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PERFORMANCE COMPARISON OF IMAGE ENHANCEMENT TECHNIQUES

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***Abstract*— Development in the technology has significantly improved the image quality. But, during analog to digital transformation, there will be an addition of noise and uneven illuminations that causes low contrast. Images with low contrast are not pleasing to the human eye and may not be useful for further processing. In this project an alternative method is proposed for the effects caused in an image due to low contrast, noise and improper usage of neighborhood pixels. These drawbacks are overcome by implementing "Contrast enhancement using joint histogram equalization". The input image is passed through the image averaging method, a digital image processing technique often employed to enhance video image which are corrupted by random noise.**

This technique operates by computing an average (or) arithmetic mean of intensity values for each pixel position in a set of captured images. After the process of averaging image then the joint histogram equalization will be computed. It achieves the co-relation between the intensity of a pixel and the averaging intensity value of its neighborhood pixel to improve the contrast of an image. The output of enhanced method will be evaluated by probability density function and cumulative distribution function in two dimensional. To get the output pixel, the intensity mapping function is utilized. Every neighborhood pixel was used efficiently to enhance the contrast of an image.

***Keywords*— Contrast enhancement; Histogram equalization; Joint histogram; Image processing.**

1. INTRODUCTION

The acquisition and processing of digital imagery belonged almost entirely in domain of academic and research laboratories [1]. In recent years, the need of digital image processing for military, medical and industrial purposes is growing [2]. Today, many digital images are being downloaded from World Wide Web, parents store photographs on a digital CD and business executives cut deals via digital video teleconferencing [3]. These digital images are properly considered to be sampled versions of continuous real-world pictures [4]. Because they are stored in processed on digital computers, digital images are typically discrete domain, discrete range signals [5]. These signals can be conveniently represented and manipulated as matrices containing the light intensity or color information at each sample point [6]. When the acquired digital image is not fit for a prescribed use, image enhancement techniques are used to modify the characteristics [7].

Image Enhancement:

Image Enhancement is the process of improving the visual appearance of an image to make it more acceptable for the human or machine [8]. The principal objective of image enhancement is to modify attributes of an image to make it more suitable for a given task and a specific observer [9]. During this process, one or more attributes of the image are modified [10]. The choice of attributes and the way they are modified are specific to a given task [11]. Image enhancement is done by changing some attributes of the image [12]. Image enhancement is applied in every field where images are ought to be

understood and analyzed [13]. For example, medical image analysis, analysis of images from satellites etc. Different techniques are available for the image enhancement [14]. Contrast enhancement is one of the image enhancement techniques [15]. Contrast enhancement is done when the image quality is suffering from poor contrast due to the environmental lighting conditions or due to defect in photographic devices [16]. In the case of dimmed images or dimmed videos the contrast enhancement is an essential factor that needs to be considered [17]. Image enhancement methods can be categorized into two type's namely spatial domain methods and frequency domain methods [18]. The attributes of original image are changed in order to get enhanced clear images [19]. Spatial domain techniques operate directly on the pixels of an image [20]. However, the spatial domain techniques introduce some noise artifacts and hence frequency domain techniques are implemented for image enhancement. Image enhancement in frequency domain is straight forward [21]. First the image is transformed into frequency domain by using certain transformation techniques and then the operations are performed to obtain the desired task [22]. More complex methods involve modifying the image content in another domain, such as the coefficient domain of a linear transformation of the Image were also implemented for better performance [23].

Contrast Enhancement:

Image enhancement techniques have been widely used in many applications of image processing where the subjective quality of images is important for human interpretation [24]. Contrast is an important factor in any subjective evaluation of image quality [25]. In other words, contrast is the difference in visual properties that makes an object distinguishable from other objects and the background [26]. In visual perception, contrast is determined by the difference in the color and brightness of the object with other objects [27]. The visual system is more sensitive to contrast than absolute luminance; therefore, we can perceive the world similarly regardless of the considerable changes in illumination conditions [28]. Contrast enhancement plays a fundamental role in image or video processing [29]. Contrast enhancement changes the image value distribution to cover a wide range [30]. If the image values concentrated near a narrow range, then it refers to low contrast [31]. If the contrast of an image increases lighter area becomes lighter and darker area becomes darker [32]. If the contrast of an image decreases all the pixels is mid shade of gray which makes the image to fade [33]. Adjusting the pixels of an image for improving the contrast of an image for natural looking of an image contrast enhancement. Contrast of an image can be revealed by its histogram [34].

Histogram Equalization:

Histogram equalization is a method in image processing of contrast adjustment using the images histogram [35]. Histogram equalization often produces unrealistic effects in photographs, however it is very useful for scientific images like thermal, satellite or x-ray images, often the same class of images to which one would apply false-color [36]. Also histogram equalization can produce undesirable effects (like visible image gradient) when applied to images with low color depth [37]. Histograms are easy to calculate in software and also lend themselves to economic hardware implementations, thus making them a popular tool for real time image processing [38]. This method usually increases the global contrast of many images, especially when the usable data of the image is represented by close contrast values [39]. Through this adjustment, the intensities can be better distributed on the histogram [40]. This allows for areas of lower local contrast to gain a higher contrast [41]. Histogram equalization accomplishes this by effectively spreading out the most frequent intensity values [42]. It is the uniform distribution of pixels over the intensity scale [43].

2. OBJECTIVES

- The main limitation to the most commonly used histogram equalization (HE) technique is the inconsideration of neighbourhood information near each pixel for contrast enhancement. This leads to noise in the output image.
- To overcome this effect, a joint histogram equalization (JHE) technique is proposed. The main focus is to utilize the information among each pixel and its neighbours which improves the contrast of an image.

3. MOTIVATIONS AND CHALLENGES

Image enhancement finds extensive applications in various fields for improving the quality of the image. Several techniques in both spatial and transform domain are available for image enhancement.

Recently a new technique called Joint histogram Equalization(JHE) is proposed for image processing where it overcome the noise in the output image and it utilize the information among each pixel and its neighbours, which improves the contrast of an image.

4. METHODOLOGY USED

A Joint histogram equalization (JHE) algorithm which utilizes correlation between the intensity of a pixel and the average intensity value of its neighbourhood to improve the contrast of the image. A joint histogram is created by choosing a group of local pixel attributes. The individual cells in the joint histogram matrix represent the number of pixels in the image expressed by a certain combination of attribute values. The individual entry in it represents the number of pixels in the image expressed by a certain combination of the attribute values.

The conventional approach for image enhancement is to replace individual pixel intensities with the required intensity values by forming a one-dimensional (1D) histogram of the input image. Then the required intensity values are computed from the corresponding probability distribution. The two-dimensional (2D) cumulative distribution function (CDF) is obtained from the count function. By this the contrast enhanced output pixel intensity will generated. Besides, all the methods which perform contrast enhancement regardless the level of the contrast available on an image. This may result in degraded contrast in case of image has high level of contrast. Furthermore, contrast enhancements methods are generally utilized as pre-processing step for majority of image processing or computer vision algorithms.

5. IMPLEMENTATION

Implementation can be done by using software that can be clearly can be observed in the below diagram.

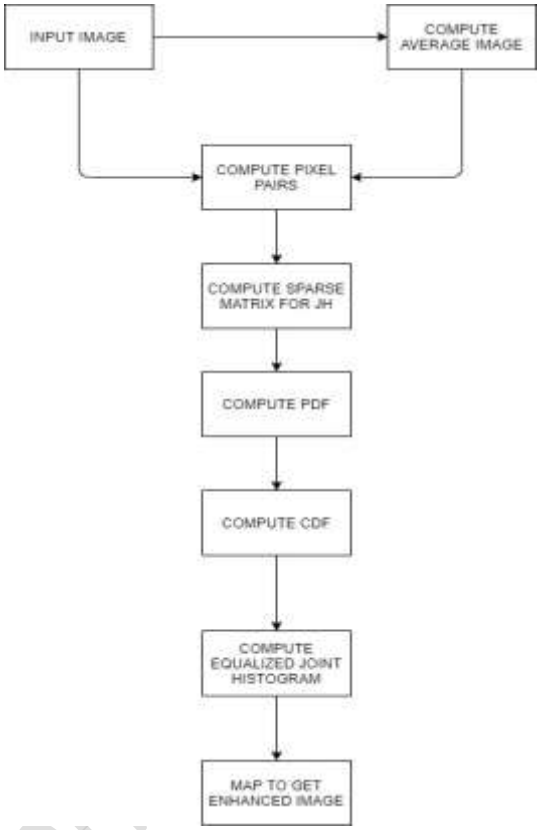


Fig1: Schematic block diagram of suggested technique

ALGORITHM FOR PROPOSED METHOD

STEP 1: Consider the input image I and compute the average image I using

$$g(x,y) = \left[\frac{1}{w*w} \sum_{m=-k}^{k} \sum_{n=-k}^{k} f(x+m, y+n) \right] \quad \text{.....eq (1)}$$

where each pixel intensity value is substituted by the average intensity value of its neighboring pixels.

STEP 2: Compute the joint histogram by comparing the input image I and the average image I using

$$H = \{ h(i, j) \mid 0 \le i \le L-1, 0 \le j \le L-1 \} \quad \text{.....eq (2)}$$

Where h(i, j) is the number of occurrences of the grey level pair f(x, y) and g(x, y) at the same spatial location (x, y) of the images I and I respectively. It computes the count function.

STEP 3: The joint histogram count function is then used to obtain the two-dimensional cumulative distribution function using

$$CDF(i,j) = \sum_{m=0}^{i} \sum_{n=0}^{j} h(m,n) \quad \text{.....eq (3)}$$

Computation of CDF does not depend on the size (M, N) of the images. In this method 2D CDF value is used to generate the contrast enhanced output pixel intensity.

Image Contrast Enhancement Using Joint histogram Equalization:

STEP 4: The equalized value of the intensity pairs (i,j) in the output image using the proposed method is obtained as

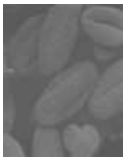
$$heq(i, j) = round((L-1/MN-1)(CDF(i,j) - CDF(i,j)min)) \quad \text{.....eq (4)}$$

6. RESULTS

The input image is a gray scale image. In this method new intensity value for particular grey-level according to the neighbourhood grey-level distribution will be calculated. It modifies only a few selected instances of the grey-level according to the probability distribution instead of modifying all the occurrences of the grey level. Thus, this method results in a more natural looking output image as compared to the global histogram equalization method. Since this method considers the grey-level distribution around a pixel as a feature to compute the histogram, it is named joint histogram equalization. Here, the JHE method is also extended to color images to enhance the contrast. The algorithm is applied to the luminance component only in color images, thereby preserving the color information in them.

The joint histogram is constructed using the original image and its average image. The proposed idea is a special case of the 2D histogram. It uses the grey level pixel pairs, instead of the grey level differences, for contrast improvement. It does not require a target uniform distribution for generating the output. By contrast, the two-dimensional cumulative distribution function (CDF) is used as a mapping function to get the output pixel grey level.

Original image



Histogram Equalization | Gamma Correction

Low pass filtered Image | High pass filtered Image

Joint Histogram image

Fig. 2 Results of contrast enhancement for Lenadark image using different methods

Original image

Histogram Equalization | Gamma Correction

Low pass filtered Image | High pass filtered Image

Joint Histogram image

Fig. 3 Results of contrast enhancement for Food image using different methods

Original image

Histogram Equalization

Gamma Correction

Low pass filtered Image

High pass filtered Image

Joint Histogram image

Fig. 4 Results of contrast enhancement for Image16 image using different methods

COMPARISON THEORY

In spatial domain, the above examples show the different techniques related to contrast enhancement. While discussing about drawback of Gamma correction, if the parameter gamma raises a value less than 1 or greater than 1 the output image will be darker than darker and brighter than brighter respectively. In order to prevent this, the gamma should be set to 1 which maintains acceptable perception levels. The above condition can be said as a limitation to the contrast enhancement.

Low pass filters are usually called to be smoothening filters and high pass filters are called to be sharpening filters. The low contrast images that are taken for enhancement cannot be enhanced properly using the low pass filter and high pass filter.

The histogram equalization technique has a limitation called to be the inconsideration of neighbourhood information near each and every pixel for contrast enhancement.

Among all the above techniques adopted, on the basis of each and every neighbourhood pixel of an image Joint Histogram Equalization (JHE) is proved to be far better for contrast enhancement.

PERFORMANCE OF METRICS

To gauge the quality of enhanced image, three quantitative measures such as,

- Absolute mean brightness error (AMBE)
- Discrete entropy (DE)
- Edge based contrast measure (EBCM)

ABSOLUTE MEAN BRIGHTNESS ERROR (AMBE):

The objective measurement utilized to evaluate the performance of the approaches in preserving the original brightness of the input image is AMBE. This is expressed as the absolute difference between the average values of the input and the output image as

$$AMBE (I, O) = 1/(1+ | E(I)-E(O) |)$$

where I and O represent the input and output image E (.) represents the statistical mean value

- A higher absolute mean brightness error value shows improved brightness error.
- A lower absolute mean brightness error value indicates that the brightness is better preserved.

Comparison of AMBE for different enhancement techniques is given as

Images	Histog - ram Equalization	Gamma Correction	Joint histogram
Lenadark.png	0.019	0.652	0.018
dark22.jpg	0.008	0.0235	0.008
Image16.jpg	0.0157	0.039	0.015
Average:	0.0142	0.229	0.0136

Table 1: Calculation of AMBE for different techniques

DISCRETE ENTROPY (DE):

Discrete entropy is a statistical quantity of randomness which is utilized to describe the characteristics of the input image. It determines the content in an image. A higher value indicates richer details. It is expressed as

$$DE(I) = -\sum_{k=1}^{L-1}((p(r_k) * \log(p(r_k)))$$

where $p(r_k)$ is the probability of pixel intensity and r_k is computed from the normalized histogram of the input image I

$$DE(O) = -\sum_{k=1}^{L-1}((p(r_k) * \log(p(r_k)))$$

where $p(r_k)$ is the probability of pixel intensity *and* r_k is computed from the normalized histogram of the output image O.

The normalized DE for the input image I and the corresponding output image O is defined as

$$DEn = \frac{1}{1 + \frac{\log(256) - DE(O)}{\log(256) - DE(I)}}$$

Comparison of DEn for different enhancement techniques is given as

Images	Histogram Equalization	Gamma Correction	Joint histogram
Lenadark.png	0.5196	3.736	0.3801
dark22.jpg	0.5246	17.02	0.357
Image16.jpg	0.5814	1.9806	0.459
Average	0.5418	7.5	0.398

Table 2: Calculation of DEn for different techniques

EDGE BASED CONTRAST MEASURE (EBCM):

It is based on the observation of edges on the windowing image and expected that an enhanced image should have more edge pixels than the original image. This parameter measure the intensity of edge pixels in small windows of the image. It is computed on the basis of the sensitivity of human perception mechanisms to contours (edges). By calculating the weighted mean value the intensity values can be obtained. EBCM value of output image should be smaller than the EBCM value of the input image for better result.

Contrast con(x, y) is defined as

$$con(x, y) = \left| \frac{i(x, y) - e(x, y)}{i(x, y) + e(x, y)} \right|$$

$$e(x, y) = \frac{\sum_{k,l \in N(x,y)} g(k, l)\, i(k, l)}{\sum_{k,l \in N(x,y)} g(k, l)}$$

where N(x, y) represents the neighboring pixels of the pixel located at (x, y)

g(k, l) represents the edge value of the pixel located at (k, l) and image gradient magnitude calculated by using Sobel operator.

The EBCM for an image is then calculated as average contrast value, i.e.

$$EBCM = \frac{\sum_{x=1}^{M} \sum_{y=1}^{N} con(x, y)}{MN}$$

The normalized contrast measure CMn is given as

$$CMn = \frac{1}{1 + \frac{1 - EBCM(O)}{1 - EBCM(I)}}$$

Comparison of CMn for different enhancement techniques is given as

Images	Histogram Equalization	Gamma Correction	Joint histogram
Lenadark.png	0.1417	0.172	0.1517

dark22.jpg	0.316	0.519	0.326
Image16.jpg	0.469	0.522	0.484
Average:	0.308	0.404	0.32

Table 3: Calculation of CMn for different techniques

7. CONCLUSION

Several techniques such as spatial domain and frequency domain techniques were available in image enhancement. These techniques were involved in performing the operations. The spatial domain techniques are easy to implement but they are suitable for images with low illumination. The joint histogram equalization scheme utilizes the intensity distribution surrounding each pixel in an image to improve the contrast. Both the grey and colored images can be implemented by using joint histogram equalization to enhance the contrast of an image. The joint histogram technique is helpful in producing the noise free output in which the brightness, contrast richer details of an image. An image with narrow dynamic range produces the best results by using the suggested technique. This method implements both global and local contrast enhancement. Different performance metrics were implemented on dark images to validate the algorithm. It uses 2- dimensional cumulative distribution function to generate output pixel grey level.

8. REFERENCES

[1]Hongbo, Y., Xia, H., 2014. Histogram modification using grey-level co-occurrence matrix for image contrast enhancement. IET Image Proc. 8 (12), 782–793.

[2]Jabeen, A., Riaz, M.M., Iltaf, N., Ghafoor, A., 2016. Image contrast enhancement using weighted transformation function. IEEE Sens. J. 16 (20), 7534–7536.

[3]Kim, Y.T., 1997. Contrast enhancement using brightness preserving bi-histogram equalization. IEEE Trans. Consum. Electron. 43 (1), 1–8.

[4]Kim, T.K., Paik, J.K., Kang, B.S., 1998. Contrast enhancement system using spatially adaptive histogram equalization with temporal filtering. IEEE Trans. Consum00000000000000. Electron. 4 (1), 82–87.

[5]Ling, Z., Liang, Y., Wang, Y., Shen, H., Lu, X., 2015. Adaptive extended piecewise histogram equalization for dark image enhancement. IET Image Proc. 9 (11), 1012–1019.

[6]Martin, D., Fowlkes, C., Tal, D., Malik, J., 2001. A database of human segmented natural images and its application to evaluating segmentation algorithms and measuring ecological statistics. In: Proceedings of 8th International Conference on Computer Vision, 2, pp. 416–423.

[7]Menotti, D., Najman, L., Facon, J., de Araujo, A., 2007. Multi-histogram equalization methods for contrast enhancement and brightness preserving. IEEE Trans. Consum.Electron. 53 (3), 1186–1194.