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A Review On: Contrast Enhancement Technique for Remotely Sensed Satellite Images

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Abstract**—The reason of image enhancement methods is to raise image visibility and aspects. Image enhancement is one of the ways as they get better of an image form by ever-increasing dominance of some aspects or by decreasing uncertainty among unusual areas of the image. Image enhancement methods exist of a collected works of techniques that try to find to improve the visual appearance of an image or to convert the image to a form enhanced appropriate for investigation by anyone or any piece of tools. Several images bear from poor contrast on behalf of that inspiration, it is vital to enhance the contrast.**

Contrast enhancement is one of the most demanding concerns in low level image processing. Contrast enhancement methods are utilized for get better for the visual observation and color facsimile of low contrast images. In this paper, various contrast enhancement techniques for low contrast images are reviewed.

Index Terms**— Contrast Enhancement, DWT, Wavelet, Histogram Equalization.**

I. INTRODUCTION

Image enhancement is mainly attractive the easiest, and visually interesting areas of image processing. It can be used to get better the quality of assured features of an image. The aim of the image enhancement is to enhance the interpretability or to make available improved input for other automated image processing. The objective of image enhancement techniques is to get better a quality of an image such that enhanced image is better than the original image. Numerous techniques for image improvement have been suggested by various researchers in both spatial and transform domains. Image enhancement techniques are mostly classified into two wide-ranging categories: spatial domain methods, which are found on the straight exploitation of pixels in an image. Frequency domain methods, which are found on transforming the Fourier transform of an image. According to spatial domain techniques, concentration values of images have been personalized [1].The visual consequences provide the visual interpretability of an image. The quantitative outcomes are used to find out which techniques are most suitable for processing.

Contrast enhancement is commonly referred to as one of the most significant problems in image processing. Contrast enhancements get better the perceptibility of objects in the prospect by enhancing the brightness difference between objects and their surroundings. Contrast enhancements are usually carried out as a contrast stretching process. The design behind contrast stretching is to enhance the self-motivated variety of gray levels in the image being processed. A contrast stretch get betters the brightness differences consistently across the dynamic range of the image, while tonal enhancements get better the brightness differences in the shade (dark), mid-tone (grays), or underscore (bright) regions at the expense of the brightness dissimilarity in the other regions.

Fig: Difference between low contrast and high contrast of an image.

Contrast enhancement plays a essential role in image processing applications, such as remote sensing images, medical image analysis, remote sensing, LCD display processing, electron microscopy images and scientific visualization. There are a number of reasons for an image/video to have poor contrast: the poor quality of the used imaging piece of equipment, lack of proficiency of the operator ,and the disagreeable exterior conditions at the time of attainment. These results outcome in under-utilization of the proposed dynamic range. Therefore, such images and videos may not expose all the features in the captured view, and may have a cleaned-out and abnormal look. Contrast enhancement objectives to get liberate of these problems, thus to obtain a more visually-pleasing or useful image or both. Characteristic viewers describe the enhanced images as if a shade of smog has been take away from the picture [2].

Image improvement produces a creation of image that unconsciously come across enhanced than the original image by shifting the pixel's intensity of the involvement image. The motivation of image enhancement is to get better the interpretability or observation of information surrounded in the image for entity viewers, or to make offered an improved input for other automated image processing systems. It take part an significant responsibility in the use of images in various applications like cancer and tumor detection, medical image processing, radar image processing remote sensing images etc. There are many image enhancement techniques that have been proposed and developed, the most popular method being Histogram

Equalization. This technique is one of the most popular methods for image enhancement due to its simplicity and efficiency. It usually increases the global contrast of the images mostly in cases where the important and useful data of the image is shown by low contrast values. Histogram equalization (HE) is a simple and effective contrast enhancement technique which distributes pixel values uniformly such that enhanced image have linear cumulative histograms. The HE technique is a global operation hence; it does not preserve the image brightness.

DWT includes any wavelet transform for which the wavelets are discretely sampled. Some of the mostly used wavelets include Haar Wavelet, Daubechies Wavelets (DB), Symlets (sym). The wavelet transform used here is the Haar transform, since Haar Transform captures not only a notion of the frequency content of the input, by inspecting it at diverse scales, but also chronological content, i.e. the moment at which these frequencies take place. After applying the DWT, the image is subjected to histogram equalization. Sometimes, the parts of the image that contains the useful data are represented by low contrast values. Using histogram equalization method the contrast of these areas is enhanced which provides improved image quality.

Many such techniques have been proposed such as brightness preserving bi-histogram equalization (BBHE) [3], Recursive Mean Separation Histogram Equalization (RMSHE) [7] enhances image by iterating BBHE. The mean intensity of the output image will come together to the average brightness of the original image when the iteration increases. Consequently the brightness of the enhanced image to the original image can be sustained much improved. Although these methods revealed over can repeatedly increase the contrast of the image, these move towards more often than not bring some undesired effects. In general the conventional global histogram equalization (GHE) will origin unnecessary enhancement, and the local histogram equalization (LHE) for a moments will bring block effect [8]. Consecutively to overcome these problems an image contrast enhancement algorithm based on the weighted average of histogram equalization and gamma correction in which the level of contrast enhancement can be restricted by regulating the weighting coefficients. Dualistic sub-image histogram equalization (DSIHE) [4], minimum mean brightness error bi-histogram equalization (MMBEBHE) [5], recursive mean separate histogram equalization (RMSHE), Recursively Separated and Weighted Histogram Equalization (RSWHE), multi-histogram equalization (MMLSEMHE) [6], brightness preserving dynamic histogram equalization (BPDHE), and Image Dependent Brightness Preserving Histogram Equalization (IDBPHE).

II. Image Quality Evaluation

Contrast-enhancement algorithms accomplish different amounts of specify preservation. Contrast enhancement can show the way to colour shift, washed out form and saturation artifacts in regions with high signal action or textures. Such regions should accept less weight, while the areas with greater details or with low signal action should receive higher weight throughout fusion. We define image quality measures which show the fusion process. These evaluation are combined into a scalar weight map to attain the fusion goals described. This section is organized as follows. We first define metrics to evaluation the contrast and luminance of the enhanced images. Next, the computation of a scalar weight map is explained.

Contrast Evaluation

Given an input image I(x, y)where x and y are the row and column coordinates, in that order. The gradient vector at any pixel location p=(x, y) is computed by concerning the two-dimensional directional derivative.

$$\nabla I(x,y) = \begin{bmatrix} G_x \\ G_y \end{bmatrix} = \begin{bmatrix} \frac{\partial}{\partial x} I(x,y) \\ \frac{\partial}{\partial y} I(x,y) \end{bmatrix} \tag{1}$$

where Gx and Gy are approximated by

$$G_x = I(x,y) - I(x+1,y)$$
$$G_y = I(x,y) - I(x,y+1) \tag{2}$$

The absolute value of the image gradient |∇I| is in use as a simple display of the image contrast C and used as a metric to estimate the scalar weight map.

$$|\nabla I| = \sqrt{G_x^2 + G_y^2} \tag{3}$$

We make use of first-order derivative to compute the contrast metric because first-order derivatives have a stronger reply to gray level step in an image and are less susceptible to noise. A comparable contrast measure based on the local pixel intensity differences was proposed in [11]. Additional authors measure the contrast by be appropriating a Laplacian filter (second-order derivative) to the image and attractive the absolute value of the filter response [10]. Second-order derivatives have a stronger response to a line than to a step and to a point than to a line [9]. As second-order derivative is much more insistent than first-order derivative in enhancing sharp transforms, it can enhance noise points much more than first-order derivative.

Brightness/ Luminance Preservation Evaluation

Contrast enhancement frequently consequences in a considerable shift in the brightness of the image generous it a washed out emergence, which is unattractive. The nearer the intensities of the enhanced images to the mean intensity of the original image the improved they are in term of intensity distribution. We define a metric L found on how to close the intensities of the enhanced image pixels are to the mean intensity of the original image. L allocates a higher value to the intensities (i) nearer to the mean intensity of the original image and vice versa such that the intensities (ii) nearer to the mean intensity of the original image obtain a higher weight in the fused output image. This is accomplished by using a Gaussian kernel centered on the mean image intensity of the original image given by:

$$L(i; m_o, \sigma) = exp\left(-\frac{(i - m_o)^2}{2\sigma^2}\right) \tag{4}$$

where σ is chosen as 0.2 and m_o is the mean intensity of the original image.

Scalar Weight Map

The difficulty of produce a composite/fused image transforms into the trouble of calculated the weights for the fusion of the source images. A normal approach is to allocate to each input image a weight that depends increasingly salience on the task. Measures of salience are based on the criterion for the exacting vision undertaking. The salience of a constituent is high if the outline participates a responsibility in instead of important information. For the anticipated fusion application, the less contrasted and saturated regions should be given less weight(less salience), whereas attractive areas containing bright colours and aspects (high visual saliency) should have high weight. Based on this prerequisite, weights (for the fusion process) are calculated by mixed the measures defined (according to the visual saliency) for the contrast, saturation and luminance. We mix these measures (contrast, luminance) into a weight map using multiplication (AND) operation. The reason for using multiplication (AND operation) over addition (OR operation) is that the scalar weight map should have a involvement from all the measures (contrast, luminance) at the same time. We checked the fusion consequences using different combinations (linear and logarithmic operations) of the measures to calculate the weight maps. On the other hand, the best outcomes are accomplished using a multiplicative combination for the computation of the weight map. The scalar weight map, for each pixel that put into effects the contrast and luminance characteristics all at once, is given by-

$$P_{i,j,k} = (C_{i,j,k})^{\alpha} (L_{i,j,k})^{\beta} \quad (5)$$

where C and L are the contrast and the luminance, respectively. The N weight maps (for N input images) P i, j, k are normalized such that they sum to one at each pixel (i, j). This is given by

$$\hat{P}_{i,j,k} = \left[\sum_{k'=1}^{N} P_{i,j,k'}\right]^{-1} \quad (6)$$

We can manage the control of each measure in the metric P using a power function, where and are the corresponding weighting exponents. The subscript i, j, k refers to pixel (i, j)in image k. If an exponent (or) equals 0, the corresponding measure is not taken into account. $P_{i,\ j,\ k}$ is a scalar weight map which controls the fusion process.

III. Prior Work on Contrast Enhancement

Normalization of Image Brightness:

The image obtained after the dynamic histogram equalization of each sub histogram is has the mean brightness that is slightly different than the input image. To remove this difference the normalization process is applied to the output image.

In 2005 Chao Wang and Zhongfu ye proposed approach for histogram equalization, histogram specification. HE should be as flat as possible to maximize the entropy so the author gives Brightness Preserving Histogram Equalization with Maximum Entropy (BPHEME). In this approach the target histogram maximizes the entropy by taking the fixed mean brightness and it transforms the original histogram to that target one using histogram specification. BPHEME can enhance the image effectively and preserve the original brightness quite well [7].

Histogram Specification

When a histogram transformation method is judged, many applications require a desirable shape of the histogram. We want to generate a processed image that has the specified desirable histogram, which is called Histogram Specification (HS) or histogram matching. Since a histogram can be viewed as the probability density function of the variable for gray levels, [7] we introduce the histogram processing methods from a continuous view in the following parts.

Discrete Wavelet Transformation

The Discrete Wavelet Transform or DWT is separate in time and scale, it means that the DWT coefficients may have floating-point values, excluding the time and scale significances used to index these coefficients. A signal is decomposed by DWT into one or more levels of resolution (also called octaves), A one-dimensional, one octave DWT. It includes the analysis (wavelet transform) on the left side and the synthesis (inverse wavelet transform) on the right side. The low-pass filter produces the average signal, while the high pass filter produces the detail signal. In multi-resolution analysis, the average signal at one level is sent to another set of filters , which produces the average and detail signals at the next octave. The detail signals are kept, but the higher octave averages can be discarded, since they can be re-computed during the inverse transform. Each channel's outputs have only half the input's amount of data (plus a few coefficients due to the filter. Thus, the wavelet illustration is around the identical size as the original. The DWT can be 1- Dimensional, 2-D, 3-D, etc. depending on the signal's dimensions.

The 2-D wavelet decomposition of an image is performed by applying 1-D DWT along the rows of the image first, and, then, the results are decomposed along the columns. This operation results in four decomposed sub band images referred to as low–low (LL), low–high (LH), high–low (HL), and high–high (HH). Where, the signal is denoted by the sequence CAj, where Aj is an integer. The low pass filter is denoted by Lo_D while the high pass filter is denoted by Hi_D. At each level, the high pass filter produces detail information, while the low pass filter associated with scaling function produces coarse approximations. At each decomposition level, the half band filters produce signals spanning only half the frequency band. This doubles the frequency resolution as the uncertainty in frequency is reduced by half. The frequency components of those sub-band images cover the frequency components of the original image as shown in Figure.

LL	HL
LH	HH

Fig: Outcome of 2-D DWT

The 2-D transform is simply an application of the 1-D DWT in the horizontal and vertical directions [17], at least for the separable case. The indistinguishable 2-D transform efforts in a different way from the one shown, since it work out the transform supported on a 2-D sample of the input convolved with a matrix, but the outcome are the identical. The distinguishable scheme can be comprehensive to the 3-D DWT.

1-D Wavelet Architecture

One-dimensional architectures can be classified into many types, the main ones are: space multiplexed, systolic array, time multiplexed, folded, and digit-serial. There are techniques for improving these designs, which include lattice, pipelining/register networking, combined DWT and IDWT, and approximating results. However, each improvement involves a certain tradeoff: for example, lattice uses less space at the expense of a slower speed. Examples of each category will be discussed below. Architectures are often designed with applications in mind. For 1-D transforms, applications may include denoising a nuclear magnetic resonance (NMR) signal, compressing seismic information, and identifying noisy FM signals.

According to Kim [3], 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 [3]. Kim proposed a technique whereby the input histogram is divided into two sub-histograms on the basis of its mean value. The main motive behind this technique

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was to preserve the brightness of the image while enhancing its contrast.

Wan et. Al. [4] Proposed Dualistic sub-image histogram equalization (DSIHE). They also do the same thing that BBHE does but the criterion for separation of histograms is the median value. They also proposed another technique namely Recursive Mean Separate Histogram Equalization (RMSHE), where the histogram is recursively partitioned based on local mean values and the number of sub-histograms (2^r) are given by the user.

Minimum Mean Brightness Error Bi-Histogram Equalization (MMBEBHE) technique was proposed by Chen and Ramli [5]. 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.

Wang et. al. [12] proposed a technique called Brightness Preserving Histogram Equalization with Maximum Entropy (BPHEME). 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 apply histogram transformations to transform the original histogram to the targeted one. The results showed that this technique is better than BBHE, DSIHE and MMBEBHE.

Multi-histogram equalization (MMLSEMHE) methods were proposed by Menotti et. al. [6]. According to them, though bi-HE methods preserve the brightness of the original image but, the output image may not look as natural as the original image. They proposed a technique which on one hand preserves the brightness of the input image and on the other hand generated images with natural appearances. Later in the same year, Ibrahim et. al. Proposed their method for preserving the brightness entitled preserving dynamic histogram equalization (BPDHE), in which the histogram is first subjected to 1-D Gaussian filter and then it is sub-partitioned into a number of sub-histograms based on its local maximums. Each sub-histogram is then equalized separately.

Hossain et. al. [13] proposed a technique called Minimum Mean Brightness Error Dynamic Histogram Equalization (MMBEDHE) whereby, the input image is divided into a number of sub-images and then the classical HE is applied to each of them. The absolute average error using this technique was calculated to be very less as compared to since then existing techniques [13]. In the same year, Xie et. al. [14] came up with their technique for image enhancement known as "An Adaptive Image Enhancement Technique Based on Image Characteristic". According to this method, the actual or original image is primarily subjected to Laplace Filter which is a spatial high-pass filter. Based on its output, the first-order classifying of the image is done. Here the image is smoothened using a low - pass filter and the edges are sharpened using a high - pass filter. At the end, HE is applied to it [14].

Continuing with the research Demirel et. al. [15] proposed a new method for enhancement of satellite images contrast called Satellite Image Contrast Enhancement Using Discrete Wavelet Transform and Singular Value Decomposition. Their method was based on Discrete Wavelet Transform (DWT) and singular-value decomposition. They first applied DWT to the input image to divide it into four frequency sub-bands, then used singular value decomposition and then again applied inverse DWT to reconstruct the image. Their technique showed better results than conventional BPDHE. In the same year, P. Rajavel came up with his proposed algorithm for brightness preservation called Image Dependent Brightness Preservation Histogram Equalization (IDBPHE) [1] .In this technique the bright regions of the images are identified using Curvelet Transform and then the histogram of the original image is modified with respect to the histogram of the identified regions.

Continuations with literature review, a new technique was proposed in [16] for image brightness preservation that used transformation functions that utilize both the global as well as local information contents of the image. The name of this proposed technique was given as Brightness Preserving Image Contrast Enhancement Using Weighted Mixture of Global and Local Transformation Functions [16]. Sheet et. al. Proposed a new technique in November 2010 called Brightness Preserving Dynamic Fuzzy Histogram Equalization (BPDFHE) which was the modified version of BPDHE whereby the fuzzy statistics of digital images were used to represent and process them. The results showed that this method was better than BPDHE for preserving the brightness and enhancing the contrast of the image.

In 2009 Tarik Arici, Salih Dikbas, and Yucel Altunbasak proposed a protocol which uses histogram equalization for image contrast enhancement is presented. Contrast enhancement minimizes cost function. Histogram equalization is an efficient method for contrast enhancement. Conventional histogram equalization (HE) gives excessive contrast, the image has an unnatural look and creates visual artifacts. It can enhance the level of contrast and can the noise robustness, white or black stitching and mean-brightness preservation [18].

In 2010 Hasan Demirel, Cagri Ozcinar, And Gholamreza Anbarjafari proposed technique which uses a new satellite image contrast enhancement technique that is based on the discrete wavelet transforms (DWT) and singular value decomposition. The technique uses DWT and decomposes the input image into the four frequency subbands and estimates the singular value matrix of the low–low subband image after that the image get deconstructed by inverse DWT. Standard general histogram equalization and local histogram. This technique proves itself than equalization, state-of-the-art techniques such as brightness preserving dynamic histogram equalization and singular value equalization [19].

In 2010 Yen-Ching Chang and Chun-Ming Chang proposed a simple histogram modification technique. Two boundary values for histogram are found and set to the corresponding values, respectively. It recomputes the probability density function of an image and the updated mapping function is used to perform histogram equalization. The technique can effectively improve the quality of images enhanced by histogram equalization and specification methods [20].

In 2011 Debashis Sen, Member and Sankar K. Pal proposed an automatic exact histogram specification technique. It is used for global and local contrast enhancement of images. It first subjects the image histogram to a modification process and then by maximizes measures that represents an increase in information and decreases in ambiguity and thus create a good histogram. It measures image contrast based upon local band-limited approach and center-surround retinal receptive field model approach. This is used in multiple scales frequency band [21].

IV. CONCLUSION

Contrast enhancement acting a critical part in low level image processing, mainly low contrast images. Contrast enhancement technique make available enhanced visual perception and color facsimile. Here in this paper a contrast enhancement algorithms offer a wide variety of approaches for transforming images to accomplished illustration satisfactory images. The alternative of such techniques is a purpose of the definite task, observer characteristics, image substance, and observing circumstances. The review of contrast enhancement techniques in both domain have been successfully carried out and is one of the most important and difficult component of digital image processing

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