sub-image histogram equalization method, *IEEE Trans. Consum. Electron*, vol. **45**, no. 1, pp. 68–75.

[6]. S. Chen and A. Ramli, (2003). Contrast enhancement using recursive mean separate histogram equalization for scalable brightness preservation, *IEEE Trans. Consum. Electron,* vol. **49**, no. 4,pp. 1301–1309.

[7]. T. Kim and J. Paik, (2008). Adaptive contrast enhancement using gain controllable clipped histogram equalization, *IEEE Trans. Consum. Electron*., vol. **54**, no. 4,pp.1803–1810.

[8]. Soong-Der Chen, and Abd. Rahman Ramli, (2003). Minimum mean brightness error bi-histogram equalization in contrast enhancement, *IEEE Transactions on Consumer Electronics*, Vol. **49**, no. 4, pp.1310-1319.

[9]. Chao Wang and Zhongfu Ye, November (2005). Brightness Preserving Histogram Equalization with Maximum Entropy: A Variational Perspective *IEEE Transactions on Consumer Electronics,* Vol. **51**, No. 4.

[10]. H. Demirel, C. Ozcinar, and G. Anbarjafari, (2010). Satellite image contrast enhancement using discrete wavelet transform and singular value decomposition, *IEEE Geosci. Remote Sens. Lett.,* Vol. **7**, no. 2,pp. 3333–337.

[11]. H. Ibrahim and N.S.P. Kong, (2007). Brightness Preserving Dynamic Histogram Equalization for Image Contrast Enhancement. Consumer Electronics, *IEEE Transactions*, vol. **53**, Issue. 4, pp.1752-1758.

[12]. Hojat Yeganeh, Ali Ziaei and Mirhossein Rezaie, (2008). A novel approach for contrast enhancement based on histogram equalization, *In Proceedings of the International Conference on Computer and Communication Engineering*, pp.256-260.

[13]. P. Rajavel, (2010). Image Dependent Brightness Preserving Histogram Equalization, Consumer Electronics, *IEEE Transactions* Vol. **56**, 2. pp. 756 – 763.