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A Survey of Image Enhancement Techniques

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Abstract: ***As we know Image processing is in vogue, image enhancement technique has become favorite research field recently. Image enhancement improves the quality of image. In this review paper we have discussed recently used image enhancement techniques, which give a wholesome idea of digital image enhancement techniques and their result. Here we have brief study on image enhancement techniques, which are Histogram Equalization, Adaptive Histogram Equalization, Contrast Limited Adaptive Histogram Equalization, Exact Histogram Equalization and many more. Every technique has their pros and cons, but every technique is significant in different fields. So here is a over view or a review on image enhancement techniques.***

Keywords: Image enhancement, Spatial Domain Method, Frequency Domain Method, Histogram Equalization, Adaptive Histogram equalization, Contrast Limited Adaptive Histogram Equalization and Exact Histogram Equalization.

1. Introduction

The basic principle of image enhancement is to process an image so that the outcome is more suitable than the original image for a particular specific application. The word particular belongs to a certain applications. As we know different methods and techniques used in image processing image enhancement has become a hot research. There is no specific theory of image enhancement. When the image is processed then the viewer is the final judge of how good a particular method works. For example see figure(1) and figure(2). Figure(1) shows the poor contrast image and figure(2) shows the enhanced image. Here are some papers discussed below on recently used image enhancement techniques.

Figure1. Image

There are basically two types of image enhancement techniques,

a) Spatial Domain Technique.
b) Frequency Domain Technique.

Figure 2. Enhanced image

A. Spatial Domain Techniques:

Spatial domain method is a method which has a concern with pixels of the input images. The values of the pixel are manipulated to attain desired enhancement. Spatial domain techniques like the logarithmic transforms, power law transforms, histogram equalization is based on the direct manipulation of the pixels in the image. Spatial techniques are specifically useful for directly changing the gray level values of single pixels and therefore the overall contrast of the whole image. But they usually enhance the whole image in a uniform manner which in many cases produces undesirable results. It is not pragmatic to selectively enhance edges or other required information effectively. Techniques like histogram equalization are effective in many images. The approaches can be classified into two categories: Spatial filter operations and Point Processing operation. An overview of some of the well known methods is discussed here. The pixel values of the processed image depend on pixel values of the original image. It can be given by the expression $g(x, y) = T[f(x, y)]$, where T is a gray level transformation in point processing. The Point processing technique can be divided into four categories as image negative. Let us Consider a 8 bit digital image whose size is $M \times N$, then each pixel value is subtracted from the original image 255 as $g(x, y)=255- f(x, y)$ for $0 \le x < M$ and $0 \le x < N$. In a normalized gray scale, s = 1.0 – r. Negative images are useful for enhancement of gray or white detail embedded in dark regions of an image.[1]

B. Frequency Domain Techniques:

Frequency domain methods are based on the operation of the orthogonal transform of the image preferable than the image itself. Frequency domain method are convenient for processing the image in manner of the frequency content. The orthogonal transform of the image has two components, magnitude and phase. The magnitude subsists of the frequency content of the image. The phase is used to revamp the image back to the spatial domain. The Fourier transform, Hartley Transform etc. The transform domain permits the operation on the frequency content of the poor contrast image, and therefore the high frequency content such as edges and other subtle knowledge can simply be enhanced. Frequency domain which works of Fourier transform of an image.

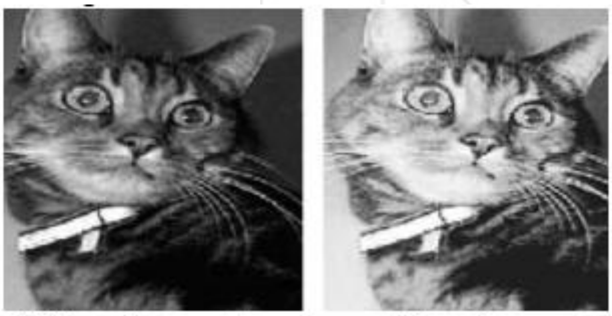
- Edges and sharp transitions (e.g. Noise) in an image donate meaningfully to the high frequency content of the Fourier transform.
- Low frequency contents in the Fourier transform are responsible for the common appearance of the image over smooth areas.

The scheme of the cleanse is easier to visualize in the frequency domain. Hence, enhancement of image f (x, y) is done in the frequency domain based on DFT. This is mainly valuable in convolution if the spatial extent of the point spread sequence h (x, y) is large then convolution theory. [2] g(x, y)= h(x, y)*f(x, y) Where g (x, y) is enhanced image.

2. Image Enhancement Techniques

A. Adaptive Histogram Equalization:

Adaptive Histogram Equalization is used for improving contrast in images. It differs from Histogram Equalization by adaptive method that computes several histograms and each histogram corresponding to a distinct section of an image. The contrast of a region of an image will not be sufficiently enhanced by Histogram Equalization. AHE improves this enhancement by transforming each pixel with a transformation function derived from a neighboring region. It is used to overcome some limitations of global linear min-max windowing method. Thus, it decreases the portion of noise in regions of the image. And also AHE have the capacity of revamp the contrast of grayscale and color image. Before enhancement After enhancement Fig. 3: Adaptive Histogram Equalization



Before enhancement After enhancement

Figure 3: Adaptive Histogram Equalization

B. Histogram Equalization

Histogram of an image is concerned with the gray levels. Using histograms to decide that given image is whether a dark image or light image or low contrast or high contrast image. It can be expressed using discrete function as, to an image. It is used to increase the visual appearance of an image [3]. This technique involves, 1) Dividing image into segments. 2) The histogram is applied to find out the pixel intensity values for the gray levels and the image has gray levels or intensities in the range from 0 to 255. 3) Histogram Equalization is used to calculate the intensity values and make them uniform distribution of pixels to get an enhanced image. Thus HE technique is used to grow the dynamic range of pixels for the appearance of an image.

(a) Original Image (b) Enhanced image for Histogram Equalization

Figure 4: Histogram Equalization

C. Contrast-Limited Adaptive Histogram Equalization (CLAHE):

Enhances the contrast of the grayscale image by transforming the standards by CLAHE (contrast-limited adaptive histogram equalization). It works on the minor regions in the image, named tiles, rather than the full image [8]. Wholly tile's contrast is the enhanced, so that the histogram of the output region completely matches the histogram specified by the spreading criterion. The nearby tiles are then joined by bilinear interpolation to remove artificially induced boundaries. The contrast, especially in the homogeneous areas, can be partial to shun the revamp any noise that might be present in the image.

Figure 4: Original Image and Image Enhanced by CLAHE.

3. Literature Survey

Mithilesh Kumar and Ashima Rana, [1]. In this paper they present a hybrid technique which is composed of three methods. They have present the Image Enhancement using Contrast Limited Adaptive Histogram Equalization (CLAHE) method and Wiener filter to eliminate the noise which can be present in the digital image. They also used Gamma correction technique into transfer the image into acceptable dynamic range. To avoid amplifying any noise that might be present in an image they have used contrast limited adaptive histogram equalization parameter to bound the contrast especially in homogeneous area. As a conclusion they get the following results. The Contrast Limited Adaptive Histogram Equalization technique and

Wiener filtering yields perfect contrast enhancement while preserving the brightness of given image and suitable for images enhancement. Wiener filter is good for image sharpening and Limited Adaptive Histogram Equalization method is better for contrast enhancement of the image.

Y. F. Liu; J. M. Guo; J. C. Yu, [2]. In this paper, a contrast enhancement technique, known as stratified parametric-oriented histogram equalization (SPOHE) is proposed to provide a regional enhanced effect without visual artifacts, e.g., blocking artifacts, which normally incurred in the former simplified enhancement technique. The stratified sampling theory is applied to uniformly distributed samples the original image through many divided strata with size defined by the two parameters (α,). Moreover, the required statistical information are efficiently derived through the integral image concept. Eventually, the corrected SPOHE (CSPOHE) is also proposed to further improve the contrast with a limited tradeoff computation. Experimental results demonstrate that the proposed technique produces a similar CDF to the original one for an accurate contrast enhancement performance while significantly decreases the computational complexity. Moreover, comparing with the old speed oriented technique good contrast and error-free results can be produced simultaneously.

Jan et al. [3], In this paper in order to achieve a good stability between power consumption and visual perception, authors have suggested a histogram-based power saving algorithm to enhance the image contrast for OLED display panels. The suggested algorithm amends the empty bins of the image histogram graph as a pre-process of power depletion. Additionally, the visual effect was reimbursed using the power saving histogram equalization algorithm. Experimental results show that the suggested algorithm not only reduces the display power, but also generates the highly perceptual contrast of the digital images. They have suggested the PSHA (Power Saving Histogram Algorithm) algorithm to be the pre-processing of the image enhancement algorithms for OLED panels. They have presented the embodiment that modified the PCCE algorithm to adaptively generate the parameter according to the image characteristic. Compared to the prior work, the proposed PSHA (Power Saving Histogram Algorithm) algorithm effectively balances the effect between contrast enhancement and power reduction. In our future works, the statistical data of the transformation curve will be analyzed to construct Look Up Table for the real-time hardware implementation. Moreover, the approach mentioned in this paper is only applied to static images. One of the future directions would be investigating extended methods that are applied to video sequences.

P. Gupta and A. Dhingra [4], in this paper the alteration model of a histogram which is elementary to take care of such sort of issues as per trait of implementation. The bounded estimations which are two in number of backing of histogram chart are invented and positioned to relating qualities, individually. The probability density function for calculating probability of the digital image is then is enumerate & revised function of mapping is utilized to achieved HE. Outputs of trial demonstrate that the methodology suggested may viably enhance image standard revamp by HE & HM routines, & even HR called as redistribution of histogram, for example, (GLG) grouping of gray level, RGB color spacing and color maintaining methods. Taking R, G and B component individually and remap them. In most prevailing methods of CE, refer to the enhancement of Contrast don't take into consideration of issues with a substantial extent of section of gray is retained in the periphery of backing of chart of the histogram. In particular document, we suggest a modified scheme of an elementary chart of histogram to manage this concern. The mentioned plan can be connected in HR, HS and HE methods along with colour images. Test results exhibit that our proposed plan can viably and essentially dispose of the stonewashed impression & nasty artifacts incited because of few current methodologies. Moreover, it may be anticipated that the computed picturisation of the image is making use of the tricks that are suggested, that takes into the account of some issues ingrained in a section of histogram chart, may retain their original glimpse.

S. Zhang, J. Pang, H. Chen and S. Zhang [5], in this paper, authors have suggested a new spatially different operator based on the layered iCAM06 model and image enhanced adaptive histogram equalization. They have first disintegrated the HDR image into base layer and detail layer, and then apply the image enhanced operator to all layers. Last, they experiment the operator on a series of HDR luminance image, and get adequate result with enhanced contrast and visual sensation, as well as lowered time cost with respect the original iCAM06 operator. The developed operators revamp the contrast and details, as well as the visual sensation of all the LDR images comparing to the native operator. In this paper, we propose a new tone-mapping operator to tone-map HDR image. We apply a layered model and CEAHE to tone map the HDR image and get satisfactory result. The experiment of our operator and iCAM06 model shows that, our operator lowers the time cost of layering of HDR image by a fast algorithm of bilateral filter, and also improves final contrast and detail of the LDR image by CEAHE. In the future, the operator can be further improved with respect to the HVS theory to give better image sensation, and faster algorithm and more vivid LDR image can be rendered by the operator. And our future work will also cope with the implementation of adaptive operator with automated fitted parameters. Totally, faster and more improved tone-mapping algorithm can be obtained with our newly proposed tone-mapping knowledge.

S. P. Panda [6], in this paper author is suggested a brand new technique of interpolation by using fuzzy logic interpolation. The suggested technique is used to define pixel intensity level transformation function form a group of locally stretched pixel intensity. The transformation function obtained from proposed method is applied to colored image and then compared with the results produced from cubic spline interpolation method. The comparison results illustrates that the suggested technique can be used for interpolation to enhance contrast of an image. The methods described in the previous sections are implemented using MATLAB® R2013 software. The Fuzzy Logic Toolbox provided in the MATLAB software is used to evaluate the data and was stored in a look-up-table. The interpolation results stored in a look-up-table for locally stretched image points are applied to the image. As the image is a colored image in RGB format, the image format is converted to HSV format and then the intensity interpolation information form look-up-table is applied to the converted image. The images are contrast enhanced images due to cubic spline interpolation and fuzzy based interpolation respectively. The pixel intensity transformation curve of fuzzy based interpolation and cubic spline interpolation. The Root Mean Square (RMS) contrast of the actual image, cubic spline based contrast enhanced image and fuzzy interpolation based contrast enhanced image. The results obtained from the fuzzy logic based interpolation are very promising and inspiring. The method used in this paper is the simplest of all fuzzy logic methods. There are so many advanced methodology developed due to extensive research in field of fuzzy logic, which may be used to obtain better results for fuzzy based interpolation. This paper concludes that, the fuzzy logic interpolation method can be used for contrast enhancement purposes, although, the transformation curve of fuzzy interpolation deviates slightly. Reduction of this slight deviation using advanced fuzzy methods will be a future scope of research.

Amil et al. [7], authors have introduced a new image enhancement technique namely Bilateral Histogram Equalization with Pre-processing (BHEP) which uses Harmonic mean to divide the histogram of the image. They have performed both qualitative and quantitative measurements for experiments and the results show that BHEP creates less artifacts in several standard images than the existing state-of-the-art image enhancement techniques. In this research paper, a new medical image illumination enhancement and sharpening technique based on SWT was proposed. The proposed technique decomposed the input image into four subbands by employing SWT. Afterwards the illumination of LL subband image was being enhanced by combining the input image and the LL subband image using weighted sum rule. Finally the output was obtained by applying ISWT on updated LL and the high frequency subbands of original image which was resulting in sharper image. The proposed technique was compared with the GHE, LHE, SVE, and DWT+SVD techniques and the visual result were illustrated in the paper. Qualitative outputs were confirming the superiority of the proposed technique over the conventional and the state-of-art techniques.

Rasti et al. [8], In this paper authors have proposed a new medical image illumination enhancement and sharpening technique based on stationary wavelet transform which is addressing the aforementioned problem. The technique decomposes the input medical image into the four frequency sub-bands by using stationary wavelet transformation and enhances the illumination of the low-low sub-band image, and then it enhanced edges of image by adding the high frequency sub-bands to the image. The technique is compared with the conventional and state-of-art image illumination enhancement techniques that are histogram equalization (H.E), local histogram equalization(LHE), singular value equalization(SVE), and discrete wavelet transform followed by singular value decomposition contrast enhancement techniques. The experimental results shows the supermacy of the proposed technique over the conventional and the state-of-art method.

Kim et al. [9], In this paper Histogram equalization (HE) methods using the 2D histogram (2DH) have obtained a great success in image enhancement. The 2DH is constructed by using the occurrence of a local pixel pair (LPP) composed of each pixel and its neighbouring pixels. However, the 2DH-based methods often produce over-stretching artefacts because the low-textured regions principally existing in the image generate a spike at some LPPs in the 2DH. To solve this problem, the 2DH is constructed by employing two properties of the human visual system (HVS) as follows: the HVS has the best brightness differentiation in the dark region according to Weber's law, and the HVS is less sensitive to visual artefacts in the higher-textured regions. To create a prong-free 2DH, a weighting function reflecting these two qualities of the HVS is designed for the LPP. As compared with the popular 2DH-based methods, the HE with the proposed 2DH can effectively enhance the image contrast while producing the good perceptual similarity score in between the input and output digital images.

T. O Onur and R. Hacıoglu [10], in this paper, two dissimilar methods are proposed in order to provide contrast enhancement in ultrasonic B-mode imaging. By obtaining RF data from two different phantom used to form B-mode image, their spectral properties were perceived. Then by formation of RF envelope from obtained data, conversion of envelope to color image is provided. Logarithmic compression and histogram equalization techniques found in literature are used to revamp image property. From the results produced, it is perceived that both algorithms are effective based on the intended use when they are bid individually.

G. Senthamarai and K. Santhi [11], Histogram Equalization is the efficient method for enhancing the contrast of the image. However, it is a source cause of high-enhancement so it fails to preserve the natural occurrence of an image. To beat this drawback, Multi-HE technique is used to preserve both brightness and natural occurrence of the digital image. In the suggested technique, the histogram of an input digital image is subdivided into multiple sub-histograms on the basis of mean and median values of thresholds. The narrow segments are identified using the factor which depends on the number of segments, vital range of each slab and intensity level. After identifying the narrow segments, it is scaled to the full dynamic range while the wider segments remain unaltered. The histogram equalization is applied to each slab individually. Ultimately the normalization is to be produced out for equalized histogram to shun intensity saturation and craggy distribution of bins. When the number of segments is increased, the contrast of the image is increased with improved brightness preservation. But the natural occurrence of the digital image is not preserved with loss of information. These properties are establish by the parameters known as Universal Image Quality and Discrete Entropy parameter. The comparison of various histogram equalization techniques is done by MedCalc statistical software. The Segment Dependent Dynamic Histogram Equalization method involves dynamic expansion to narrow segments and weighted normalization to avoid intensity saturation. This results in preserving significant brightness of the image with lower value of Absolute Mean Brightness

Error. Moreover, it preserves the contrast of the image with increasing the number of segments. But the proposed method fails to preserve the natural appearance of the image with detailed information. It preserves both brightness and natural appearance of the image with computational complexity. The average Peak Signalto-Noise Ratio of 24% is achieved for Segment Dependent Dynamic Histogram Equalization (SDDHE).

Jinwen Yang, Weihe Zhong And Zheng Miao [12], With the using of image processing widely Image enhancement technology has become a hot research field of image processing recently, it can revamp the property of images. This article mainly introduces two aspects, namely, histogram equalization processing and provision of enhanced methods. Simultaneously, comparing the pre-processing with post-processing, the formulas and standard digital images have been given in this paper. The experimental results have shown that the histogram equalization and specifications can revamp the contrasted effect. According to the method of histogram equalization and specifications, intensive gray distribution of the original image has become more sparse, so the image processing visual effects and its contrast can be revamped.

4. Conclusion

In this paper, we have discussed about the image enhancement techniques, especially Histogram Equalization and its modified methods such as Adaptive Histogram Equalization, Contrast Limited Adaptive Histogram Equalization, Exact Histogram Equalization with many more techniques to increase the efficiency. Histogram equalization give under contrast enhancement and Adaptive Histogram Equalization gives over contrast enhancement. To another method is given to overcome from over contrast enhancement namely Contrast Limited AHE.

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