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A Study on Image Enhancement Techniques and Performance Measuring Metrics

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ABSTRACT: The most main procedures in digital image processing is enhancement of the digital images. Contrast enhancement is an approach that is used to enhance images for viewing system or for extra evaluation of images. Primary proposal behind this work is to summarize different contrast enhancement procedures and measuring metrics to increase the image contract in such a way that the original quality of the image is retained. Different techniques like Histogram equalization (HE) and AGCWD is discussed in the paper below.

KEYWORDS: AGCWD, HE (Histogram Equalization), AMBE, Entropy.

I. Introduction

The image enhancement is one of the prominent approaches in digital image processing. It has a most important position in various fields where the images are to be understood and analyzed. Image enhancement is performed on an image to improve its visible results and or to make it extra suitable for additional processing by software. The contrast enhancement is one of the generally used image enhancement process.

Contrast enhancement plays a principal position in the development and improvement of visual quality for pattern recognition, computer vision and the processing of digital images. Terrible contrast in digital video or images can outcome from many instances, including lack of operator expertise and Inadequacy of the image capture gadget. Unfavorable environmental Conditions within the captured scene, such as lack of sunlight or indoor lights, presence of clouds and other Conditions might also result in decreased image quality. Just about, if the total luminance is insufficient, then the Details of the photograph or video aspects will probably be obscured [11].

II. Related Work

Xueyang Fu et.al [01] proposed a system for image enhancement is proposed. Probabilistic method of illumination and reflectance estimation is carried out. The proposed methodology gives better estimation of illumination and reflectance in the linear domain. With priors of both reflectance and illumination a maximum a posterior (MAP) formulation is employed. Different approach of multiplies is adopted for the clearance of MAP main issue for the estimation of reflectance and illumination is done. When compared with different trying out ways, the proposed approach yields higher outcome on both subjective and function assessments.

Seema Rani et. al [02] proposed a method that first segments histogram of image recursively after which applies Adaptive Gamma Correction with Weighting Distribution (AGCWD) method. The proposed procedure is truly a development over AGCWD manner and aims to get better contrast enhancement and brightness than AGCWD manner without segmenting the histogram. Thus this work improves results by following recursive segmentation approach of histograms for better image enhancement.

S.Gayathri et.al [07] offered a new enhancement approach for the improvement of image brightness and preservation of information present in an image. In gamma correction, it defines the organization between a pixel's numerical value and its original brightness. Gama value is calculated and is applied on the original image for the improvement of image quality. Entropy calculation is also done for to get final enhanced image. Researchers in [09], [10] Histogram equalization is the typical process for contrast enhancement. It in actual fact maps gray levels based on probability distribution of input images. However images received by using this procedure can produce undesirable effects in images and in addition actual brightness of image just isn't preserved. Histogram equalization procedure redistributes

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likelihood densities. Adaptive Gamma Correction with Weighting Distribution (AGCWD) system is established on histogram modification system [06].
This technique combines each gamma correction and histogram equalization procedures. Gamma correction method had challenge that unvaried modification results for every image in view that a predefined value used to be used for all images. Histogram equalization had main issue under enhancement and over enhancement. So the AGCWD procedure eliminated risks of each gamma correction and Histogram Equalization strategies via combining each tactics and making use of a weighting function [05]. To extra fortify this system to get better contrast enhancement and higher brightness preservation and growth is proposed in this paper

III. IMAGE ENHANCEMENT TECHNIQUES

A. Histogram EQUALISATION

Histogram equalization technique is commonly employed for image enhancement because of its simplicity and comparatively better performance on almost all types of images. Various histogram techniques includes Conventional Histogram Equalization, Brightness Preserving Bi-Histogram Equalization, Dualistic Sub-Image Histogram Equalization, Minimum mean brightness error Bi-HE, Recursive Mean-Separate HE Method, Mean Brightness Preserving Histogram Equalization, Dynamic Histogram Equalization and Brightness Preserving Dynamic Histogram Equalization.CHE can introduce a significant change in brightness of an image, which hesitate the direct application of CHE scheme in consumer electronics. Brightness Preserving Bi-Histogram Equalization method divides the image histogram into two parts. In this method, the separation intensity is presented by the input mean brightness value, which is the average intensity of all pixels that construct the input image.
After this separation process, these two histograms are independently equalized. By doing this, the mean brightness of the resultant image will lie between the input mean and the middle gray level. Instead of decomposing the image based on its mean gray level, the DSIHE method decomposes the images aiming at the maximization of the Shannon's entropy of the output image. For such aim, the input image is decomposed into two sub-images, being one dark and one bright, respecting the equal area property (i.e., the sub-images has the same amount of pixels).The main difference between the BBHE and DSIHE methods and the MMBEBHE one is that thelatter searches for a threshold level that decomposes the image I into two sub-images I [0, lt] and I [lt +1, L −1], such that the minimum brightness difference between the input image and the output image is achieved, whereas the former methods consider only the input image to perform the decomposition. Once the input image is decomposed by the threshold level lt, each of the two sub-images I [0, lt] and I [lt +1, L−1] has its histogram equalized by the classical HE process, generating the output image. RMSHE method proposes to perform image decomposition recursively, up to a scale r, generating 2r sub-images . After, each one of these sub-images Ir [ls, lf] is independently enhanced using the CHE method. Note that when r = 0 (no sub-images are generated) and r = 1, the RMSHE method is equivalent to the CHE and BBHE methods, respectively. The brightness of the output image is better preserved as r increases. The mean brightness preserving histogram equalization (MBPHE) methods basically can be divided into two main groups, which are bisections MBPHE, and multi-sections MBPHE. Bisections MBPHE group is the simplest group of MBPHE. Fundamentally, these methods separate the input histogram into two sections.
These two histogram sections are then equalized independently. However, bisections MBPHE can preserve the mean brightness only to a certain extent. However, some cases do require higher degree of preservation to avoid unpleasant artifacts. The Dynamic Histogram Equalization (DHE) technique takes control over the effect of traditional Histogram Equalization so that it performs the enhancement of an image without making any loss of details in it. DHE divides the input histogram into number of sub-histograms until it ensures that no dominating portion is present in any of the newly created sub-histograms. The brightness preserving dynamic histogram equalization (BPDHE), which is an extension to HE that can produce the output image with the mean intensity almost equal to the mean intensity of the input, thus fulfils the requirement of maintaining the mean brightness of the image.

B. Adaptive Gamma Correction with Weighting Distribution (AGCWD)

For the significant adjustment of the input image after gamma correction an adaptive compensated parameter cdf is used which modifies the image quality by increasing the intensity level of the image. The proposed AGCWD is formulated as in eq.(1)

$$T(l) = lmax\left(\frac{l}{lmax}\right)^{\gamma} = lmax\left(\frac{l}{lmax}\right)^{1-cdf(l)} \quad (1)$$

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Progressive increase in low intensity and decrease of high intensity is gained using AGC. Further modification of statistical histogram and for the reduction of adverse effects weighted distribution (WD) function is applied and is formulated as in eq. (2).

$$pdf_w(l) = pdf_{max} \frac{pdf(l) - pdf_{min}}{pdf_{max} - pdf_{min}}^{\alpha} \quad (2)$$

Adjustment parameter is denoted by α, maximum pdf is denoted by pdf_{max} . Based on the above equation the approximated cdf is given by,

$$cdf_w(l) = \frac{\sum_{l=0}^{l_{max}} pdf_w(l)}{\sum pdf_w} \sum pdf_w \quad (3)$$

The summation of pdf_w is done using the eq. ().

$$\sum pdf_w = \sum_{l=0}^{l_{max}} pdf_w(l) \quad (4)$$

The modified gamma parameter based on calculated cdf is given by,

$$\gamma = 1 - cdf_w(l) \quad (5)$$

The obtained gamma corrected Image is then passed to mapping curve block as in flowchart 2. The detailed flow given below shows that initially colour image is taken as the input. RGB to HSV plane separation of the image is done. Illumination plane and reflectance plane of both these color planes are separated. Illumination plane is then subjected to AGCWD block for gamma correction. Gamma corrected image then passed to mapping curve block [03].

IV. METRICS USED TO ASSESS IMAGE QUALITY

A. Peak Signal To Noise Ratio (PSNR):

It is the evaluation standard of the reconstructed image quality, is the most wanted feature. PSNR is measured in the decibels (dB) and it is given by

$$PSNR = 10\log(255 / 2\,MSE) \quad (6)$$

Where the value 255 is the maximum possible value that can be attained by the image signal. Mean square error is defined as where M*N is the size of the original image. Higher the PSNR value betters the reconstructed image.

B. Absolute Mean Brightness Error(AMBE):

It is the difference between the brightness of the original image and enhanced image. It is given by,

$$AMBE = |E(x) - E(y)| \quad (7)$$

Where E(x) is the average intensity of the input image and E(y) is the average intensity of enhanced image. The value of AMBE should be as small as possible.

C. Entropy:

For a given PDF p, entropy Ent[p] is computed. In general, the entropy is a useful tool to measure the richness of the details in the output image.

$$Ent[p] = -\Sigma k = 0\,(k)\log 2\,p\,(k) \quad (8)$$

D. Mean Square Error (MSE):

The average squared difference between the reference signal and distorted signal is called as the means quare error. It can be easily calculated by adding up the squared difference pixel-by-pixel and dividing by the total pixel count. Let m x n is a noise free monochrome image I, and K is defined as the noisy approximation. Then the mean square error between these two signals is defined as:

$$MSE = 1\, m \times n\, [I\, i,j - K\, i,j]\, n - 1\, 2\, j = 0\, m - 1\, i = 0 \quad (9)$$

E. Signal-To-Noise Ratio (SNR):

Signal-to-noise ratio is defined as the ratio of signal power to the noise power, often expressed in decibels. Higher the SNR value betters the reconstructed image

$$SNRdB = 10\log 10\, Psignal\, Pnoise = Psignal, dB - Pnoise, dB \quad (10)$$

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V. CONCLUSION

Histogram equalization is a straight forward image processing techniques often used to achieve better quality images while designing image enhancement techniques the speed of execution of the program is also an important factor. In this Paper, a framework for image enhancement based on prior knowledge on the Histogram Equalization techniques has been presented. Algorithms of many image enhancement techniques like Conventional Histogram Equalization (CHE), Contrast Limited Adaptive Histogram Equalization (CLAHE), Background Brightness Preserving Histogram Equalization (BBPHE),and Brightness Preserving Dynamic Fuzzy Histogram Equalization (BPDFHE) has been explained in detail. Also Adaptive Gamma correction with Weighting Distribution (AGCWD) has been explained. The image quality obtained after applying these algorithms is assessed with metrics . These metrics include Peak Signal To Noise Ratio (PSNR), Absolute Mean Brightness Error(AMBE),Entropy and Mean Square Error (MSE) which are discussed in this paper.

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