REVIEW PAPER ON IMAGE CONTRAST ENHANCEMENT TECHNIQUES

Ms. K.T.Chalekar, Prof T. Yengantiwar

Abstract— **Contrast is the visual difference that makes an object distinguishable from background and other objects. For better and easier human interpretation of images and higher perceptual quality, contrast enhancement becomes necessary and it has been active research topic since early days of computer vision and digital image processing. In this paper, various image contrast enhancement techniques for low contrast images are reviewed, such as histogram equalization, contrast stretching, adaptive histogram equalization and contrast limited adaptive histogram equalization etc. however the conventional histogram equalizations methods usually reserved in excessive contrast enhancement. This paper formulates the problem of over enhancement and various techniques are identified for effective contrast enhancement.**

Index Terms— **Contrast enhancement, CLAHE, Histogram equalization, over enhancement.**

I. Introduction

To human viewers, sharp contrast of edges and subtle tone of smooth surfaces in an image are often interpreted as high perceptual quality. But various condition, such as foggy weather, poor illumination, low grade imaging sensor, etc., can make an acquired image look faded and blurry. However, it is not uncommon that raw image with low perceptual contrast still contains information on the details of the captured scene. Therefore, since every early days of image processing many contrast enhancement techniques have been proposed and used., aiming to fully utilize the dynamic range of the raw sensor data and reproduce a visually more appealing and informative image.

Contrast enhancement techniques are mainly classified into two groups: context-sensitive (point-wise operators) and context-free (point operators). In context-sensitive approach the contrast is defined in terms of the rate of change in intensity between neighboring pixels. The contrast is increased by directly altering the local waveform on a pixel by pixel basis. For instance, edge enhancement and high-boost filtering belong to the context-sensitive approach. Although intuitively appealing, the context-sensitive techniques are prone to artifacts such as ringing and magnified noises, and they cannot preserve the rank consistency of the altered intensity levels. The context-free contrast enhancement approach, on the other hand, does not adjust the local waveform on a pixel by pixel basis. Instead, the class of context-free contrast enhancement techniques adopts a statistical approach. They manipulate the histogram of the input image to separate the gray levels of higher probability further apart from the neighboring gray levels. In other words, the context-free techniques aim to increase the average difference between any two altered input gray levels. Compared with its context-sensitive counterpart, the context-free approach does not suffer from the ringing artifacts and it can preserve the relative ordering of altered gray levels.

Manuscript received Feb, 2013.

Ms. K.T.Chalekar, *CSE, Tulsiramji-Gaikwad Patil College of Engineering and Technology. Nagpur, India,*
Prof.Tarun Yengantiwar, *CSE, Tulsiramji-Gaikwad Patil College of Engineering and Technology. Nagpur, India*

II. Literature Survey

A. Histogram Equalization

One of the earliest and most widely used contrast enhancement techniques is histogram equalization (HE), which remaps pixel values of the input image such that the processed image has as uniform a histogram as possible. HE permits area of lower contrast to achieve a higher contrast. Histogram equalization automatically determines a transformation function seeking to produce an output image with a uniform Histogram. Histogram equalization is a technique in image processing of contrast adjustment using the histogram of image. It usually increases the contrast of images globally, when the valuable data of the image is showed by close contrast values. Through this contrast adjustment, the intensity values can be better distributed on the histogram. It is possible this by effectively spreading out the most frequent intensity values. Histogram equalization automatically determines a transformation function seeking to produce an output image with a uniform Histogram.

Let X={X(i,j)} denotes a image composed of L discrete gray levels denotes as

X= $\{X0, 1, \ldots\ldots, _{-1}\}$.For a given Image X, the probability density function $p(X_k)$.

$$p(X_k)=\frac{nk}{n}$$

ISSN: 2278 – 1323

Where

- K=0, 1,……−1.
- n^k shows the total number of times when the level X_k occurs in the input image X.
- n denotes total number of samples in an input image.
- (X_k) is associated with the histogram of the input image which represents the number of pixels that have a specific intensity X_k.

Based on the probability density function, the cumulative density function is defined as

$$c(x)= \sum_{j=0}^{k} p(Xj)$$

Where

- $X_k = x$ for k=0,1,.......L-1
- (X_{L-1}) =1 by definition.
- HE is a scheme that maps the input image into the entire dynamic range,(X_0,X_{L-1}) by using the cumulative density function as a transform function.

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

$Y=f(x)$

$=f\{(X(i,j)/\forall X(i,j)\in X\}$.

Based on information theory, entropy of message source will get the maximum value when the message has uniform distribution property.

B. Problems in Histogram Equalization

1. The Histogram Equalization method does not consider mean brightness of an image into account.
2. The HE method may result in over enhancement and saturation artifacts due to the stretching of the gray levels over the full gray level range.
3. With the help of Histogram equalization it is possible to change brightness of an image after the histogram equalization. .
4. Nevertheless, HE is not commonly used in consumer electronics such as TV because it may significantly change the brightness of an input image and cause undesirable artifacts.
5. It can be observed that the mean brightness of the histogram-equalized image is always the middle gray level regardless of the input mean.

C. Contrast Stretching

To expand the range of brightness values in an image the contrast enhancement techniques are used, so that the image can be efficiently displayed in a manner desired by the analyst. The level of contrast in an image may vary due to poor illumination or improper setting in the acquisition sensor device. Therefore, there is a need to manipulate the contrast of an image in order to compensate for difficulties in image acquisition. The idea behind contrast stretching is to increase the dynamic range of the gray levels in the image being processed. The idea is to modify the dynamic range of the grey-levels in the image. Linear Contrast Stretch is the simplest contrast stretch algorithm that stretches the pixel values of a low-contrast image or high-contrast image by extending the dynamic range across the whole image spectrum from 0 – (L-1).

D. Brightness Preserving Bi Histogram Equalization

The Brightness preserving bi histogram equalization firstly decomposes an input image into two sub images based on the mean of the input image. One of the sub image is set of samples less than or equal to the mean whereas the other one is the set of samples greater than the mean. Then the BBHE equalizes the sub images independently based on their respective histograms with the constraint that the samples in the formal set are mapped into the range from the minimum gray level to the input mean and the samples in the latter set are mapped into the range from the mean t the maximum gray level. Means one of the sub image is equalized over the range up to the mean and the other sub image is equalized over the range from the mean based on the respective histograms [1].Thus, the resulting equalized sub images are bounded by each other around the input mean, which has an effect of preserving mean brightness.

In this the computation unit counts and store the respective number of occurrences nk for k=0,1,…..,L−1,the Histogram Splitter the splits the number of occurrences as $(n0,n1,\dots,nm)$ and $(nm+1,\dots,nL-1)$ respectively and where the mapped outputs Y(i,j) as $Y(i,j)=(X0+(Xm-X0)cL(x)Xm+1+(XL-1-Xm+1)cU(x)$ Which is based on (XL) ∪(XU).The computation of Histogram and the mean typically need to be done during one frame period; thus a frame memory to store the image being processed is necessary.

D.Dualistic Sub-Image Histogram Equalization Method

This is one of the histogram equalization technique in which the original image is divided into two equal area sub-images based on gray level probability density function of input image. Then these two sub-images are going to equalized respectively. At the end, we got the result after the processed sub-images are composed into one image. This algorithm not only enhances the visual information effectively but also constrains higher the original images average luminance. This makes it possible to be utilized in video system directly.

F. Dynamic Histogram Equalization For Image Contrast Enhancement

It employs a partitioning operation over the input histogram to chop it into some sub histograms so that they have no dominating component in them. After that each sub histogram must go through HE and is allowed to occupy a specified gray level range in the enhanced output image. Therefore a better overall contrast enhancement is achieved by Dynamic Histogram Equalization with controlled dynamic range of gray levels and eliminating the possibility of the low histogram components being compressed that may cause part of the image to have washed out appearance.

G. Contrast Limited Adaptive Histogram Equalization (CLAHE)

Adaptive histogram equalization is a one of the image processing technique which is used to improve contrast in low contrast images. It can be differ from basic histogram equalization with respect to the adaptive method because it computes several histograms and each corresponding to a different section of the input image, and uses them to redistribute the lightness values of the image. A single histogram for an entire image is used by ordinary histogram equalization.

Consequently, adaptive histogram equalization is considered an image enhancement technique capable of improving an image's local contrast, bringing out more detail in the image. However, it may be produce significant noise in an image. A generalized form of adaptive histogram equalization is called as contrast limited adaptive histogram equalization which is also known also known as CLAHE. It was developed to address the problem of noise amplification. CLAHE operates on tiles which are small regions in the image, rather than the entire image [2]. Contrast is enhanced of each tile's in such a way that so that the histogram of the output region approximately matches the histogram specified by the 'Distribution' parameter.. To eliminate artificially induced boundaries the neighboring tiles are combined using bilinear interpolation [2]. With the help of contrast in homogeneous areas, it can be possible to avoid amplification of any noise that might be present in the low contrast image.

III. Problem Formulation

In our view, directly processing histograms to achieve contrast enhancement is an ill-rooted approach. The histogram is clumsy, hide contrast of an image. The popularity of HE as a context-free contrast enhancement technique is apparently because no mathematical definition of context-free contrast has ever been given in the literature. We fill the aforementioned long-standing void by defining a measure of context-free contrast gain of a transfer function, with this measure being 1 if the input image is left unchanged. Furthermore, to account for the distortion of subtle ones caused by contrast enhancement, which is inevitable in most cases, a measure of tone distortion is also introduced.

IV. Conclusion

In this Paper, a frame work for image contrast enhancement based on prior knowledge on the Histogram Equalization has been presented. Many image enhancement schemes like Contrast limited Adaptive Histogram Equalization (CLAHE), Equal area dualistic sub-image histogram equalization (DSIHE), Dynamic Histogram equalization (DHE) Algorithm has been reviewed . Furthermore, to account for the distortion of subtle tones caused by contrast enhancement, which is inevitable in most cases, a measure of tone distortion is also introduced.

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Ms. K. T. Chalekar is pursuing M.Tech. in Computer Science and Engineering from Tulsiramji Gaikwad Patil College of Engineering and Technology, RTMNU University, Nagpur (MH), India.

Prof.Tarun Yengantiwar is PG holder and currently working as an Associate Professor in Tulsiramji Gaikwad Patil College of Engineering and Technology, Nagpur (MH), India.

ISSN: 2278 – 1323