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Analysis of Contrast Enhancement Method using Histogram Equalization

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Abstract: This paper is to produce a contrast enhancement technique to recover an image within a given area, from a blurred and darkness specimen, also improve visual quality of it. Images are represented by an array of pixels, which can represent the gray levels or colors of the image. There are many aspects of images that are ambiguous and uncertain. Examples of these vague aspects include determining the border of a blurred object and determining which gray values of pixels are bright and which are dark [1].

Keywords: Enhancement, Contrast, Histogram, Adaptive contrast, Luminance-Hue-Saturation.

I. INTRODUCTION

The objective of image enhancement is dependent on the application context; criteria for enhancement are often subjective or too complex to be easily converted to useful objective measures. Image enhancement techniques are widely used in many fields, where the subjective quality of images is important. Many algorithms for achieving contrast enhancement have been developed. Those enhancement algorithms can be classified into two types point operations, which are global and spatial neighborhood techniques, which are local. Recently several algorithms for carrying out contrast enhancement have been developed among them histogram modification techniques, which are attractive due to their simplicity. Histogram equalization is a technique that generates a gray map which changes the histogram of an image and redistributing all pixels values to be as close as possible to a user-specified desired histogram [3], [4].There is no doubt that the quality of the images obtained by digital cameras, regardless of the context in which they are used, has improved significantly since early days. Part of these improvements is due to the higher processing capability of the systems they are built-in and memory availability. However, there are still a variety of problems which need to be tackled regarding the quality of the images obtained, including:

A. Contrast defects,
B. Chromatic aberrations,
C. Various sources of noises,
D. Vignetting (i.e., a reduction of an image brightness or saturation at the peripheral compared to the image center)
E. Geometrical distortions,
F. Color demosaicing and
G. Focus defects.

Among the seven problems related above, some are more dependent on the quality of the capturing devices used (like 2-7), whereas others are related to the conditions in which the image was captured (such as 1). When working on the latter, the time required to correct the problem on contrast is a big issue.

He is a histogram specification process [3] which consists of generating an output image with a uniform histogram (i.e., uniform distribution). In image processing, the idea of equalizing a histogram is to stretch and/or redistribute the original histogram using the entire range of discrete levels of the image, in a way that an enhancement of image contrast is achieved. HE is a technique commonly used for image contrast enhancement, since it is computationally fast and simple to implement. Our main motivation is to preserve the best features the HE methods have, and introduce some modifications which will overcome the drawbacks associated with them. In the case of gray-level image contrast enhancement, methods based on HE have been the most used. Despite its success for image contrast enhancement, this technique has a well-known drawback: it does not preserve the brightness of the input image on the output one. This problem makes the use of classical HE techniques [5] not suitable for image contrast enhancement on consumer electronic products, such as video surveillance, where preserving the input brightness is essential to avoid the generation of nonexistent artifacts in the output image [14, 10].

In order to overcome this problem, variations of the classic HE technique, such as [6, 15, 2, 1], have proposed to first decompose the input image into two sub-images, and then perform HE independently in each sub-image (Bi-HE). These works mathematically show that dividing the image into two rises the expectance of preserving the brightness. Although Bi-HE successfully performs image contrast enhancement and also preserves the input brightness to some extend, it might generate images which do not look as natural as the input ones. Unnatural images are unacceptable for use in consumer electronics products [14, 10].

Hence, in order to enhance contrast, preserve brightness and produce natural looking images, we propose a generic Multi-HE (MHE) method that first decomposes the input image into several sub-images, and then applies the classical HE process to each of them. We present two discrepancy functions to decompose the image, conceiving two variants of that generic MHE method for image contrast enhancement, i.e., Minimum Within-Class Variance MHE (MWCVMHE) and Minimum Middle Level Squared Error MHE (MMLSEMHE) [1]. Moreover, a cost function, which takes into account both the discrepancy between the input and enhanced images and the number of decomposed sub images, is used to automatically determine in how many sub-images the input image will be decomposed on.

II. DIFFERENT TECHNIQUES FOR CONTRAST ENHANCEMENT

Image enhancement methods and techniques have been studied for more than 40 years, and during this time a vast number of methods have been developed. At first, methods were more concentrated in improving the quality of gray-level images. Later, when the acquisition of color images became more accessible, many of these early methods were adapted to be applied to color images[9].

a. The classification is based on:
b. The operator sensitivity to the image context;

c. The area of the image covered by the operation;
d. The goals of the operation;

According to the operator sensitivity to the image context, enhancement methods can be classified as (a) context-free and (b) context-sensitive. A context-free method provides a position-invariant operator, in which all the parameters are fixed a priori. A context-sensitive method, in contrast, works with a position-variant operator, in which the parameters change in response to local image characteristics. Context-free operators are computationally simpler to apply. However, for images with variable information content, a context-sensitive operator is more suitable.

Regarding the area of the image covered by the operator, the existing methods can be divided into local and global. Local operators divide the original image into sub-images (or masks), and take one sub-image into consideration at a time. Those operators can be further subdivided into fixed-size and variable-size. For further details see [5]. In a global operation, in turn, the whole image is considered at once. Computationally speaking, the application of a local operator requires less storage space than a global operator does. Based on their goals, the existing methods can be grouped into (a) noise cleaning, (b) feature enhancement, and (c) noise cleanup plus feature enhancement. The noise-cleaning operator aims at removing random noise from the image. In other words, it disregards the image irrelevant information[6]. The feature-enhancement operator attempts to decrease the blurring, and to reveal the image features of interest. These two operators deal with different degradation phenomena. In practice, however, many operators are a combination of both. According to the techniques involved, the published methods can be organized into four approaches.

They are:

i. Frequency domain filtering, which utilizes low or/and high-pass filters in the frequency domain.
ii. Spatial smoothing, which employs linear or nonlinear spatial domain low-pass filters;
iii. Edge-enhancement, which involves linear or nonlinear spatial-domain high-pass filters;
iv. Radiometric scale transformation, which manipulates or re-quantizes the levels of a channel (e.g., the gray-level image) for contrast enhancement;

III. HISTOGRAM PARTITION

A. *Linear Contrast Expansion*

Since gray level of pixel is concentrated in some narrow interval of histogram, such image is then low contrast. Linear contrast expansion in each group of histogram is employed to solve brightness saturation problem. Based on peak value calculated is used to class groups of histogram. Contrast of each of the grouped one is expanded linearly by which maximum and minimum point of gray level is number of the previous calculated peak. The entire image is expanded full range as 0-255 levels[7]. Let min X and max X are range of original histogram expanded into min Y and max Y .shown in Figure 1. Range of gray level in image X is min max X ≤ X ≤ X . To solve problem in calculation, if X is less than min X , X is then min X and if X is more than max X , X is then max X . New gray level can be obtained from equation below.

$$Y = \frac{(X - X_{\min})}{(X_{\max} - X_{\min})} (Y_{\max} - Y_{\min}) + Y_{\min}$$

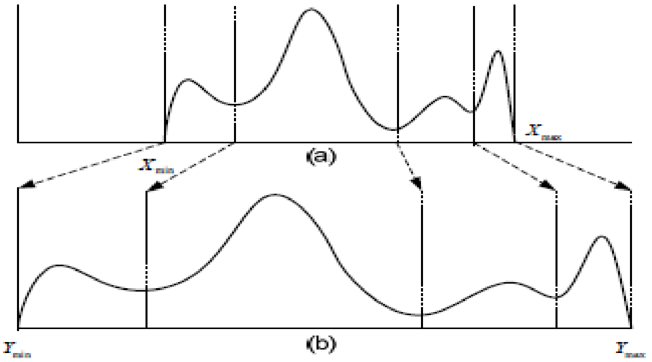

Figure 1. Linear contrast expansion (a) Original histogram (b) New histogram

B. *Quality Measuring Criterion*

The proposed method is trying to preserve brightness mean more and more possible by considering value of

Absolute mean brightness error (AMBE). AMBE is calculated from equation below[2].

AMBE =| E[Y]− E[X] |

where E[Y] and E[X] are mean of new and original gray level of image, respectively. Generally, classing number of histogram region affects to AMBE value. The more one is, the less AMBE. Also, suddenly hanging of slope of gray level in image indicates that contrast is either increase or decrease. Gradient is slope between pixels used to detect image edge to verify image quality[4]. The Tenendrad criterion (TEN) is based on gradient magnitude maximization. The value of TEN is calculated from gradient of all pixels in image. The partial derivatives are obtained by a high pass filter using Sobel operator with the convolution kernels i_x and i_y. The gradient is given as

$$S(x, y) = \sqrt{(i_x * I(x, y))^2 + (i_y * I(x, y))^2}$$

where $*$ stands for convolution, $I(x, y)$ is enhanced image. The Tenendgrad criterion is formulated as

$$TEN = \sum_x \sum_y S(x, y)^2$$

C. *The Proposed Histogram Partition*

To preserve brightness mean of finally enhanced image, partitioning of smoothed histogram corresponding to quality criterion is important. We will present the method to partitions histogram to get the lowest AMBE by shifting peak point based on local minima both lower and upper. The shifting process is described as following[1].

Step 1 Using peak points which has got from the smoothed multi-peak histogram searching, let P1, P2, P3,…,P_N are gray levels of each peak. Histogram is classed into N group N=P_N.

Step 2 Calculating original mean,

$$E[X] = \sum_{i=0}^{L-1} f_i g_i \Big/ \sum_{i=0}^{L-1} f_i$$

where L is the maximum gray level such as 255, f_i is frequency of i^{th} gray level, g_i is i^{th} gray level.

For instance no of peak point is of 3(N=3) P1,P2,P3.

Histogram is grouped into 4 regions[0-P1],[P1+1-P2],
[P2+1-P3],[P3+1-L].

Step3: calculating mean from enhanced image

$$E[Y] = \sum_{i=0}^{L-1} f_i' g_i \Big/ \sum_{i=0}^{L-1} f_i'$$

where f_i' is frequency of i^{th} gray level via enhancement.

Step 4 Histogram mentioned in step 1 is expanded by using linear contrast expansion method together with getting new peak P’1, P’2, P’3,…,P’N but the number of histogram groups is the same as step 1.

Step 5 The gray level of peak point P’1, P’2, P’3,…,P’N is shifted into both lower and upper with ε shifting range value and AMBE of both original and enhanced image by using histogram equalization based on such peak point to group sub-histogram is calculated[11]. If AMBE is still higher, the gray level of peak point is then adjusted by increasing ε value until the lowest AMBE is obtained

IV. RESULT

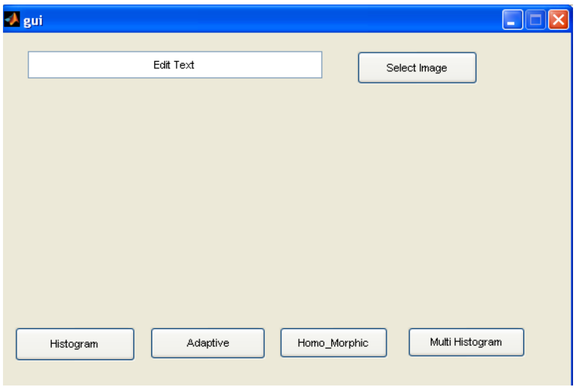

Figure 1 : Layout of Proposed System

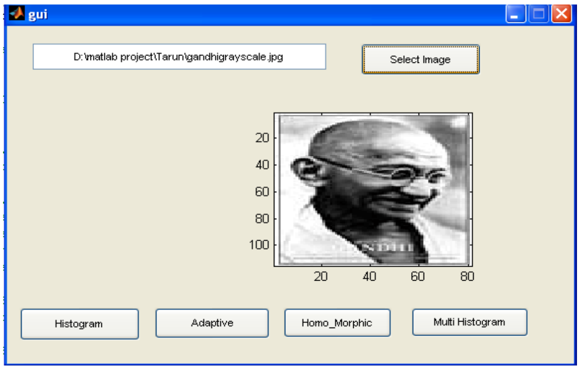
D:\matlab project\Tarun\gandhigrayscale.jpg

Figure 2: Input Image

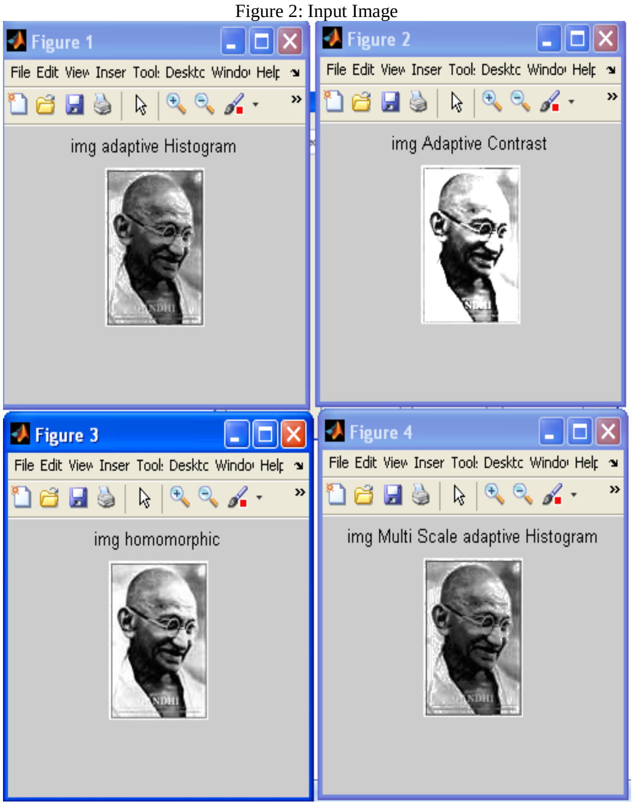

Figure 3 : (a) Adaptive Histogram, (b) Adaptive Contrast , (c) Homomorphic, (d) Multi scale adaptive histogram

V. CONCLUSION

The gray-level multi-histogram equalization methods, differ from other methods previously proposed in the literature in one major point. They segment the image into several sub-images based on discrepancy functions borrowed from the multi-thresholding literature, instead of using image statistical features. As showed by experiments result the proposed methods are successful in enhancing the contrast of images while preserving their brightness and avoiding the appearance of unnatural artifacts.

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