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Contrast Enhancement Techniques: A Brief and Concise Review

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Abstract - *The contrast enhancement is the most crucial criterion to judge the quality of an image. The contrast levels are needed to bring out the vital information that can be extracted through an image. The contrast enhancement becomes more significant when the images are affected with the low illumination. The brightness levels, lightening problems are addressed by the contrast enhancement techniques. The subjective and objective image qualities of an image are mainly accomplished by means of applying the various contrast enhancement techniques. In this paper, a number of these techniques are been discussed according to its usage in various applications. This study will not only discuss various advantages and disadvantages of different contrast enhancement techniques but also demonstrate the different aspects that are to be studied for analysis in an image.*

Key Words: **Contrast Enhancement, Histogram Equalization, Image Processing, Illumination.**

1. INTRODUCTION

The digital image processing is the field in which different algorithms are been applied to perform the digital processing on the different set of images. The digital image processing is characterized by a number of different methods namely, enhancement, detection, classification. The image enhancement is the basis for the examination of the image in all phases. The image enhancement is required for improving the visual appearance or to obtain an improved and transformed illustration of a particular image. The processing of an image is defined by the domain analysis. The domains that are widely used are frequency and spatial domain. The spatial domain is the reference to the plane of an image and in this pixels are manipulated directly in a particular image [1]. There is a modification in the pixels that helps to obtain an improved appearance and visibility of objects in an image [2]. The spatial domain techniques are more popular than the frequency based methods, because they are applied on the direct pixels values. Some of the spatial domain techniques use either linear or non linear level of intensities transformations functions, while others use the composite study of the diverse features of image like the edge detection and information of connected components [3].

The image enhancement is done particularly for low light and moderately low light conditions. [4] The purpose of enhancement process is to obtain an image in which the result is more appropriate than the original image for a particular or definite application [5]. Nowadays, extend of new image enhancement techniques is vital and desirable problems in study of image processing. [6].

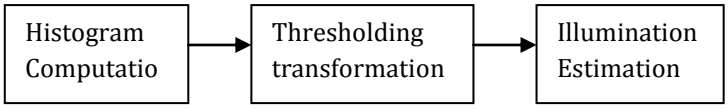

Fig. 1 Pre Processing Steps [7]

The Fig. 1 tries to explain the pre processing steps that are applied to the input image and desired image is obtained by application of these methods. It also helps to eliminate the problem by increasing the dynamic range of digital values of the pixel [5]. The known methods of image enhancement techniques can be defined namely into two main branches i.e. Global and local methods [6]. The paper is organized as follows: Section 1 deals with the introduction to image enhancement. The section 2 deals with the previous work on contrast enhancement. Section 3 deals with the different histogram techniques. Section 4 gives the conclusion and the future work that might be useful in implementing the different techniques on different set of images.

2. CONTRAST ENHANCEMENT

The Contrast Enhancement is the most significant and essential technique of the spatial based image enhancement. The basic intend of the contrast enhancement technique is to adjust the local contrast in the image so as to bring out the clear regions or objects in the image [1]. The contrast enhancement tries to change the intensity of the pixel in the image, particularly in the input image for the purpose to obtain a more enhanced image. Contrast enhancement is based on the number of techniques namely local, global, dark and bright levels of contrast [8]. The contrast enhancement is considered as the amount of color or gray differentiation that lies among the different features in an image [9].
The contrast enhancement improves the quality of image by increasing the luminance difference between the foreground and backgrounds [5].

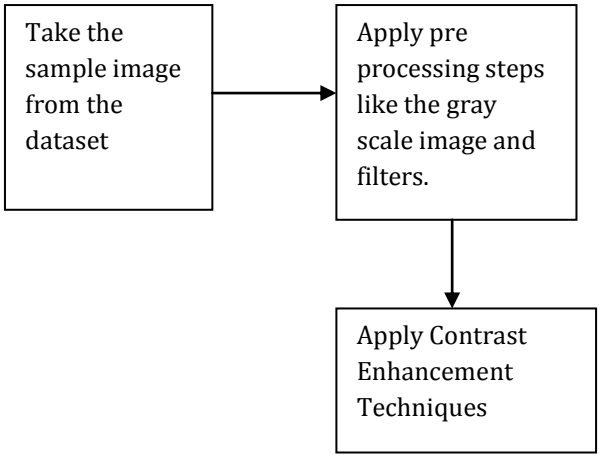

Fig. 2 The methodology for applying the enhancement techniques

The Fig. 2 gives the methodology applied to obtain enhanced image. The contrast enhancement is an important technique of image processing for the enhancement of an image in the spatial domain [10]. The Contrast Enhancement deals with a number of techniques, mainly Histogram Equalization. The histogram Equalization is the technique that assists in improving the different ranges particularly the dynamic range of the histogram of that of a particular image. The histogram equalization depends on the global and local variables for the aim to enhance the contrast of an image [5]. It is extensively available for processing of medical images and acts as basis for pre processing move for the applications in speech recognition, synthesis of texture in images and other applications of video processing [11].3

3. HISTOGRAM EQUALIZATION

The histogram equalization is the basis for the modified histogram techniques. The various histogram equalizations techniques are available depending on their applications. The techniques can be applied to the different image datasets. The images may be of day or night conditions, find its applications in medical or traffic applications. The image after using histogram equalization gives brighter image as compared to input image because it shows uniform distribution [10]. But due to its limitation of mean brightness in histogram equalization, histogram matching takes place. Histogram Equalization works by histogram flattening and to stretch the dynamic ranges of the gray levels by the using the principle of the cumulative density function of the image.

The histogram equalization can be applied on the number of images. A sample image is taken from the dataset and the histogram is showed in Fig. 3 and Fig. 4. The histogram equalization technique executes the operation by remapping the levels (gray level) of a particular image taken which is based on the probability distribution of the gray levels of the input image [11].

The histogram equalization method is most likely the best known contrast enhancement methods for images (especially the gray level images) due to its ease of usage and outcomes [12]. The histogram equalization preserves the brightness on the output image but does not have a natural look. The histogram equalization emphasize on the edges and boundaries for the different set of images, but assist in reducing the local details of the taken images and is not suitable for enhancement of local details [3]. The classical histogram equalization can well organized make use of the intensities but it also likely to over enhance the contrast levels if the histogram contains the high peak values, which sometimes obtains a noisy and blurred emergence of the desired image. [13]. Histogram is classified as the statistic probability distribution of gray level in an image. Histogram Equalization is one of the distinguished methods which aim to enhance the contrast level of the taken images, producing the desired image to have a distribution and more precisely uniform distribution of the gray levels in an image. It also performs the compressing and stretching the range of the histogram of an image and consequence results particularly for contrast enhancement. [14].

I. Global Histogram Equalization: is a technique that utilizes the information of histogram of the original image by applying the transformation function to the image. Though, this method or approach is appropriate for the whole enhancement procedure, but it falls short to adjust with the features, specifically like the brightness levels of the original image. If there is an existence of a few numbers of gray levels in the image which has high frequencies, then they take control of the remaining levels which have low frequencies. In situation like this, Global Histogram Equalization tries to remaps the gray levels in a desired method in which the technique of contrast stretching turn out to be limited in various dominating gray levels, which has the bigger components of image histogram and results in major loss in contrast levels for some small ones [11].

II. Local histogram equalization: method is the process that develops the input image on the basis of block-by-block method and makes use of the transformation function of histogram equalization and the role of the developed block is to adjust the centre pixel of an image. The other part of this technique is the Automatic Local Histogram Specification, which is useful for the local details in a way that for every pixel in its neighborhood/block of desired size is distinct with the every other pixel being at the centre of the block. This technique basically specifies the desired histogram automatically which produces the enhancement which is not only clear but also optimal enough to preserve the mean brightness of the desired block about every pixel in a digital image. This technique is proved by the results through means of simulation in which a great balance is between the enhancement details and the original image preservation in a desired image that aims to attain by means of utilizing the different histogram equalization methods [12].

The Histogram Equalization is applied to the digital images by various techniques:

I. Adaptive Histogram Equalization: It is a histogram technique in which the various are used to improve the levels of contrast values. It varies from the ordinary equalization in the way that this method attempts to compute the several histograms, in which every histogram will correspond to a different sections of the image, and usage is found to restructure the values of the lightness in the processed image [5]. Therefore, it is suitable for recovering the value of the local contrast level and improves to enhance the boundaries or edges in every region of an image.

II. Contrast limited Adaptive Histogram Equalization: This method works on the principle that the image is being divided into number of parts and the enhancement on each and every part is analyzed individually. The resultant part is the combined result of the part taken all together. The application part is the sky images and underwater images. [10]. The Contrast limited Adaptive histogram Equalization is an efficient algorithm for enhancement of the local details in an original image. The main disadvantage is that it exploited to the effects of overstretching of the contrast levels and various problems of noise. [13]

(i). CLAHE – DWT – The sample image taken from the dataset is decomposed into the components of both low and high frequency by the principle of DWT. The coefficients of low frequency that make use of contrast limited adaptive histogram equalization are enhanced and by keeping the coefficients of high frequency unaffected which limits noise enhancement. This method reconstructs the digital image by taking the reverse DWT of the obtained coefficients [14].

III. Dynamic Histogram Equalization: This method assists in the control of the effect of an image without crafting any loss of any information in the image. This method partitions the histogram of an image that has the foundation on the principle on local minima and allocates the desired ranges of gray level for every partition ahead of applying equalization to them separately. These dividing levels go further through one more partitioning level to make sure the lack of any ruling portions [11]. The dynamic histogram equalization utilizes a better partitioning method over the histogram of the input image for chopping the histogram some sub-histograms which does not have any dominating component. Then every sub-histogram passes through histogram equalization and is approved to engage in a desired range of gray levels obtained in the improved image. So, in general an improved contrast enhancement level is gained by the dynamic histogram with the help of dynamic gray levels ranges which are controlled and to eliminate the option of components of low histogram as they are compressed which might cause few parts of the image which have washed out appearance. The main advantage of this technique is that it ensures the consistency in preserving image information and it is protected from any severe side effects. The whole procedure can be defined into the three main parts namely, partition the levels in the histogram, assigning the ranges of gray levels for every sub-histogram and assigning the histogram equalization technique on every partitioned part [11].

(i). Brightness Preserving Dynamic Histogram Equalization: In this technique, the original image is decayed into many sub parts or sub images by means of using the concept of local maxima, then this equalization technique is functional to the every sub part and resulting the combination of sub images.. It separates the histogram which is directed on the basis of local maxima. It generates the desired image with the aim to find out the mean intensities which are almost equivalent to the mean intensity of the input image and by that it accomplishes the main condition of preserve the brightness of the digital or desired image [8].

IV. Multi Histogram Equalization: In order to improve the natural image that is desired after applying the histogram is provided by this technique. This technique also uses the method of decomposing the image into several sub images and technique of histogram equalization is processed to each sub-image. [3].The intensity value that divides the images to sub images is the optimal threshold set. It uses two algorithms by which the threshold values are calculated.

The first algorithm calculates the optimal threshold set based within class variance and separates the input image in to different sub images based on the threshold set. The second part separates the input image into several sub images that form basis to the optimal threshold set using the Otsu Method. The main advantage is that improves image contrast by brightness preserving and generates natural looking images. It has also been found out that it preserves the brightness more efficiently than other methods and also the error is also reduced. [3].

V. Brightness Bi-Histogram Equalization: The traditional histogram equalization has the main drawback in terms of not preserving the original brightness and the essential contrast levels. The drawback is overcome the brightness. The basic theory behind the BBHE is that the image is decomposed into the sub-images. This technique generates an image which has the brightness values placed in the middle of the input image mean [8].

(i). Minimum Mean Brightness Error Bi-Histogram Equalization: This method is the extension of the BBHE, in the respect that in this method the threshold level is searched and then the decomposition of the images takes places into the sub-images. The aim behind this is that the minimum brightness between the images of input and output is achieved [8]. It also provides the maximum brightness preservation. It also used to carry out the separation which has threshold level as its source, which further obtains the value of minimum Absolute Mean Brightness Error.

(ii) Brightness Preserving Histogram Preserving with Maximum Entropy: The concept of maximum entropy attempts to obtain the values by the variational approach, the objective histogram those maxims the entropy, under the values of constraints in which there is a fixed value of mean brightness and then alters the histogram originally obtained which is desired histogram by using the histogram specification [14]. Thus, an optimized brightness preserving method under histogram transformation is maximized to the target entropy of histogram under the constraints values of brightness levels.

Fig. 3 Original image

Fig.4 The histogram equalised image

Techniques (Application Specific)	Main points
Histogram Equalization	Easy to use. Loss of mean brightness.
Adaptive Histogram Equalization	Improves to enhance boundaries in an image.
Contrast Limited Adaptive Histogram Equalization	Efficient algorithm for enhancement of local details. Applied to sky images and underwater images [10]. Exploited to the effects of overstretching and noise issues [13].
Dynamic Histogram Equalization	Consistency in preserving image information [11].
Bi-Histogram Equalization	Overcome brightness levels [8].

4. CONCLUSIONS & FUTURE WORK

This paper tries to sum up all the techniques that can be applied in the image. An analysis of these entire contrast enhancement techniques leaves a scope of more improvement in the histogram techniques based on the different applications. The future work should not only be to identify which enhancement technique is better for a particular application but also that enhancement results should be further used in detection and classification of the data.

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